EEL331

MICROPROCESSORS AND MICROCONTROLLERS LAB

B.TECH

(2019 SCHEME)

SEMESTER – V

Department of Electrical and Electronics Engineering

AHALIA SCHOOL OF ENGINEERING & TECHNOLOGY
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Preamble

This laboratory course is designed to train the students to familiarize and program microprocessors and microcontrollers. Students will also be introduced to a team working environment where they develop the necessary skills for planning, preparing and implementing embedded systems.

Prerequisite

Fundamentals of Digital Electronics and C programming

Course Outcomes:

After the completion of the course the student will be able to:

C0 1	Develop and execute assembly language programs for solving arithmetic and logical problems using microprocessor/microcontroller.
CO 2	Design and Implement systems with interfacing circuits for various applications.
CO 3	Execute projects as a team using microprocessor/microcontroller for real life applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	**3**	**2**	**2**	**3**	**-**	**-**	**2**	**2**	**3**	**-**	**2**
CO 2	**3**	**3**	**2**	**2**	**3**	**-**	**-**	**2**	**2**	**3**	**-**	**2**
CO 3	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**

Vision

Grow as a centre of learning and research, transforming students to professionals with knowledge, skill, competence, commitment, confidence and ethics to serve the society.

Mission

- To impart value-based education and promote curricular, co-curricular & extracurricular activities amongst students through extensive theoretical & practical training by qualified and experienced personnel using state-of the-art facilities.
- To promote research and consultancy for institution development and contribution to the society.

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Experiment No.1

Study of Intel 8085 Microprocessor kit: Micro -85 LC

Aim:

To study the architecture of the 8085 microprocessor trainer kit: Micro – 85 LC

Intel 8085 Microprocessor kit: Micro -85 LC

Micro – 85 LC microprocessor kit has an Intel 8085A microprocessor. The memory comprises of 32K EPROM (27256) and 8K RAM (6264). The system RAM address rangers from 0x4000 -0x5FFF of which 00x4100 – ox5FFF is user RAM area. Besides user RAM expansion is possible in address range 0x6000-0xBFFF.

The display used is a 16 x 2 alphanumeric display with backlight. A 105- keys IBM PC keyboard is used as interface for programming the microprocessor kit.

INPUTS TO AND OUTPUTS FROM CPU

The CPU gets the clock from the clock generator which is a crystal at 6.144 MHz the reset, interrupt lines, and data lines are also inputs to the CPU. The CPU outputs comprises the clock, reset out, address lines, data lines and control lines.

ADDRESS AND DATA BUS

The lower order address lines are latched using ALE and are thus de-multiplexed from the data lines. The higher order address lines are taken directly from the 8085.These two sets of lines are the 16 bit address bus. The 8 data lines are taken directly from the 8085.

CONTROL BUS

The other bus is the control bus. The control signals required for proper operation of the system are the IOR and IOW are utilized. The memory read memory write signals are used to enable an EPROM & RAM and write into RAM respectively. These signals are generated from the IO/M and WR, RD signals.

CHIP SELECT LOGIC

The selection of any peripheral or memory requires a CS to enable that particular device. This requires address decoding, both memory and I/O. All the above signals address, data, control and chip select are routed to all the peripherals and memory devices in the trainer.

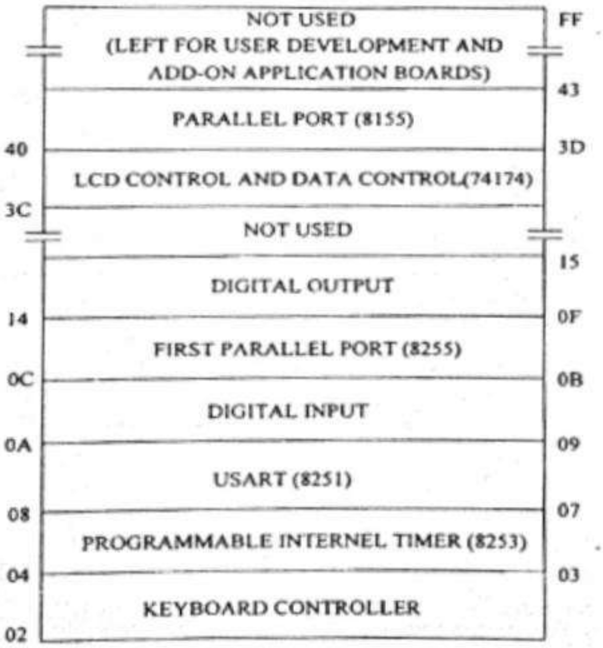
MEMORY

The Micro-85 LC can support an 8KB or 32KB EPROM and an 8KB or 32 KB RAM

PERIPHERALS

The 8253 TIMER is used for baud clock generation and single step operation: the 8251 USART is for serial communication with associated drivers for interference Immunity and overcoming attenuation: the 8255 PPI for TTL I/O drivers; the audio cassette Interface are also depicted in the block diagram. System expansion is facilitated by virtue of the expansion slots provided on board.

ALLOCATION PROCESS OF I/O ADDRESSES:



The peripherals available on Micro – 85 LC LCD are all I/O mapped. The complete I/O allocation table is as shown in table. The on – board peripherals occupy I/O address from 0x00 to 0x3F. The add on application boards occupy I/O address from 0x80 to OxFF. Apart from these reserved I/O address, the rest are available to the users for their own development purposes

MEMORY CONFIGURATION OF MICRO – 85 – LC MICROPROCESSOR KIT

C000	EPROM EXPANSION	FFFF
6000	USER EXPANSION RAM	BFFF
4100	USER RAM AREA	5FFF
4000	MONITOR PROGRAM DATA AREA	40FF
0000	MONITOR FROM AREA	3FFF

MICRO – 85 LC COMMANDS

The commands are entered immediately after the # prompt without blank space.

Syntax notations:

<Add> - 16 – bit address in hexadecimal.

<Data> - 8 – bit data in hexadecimal.

<Port Add> - 8- bit I/O port address in hexadecimal

<CR> - carriage return (enter key press)

1. SUBSTITUTE MEMORY COMMAND (SU):
   Syntax : SU <Addr> <CR>

Function: To examine the contents of selected memory locations and modify the contents (of RAM)

2. REGISTER COMMAND (R):
   Syntax: R<CR>
   Function : To examine and modify the special function register (A,PSW,PCH,PCL,SPH,SPL,H,L,D,E,B,C,INT- REG) contents of the CPU.
3. GO AND EXECUTE COMMAND (G):
   Syntax: G<Addr><CR> or G<Start Addr > < End Addr> <CR>
   Function : To run the user program This command transfer the 8085 CPU control from the monitor program to the user program and executes it.
4. TRACE COMMAND (TR):
   Syntax : TR<Addr><CR>
   Function : To execute the user program in streps (step – by step/instruction by instruction execution) for debugging purposes.
5. FILL COMMAND (F):
   Syntax : F<Start Addr> <End Addr><Data><CR>
   Function : To fill a block of RAM with desired data.
6. BLOCK MOVE COMMAND:
   Syntax : M<Start Addr> <End Addr><Dest Addr><CR>
   Function : To move the contents of the specified block of RAM to another block of RAM whose start address (ie, of destination) is specified.
7. INSERT COMMAND (IS):
   Syntax: IS<Insert Addr><Programm End Addr><No.of Bytes><CR>
   Function : To insert the specified bytes in the desired memory locations.
8. DELETE COMMAND (D)
   Syntax: D<Strt Addr>< End Addr><Programm End Add><CR>
   Function : Delete a block of bytes from memory
9. INPUT COMMAND (IN)
   Syntax: IN<Port Addr>< CR>
   Function : To input data from desired port of which the address is given.
10. OUTPUT COMMAND (IN)
    Syntax: OU<Port Addr><Data><CR>
    Function : To output data to desired port
11. SERIAL INPUT COMMAND (SI)
    Syntax: SI<Strt Addr><End Addr>< CR>
    Function : To input data from the serial port of Micro-85LC Microprocessor
12. SERIAL INPUT COMMAND (SO)
    Syntax: SO<Strt Addr><End Addr>< CR>
    Function : To output data serially through the serial port of Micro-85LC Microprocessor
13. ASSEMBLE COMMAND(A)
    Syntax: A< CR>
    Function: To enter the origin address of the program(ORG<Addr>) and then instructions.
14. UNASSEMBLE COMMAND(U)
    Syntax: U< CR>

Function: To enter the origin address of the program and then unassembled the opcode and it.

15. ASSEMBLE COMMAND(A)

    Syntax: A< CR>

    Function: To enter the origin address of the program(ORG<Addr>) and then instructions.

16. BLOCK SEARCH COMMAND(BS)

    Syntax: BS< Start Addr >< End Addr >< Byte >< CR >

    Function: To search a block of memory for a particular byte and to modify it.

STEPS TO ENTER A PROGRAM

1. Turn on power supply to the Micro-LC microprocessor kit.
2. The kit turns on ,gets reset and the display reads “MICRO-85 EB”in line one and “#_” in the second line.
3. The reset button on the kit is pressed at any stage before starting to enter the commands and the display reads “MICRO-85EB” in line one and “#_” in the second line.
4. Type “A” and press enter key.
5. Now the display reads “ORG?” in line one and “LINE ASSEMBLER” in the second line.
6. Type the start address of the program immediately after “ORG?” and press enter key. Eg: ORG ? 4100
7. Now the display shows the start address in line one .ie.4100 in the above example.
8. The kit is now ready to accept the program code in mnemonics, which can be entered using the IBM PC keyboard.
9. Inorder to enter “MVI A, 09” type “MVI A,09” and pree enter key.
10. The next address location is displayed and the above step is repeated till the last of the program is entered.

STEPS TO EXECUTE A PROGRAM

1. The reset button on the kit is pressed and the display reads “MICRO -85 EB” in the line one and “#_” in the second line.
2. Type “G”, then a space followed by the start address and press the enter key.
3. The display reads “GO EXECUTE” and the program is executed.
4. Now press the reset key again.

STEPS TO VIEW A PROGRAM STORED IN THE MICRO-85 LC RAM

1. The reset button on the kit is pressed and the display reads “MOICRO-85 EB” in the line one and “#_” in the second line.
2. Type “U” and press enter key.
3. Now the display reads “ORG”.
4. Here, type the start address of the program and press the enter key.
5. The first line of the code in mnemonics is displayed.
6. The succeeding lines of the program could be displayed by pressing the enter key repeatedly.

STEPS TO EDIT A PROGRAM STORED IN THE MICRO-85 LC RAM

1. The reset button on the kit is pressed and the display reads “MICRO-85 EB” in line one and “#” in the second line.

2. Type “A” and press the enter key.

3. Now the display reads “ORG?” in the line one and “LINE ASSEMBLER” in the second line.

4. Type the desired address of the program line to be edited immediately after “ORG?” and press the enter key.

5. Now the display shows the selected address in line one. i.e., 410A in the above example.

6. The kit is now ready to accept the alternative program code in mnemonics.

7. In order to enter “MVI A, 09” and press the enter key to move to the next address location.

8. The above step is repeated till the desired number of lines of the program are edited.

Note: The address locations might change when the code is edited. Hence new address might need to be used for the jump statements.

EXPERIMENT NO: 2

Data transfer using different Addressing modes in 8085

Aim:

1. To transfer 8 bit numbers using,
    a) Immediate addressing mode
    b) Direct Addressing mode
    c) Indirect addressing mode.
2. To move a block of memory from one location to another

Apparatus required:

8085 microprocessor kit, keyboard and (0-5V) DC Supply.

1. Data transfer using different Addressing modes

Immediate addressing mode:

In immediate addressing mode the source operand is always data. If the data is 8-bit, then the instruction will be of 2 bytes, if the data is of 16-bit then the instruction will be of 3 bytes.

Direct addressing mode:

In this mode, the data is directly copied from the given address to the register.

Indirect addressing mode:

In this mode, the data is transferred from one register to another by using the address pointed by the register. For example: MOV K, B: means data is transferred from the memory address pointed by the register to the register K

Algorithm

1. Set up memory pointers for source ,destination
2. Move the byte from the source to destination through Accumulator. Increment the memory pointers.

PROCEDURE

1. Enter program in memory from starting locations
2. Enter the numbers in the given memory locations
3. Execute the program and verify result.

a) Immediate addressing mode:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data : Given in Program

Output Data:

b) **Direct addressing mode:**

Address	label	Opcode	Operands	Comment

Observations:

Location **Data**

Input Data:

Output Data:

c) **Indirect addressing mode:**

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data:

Output Data:

2. Block transfer of data:

Theory

The data are stored in memory locations starting from a given memory location the specified location. The HL register pair is used as a pointer for the source memory and another register as pointer for the destination memory. A counter is set up using a register. Initially the first number from the source is moved to the accumulator. The data in accumulator is then moved to the first location of destination. After that the address pointers are incremented to point to the next source and destination locations and the counter is decremented to indicate that one byte is transferred. If the counter is not zero the above process will continue. If the counter is zero, it implies that all the data are transferred from the source to destination.

Algorithm

3. Set up memory pointers for source ,destination and counter
4. Move the byte from the source to destination through Accumulator. Increment the memory pointers and decrement the counter.
5. Repeat the above step until all data are moved.

PROCEDURE

1. Enter program in memory starting locations
2. Enter the numbers in memory locations

3. Execute the program and verify result.

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data:

Output Data:

Result:

Wrote assembly language programs to perform;

1. The data transfer of an 8 bit number using the following addressing modes and verified the results.

   a) Immediate addressing mode

   b) Direct Addressing mode

   c) Indirect addressing mode.

2. The block data transfer of 10 numbers from the memory location to the specified memory location and verified the result.

EXPERIMENT NO: 3

Arithmetic operations using 8085

Aim:

a) To write an assembly language program for the following arithmetic operations using binary and BCD numbers

Apparatus required:

8085 microprocessor kit, keyboard and (0-5V) DC battery

PROCEDURE

1. Enter program in memory locations starting from …….H
2. Enter the numbers in memory locations ……H and …….H
3. Execute the program and verify result in memory locations starting from ………H

A) Addition:

ALGORITHM:

1. Move the first number to accumulator
2. Increment the address pointer and add first number with next number and sore the result in the destination address

Addition of two binary numbers:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

Addition of two BCD numbers:

Theory: In BCD addition any number larger than 9(from A to F) is invalid. DAA instruction is used in the assembly language program to convert the result to BCD number after ADD instruction.

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

B) Subtraction:

ALGORITHM:

1. Move the first number to accumulator
2. Increment the address pointer and subtract first number from the next number and sore the result in the destination address.

Subtraction of two binary numbers:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

Subtraction of two BCD numbers:

Theory:

Instruction DAA cannot be used with subtraction of 2 BCD numbers, because it applies only to addition. Alternatively subtraction of BCD numbers can be done by adding 10's compliment of the subtrahend to the minuend. For example 82-48 = 34 can be performed as follows.

100's compliment of the subtrahend = 100-48= 52

82+52 = 134 = 34 if the carry is ignored.

100's compliment of a number can be obtained by adding 01 to its 99's compliment.

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

C) Multiplication:

ALGORITHM:

1. Move the first number to accumulator and set it as counter.
2. Increment the address pointer and enter the second number.
3. Add multiplicand and decrement the counter.
4. If counter is zero, stop otherwise go to above strep.
5. If counter is zero store the result in the destination address.

Multiplication of two binary numbers:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

D) Division:

Algorithm:

1. Load divisor and dividend in the memory locations, initialize quotient to 0.
2. Subtract divisor from the dividend and increment quotient.
3. If dividend is larger than divisor, repeat above step. Otherwise save remainder.

Division of two binary numbers:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

Result:

Assembly language program for various arithmetic operations using binary and BCD numbers has been written and verified.

EXPERIMENT NO: 4

Sorting in Ascending/Descending order Using 8085

Aim:

Write an Assembly Language Program to sort data in ascending /descending order whish are initially stored in memory location

Apparatus required:

8085 microprocessor kit, keyboard and (0-5V) DC battery

Theory:

Program uses the bubble sort technique. In this type of sorting first and second bytes are compared and the bigger is kept in the second address. Then second and third bytes are compared and the bigger is kept in the third address and so on. After one cycle (i.e. N-1 comparisons, where N is the number of bytes in the data), largest number will be in the last address. In the second cycle second largest number will be stored in the last but one location.

ALGORITHM:

1. Set the cycle counter at N-1, where N is the length of the array.
2. Copy the content of cycle counter to compare counter. Take the first data to accumulator.
3. Compare with the next number. If the next number is greater than the next go to next step.
4. Decrement compare counter. If it is not zero go to step 3.
5. Decrement cycle counter. If it is zero stop. Otherwise, go to step2.

PROCEDURE

1. Enter program in memory locations starting from …….H
2. Enter the numbers in memory locations ……H and …….H
3. Execute the program and verify result in memory locations starting from ………H
4. Modify the algorithm (step 4) and program to sort in descending order.

Program: Ascending order

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

Program: Descending order

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

Result:

Written an Assembly Language Program to sort data in ascending /descending order whish are initially stored in memory location and verified the result.

EXPERIMENT NO: 5

Code conversion Using 8085

Aim:

Write an Assembly Language Program to convert

1. Binary number to BCD number
2. BCD number to Binary number

Apparatus required:

8085 microprocessor kit, keyboard and (0-5V) DC Supply.

1. Binary to BCD

Theory: An unsigned 8 bit number has a range from 00H to FFH. Its equivalent BCD number is 00 to 255. A BCD number is obtained from a binary number by finding the number of hundreds, tens and units.

Algorithm

1. Find the number of hundreds in the binary number. For that subtract 100 (64H) from the binary number.

2. Find the number of tens in the remainder obtained by subtracting 10 (0AH).

3. The remainder obtained by subtracting tens in units. Arrange the number of hundreds, tens and units in the proper positions to obtain BCD number.

Procedure:

1. Enter the program in the memory starting from ……

2. Execute the program and verify the result in ………

3. Repeat the experiment by changing the number in the first line in the program.

Program:

Address	Label	Mnemonics	Operands	Comments

Observations:

		Location	Data
Input Data:	Binary		
Output data:	BCD		

2. BCD to BINARY

Theory: The conversion of BCD number in its binary equivalent employs the principle of positional weighting in a given number. In order to convert a 2 digit BCD number to its binary equivalent, first the digits are separated and each digit is multiplied with position and added together.

Algorithm:

1. Separate the LSD of the B CD number by AND-ing the BCD number with 0000 1111 (0FH) and store it in a register.
2. Separate the MSD by AND-ing the BCD number with 1111 0000(F0H) and shift the bits right four times. Multiply MSD by 10.
3. Add the product with the LSD.

Procedure:

1. Store BCD number in the given memory location.
2. Enter and execute the program and verify whether the contents of memory location.

Program:

Address	Label	Mnemonics	Operands	Comments

Observations:

		Location	Data
Input Data:	BCD	:	
Output data:	Binary	:	

Result:

Wrote Assembly language program for code conversion using 8085 processor and verified the result.

EXPERIMENT NO: 6

Block Data transfer using 8051

Aim:

To move a block of memory from one location to another

Apparatus required:

8051 microcontroller kit, keyboard and (0-5V) DC Supply.

Theory

The data are stored in memory locations starting from a given memory location in the specified location. A counter is set up using a register. Initially the first number from the source is moved to the accumulator. The data in accumulator is then moved to the first location of destination. After that the address pointers are incremented to point to the next source and destination locations and the counter is decremented to indicate that one byte is transferred. If the counter is not zero the above process will continue. If the counter is zero, it implies that all the data are transferred from the source to destination.

ALGORITHM

1. Set byte counter
2. Get the number from source and copy it in destination
3. Decrement counter and repeat the above step until byte counter is reset

PROCEDURE

1. Enter program in memory locations starting from ….H
2. Enter 5 numbers in memory locations starting from …..H
3. Execute the program and verify result in memory locations starting from …..

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data:

Output Data:

Result:

The program to move a block of data was executed and verified the result.

EXPERIMENT NO: 7

Sorting and searching using 8051

Aim:

1. Write an Assembly Language Program to sort data in ascending /descending order which are initially stored in memory location using 8051 microcontroller.
2. Write an Assembly Language Program to find largest number in an array using 8051.

Apparatus required:

8051 micro controller kit, keyboard and (0-5V) DC power supply.

1. **SORTING (ASCENDING AND DESCENDING)**:

Theory:

Program uses the bubble sort technique. In this type of sorting first and second bytes are compared and the bigger is kept in the second address. Then second and third bytes are compared and the bigger is kept in the third address and so on. After one cycle (i.e. N-1 comparisons, where N is the number of bytes in the data), largest number will be in the last address. In the second cycle second largest number will be stored in the last but one location.

ALGORITHM:

1. Store the elements of the array from an address
2. Initialize a pass counter with array size-1 count (for number of passes).
3. Load compare counter with pass counter contents & initialize DPTR to point to the start address of the array
4. Store the current and the next array elements pointed by DPTR in registers
5. Subtract the next element from the current element.
6. If the carry flag is set (for ascending order) then exchange the 2 numbers in the array.
7. Decrement the compare counter and repeat through step 4 until the counter becomes 0.
8. Decrement the pass counter and repeat through step 3 until the counter becomes 0.

Procedure:

1. Enter program in memory locations starting from …….H
2. Enter the numbers in memory locations ……H and …….H
3. Execute the program and verify result in memory locations starting from ………H
4. Modify the algorithm and program to sort in descending order.

Program: Ascending order

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

Program: Descending order

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

2. Largest number in an array of data

ALGORITHM:

1. Initialize address pointer and counter. Store zero in an internal memory location. Get the first number to the accumulator.
2. Compare the number with internal memory location content. If accumulator content is larger, skip. Otherwise, update the memory location with largest number.
3. Get next number and decrement counter. If counter is zero, store result. Otherwise get next data and go to step 2

PROCEDURE:

1. Enter program in memory locations starting from ……..H
2. Enter ‘N’ numbers in memory locations starting from ……H
3. Execute the program and verify result in memory locations starting from ….H

Program: Largest number

Address	label	Opcode	Operands	Comment

Observations:

	Location	Data
Input Data :		
Output Data:		

Result:

1. Written an Assembly Language Program to sort data in ascending /descending order whish are initially stored in memory location and verified the result.

2. The program to find the largest number from a series was executed and the output is obtained

EXPERIMENT NO: 8

Arithmetic operations using 8051

Aim:

b) To write an assembly language program for the following arithmetic operations using binary numbers

Apparatus required:

8051 microcontroller kit, keyboard and (0-5V) DC battery

PROCEDURE

1. Enter program in memory locations starting from …….H
2. Enter the numbers in memory locations ……H and …….H
3. Execute the program and verify result in memory locations starting from ………H

E) Addition:

ALGORITHM:

1. Move the first number to accumulator
2. Increment the address pointer and add first number with next number and sore the result in the destination address

Addition of two binary numbers:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

F) Subtraction:

ALGORITHM:

1. Move the first number to accumulator
2. Increment the address pointer and subtract first number from the next number and sore the result in the destination address.

Subtraction of two binary numbers:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

G) Multiplication:

Theory:

8051 provides MUL AB instruction. By using this instruction, the multiplication can be done. In some other microprocessors like 8085, there was no MUL instruction. In that microprocessor, we need to use repetitive ADD operations to get the result of the multiplication. When the result is below 255, the overflow flag OV is low, otherwise it is 1.

ALGORITHM:

1. Start.
2. Get the first number.
3. Store the number.
4. Get the second number.
5. Multiply A & B.
6. Increment data pointer.
7. Get the higher byte & lower byte of result.
8. Stop

Multiplication of two binary numbers:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

H) Division:

Theory:

8051 provides DIV AB instruction. By using this instruction, the division can be done. In some other microprocessors like 8085, there was no DIV instruction. In that microprocessor, we need to use repetitive Subtraction operations to get the result of the division.

Algorithm:

1. Start.

2. Get the first number.
3. Store the number.
4. Get the second number.
5. Divide A & B.
6. Increment data pointer.
7. Get the quotient, reminder & display.
8. Stop

Division of two binary numbers:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

Result:

Assembly language program for various arithmetic operations has been written and verified the result.

EXPERIMENT NO: 9

Square and cube of 8 bit numbers using 8051

Aim:

3. Write an Assembly Language Program to find square of a given 8-bit data using 8051 microcontroller.
4. Write an Assembly Language Program to find cube of a given 8-bit data using 8051 microcontroller.

Apparatus required:

8051 micro controller kit, keyboard and (0-5V) DC power supply.

Theory:

In 8051 microcontroller there is no any instruction to fond the square or cube of a given number. So this can be done either by MUL AB instruction or by repeated addition method.

1. Square of a given 8-bit data

ALGORITHM:

1. Start the program by specifying the memory address.
2. Set the number whose square is to be calculated.
3. Get the number in the accumulator.
4. Multiply the accumulator content with the saved number.
5. Move the accumulator content to the specified address.
6. stop

Procedure:

1. Enter program in memory locations starting from …….H
2. Enter the numbers in memory locations ……H
3. Execute the program and verify result in the memory specified.

Program:

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

2. Cube of a given number.

ALGORITHM:

1. Initialize address pointer.
2. Store the number in the specified memory location.
3. Move this number to another register.
4. Multiply these two numbers and save in accumulator.
5. Again multiply this number with accumulator content.
6. Save the result in a specified memory location from accumulator.
7. Stop.

PROCEDURE:

1. Enter program in memory locations starting from ……..H
2. Enter the number in memory location……H
3. Execute the program and verify result in the specified memory location

Program: Largest number

Address	label	Opcode	Operands	Comment

Observations:

Location Data

Input Data :

Output Data:

Result:

The program to find the square and cube of a given number was executed and the obtained output is verified.

EXPERIMENT NO: 10

Up/Down counters using 8051

Aim:

To write an Assembly Language Program to implement the following counters

a) Hexadecimal up/down Counters

b) BCD up/down counters

Apparatus required:

8051 microcontroller kit, keyboard and (0-5V) DC Supply.

Theory:

By assembly language programming using 8051 microcontroller up/down counters can be generated. Hexadecimal counter design is comparatively simple when compared to BCD counter. The values that a BCD counter counts are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 in binary format, and many others. A four-bit decade counter will operate as a BCD counter by skipping any 6 outputs from the 24 outputs.

1. a) Hexadecimal Up Counter

Algorithm

1. Move 0(starting number) to accumulator.
2. Initialize the data pointer with a memory location.
3. Move the count to a register.
4. Move the accumulator content to the data pointer memory address.
5. Increment the accumulator content.
6. Increment the data pointer.
7. Decrement the counter and repeat from step 4 if it is not zero, otherwise stop.

Procedure:

1. Enter the program in the memory starting from ……

2. Execute the program and verify the result in ………

Program: Up Counter

Address	Label	Mnemonics	Operands	Comments

Observations:

Location **Data**

Input Data:

Output data:

1 b). Hexadecimal down counter

Algorithm:

1. Move (starting number) to accumulator.
2. Initialize the data pointer with a memory location.
3. Move the count to a register.
4. Move the accumulator content to the data pointer memory address.
5. Decrement the accumulator content.
6. Increment the data pointer.
7. Decrement the counter and repeat from step 4 if it is not zero, otherwise stop.

Procedure:

1. Enter the program in the memory starting from ……
2. Execute the program and verify the result in ………

Program:

Address	Label	Mnemonics	Operands	Comments

Observations:

Location Data

Input Data:

Output data:

2 a) BCD up counter

Algorithm

1. Move '0' (starting number) to accumulator.
2. Initialize the data pointer with a memory location.
3. Move the count to a register.
4. Move the accumulator content to the data pointer memory address.
5. Increment the accumulator content.
6. Compare the accumulator content with '0A' and go to step 8 if not equal.
7. Add '06' to accumulator content.
8. Increment the data pointer.
9. Decrement the counter and repeat from step 4 if it is not zero, otherwise stop.

Procedure:

1. Enter the program in the memory starting from ……
2. Execute the program and verify the result in ………

Program: Up Counter

Address	Label	Mnemonics	Operands	Comments

Observations:

Location Data

Input Data:

Output data:

2 b). BCD down counter

Algorithm:

Algorithm

1. Move (starting number) to accumulator.
2. Initialize the data pointer with a memory location.
3. Move the count to a register.
4. Move the accumulator content to the data pointer memory address.
5. Decrement the accumulator content.
6. Increment the data pointer.
7. Compare the accumulator content with ‘0A’ and go to step 4 if not equal.
8. Subtract ‘06’ from accumulator content.
9. Jump to step 4
10. Decrement the counter and repeat from step 5 if it is not zero, otherwise stop.

Procedure:

1. Enter the program in the memory starting from ……
2. Execute the program and verify the result in ………

Program:

Address	Label	Mnemonics	Operands	Comments

Observations:

	Location	Data
Input Data:		
Output data:		

Result:

Wrote Assembly language program to implement Hex and BCD Up/down counters using 8051 Micro controller and verified the result.

EXPERIMENT NO: 11

DAC interfacing: Generation of Waveforms using 8085

AIM

To generate the following waveform using 8085 and DAC interfacing unit

1) Square waveforms of frequency 500Hz
2) Triangular waveform

DAC Interfacing

VBMB-002 is a DAC which contains two DA0800 chips. It is a simple 8 bit DAC. This provides two DAC outputs DAC1 and DAC2. The port address of DAC is given by C0H& Port address of DAC2 by C8H.

Since DAC 0800 is an 8 bit & output voltage variation is between -5V & 5V. The output voltage varies in steps of (1/256) =0.04 approx. The digital data input & corresponding output are presented.

Input voltage Table:

INPUT DATA IN HEX	OUTPUT VOLTAGE
00	-5.00
01	-4,496
02	-4.92
…	…
…	…
…	…
7 F	0
…	…
...	…
…	…
FD	4.92
FE	4.96
FF	5.00

Square waveform of equal width and frequency 500Hz

The idea behind generation of square wave is that accumulator is located with 00H and FFH and is plotted on CRO with the help of DAC interface. The data 00H corresponds to low level & FFH to high level of square wave. Both the data are plotted for a particular time delay. The time delay can be obtained using delay program. By suitable programming the delay program square wave of derived frequency can be obtained. The delay time can be calculated from the knowledge of total no. of states and time for one stable for Intel 8085. The time state is 320nsec.

The delay time = total no. of states X 320ns

Square Waveform

Count calculation

Given derived frequency = 500Hz

T=1/f = 1/500 = 2ms

For half period, t=1ms

$$1\text{ms} – \text{total no of states X } 320 \text{ X } 10^{-9}\text{s}$$

Calculating the total no. of states

The delay program is –

Instruction	**T States**	**Execution of Instruction**
MVI B,01	T	1
L1 MVI C,[count]	T	1X01 (01 unit in B register)
L2 DCR C	4	1 count
JNZ L2	T/10	[(count - 1)+1] X 01
DCR B	4	01
JNZ L1	7/10	[count - 1]+1

Count calculation for 1ms delay using 2 registers.

Let us load B register with 01 & find out the 'count' to be entered in C register.

Total states = 7x1 + 7x01 + 4xCOUNTx1 + 10(count - 1)x01 + 7x1 + 4x1 + 10x0 + 7x1 + 10x1

Delay time = Total State x Time of 1 State

$1\text{x}10^{-3}\text{s} = (14 + 4C + 10C – 10 + 7 + 4 + 7 + 10) \text{ x } 320 \text{ x } 10^{-9}$

$= 312\text{s} = 32 + 14C$

$C = (220)_{10} = \text{DCH}$

Program

Memory Address	Label	Mnemonics	OpCode	Comments
4100	START	MVI A,00	3E,00	Low Level
4102		OUT 0CH	D3,C0	Call it on CRO
4104		CALL DELAY	CD,11,41	Call delay program
4107		MVI A,OFF	3E,FF	Load the final values
4109		OUT OCH	D3,C0	Get it on CRO
410B		CALL DELAY	CD,11,41	
410E		JUMP START	C3,00,41	After desired delay go to start
4111	DELAY	MVI B,01	06,01	
4113	L1	MVI, DC	0E,DC	
4115	L2	DCR C	OD	Decrement C
4116		JNZ L2	C2,15,41	If C ≠ 0 repeat L2
4119		DCR B	01	C=0 decrement C
411A		JNZ L1	C2,13,41	B ≠ 0 repeat
411D		RET	C9	If B=0,return to instruction immediately after delay call

Program Description

The delay program is executed here using 2 registers as the 1st register (reg:B),arbitrary count (01H) is loaded. For entering count in 2nd register, the count is calculated based on the delay time as shown.

The max delay time can be obtained by loading the two registers with FF(H)

Triangular Wave

Program Description

Load the accumulator with the content (initial values) corresponding to -5V. Plot the voltage corresponding to that value then increase the content & accumulator one by one and correspondingly plot the voltage. The output voltage will have values as per table.

N:B :

The delay program can be obtained using

a) A single register.
b) Two Register
c) Three Register

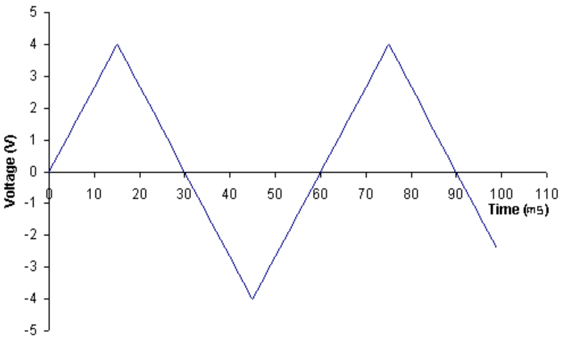
The maximum delay time that can be obtained using a single register is 1.1168ns.The max delay time that can be obtained using 2 register is 0.2938s

Program

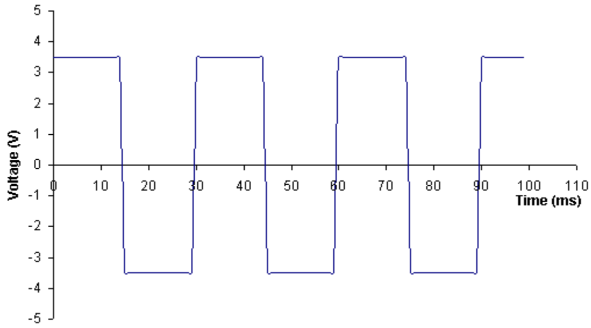
Memory Address	Label	Mnemonics	OpCode	Comments
4100	Start	MVI A,00	3E,00	Load the initial values
4102	Loop 1	OUT C0	D3,C0	Plot it
4104		INR A	3C	Increment the value
4105		CPI FF	FE,FF	Compare the final values
4107		JNZ Loop1	C2,02,41	If not reached, loop is executed Plot this value
410A	Loop2	OUT C0	D3,C0	If reached plot it
410C		DCR A	3D	Decrement
410D		JNZ loop2	C2,0A,41	If not reached, repeat the loop2
4110		JMP Start	C3,00,41	If zero, go to start

The frequency of triangular wave generator by above program mainly depends upon the initial 00H and final value FFH.

Triangular Waveform



Square waveform



Procedure:

1) To go to an address, press SOB, then NEXT.
2) To execute a program after entering the opcode and press INT, then go starting address. The screen will display E.
3) Press EXE and obtain the result corresponds to program.

RESULT

Generated the following waveform using 8085 and DAC interfacing unit.

1) Square waveform of frequency 500Hz
2) Triangular waveform

EXPERIMENT NO: 12

ADC interfacing using 8085

Aim:

Write an Assembly Language Program to obtain the digital output corresponding to an analog input using ADC interface.

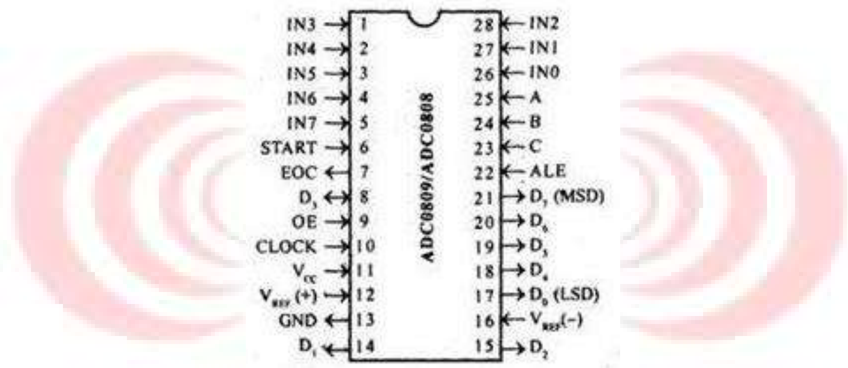
Apparatus required:

8085 microprocessor kit, ADC interface board - ADC 0809, keyboard and (0-5V) DC Supply.

Theory:

In this program start of conversion is done by a switch provided in the ADC card. The analog signal is is fed to channel in the ADC board and SOC switch is pressed to start the analog to digital conversion. Eight LEDs provided in the card gives digital output. The ADC 0809 is an 8 bit analog to digital converter. It has 8 channel multiplexer to interface with the microprocessor. This uses Successive approximation technique to convert analog signal to digital form. The jumpers in the card select SOC, ALE or software modes to start conversion. In this program ALE signal is used for analog to digital conversion.

Pin Diagram (ADC 0809):



Procedure:

1. Connect the jumper in positions to select the ALE mode and select the channel
2. Enter the program.
3. Vary the analog voltage using trim pot and execute the program to observe the digital output as LED display. Measure the analog voltage using multi meter connecting between channels and ground in the socket.
4. Repeat the previous step for different voltages. Measure the analog voltage and note down the digital display output corresponding to the analog voltage in a table.
5. Remove the channel jumper and feed external input signal from the power supply across the channel and ground points in the socket on the DAC card.
6. Vary the input voltage between 0 and 5V and execute the program to observe corresponding digital display output. Enter reading in table.

Program:

Address	Label	Mnemonics	Operands	Comments

Observations:

	Location	Data
Input Data:		
Output data:		

Result:

Wrote Assembly language program to obtain the digital output corresponding to an analog input using ADC interface and verified the result.

EXPERIMENT NO: 13

Code conversion Using 8051

Aim:

Write an Assembly Language Program to convert

3. Hexadecimal to decimal
4. Decimal to Hexadecimal
5. Decimal to ASCII
6. ASCII to Decimal

Apparatus required:

8051 microcontroller kit, keyboard and (0-5V) DC Supply.

1. Hexadecimal to decimal

Theory:

Hexadecimal number is one of the number systems which has value is 16 and it has only 16 symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and A, B, C, D, E, F. Where A, B, C, D, E and F are single bit representations of decimal value 10, 11, 12, 13, 14 and 15 respectively. Whereas **Decimal** system is most familiar number system to the general public. It is base 10 which has only 10 symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9. There are various indirect or direct methods to convert a hexadecimal number into decimal number. In an indirect method, convert a hexadecimal number into binary or octal number, then convert it into decimal number. However, there is a simple direct method to convert a hexadecimal number to decimal number. Since, there are only 16 digits (from 0 to 7 and A to F) in hexadecimal number system, division method is simple. Start with any decimal number. In this method first the hexadecimal number will be divided by the largest powers of 16. Then find the reminder and divide the remainder by the next power of 16. Repeat this process until the full digit is converted to the corresponding decimal number.

Algorithm

1. Initialize the data pointer with a memory address.
2. Move that number to the accumulator.
3. Move the number ‘64H’ to a register.
4. Divide the accumulator content by ‘64H’.
5. Increment the data pointer.
6. Move the accumulator content to the data pointer address.
7. Move the register content to accumulator and this register is saved with ‘0A’
8. Again divide the accumulator content by ‘0A’
9. Increment the data pointer.
10. Again move the accumulator content to the data pointer address.
11. Move the register content to accumulator and increment the data pointer.
12. Move the accumulator content to the data pointer address.
13. Stop.

Procedure:

1. Enter the program in the memory starting from ……
2. Execute the program and verify the result by giving a hexadecimal number.

Program:

Address	Label	Mnemonics	Operands	Comments

Observations:

Location **Data**

Input Data: Hexa decimal no. :

Output data: Decimal no :

2. Decimal to Hexadecimal

Theory:

To convert a decimal number to hexadecimal number at first the decimal number is entered in the memory address and swap the number. Then the number will be multiplied by the '0F' to get the MSB. Then multiply this number with its weightage (10, 100, 1000 etc.). Then again the number is directly multiplied with 'OF' to get the LSB.Then both numbers will be added to get the hexadecimal number.

Algorithm:

1. Initialize the data pointer with a memory address.
2. Move that number to the accumulator.
3. Swap the content of accumulator.
4. Logically AND the accumulator content with '0FH'.
5. Move the number '0AH' to a register.
6. Multiply the accumulator and register content.
7. Move the accumulator content to aregister
8. Move the data pointer specified content to accumulator.
9. Logically AND the accumulator content with '0FH'.
10. Add the register content to the accumulator.
11. Increment the data pointer.
12. Move the accumulator content to the data pointer address.
13. Stop.

Procedure:

3. Store decimal number in the given memory location.

4. Enter and execute the program and verify whether the contents of memory location is the corresponding hexadecimal number or not.

Program:

Address	Label	Mnemonics	Operands	Comments

Observations:

Input Data: Decimal :

Output data: Hexadecimal :

3. Decimal to ASCII

Theory:

ASCII of number 00H is 30H (48D), and ASCII of 09H is39H (57D). So all other numbers are in the range 30H to 39H. If the number is less than 10 ASCII number will be obtained by adding 30H to that number. Otherwise 37H is to be added to get the corresponding ASCII number.

Algorithm:

1. Move the Decimal value to accumulator
2. Add 30H to accumulator if the number is less than ‘0**A’**
3. Increment the address pointer and store the result in that address
4. Stop.

Procedure:

1. Enter program in memory locations starting from ………..H
2. Enter value in memory location
3. Execute the program and verify result in memory location

Program:

Address	Label	Mnemonics	Operands	Comments

Observations:

Input Data: Decimal :

Output data: Binary

4. ASCII to Decimal

Theory:

The ASCII to Decimal conversion logic is very simple. The decimal numbers 0-9 are 30-39H in ASCII. So we should first compare the number with 30H if it is lesser than ‘10’ again subtract with 07H to get the decimal number. If the input is lesser than 30H it will make the errors.

Algorithm:

1. Move the ASCII value to accumulator

2. Subtract 30H from accumulator

3. Increment the address pointer and store the result in that address

Procedure:

- **a.** Enter program in memory locations starting from ………..H
- **b.** Enter value in memory location
- **c.** Execute the program and verify result in memory location

Program:

Address	Label	Mnemonics	Operands	Comments

Observations:

Input Data: Decimal :

Output data: Binary :

Result:

Wrote Assembly language program for code conversion using 8051 microcontroller and verified the result.

EXPERIMENT NO: 14

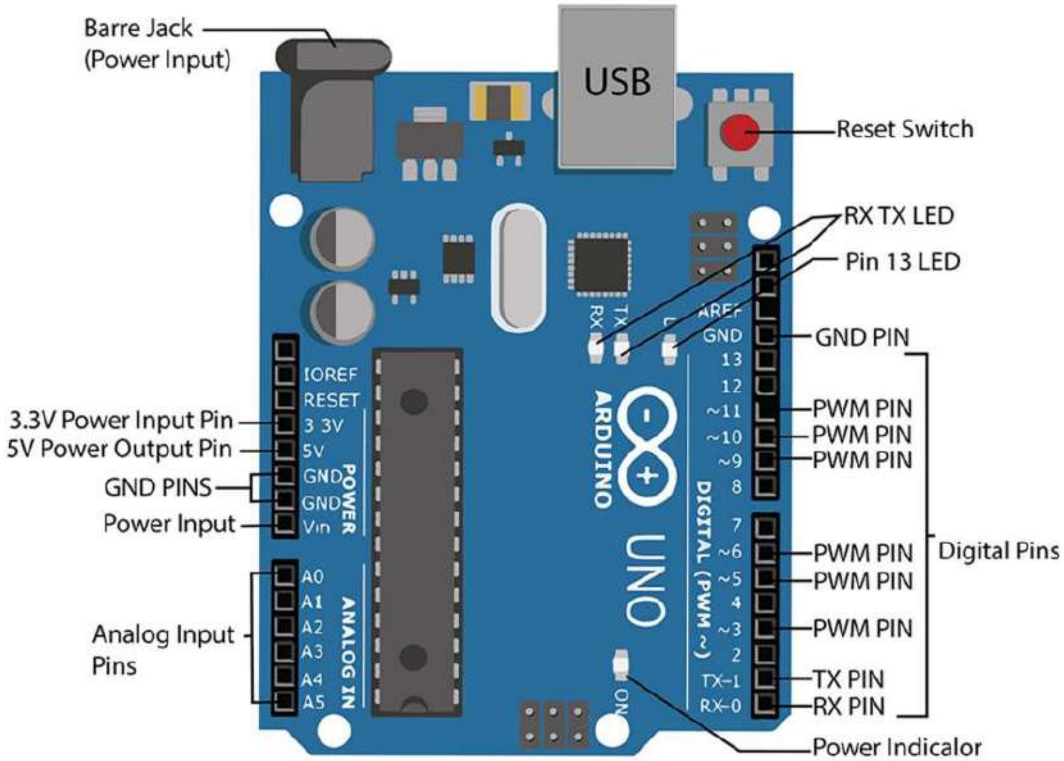
Familiarization of Arduino IDE

Aim:

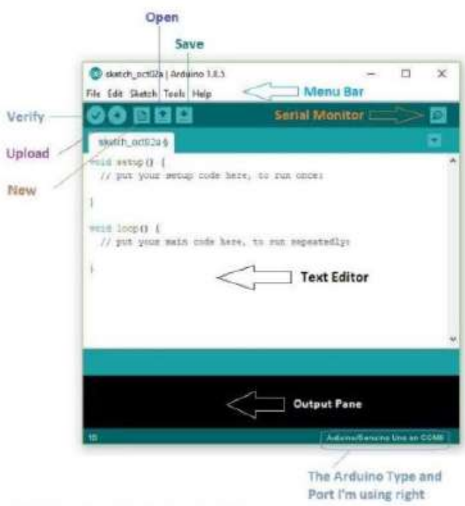
Familiarization of Arduino IDE

Theory:

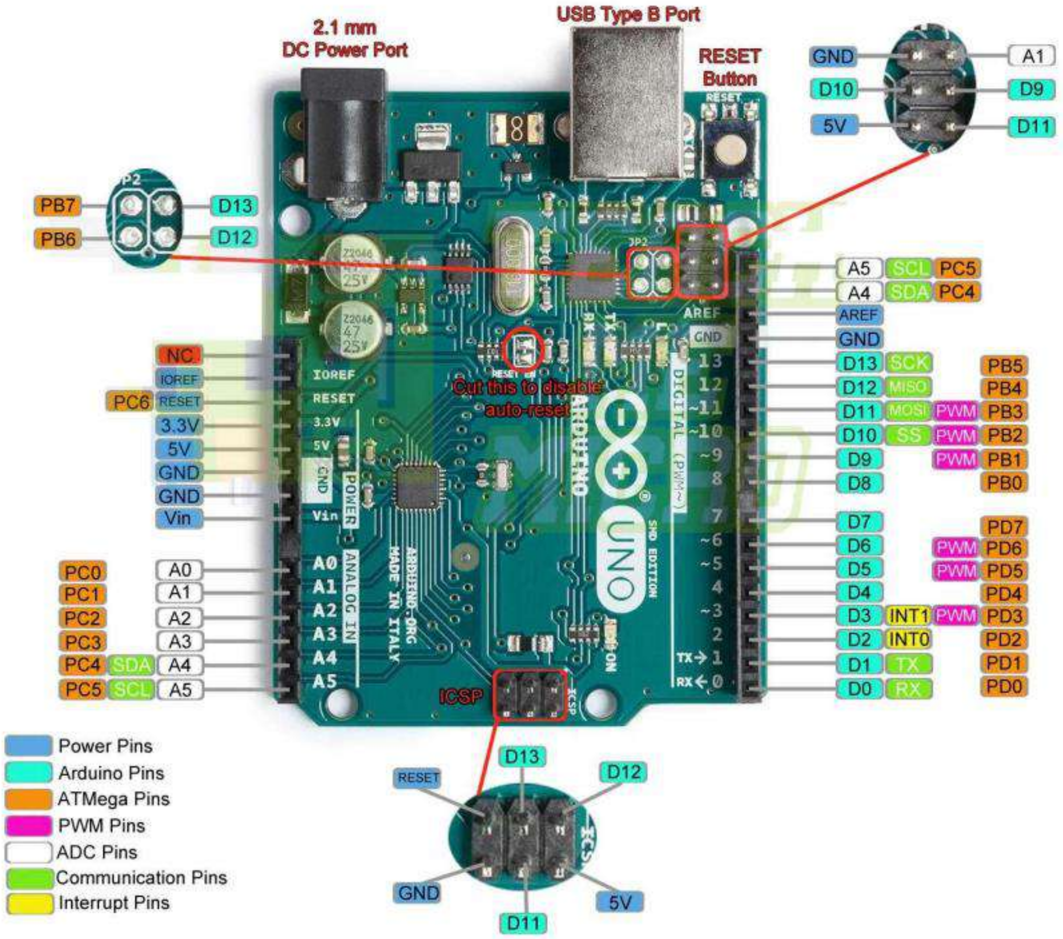
Introduction to Arduino board Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.



Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems which are inexpensive, cross-platform, Simple, clear programming environment, Open source and extensible hardware etc.



The basic structure of the Arduino programming language is fairly simple and runs in at least two parts. These two required parts, or functions, enclose blocks of statements. Where setup () is the preparation, loop () is the execution. Both functions are required for the program to work.



Pin Diagram of Arduino Uno

The setup function should follow the declaration of any variables at the very beginning of the program. It is the first function to run in the program, is run only once, and is used to set pin Mode or initialize serial communication.

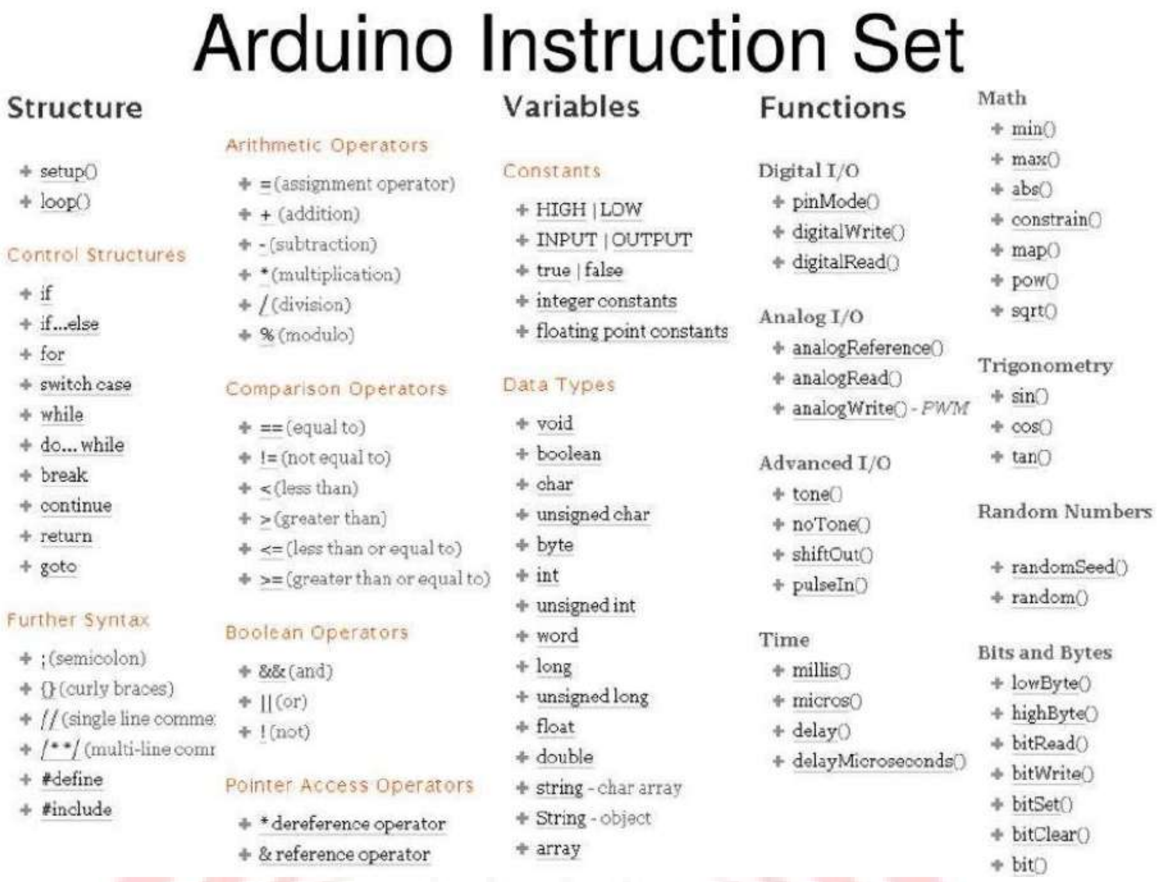
The loop function follows next and includes the code to be executed continuously-reading inputs, triggering outputs etc. This function is the core of all Arduino programs and does the bulk of the work. Curly braces ({}) define the beginning and the end of function blocks and statement blocks such as the void loop () function and the for and if statements.

Programming using Arduino IDE

Step 1 − Download Arduino IDE Software: You can get different versions of Arduino IDE from the Download page on the Arduino Official website. You must select your software, which is compatible with your operating system (Windows, IOS, or Linux). After your file download is complete, unzip the file.

Step 2 − Power up your board: The Arduino Uno automatically draw power from either, the USB connection to the computer or an external power supply. Connect the Arduino board to your computer using the USB cable. The green power LED (labeled PWR) should glow.

Step 3 − Launch Arduino IDE



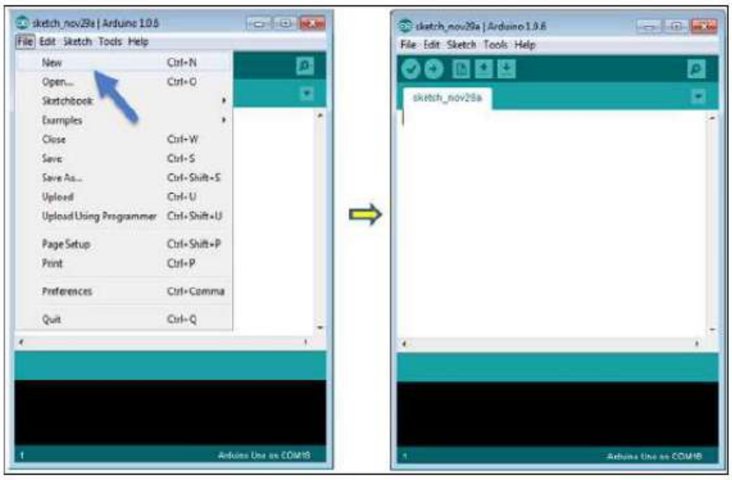
Step 4 − Open your first project: Once the software starts, you have two options

- Create a new project.
- Open an existing project example.

To create a new project, select File → New.

To open an existing project example, select File → Example → Basics → Blink.

Here, we are selecting just one of the examples with the name Blink. It turns the LED on and off with some time delay. You can select any other example from the list.

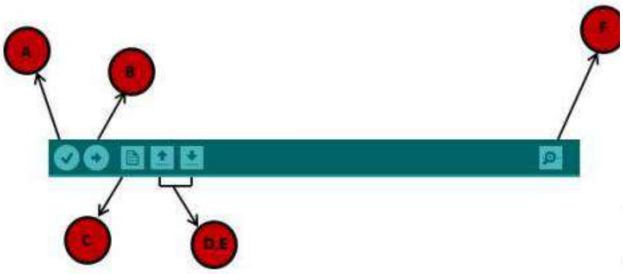


Step 5 – Select your Arduino board: To avoid any error while uploading your program to the board, you must select the correct Arduino board name, which matches with the board connected to your computer.

Go to Tools → Board and select your board

Step 6 − select your serial port: Select the serial device of the Arduino board. Go to Tools → Serial Port menu. This is likely to be COM3 or higher (COM1 and COM2 are usually reserved for hardware serial ports). To find out, you can disconnect your Arduino board and re-open the menu, the entry that disappears should be of the Arduino board. Reconnect the board and select that serial port.

Step 7 − upload the program to your board: Before explaining how we can upload our program to the board, we must demonstrate the function of each symbol appearing in the Arduino IDE toolbar. Now, simply click the "Upload" button in the environment. Wait a few seconds; you will see the RX and TX LEDs on the board, flashing. If the upload is successful, the message "Done uploading" will appear in the status bar.



A – Check if there is any compilation error.

B – Upload a program to the Arduino board.

C – Shortcut to create a new sketch.

D – Open one of the example sketch.

E – Used to save your sketch.

F – Serial monitor for serial data transfer

EXPERIMENT NO: 15

LED control using Arduino

Aim:

To control LED blinking with different ON/OFF delay timings with

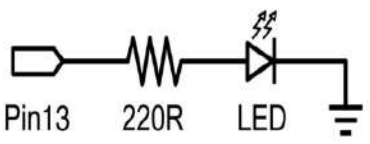
i) Inbuilt LED

ii) Externally interfaced LED

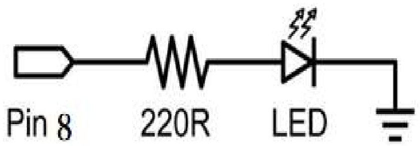
Apparatus required:

Arduino board, LED, Resistor (220 ohm), Bread board and connection wires

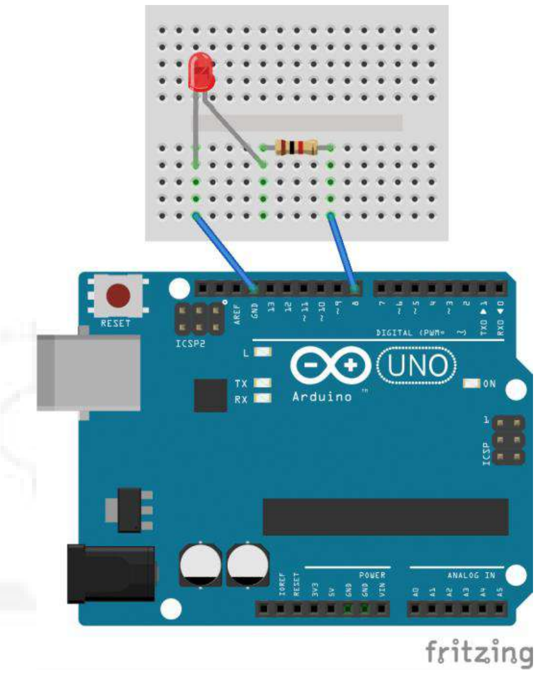
Connection diagram



Circuit for blinking of Internal LED (No External connection required)



Circuit for blinking of external LED on Pin 8



Theory

The Arduino communicates with modules and sensors by switching on and off electrical current. It's very similar to the one's and zero's in binary code. When current is switched on, it's known as a "HIGH signal". That's comparable to the "one" in binary code. When the current is switched off, that's a "LOW signal", which is similar to the zero in binary code. The length of time the current stays on or off can be changed from a microsecond up to many minutes.

Controlling the Arduino's LED (Internal):

To turn on an LED, the Arduino needs to send a HIGH signal to one of it's pins. To turn off the LED, it needs to send a LOW signal to the pin. You can make the LED flash by changing the length of the HIGH and LOW states. The Arduino has an on-board surface mount LED that's hard wired to digital pin 13. It's the one with an "L" next to it:

Controlling an External LED

An external LED or any other powered module can be controlled in a similar way. LEDs need to have a resistor placed in series (in-line) with it. Otherwise, the unrestricted current will quickly burn out the LED. The resistor can be any value between 100 Ohms and about 10K Ohms. Lower value resistors will allow more current to flow, which makes the LED brighter. Higher value resistors will restrict the current flow, which makes the LED dimmer. Also, most LED's have polarity, which means that they need to be connected the right way around. Usually, the LED's shortest lead connects to the ground side.

Procedure:

1. Set up the circuit.
2. Write the program.
3. Execute the program.

Program for external LED blink on Pin-1:

```
void setup()                        // run once
 {
pinMode(1, OUTPUT);                 // sets pin 1 as output
}
void loop()                         // run over and over again
{
 digitalWrite(8, HIGH);             // turns the LED on
delay(1000);                        // pauses for 1000 milliseconds
digitalWrite(8, LOW);               // turns the LED off
delay(1000);                        // pauses for 1000 milliseconds
 }
```

Result: Set up the circuit and the program was executed to control the LEDs.

EXPERIMENT NO: 16

Voltage measurement using Arduino module

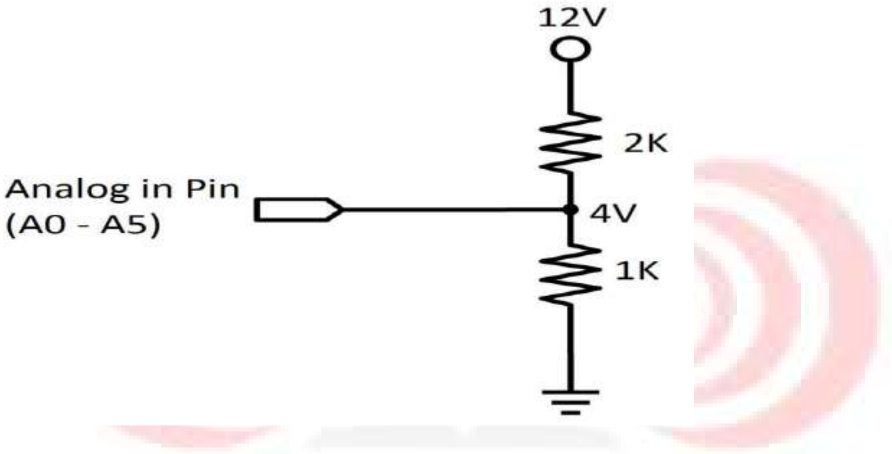
Aim:

To measure voltage of 12V solar PV module or 12V battery using Arduino and displaying the measured value.

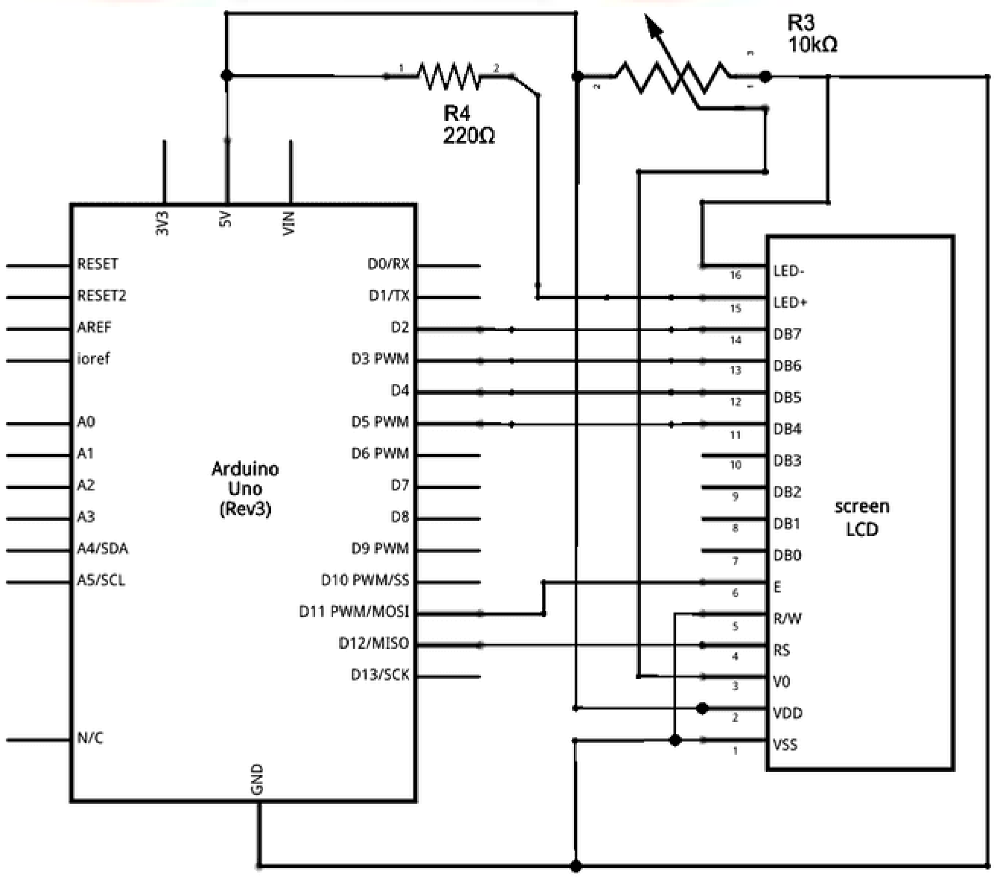
Apparatus required:

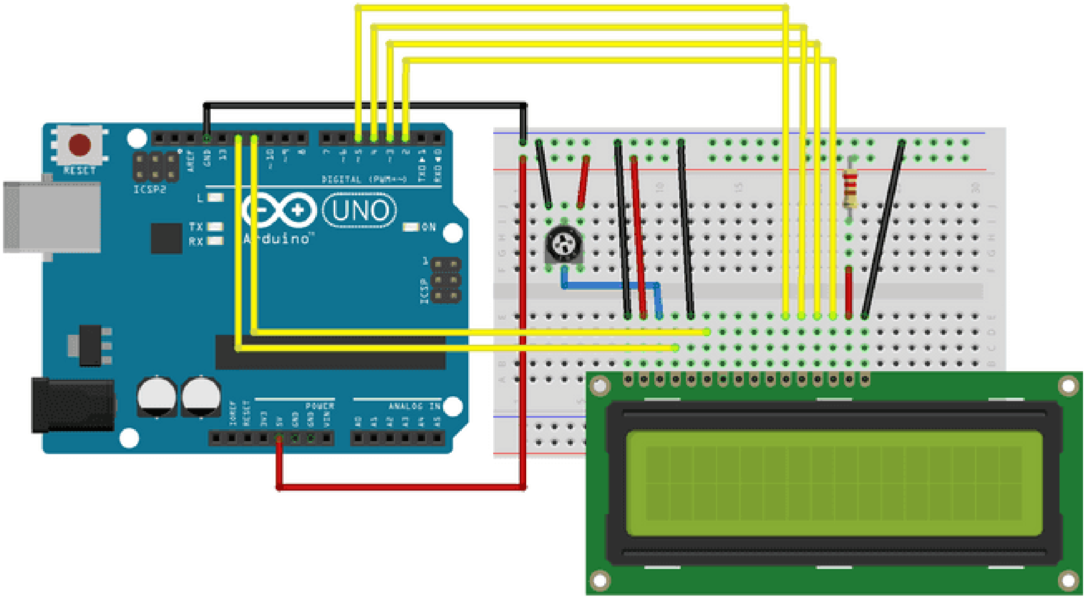
Sl.No	Item	Specification	Quantity
1	Arduino board	Arduino Uno	1
2	Resistor	(1K & 2K)	1
3	LCD display	16x2	1
4	Bread board and connection wires		
5	Power supply	12V-DC	1

Connection diagram



Circuit diagram





Theory: Arduino can measure only a maximum of 5V on the analog pins, and hence a potential divider arrangement using resistors is used to reduce the voltage to be measured, and later a multiplication factor is used in the program to scale the obtained value to actual voltage value.

LCD 16X2: An electronic device that is used to display data and the message is known as LCD 1602. It includes 16 Columns and 2 Rows so it can display 32 characters (16×2=32) in total. Every character will be made with 5×8 (40) Pixel Dots and the total pixels within this LCD can be calculated as 32 x 40 or 1280 pixels. The data register inside the display is used to save the date to exhibit on the LCD.

Procedure:

1. Set up the circuit.
2. Write the program.
3. Execute the program.

Program:

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);
int VoltPin = A0;
int VoltValue = 0;
void setup() {
lcd.begin(16, 2);                    // set up the LCD's number of columns and rows:
pinMode(VoltPin,INPUT);              // Assign A0 as input
}

void loop() {
VoltValue = analogRead(VoltPin);     //Store the ADC value of VoltPin to VoltValue
VoltValue = map(VoltValue, 0, 1023, 0,12); //Convert the ADC value to Volts
lcd.clear();                         //Clear the LCD.
lcd.setCursor(0,0);                  //Set the cursor to 0th column and 0th row of the LCD.
lcd.Print(VoltValue);                //Display the voltage on LCD
delay(100);                          // Delay for 100 milliseconds
}
```

Result: Voltage of 12V battery using Arduino was measured and displayed using the LCD display unit.

EXPERIMENT NO: 17

Current measurement using Arduino

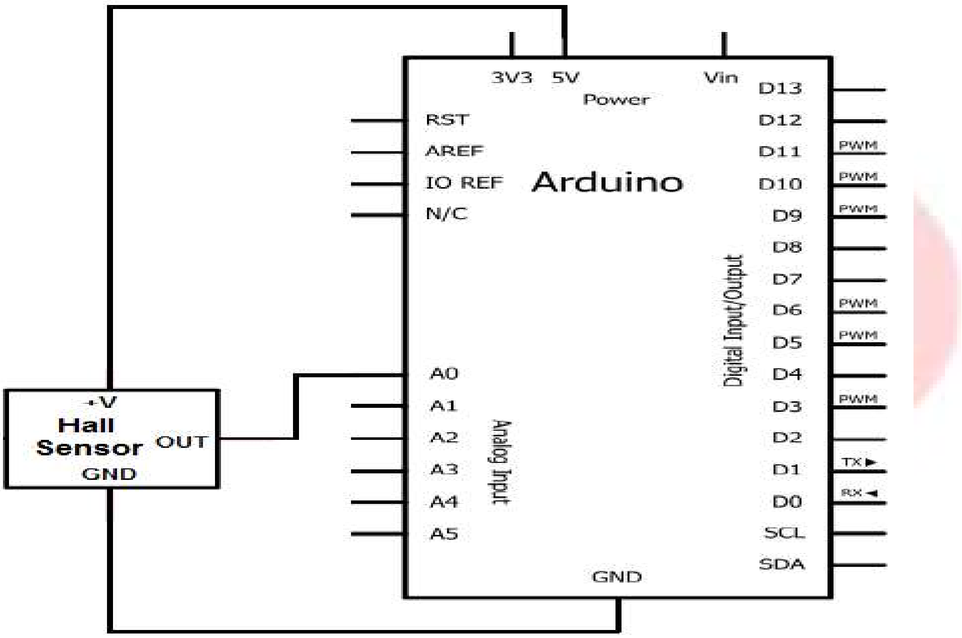
Aim:

To measure dc current using Hall-effect current sensor and Arduino module.

Apparatus required:

Sl.No	Item	Specification	Quantity
1	Arduino board	Arduino Uno	1
2	Hall effect sensor	ACS712, 20A	1
3	Resistor	10 ohm,5A	1
4	Bread board and connection wires		
5	Power supply	32V,DC	1

Circuit diagram:



Theory:

Monitoring the Current flow in a device by a mains powered appliance is just complicated one. Because continuous current flow monitoring by a circuit creates current isolation in target device, so we need to measure current flow without affecting the target device. Hall Effect current sensor circuit Using Arduino helps to monitor and log current flow to a device. This works on the principle that is “When a current carrying conductor was placed in a magnetic field, a voltage proportional to the field was generated”. This is known as Hall Effect.

The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. The ACS712 current sensor IC is placed in a breakout board and connect with Current sense target load and Micro-controller. The sensor detects current flow through IP+ and IP- pins (Resistance Current

Conductor), it creates hall effect and then proportional voltage output taken form pin 7 (VIOUT) of ACS712. It can be directly fed into micro controller's Analog input pin after the filter arrangements. As per the breakout application note Hall Effect current sensor connected with target load and output signal is connected with well-known Arduino's A0 (Analog input pin 0). This sensor breakout consumes power from Arduino power source (+5 and GND). After the setup is over upload the following Arduino code to measure the current flow to the load.

The ACS712 outputs a voltage of 2.5-volts when NO current is detected. Voltage above this is a positive flowing current, while below 2.5-volts indicated a negative current. Because there are three versions of this chip we use a "scale factor" to determine the current, as shown here:

Scale Factor

5A	20A	30A
185mV/Amp	100mv/Amp	66mv/Amp

Current(Amps) = (Vout(mv) - 2500) / Scale Factor

Procedure:

1. **Set up the circuit and give power supply.**
2. **Note down the current readings.**

Program:

```
void setup() {
Serial.begin(9600);
}

void loop() {
  float average = 0;
 for(int i = 0; i < 1000; i++) {
 average = average + (.0264 * analogRead(A0) -13.51) / 1000;  //5A mode, if 20A or 30A
                                                               mode, need to modify this
                                                               formula to
 //(.19 * analogRead(A0) -25) for 20A mode and
 //(.044 * analogRead(A0) -3.78) for 30A mode
 delay(1);
 }
 Serial.println(average);
}
```

Result: Dc current measured using Hall-effect current sensor and Arduino module.

EXPERIMENT NO: 18

DC motor speed control using Arduino

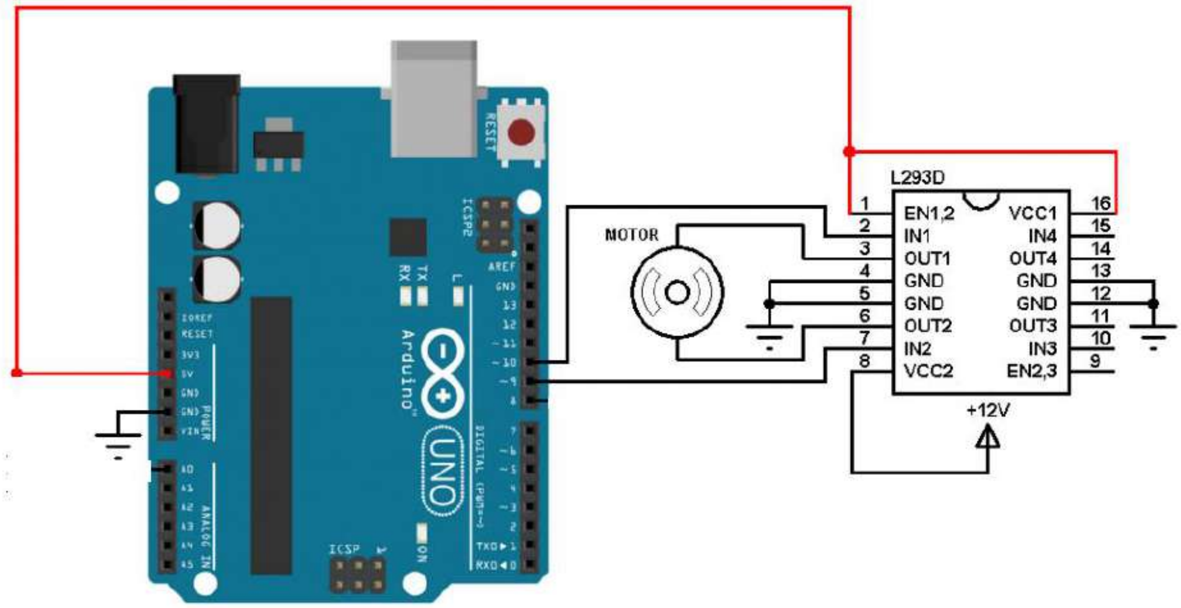
Aim:

To control the speed of a DC motor using H bridge driven by PWM signal from Arduino module

Apparatus required:

Sl.No	Item	Specification	Quantity
1	Arduino board	Arduino Uno	1
2	H bridge IC	L293D	1
3	DC Motor	9V	1
4	Bread board and connection wires		
5	Power supply	9V	1

Connection Diagram:



Theory

To control a load with more than 40ma current requirement using the Arduino, a MOSFET or H bridge could be used to switch higher current loads. Also motor speed control requires voltage variation, which could be achieved by using the PWM variable voltage signal available from the PWM enabled digital pins of the Arduino.

.To control the direction of the spin of DC motor, without changing the way that the leads are connected, you can use a circuit called an H-Bridge. An H bridge is an electronic circuit that can drive the motor in both directions. H-bridges are used in many different applications, one of the most common being to control motors in robots. It is called an H-bridge because it uses four transistors connected in such a way that the schematic diagram looks like an "H."

You can use discrete transistors to make this circuit, but for this tutorial, we will be using the L298 H-Bridge IC. The L298 can control the speed and direction of DC motors and stepper motors and can control two motors simultaneously. Its current rating is 2A for each motor. At these currents, however, you will need to use heat sinks.

Program:

```
void setup()
{
pinMode(9, OUTPUT);              // sets PWM Pins 9,10 as output
pinMode(10, OUTPUT);
}
void loop()
{
for (int i=0; i<255; i++)        // Motor speed increasing
{
analogWrite(9, i);
analogWrite(10,0);               // turns motor ON
delay(250);                      // pauses 1/4 second
}
delay(1000);                     // pauses 1 second
for (int i=0; i>255; i--)
{
analogWrite(10, i);
analogWrite(9,0);                // turns motor ON in the opposite direction
delay(250);                      // pauses 1/4 second
}
delay(1000);                     // pauses 1 second
}
```

<u>Result:</u>

The program to control the speed of a DC motor using MOSFET driven by PWM signal from Arduino module has been written and verified.

EXPERIMENT NO: 19

Uploading data to ThingSpeak Cloud

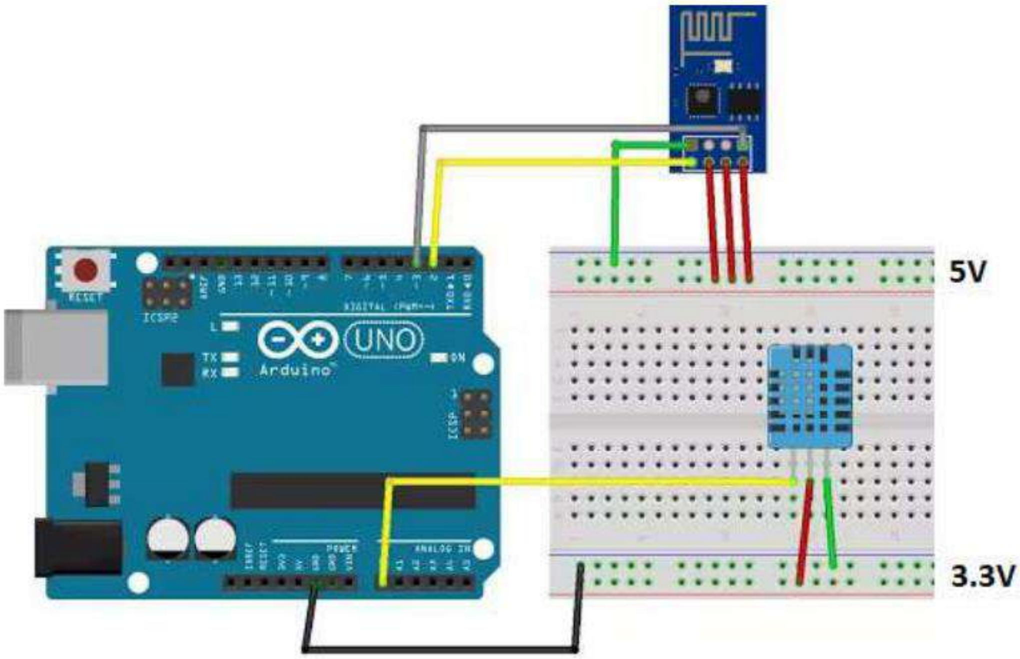
Aim:

To write a program to upload multiple sensor data (say, humidity and temperature) to ThingSpeak cloud through Wi-Fi network.

Apparatus required:

Sl.No	Item	Specification	Quantity
1	Arduino board	Arduino Uno	1
2	Wi-Fi Module		1
3	Sensors to read data	2 parameters (eg; DHT11)	1
4	Bread board and connection wires		

Connection Diagram:



Connection diagram for Arduino Thinkspeak cloud data transfer

Procedure:

1. Create a ThingSpeak account using a mail address
2. Create a channel with two field parameters and note down the Write API key
3. Create a Wi-Fi network and note down the SSID and password
4. Download necessary library files for ThingSpeak and add it to IDE
5. Develop the Arduino interface with ESP and sensors

6. Develop the program with serial monitor with 9600 baud rate
7. Verify and upload the program, and monitor the ThingSpeak cloud for data storage

Sample Code: follow references

Output:

1. Think speak account and channel details:
2. Wi-Fi network setting up:
3. ThingSpeak library file addition:
4. Circuit development and pin selection:
5. Program development and testing:

Result:

References:

1. Arduino Project hub, https://create.arduino.cc/projecthub/neverofftheinternet/thingspeak-arduino-weather-station-70b4bb

2. OIT Design Pro, https://iotdesignpro.com/projects/temperature-humidity-monitoring-over-thingspeak-using-arduino-esp8266

References

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2. Mohamed Ali Mazidi, Janice Gillispie Mazidi," The 8051 microcontroller and embedded systems using Assembly and C", second edition, Pearson/Prentice hall of India.
3. Kenneth. J. Ayala, The 8051 microcontroller, 3rd edition, Cengage Learning, 2010.
4. Donald P. Leach, Albert Paul Malvino and Goutam Saha, Digital Principles and Applications, 8/e, by McGraw Hill.
5. A. P. Mathur, Introduction to Microprocessors, Tata McGraw Hill Publishing Company Limited, New Delhi.
6. Jeeva Jose, Internet of Things, Khanna Publishing House, Delhi
7. Raj Kamal, Internet of Things: Architecture and Design, McGraw Hil

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LABORATORY OBSERVATION BOOK

Name :..

Class :..

Batch :..

No. :..

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Vision

Grow as a Centre of learning and research, transforming students to professionals with knowledge, skill, competence, commitment, confidence and ethics to serve the society

Mission

M1 - To impart value-based education and promote curricular, co-curricular and extra-curricular activities amongst students through extensive theoretical and practical training by qualified and experienced personnel using state-of-the-art facilities

M2 - To promote research and consultancy for institution development and contribution to the society

Department of Civil Engineering

Vision

To produce graduates with capabilities for adapting to new challenges and responsibilities

Mission

M1 - To provide quality education to produce competent Civil Engineering professionals

M2 - To impart professional attitude through value-based education

M3 - To instill managerial skills among budding Civil Engineers through professional orientation

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B. TECH. DEGREE PRACTICAL ASSESMENT (LAB / WORKSHOP)

Register Number

Semester: .... Branch: CE

Student Name :...

Course Code :... Course (Subject) Name:...

Expr. No.	Name of the Experiment	Course Outcome	Expr. Marks (60 Marks)	Viva Marks (10 Marks)	Total (70 Marks)

Internal Marks (Average of Total Marks out of 70)					

Course Outcome - wise Average

Course Outcome	CO1	CO2	CO3	CO4	CO5	CO6
Average Marks						

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DEPARTMENT OF CIVIL ENGINEERING

LABORATORY MANUAL

MEL203 - MATERIAL TESTING LAB

COURSE OBJECTIVES

The objective of this course is to give a broad understanding of common materials related to mechanical engineering with an emphasis on the fundamentals of structure-property application and its relationships.

COURSE OUTCOMES (CO)

CO1	To understand the basic concepts of analysis of circular shafts subjected to torsion.
CO2	To understand the behaviour of engineering component subjected to cyclic loading and failure concepts
CO3	Evaluate the strength of ductile and brittle materials subjected to compressive, Tensile shear and bending forces
CO4	Evaluate the microstructural morphology of ductile or brittle materials and its fracture modes (ductile /brittle fracture) during tension test
CO5	To specify suitable material for applications in the field of design and manufacturing.

PROGRAM OUTCOMES (PO)

1.	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
2.	**Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3.	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4.	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5.	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6.	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7.	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8.	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
9.	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10.	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11.	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12.	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

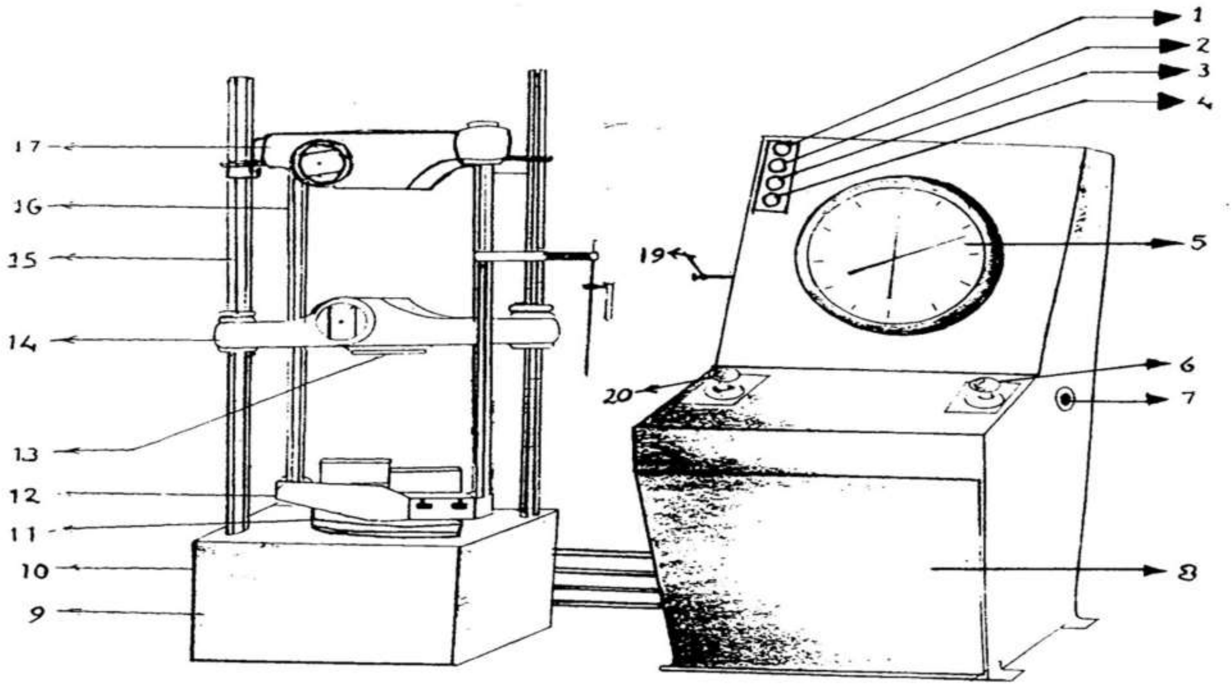
Sl. No.	LIST OF EXPERIMENTS
1	Tension test on Structural Materials: Mild Steel and Tor steel (HYSD bars) (Universal Testing machine and suitable extensometer)
2	Tests on springs (Open coiled)
3	Tests on springs (Closed `coiled)
4	Torsion pendulum on mild steel, aluminium and brass wires
5	Hardness test Brinell
6	Hardness test Vickers
7	Hardness test Rockwell
8	Impact test (Izod)
9	Impact test (Charpy)
10	Torsion test on Mild steel circular bars (Torsion Testing Machine)
11	Shear test on mild steel rods.
12	Bending test on mild steel (I sections) (Universal Testing Machine)
13	Bending Test on Timber (Universal Testing Machine and dial Gauge)
14	Bend & Rebend test on M S Rods
15	Verification of Clerk Maxwells Theorem
16	Demonstration of Fatigue Test
17	Study/demonstration of Strain Gauges and load cells

INDEX

MATERIAL TESTING LAB

Ex. No.	Date	Name of Experiment	Staff sign	Page no.
		FIRST CYCLE		
1		Tension test on Structural Materials: Mild Steel and Tor steel (HYSD bars) (Universal Testing machine and suitable extensometer)		
2		Tests on springs (Open coiled)		
3		Tests on springs (Closed coiled)		
4		Torsion pendulum on mild steel, aluminium and brass wires		
5		Hardness test Brinell		
6		Hardness test Vickers		
7		Hardness test Rockwell		
8		Impact test (Izod)		
9		Impact test (Charpy)		
10		Torsion test on Mild steel circular bars (Torsion Testing Machine)		
11		Shear test on mild steel rods.		
		SECOND CYCLE		
12		Bending test on mild steel (I sections) (Universal Testing Machine)		
13		Bending Test on Timber (Universal Testing Machine and dial Gauge)		
14		Bend & Rebend test on M S Rods		
15		Verification of Clerk Maxwells Theorem		
16		Demonstration of Fatigue Test		
17		Study/demonstration of Strain Gauges and load cells		

UNIVERSAL TESTING MACHINE



1. PUSH ON SWITCH
2. PUSH ON SWITCH
3. ON
4. OFF
5. LOAD INDICATING DIAL
6. RIGHT CONTROL VALVE
7. RANGE ADJUSTING KNOB
8. CONTROL PANEL
9. LOADING UNIT
11. LOWER TABLE
12. LOWER COMPRESSION PLATE
13. UPPER COMPRESSION PLATE
14. LOWER CROSS HEAD
15. SCREWED COLUMNS
16. STRAIGHT COLUMNS
17. TOP PLATE
18. UPPER CROSS HEAD
19. PEN HOLDER
20. RELIEF VALVE

Measurement Of Diameter:-

Least count of the vernier = 0.02 mm

No.	MSR(mm)	VSR (No: of divisions)	Total reading (mm) (MSR+VSR x LC)
1			
2			
3			
Average diameter in mm			

EXPT. NO:1

Date:

TENSION TEST ON MILD STEEL

AIM:-

To study the behavior of mild steel under tension and to find out the Young's modulus, ultimate strength, yield strength, percentage elongation etc.

TERMINOLOGY:-

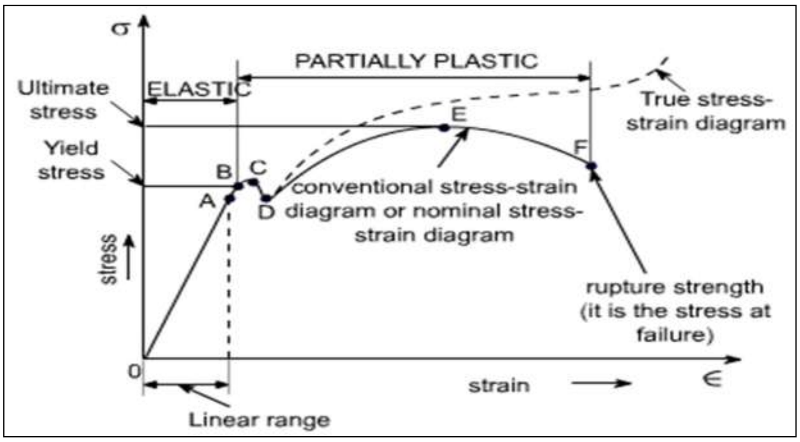
1. **Gauge Length (Lo):-** It is the prescribed part of a cylindrical or prismatic portion of test piece on which elongation is measured at any moment during the test.
2. **Percentage Elongation at Fracture (S):-** It is the variation of gauge length of a test piece subjected to fracture expressed as a percentage of original gauge length, Lo (if Lo is other than $5.65\sqrt{Ao}$, S should be suffixed by a letter indicating the gauge length used. For example S100 means percentage elongation of fracture measured on a gauge length of 100mm). A_o = original cross sectional area of specimen.
3. **Ultimate Load (fm):-** It is the highest load which the test piece withstands during the test.
4. **Nominal Breaking Stress (σ_{rup}):-** It is the breaking load divided by original area of cross section.
5. **Actual Breaking Stress: -** It is the breaking load divided by actual area of breaking.
6. **Ultimate Stress (σ_{ult}):-** It is the ultimate load divided by actual area of cross section of specimen.
7. **Yield Stress (σ_y):-** The stress at which the steel yields is known as yield stress.
8. **Proof Stress (R_p):-** The stress at which a non- proportional elongation equal to specified percentage (0.2%) of original gauge length takes place.

APPARATUS:-

The Universal Testing Machine, extensometer, scale, punching tools, Mild steel rod 1.2 cm diameter and 50cm long etc.

OBSERVATIONS AND CALCULATIONS:-

1. Mean diameter of the specimen, d =
2. Original cross sectional area, Ao =
3. Approximate ultimate load = 500Ao =
4. Range selected =
5. Original gauge length, Lo= 5.65√Ao =
6. Extensometer gauge length, Le =
7. Reduced diameter , du =
8. Reduced cross sectional area, Au =
9. Final gauge length , Lu =
10. Yield point load, Py =
11. Ultimate load, Pu =
12. Breaking Load, Pb =
13. Least count of extensometer =



A- Limit of proportionality
B- Elastic Limit
C- Upper Yield Point
D- Lower Yield Point
E- Ultimate tensile strength / tenaut
F- Breaking Stress

TEST SETUP:-

The tensile testing machine consists of mechanism for applying known forces on the test piece and for measuring the corresponding deformations. The most commonly used is of hydraulic type. Here the specimen is gripped between two cross heads and the force is applied on the specimen by moving one of the cross heads relative to the other by means of hydraulic pressure. The applied force is measured through mechanisms based on lever pendulum principles and directly recorded on the dial of the testing machine. The test piece used for tensile test is of standard dimensions having gauge length of 100 – 200 mm and 10 mm diameter. The gauge length is marked in the central region of the test piece by chisel mark and divided into suitable sub divisions of 10 mm each. This is to study the relative elongation after failure. The failure may occur at the weakest section of the specimen which may be outside the central region. Hence in practice the chisel marks on either side of the fracture section, final relative elongation over gauge length can be determined.

The elongation of test specimen in the initial stages of elastic deformation corresponding different values of loads is measured using extensometer. A load deflection graph is drawn with known data so that Hook's law can be established and Young's Modulus can be found out.

PROCEDURE:-

1) Clean the rod neatly with the sand paper. Measure the diameter at different places and find the mean diameter 'd'. Calculate the initial cross sectional area A_o.
2) Mark a gauge length of 20d (approximately 200mm) on it for calculating the percentage elongation Lo. Divide the gauge length into 'n' (approximately 10) equal parts.
3) Make the measurement for the gauge length of extensometer Le and make it on the specimen by measuring half length on either side. Note down the least count of extensometer.
4) Assuming ultimate tensile stress of 5000kg/cm^2 compute ultimate load to be applied and fix the range of loading in UTM. Assuming an upper limit

OBSERVATION

Sl.No.	Load	Extensometer reading	Elongation (mm) (mean x 0.01)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

1. Yield Stress, σ_y = Py/Ao =
2. Ultimate Stress, σ_{ult} = Pu/ Ao =
3. Nominal breaking stress, σ_{rup} = Pf/Ao =
4. Actual breaking stress = P_f/ Au =
5. Percentage reduction in area = (Ao-Au)/Ao =
6. Percentage elongation = (Lu-Lo)/Lo =
7. Young's Modulus, E = (P/δ)/ (Le/Ao)=

for the elastic range 2800kg/cm^2 compute the load for elastic deformation.

5) Fix the test piece in the grips of the machine by adjusting the cross heads so that test piece bears evenly in wedge grips. Ensure that the test piece is firmly clamped.
6) Fix the extensometer on the test piece and set its scale dial to zero. Also set the scale of the machine to zero position.
7) Switch on the machine, open the inlet valve and load the test piece. Note atleast 6 extensometer readings before the yield load is reached.
8) After the end of the sufficient observations remove the extensometer. Continue the application of load noting yield point. The maximum load (highest load which the specimen withstands during the test) is given by the pointer.
9) Now the load pointer moves backwards and the load at the instant of breaking the specimen can be noted.
10) Release the pressure and stop the machine.
11) Remove the test rod and place it together so that the length between the gauge lengths of elongation can be noted. Also note the fracture pattern (cup and cone failure)
12) Calculate the reduced cross sectional area by measuring the reduced diameter of the specimen.
13) Draw the load vs. extension graph
14) Modulus of elasticity, E is calculated.

RESULTS:-

i) Stress at yield point =………………………

ii) Ultimate tensile strength =……………………....

iii) Actual breaking stress =………………………

iv) Nominal breaking stress =………………………

DISCUSSION:-

As per IS specification, modulus of elasticity of steel is 2x10^5 – 2.2x10^5 N/mm^2. The obtained value is

OBSERVATIONS AND CALCULATIONS
For open coiled spring,

Diameter of the spring, D =
Radius of the spring, R =
Number of coils, n =
Diameter of the spring wire, d =
Length of the spring, L =
Pitch , p= L/n =

Open Coiled Springs – compression

Sl. No.	Load		Scale reading in cm	Deflection (mm)
	Load (KN)	Load (N)		
1				
2				
3				
4				
5				
6				

Angle of helix, α = $\tan^{-1}$(pitch/2πr) =

Modulus of rigidity, N $= \dfrac{64WR^3 n\sec\alpha}{d^4\delta}\left(\left(\cos^2\alpha\right)+\dfrac{2Sin^2\alpha}{2.6}\right)$

=

Stiffness of the spring $= \dfrac{load\ from\ graph}{corresponding\ deformation}$

EXPT. NO: 2
Date:

SPRING TEST-OPEN COIL SPRING

AIM:-

To find the stiffness of the given spring and modulus of rigidity of the specimen.

THEORY:-

A helical spring is a wire wound in a helix or spiral form. It can undergo considerable deflection without getting permanently distorted and is capable of considerable amount of strain energy. The helical spring are categorized as closed coiled helical spring and open coiled helical springs. In the case of closed coiled helical springs, pitch is very small and angle of helix; angle made by the coil with the horizontal is very small. Under axial load, this type of spring is subjected to torsion and the effect of bending being small is neglected. In the case of open coil spring the angle of helix is appreciable. And therefore under axial load this type of spring is subjected to torsion as well as bending.

Some terms used in the springs are:-

Proof Load: It is the greatest load which the spring can carry without getting permanently distorted.

Proof Stress: It is the maximum stress when spring is subjected to proof load.

Proof Resilience: It is the strain energy stored when subjected to proof load.

Stiffness: It is the load per unit deflection.

Axis of Helix: The angle between the plane of coil and the plane perpendicular to the axis of the helix.

Open Coiled Springs

Under the axial load W, a couple WR is produced. This couple may be resolved into two components torsion T (WR Cos α) and bending M (WR sin α)
Equating the work done by axial load to total strain energy in bending and torsion to obtain

$$\delta = \frac{64WR^3 n\sec\alpha}{d^4}\left(\frac{\cos^2\alpha}{N} + \frac{2Sin^2\alpha}{E}\right)$$

$$N = \frac{64WR^3 n\sec\alpha}{d^4\delta}\left(\left(\cos^2\alpha\right) + \frac{2Sin^2\alpha}{2.6}\right)$$

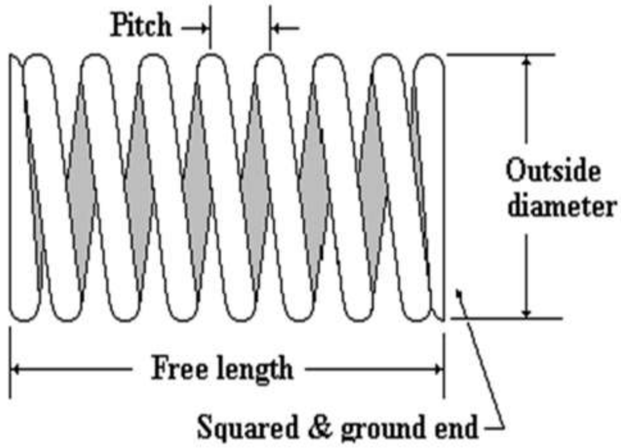
Where

W = loading in spring

R = Mean radius of the spring

n =number of turns

Where E = 2N (1+1/m) (assume 1/m = 0.3)



RESULT

Modulus of rigidity of the material of,

Open coiled spring =………….……….…..N/mm^2

Stiffness of the Open coiled spring = …………..…………..N/mm^2

DISCUSSION:-

The modulus of rigidity of mild steel lies between 7 x 10^4 N/mm^2 and 9 x 10^4 N/mm^2. The modulus of rigidity of the given open coiled spring is ___________. Hence the given material of open coiled spring is ___________

Modulus of Rigidity of some Common Materials

Material	Modulus of Rigidity (*GPa*)
Aluminum, 6061-T6	24
Aluminum, 2024-T4	28
Brass	40
Carbon Steel	77
Cast Iron	41
Copper	45
Structural Steel	79.3
Stainless Steel	77.2
Steel, Cold-rolled	75
Wood	13

EXPT. NO: 3

Date:

SPRING TEST-CLOSED COIL SPRING

AIM:-

To find the stiffness of the given spring and modulus of rigidity of the specimen.

THEORY:-

A helical spring is a wire wound in a helix or spiral form. It can undergo considerable deflection without getting permanently distorted and is capable of considerable amount of strain energy. The helical spring are categorized as closed coiled helical spring and open coiled helical springs. In the case of closed coiled helical springs, pitch is very small and angle of helix; angle made by the coil with the horizontal is very small. Under axial load, this type of spring is subjected to torsion and the effect of bending being small is neglected. In the case of open coil spring the angle of helix is appreciable. And therefore under axial load this type of spring is subjected to torsion as well as bending.

Some terms used in the springs are:-

Proof Load: It is the greatest load which the spring can carry without getting permanently distorted.

Proof Stress: It is the maximum stress when spring is subjected to proof load.

Proof Resilience: It is the strain energy stored when subjected to proof load.

Stiffness: It is the load per unit deflection.

Axis of Helix: The angle between the plane of coil and the plane perpendicular to the axis of the helix.

OBSERVATIONS AND CALCULATIONS

For close coiled spring,

Diameter of the spring, D =
Radius of the spring, R =
Number of coils, n =
Diameter of the spring wire, d =

Closed Coiled Springs

Sl. No.	Load		Scale reading in cm	Deflection (mm)
	Load (KN)	Load (N)		
1				
2				
3				
4				
5				
6				

From the graph,
Deflection, δ =
Load, W =

E = Young's Modulus
δ = deflection
N = Modulus of rigidity
α = Angle of helix = $\tan^{-1}$(pitch/2πR)

Deflection of the spring, δ = $\frac{64WR^3n}{Nd^4}$

Shear modulus or modulus of rigidity, N =

Stiffness of the spring = $\frac{load\ from\ graph}{corresponding\ deformation}$
=

Closed Coiled Springs

When coiled are wound very closely, angle of helix becomes very small. Hence the effect of WR Sin α may be neglected.

$$\delta = \frac{64WR^3 n}{Nd^4}$$

APPARATUS:-

Spring testing machine, screw gauge, scale etc.

PROCEDURE:-

Note the number of turns, length, outer diameter of the spring and diameter of the wire. Place the spring in spring testing machine. Note the initial reading in the spring for zero loading. By turning the hand wheel, apply load at common interval and note the pointer readings. Repeat the experiment for a number of loadings.

RESULTS:-

Modulus of rigidity of the material of,

Closed coiled spring = …………..…………..N/mm^2

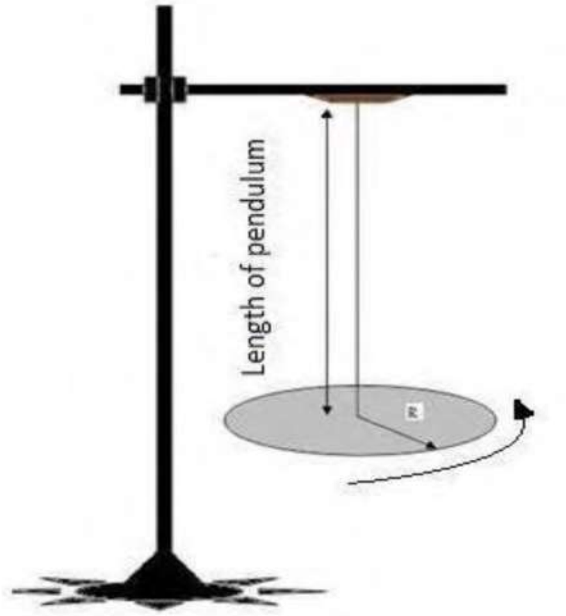
Stiffness of the Closed coiled spring = …………..…………..N/mm^2

DISCUSSION:-

The modulus of rigidity of mild steel lies between 7 x 10^4 N/mm^2 and 9 x 10^4 N/mm^2. The modulus of rigidity of the given close coiled spring is ____________. Hence the given material of close coiled spring is ___________

Modulus of Rigidity of some Common Materials

Material	Modulus of Rigidity (*GPa*)
Aluminum, 6061-T6	24
Aluminum, 2024-T4	28
Brass	40
Carbon Steel	77
Cast Iron	41
Copper	45
Structural Steel	79.3
Stainless Steel	77.2
Steel, Cold-rolled	75
Wood	13



TORSION PENDULUM

OBSERVATIONS

Specimen	Length	T1	T2	$t_1 = \frac{T_1}{10}$	$t_2 = \frac{T_2}{10}$	t_2^2-t_1^2	$\frac{1}{t_2^2 - t_1^2}$	N	AVG (N)

EXPT. NO: 4

Date:

TORSION TEST ON WIRES

AIM

To find the modulus of rigidity, N of the mild steel, aluminum and brass wires using torsion pendulum.

THEORY

When a mass suspended by a wire from a rigid support is rotated about the axis of the wire and is released, it executes angular oscillations with a period of oscillations given by

$t = 2\pi\sqrt{(I/T)}$

$= 2\pi\sqrt{(I_1 L / N J)}$

Where,

I = moment of inertia of mass about axis of rotation.

T = couple per unit twist of suspension wire.

Since N depends on T for a given length L of the wire, this will enable us to calculate N for the material of the wire provided I would be calculated from the dimensions of the suspended body.

Moment of inertia of the weight about the axis, $I_2 = \frac{M_1 r_1^2}{2} - \frac{M_2 r_2^2}{2}$

$M_1 = V_1 \times \rho$

$= \pi r_1^2 . t . \rho$

$M_2 = V_2 \times \rho$

$= \pi r_2^2 . t . \rho$

$$I_2 = \frac{M_1 r_1^2}{2} - \frac{M_2 r_2^2}{2}$$

CALCULATION

For……………….. wire

Diameter of wire =

Distance between Centre line of cylinders, 2a =

a =

Mass of the cylinder , m = g

Radius of cylinder , r = mm

Polar moment of inertia of wire , J $=(\pi*d^4)/32=$

Modulus of rigidity of the material of the wire,

$$N=\frac{4\pi^2 l[(\frac{W}{g}(a^2+\frac{r^2}{2})]}{J(t2^2-t1^2)}$$

APPARATUS

Torsion pendulum, screw gauge, stops watch, cylinder etc…

PROCEDURE

Suspend the wire, carrying the torsion disc from a grip provided with no weight on the disc. Apply a small torque on it. Note the time for a fixed number of oscillations using a stop watch and calculate the period of oscillation t_1 from the formula. Now add cylindrical weights of known value and note the time for the same number of oscillations. Repeat the same procedure for different lengths of the wire.

RESULT

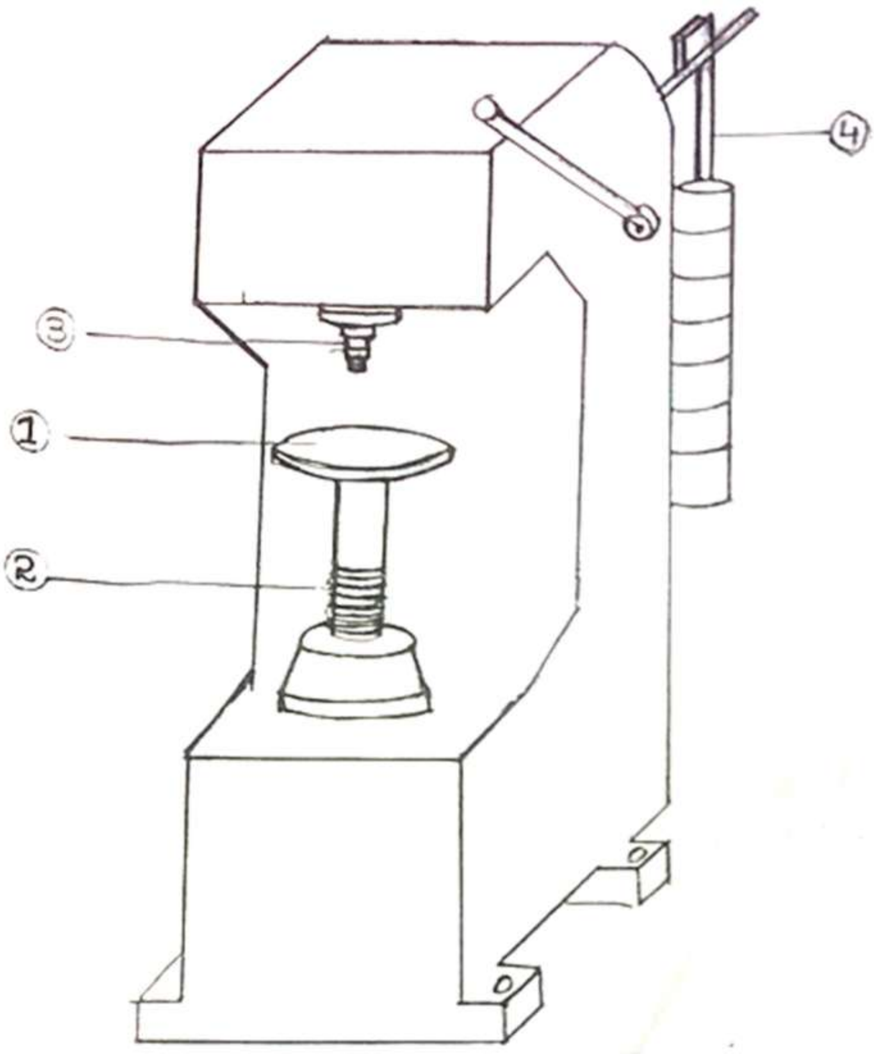
Modulus of rigidity of material of wire =

DISCUSSION

The obtained value for modulus of rigidity of steel is
Hence the given material of close coiled spring is

Material	**Modulus of Rigidity (*GPa*)**
Aluminum, 6061-T6	24
Aluminum, 2024-T4	28
Brass	40
Carbon Steel	77
Cast Iron	41
Copper	45
Structural Steel	79.3
Stainless Steel	77.2
Steel, Cold-rolled	75
Wood	13

BRINELL HARDNESS TESTING MACHINE



1. ANVIL

2. ELEVATING SCREW

3. SPINDLE SLEEVE

4. LOADING LEVE

EXPT. NO: 5

Date:

BRINELL HARDNESS TEST- STUDY

AIM:-

To determine the Brinell hardness number of the material of the test specimen.

GENERAL:-

The principle used in finding the Brinell hardness number is based on the resistance of the material to permanent indentation. The test consists in forcing a steel ball of diameter 'D' under a load of P into the specimen for a known time and measuring the mean diameter 'd' of the impression left on the surface after the removal of the load. Normally, a ball of 10 mm nominal diameter shall be used.

Depth of indentation is given by

$$h = \frac{D - \sqrt{D^2 - d^2}}{2}$$

$$\text{Brinell Hardness number (BHN)} = \frac{\text{Load on the specimen}}{\text{surface area of indentation}}$$

$$= \frac{P}{\frac{\pi D}{2}(D - \sqrt{D^2 - d^2})}$$

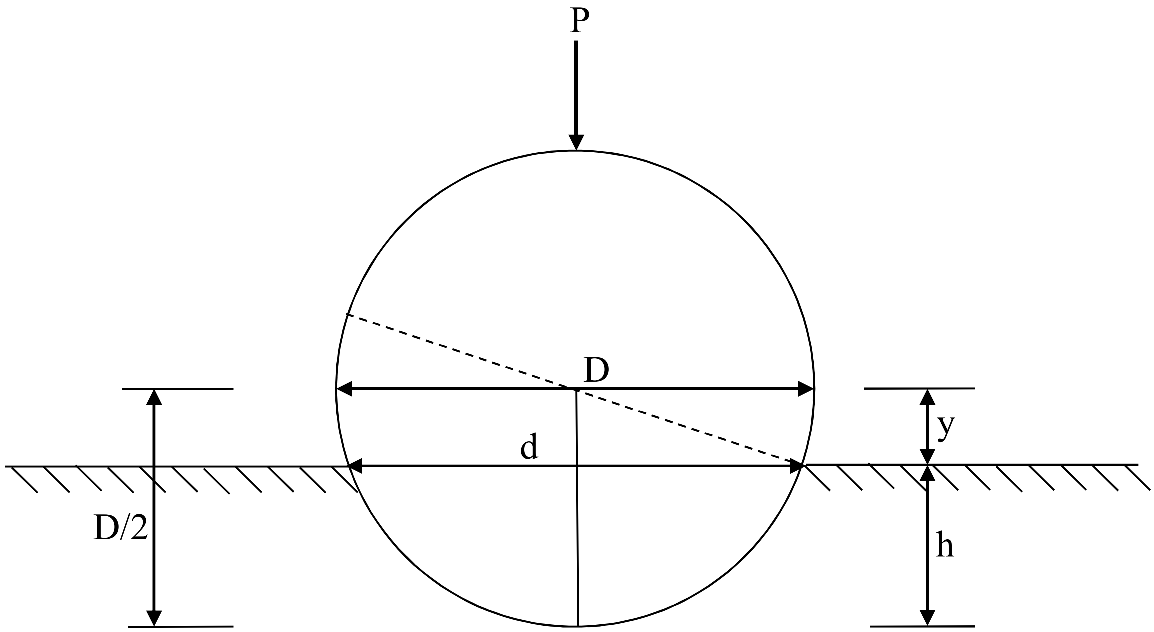
Where

D = diameter of the ball in mm

P = applied load

d = diameter of indentation in mm

OBSERVATIONS AND CALCULATIONS



$$h = (D/2) - y$$

$$y = \sqrt{(D/2)^2 - (d/2)^2}$$

$$= \tfrac{1}{2}\sqrt{D^2 - d^2}$$

$$h = \frac{D - \sqrt{D^2 - d^2}}{2}$$

$$\text{BHN} = \frac{P}{\frac{\pi D}{2} h}$$

$$= \frac{P}{\frac{\pi D}{2}\left(D - \sqrt{D^2 - d^2}\right)}$$

While changing the load P and the diameter of the indentor D, geometrical similarity of indentation can be maintained by keeping P/D^2 a constant for testing a particular material.

The following table gives the loads, the diameter of the indentor and the duration of the application of the load to be used for different materials and their thickness.

Material	**Interval of BHN**	**Thickness of specimen in mm**	**Diameter of ball, mm**	**Load in Kg**	**Test duration in S**	**P/D^2**
Ferrous materials (Cast iron and steel)	Below 140 – 150	6 3 – 6 3	10 5 2.5	3000 750 187.5	10	30
Ferrous materials	Below 140	6 3 – 6 3	10 5 2.5	3000 750 187.5	10	30
Non ferrous materials(copper, brass, bronze, Magnesium)	32 – 130	6 – 3 4 – 2 below 2	10 5 2.5	1000 250 62.5	30	10
Aluminium bearings alloy	8 -35	6 3 – 6 3	10 5 2.5	250 62.5 15.6	2.5	2.5

APPARATUS

Brinell Hardness Testing machine, microscope, stop watch, etc…

The standard Brinell hardness testing machine consists of an anvil for supporting the specimen, an elevating screw and hand wheel for raising the specimen to the required height. The mandrel with the ball is secured with the aid of a screw in spindle sleeve. The upper end of the spindle presses against the knife edge a small lever. The operation of this lever is linked to a loaded lever mechanism which is operated by an electric motor.

OBSERVATIONS

<table>
<tr><th rowspan="2">Sl No</th><th rowspan="2">Material of the specimen</th><th rowspan="2">Diameter of the ball</th><th rowspan="2">Load in Kg</th><th rowspan="2">Duration in S</th><th colspan="2">Diameter of impression, mm</th><th rowspan="2">Mean diameter in mm</th><th rowspan="2">BHN</th></tr>
<tr><th>d1</th><th>d2</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Non ferrous materials</td><td>10</td><td>1000</td><td>30</td><td></td><td></td><td></td><td rowspan="3"></td></tr>
<tr><td>10</td><td>1000</td><td>30</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>1000</td><td>30</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">ferrous materials</td><td>10</td><td>3000</td><td>10</td><td></td><td></td><td></td><td rowspan="3"></td></tr>
<tr><td>10</td><td>3000</td><td>10</td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>3000</td><td>10</td><td></td><td></td><td></td></tr>
</table>

SAMPLE CALCULATION

d1 = MSR + VSR x LC
=

d2 = MSR + VSR x LC
=

Ferrous material

d =
P =

$$BHN = \frac{P}{\frac{\pi D}{2}(D - \sqrt{D^2 - d^2})}$$

Non ferrous material

d =
P =

$$BHN = \frac{P}{\frac{\pi D}{2}(D - \sqrt{D^2 - d^2})}$$

When the machine is switched ON, the motor operates and gradually transfers the lever to spindle. The diameter of the impression is measured using a microscope.

PROCEDURE

Choose the diameter of the ball indentor depending on the thickness of the specimen. Obtain the load to be applied using the relation $P = 30D^2$ for ferrous materials and $P = 10\ D^2$ for non ferrous materials. Find out the proper time interval from above table. Place the proper loon rod suspended from the end of the lever. Keep the specimen with the smooth, clean and flat surface on the table and bring it in contact with the indentor for testing. Switch on the machine for loading. After the specified time, unload. Repeat the test on the specimen three times displacing the point of indentation to different places. The distance from the imprint centre to the specimen edge should not be less than the ball diameter and that to the centre of the neighboring imprint should be equal to at least two ball diameters. It should be ensured that the specimen thickness should be at least eight times the depth of the imprint. Remove the specimen and measure the diameter of the indentation, taking at least two readings of opposite diameters for each indentation using microscope. Compute the hardness value.

RESULT

The Brinell Hardness Number of the given materials are

Steel =	BHN	(3000/10/10 S)
Brass =	BHN	(1000/10/30 S)

DISCUSSION

According to Brinell Hardness, ferrous materials vary between 230 to 700 and Non – ferrous materials vary between 60 – 230. the obtained values are _______ for ferrous materials and ___________ for Non – ferrous materials.

EXPT. NO: 6
Date:

VICKER'S HARDNESS TEST

AIM

To determine the Vickers Hardness Number of material of test specimen.

PRINCIPLE

The resistance of material to permanent indention under static loading is taken as the basis for finding the Vicker's Hardness Number (IS 1501 – 2002). A four sided diamond pyramid indenter having an apex angle of 136^0 is pressed in to the surface of material to be tested under a specified load and for a specified time interval. This leaves an imprint of the pyramid on specimen surface. If d is the mean diagonal of the imprint on th surface, the surface area of the impression A = d^2 / (2 Sin θ / 2), where θ = 136^0. the hardness number, expressed as a number, leaving out the dimensional unit of kg/mm^2 is given by

$$HV \quad = P/A = \frac{2PSin\frac{\theta}{2}}{d^2} = 1.854\ P/d^2$$

Where,

P = applied load in Kg.

d = average length in mm of the two diagonals of the impression in the plane of the surface.

θ = angle between the opposite faces of the pyramid, i.e., 136^0.

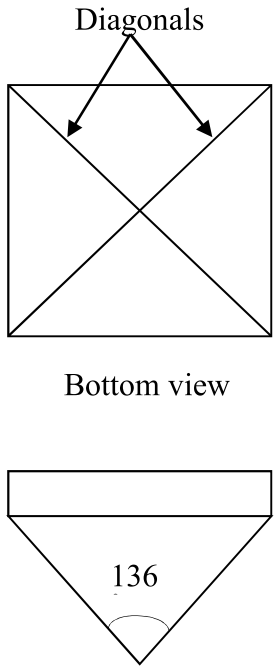
A load of 20 kg and duration of 10 seconds is generally used in laboratory tests.

APPARATUS

Vickers Hardness testing machine.

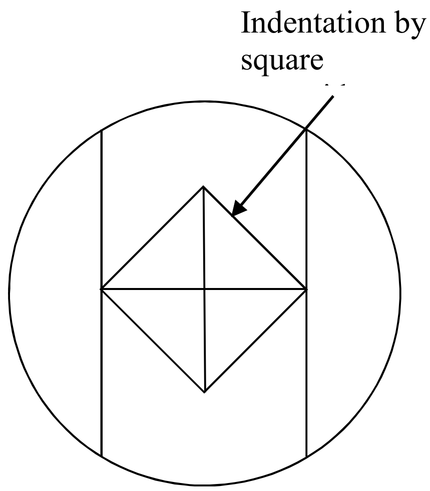
The test set up consists of a mechanism for applying a specified load which presses the diamond indenter on the specimen surface. The specimen is placed on a supporting table which can be raised or lowered by means of a hand wheel.

The Machine has an in-built arrangement for applying any desired load. The loading is applied through lever system, operated by an electric motor.



Bottom view

Front view



OBSERVATIONS AND CALCULATIONS

Sl NO	Specimen	Load in kg	Length of diagonals		Mean length (mm)	HV = 1.854 P / d^2.
			d_1 mm	d_2 mm		
1	steel	20				
2	Steel	20				
3	steel	20				

Vickers Hardness = _______________ HV 20.

Sample calculation

P =

Mean length =

$HV = 1.854\ P / d^2\ =$

After the application of load for the required time interval, the load is moved off the specimen.

The upper part of the machine has arrangements for focusing the image of the imprint on screen. A graduated Vernier scale and a micrometer are incorporated on the screen to measure the diagonal of the imprint accurately. Since the size of the impression is very small, devices are provided to project the impression on the screen with a magnification of 70 or 140. The measuring screen with the scale can be turned through 90^0 to facilitate measurement of both the diagonals of the impression.

PROCEDURE

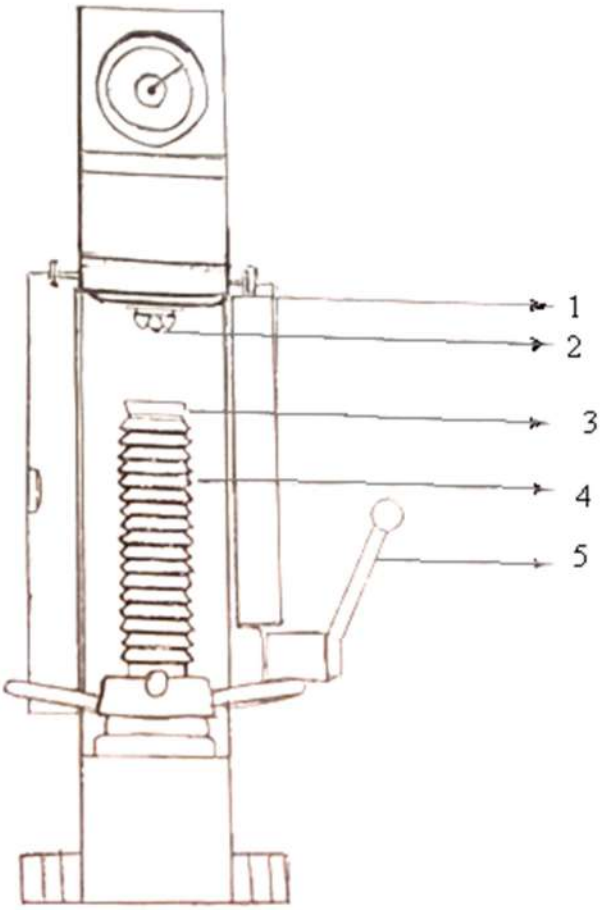
Prepare the surface of the specimen, making it smooth and bright. Support the specimen on the table and rotate the hand wheel until the specimen is sharply imaged on the screen. Engage the proper load corresponding to the material and thickness of the specimen by pressing the corresponding push button. Operate the push button switch where upon the indenter is automatically aligned over the specimen and the same is loaded. Release the push button when the DWELL indicator light becomes ON. The load is maintained for 10 seconds after which the loading stops automatically. Swing back the indenter to its original position away from the imprint. Now the impression will be focused on the screen. Centralize the image by turning the knob under the screen and bring one corner of the impression inline with the main scale division. Find the length of the two diagonals by operating the knob and the micrometer. Compute the Vicker's Hardness Number.

RESULT

Vicker's Hardness Number of the given material = ________________HV

DISCUSSION

Hardness means resistance to penetration, Vicker's Hardness Test is an indentation test. In this test, surface area of indentation is calculated and used as index of hardness of metal.



1. CLAMPING CONE
2. INDENTOR
3. TEST TABLE
4. RUBBER BELOW
5. LOADING HANDLE

ROCKWELL HARDNESS TESTING MACHINE

EXPT. NO: 7
Date:

ROCKWELL HARDNESS TEST

AIM:-

To determine the Rockwell hardness number of the material of the test specimen.

GENERAL:-

The Rockwell hardness measures the depth of penetration of a given penetrator under a specified load. The type of penetrators and the load used is selected to suit the materials being tested.

There are two types of indentors used in this test a hardened steel ball of 1.6 mm diameter for Rockwell B test and a small diamond cone having an apex angle of 120° for Rockwell C test. The diamond cone is used for testing hard materials whereas steel ball is used for testing softer materials.

In this test, the indentor is made to penetrate into the test specimen under the action of two consecutive applied loads a preliminary load of 10kg and a total (preliminary and main load together) of 100 or 150 kg.

The type of indentor and the final load to be applied are chosen from the following table:

Material	RH Scale	Indenter	Load in kgf	Symbol
copper	B	Steel ball 1/16”	150	HRB
Brass	B	Steel ball 1/16”	150	HRB
Aluminium	B	Steel ball 1/8”	60	HRB
Hard steel	C	Diamond Cone	150	HRC

OBSERVATIONS AND CALCULATIONS

Material	RH Scale	Indenter	Load in kgf	Symbol	RH Scale Reading	AVG
copper	B	Steel ball 1/16”	150	HRB		
Brass	B	Steel ball 1/16”	150	HRB		
Aluminium	B	Steel ball 1/8”	60	HRB		
Hard steel	C	Diamond Cone	150	HRC		

APPARATUS:-

Rockwell Hardness testing machine, stop watch etc.

The Rockwell hardness testing machine consists of a table to support the test piece. This table can be raised or lowered by means of a hand wheel. The indentor is fixed to a spring support to which the load can be applied through a hand lever. The initial load of 10kg is applied. The final load is transmitted through a system of weights and levers. The duration of the application of the final load is 5 to 10 seconds, after which the hand lever is released. The hardness number is then directly read on the indicator dial.

PROCEDURE:-

(a) Using steel ball (Rockwell – B)

Fix the steel ball indentor on the machine and apply an initial load of 10kg by rotating the wheel until a pointer in the dial is in the initial position. Then apply on additional load by turning the lever to the right. Apply the load for 5 seconds. When the needle of the indicator depth gauge becomes steady, the additional load is removed so as to bring the load back to the preliminary load. The Rockwell hardness number can be read directly from the indicator dial.

(b) Using diamond cone (Rockwell – C)

The above procedure is adopted with the following conditions:

Penetrator : Diamond Cone

Preliminary Load : 10 kg

Additional Load : 140 kg

Total Load : 150 kg

The Rockwell hardness number can be read directly from the indicator dial.

PRECAUTIONS:-

(a) The preliminary load is applied to make sure that there is a uniform and perfect contact between the indentor and the test specimen. This eliminates the errors that

(a) might arise as a result of differences in the surface finish of various test specimens.

(b) The surface of the test specimen should be flat and finished smooth and clean, removing all oxide scales and other impurities.

(c) The proper indentor should be chosen.

RESULT:-

The Rockwell hardness numbers of the given materials are:-

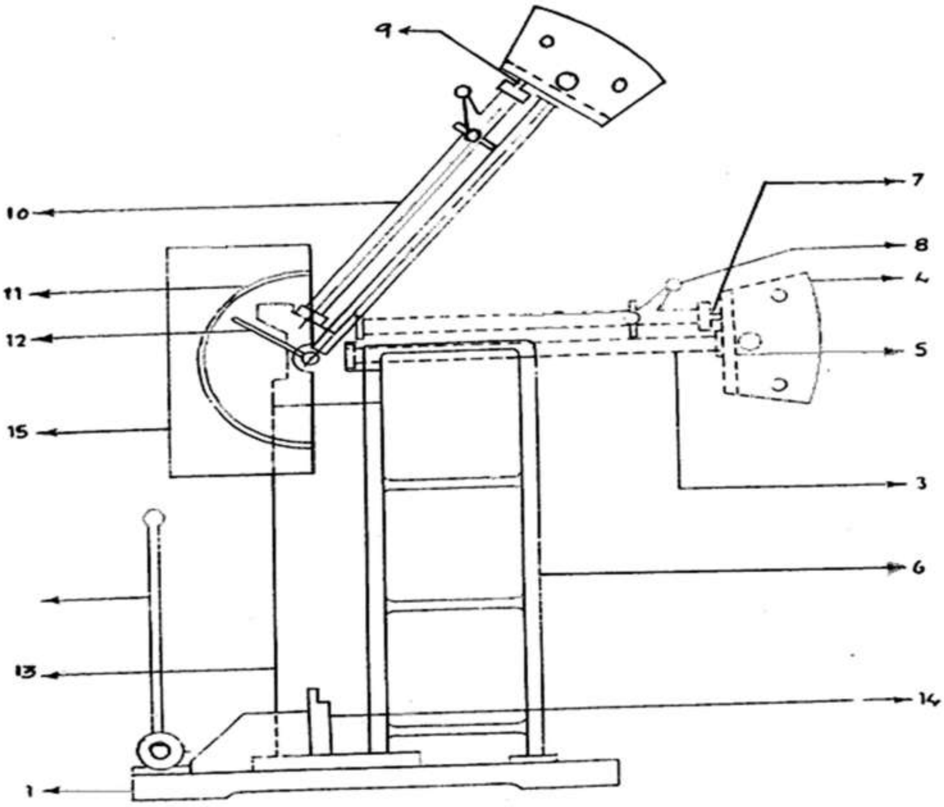
HRB of soft material = (load 100 kg, duration 5 sec)

HRC of hard material = (load 150 kg, duration 5 sec)

DISCUSSION:-

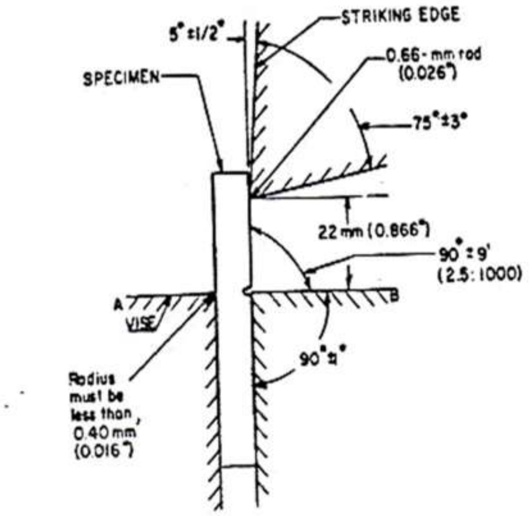
Hardness may be defined as the resistance, which a material offers to external deformation actions such as indention. Hardness of steel according to Mohr's scale is H = 6. Rockwell's Hardness test is generally performed when quick and direct reading is desirable. Rockwell Hardness number obtained for soft material =

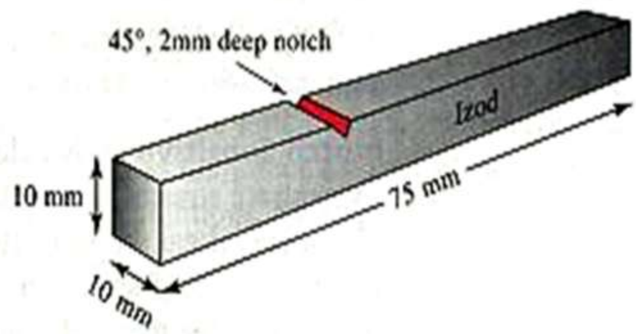
and for hard material = .



1- BASE WITH SPECIMEN SUPPORT FITTED T/O LATCH
2 COLUMN
3 PENDULUM PIPE
4 PENDULUM HAMMER
5 STRIKER
6 GUARD
8 LEVER TO RELEASE PENDULUM
10 LATCHING TUBE
11 DIAL
12 READING POINTER
13 BRAKE
14 SPECIMEN SUPPORT
15 BEARING HOUSE

IMPACT TESTING MACHINE





Izod test specimen and its position in the anvil

EXPT. NO: 8
Date:

IMPACT TEST-IZOD

AIM:-

To determine the impact strength of the material of the standard specimen.

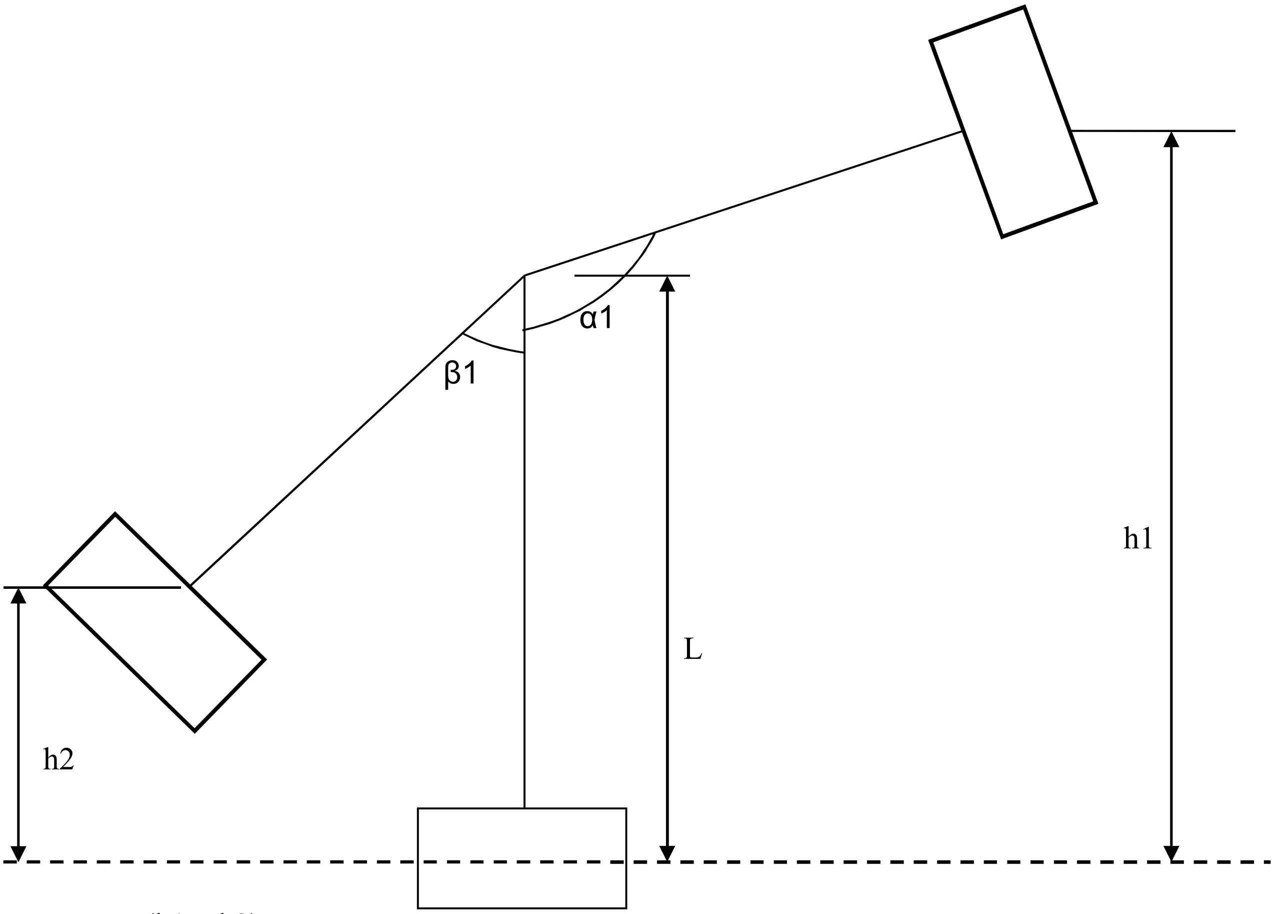
GENERAL:-

The strengths, ductility and toughness of materials are modified when impact loads are used instead of static loads. The mechanical property of toughness is a measure of the energy that the material absorbs during plastic deformation before its failure under impact loading. The material properties influencing toughness are the strength of the material and its ductility. Ductile materials, therefore, have large toughness values whereas brittle materials have low toughness. The impact test is carried out to obtain a measure of the toughness of material in terms of the energy required to fracture the specimen under dynamic loading.

The toughness of the material as determined by the impact test is dependent on the temperature, the velocity of the impact, the size of the specimen and the method of fixing. Depending upon the type of impact, impact testing may be classified as tensile impact test and impact bending test. The most widely used test in laboratories is impact bending test which is further classified into Izod and Charpy impact tests.

In Charpy test, the standard specimen as simply supported beam and the impact load is applied at the centre, while in the Izod test, the specimen is held firmly in a vice as a cantilever and the load is applied at the free end. In either case, the energy expended when the specimen fracture is taken as the measure of the impact value.

OBSERVATIONS AND CALCULATIONS



$E = wg\ (h1 - h2)$

$h = L + y$

$\quad = L + L \sin(\alpha 1 - 90°)$

$\quad = L + L (\sin \alpha 1 \cos 90° - \cos \alpha 1 \sin 90°)$

$h1 = L - L \cos \alpha 1$

$h2 = L - L \sin(90° - \beta 1)$

$\quad = L - L (\sin 90° \cos \beta 1 - \cos 90° \sin \beta 1)$

$\quad = L - L \cos \beta 1$

$E = wg\ (L - L \cos \alpha 1 - L + L \cos \beta 1)$

$E = wgL\ (\cos \beta 1 - \cos \alpha 1)$

A triaxial state of stress is produced at the base of the notch during the impact test. The brittleness of the material under this state is greater than for a simple uniaxial stress, and hence the notch-bar test provides a most sensitive means of evaluating tri axial stress brittleness or notch sensitivity.

The impact value viz. the energy Ea absorbed in the fracture of the specimen can be determined as follows:

If the initial height to which the pendulum is raised is h1(corresponding to $\alpha1$) and the highest position the pendulum reaches after breaking the specimen is h2 (corresponding to $\beta1$), then

$E_L = Wg\,(h1 - h2)$ or

$E_L = Wgl\,(\cos \beta1 - \cos \alpha1)$

The value of Wl is obtained from the known value of the energy E_L recorded in the hammer corresponding to the maximum position of the hammer.

APPARATUS:-

Impact testing machine, specimens, gauge etc.

The impact testing machine consists of a heavy pendulum which can be initially set at a specified height. The specimen is placed properly at the base of the machine to suit either the charpy or Izod test. On releasing, the pendulum swings giving a hammer blow to the specimen, thereby breaking it. In the process, the specimen absorbs some part of the energy of the pendulum and the pendulum further swings back to the opposite side. From the initial energy stored in the pendulum and the final energy after breaking the specimen, the energy absorbed by the specimen can be obtained. This value is directly given in the calibrated dial.

Generally, the range of the machine is fixed at 160J and 300J. this is achieved by changing the weight of the hammer by adding or removing necessary counterweights.

Izod Test

Length of the specimen = ……………….….mm

Cross sectional area =…………….……….mm^2

Depth of the notch =…………….………..mm

Initial energy of the pendulum, E_L = ………………j

W = 21.035kg

L = 0.814m

$\beta 1$ =……………..

$E = wgL(\cos\beta 1 - \cos\alpha 1) =$

Initial angle, $\alpha 1$ = 90^0

The value, WL =

Sl.No.	Angle (β)	Izod Test (J)
1	0	
2	10	
3	20	
4	30	
5	40	
6	50	
7	60	
8	70	
9	80	
10	90	

PROCEDURE:-

Prepare the calibration chart for the machine. Note down the dimension of the test specimen. Raise the pendulum to its maximum position and lock it. Place the specimen on the props of the test base so that the notch is directly opposite to the striking edge.

Release the lock of the pendulum allowing it to swing breaking the test piece and swing in the opposite direction. Apply the handbrake to stop the pendulum. Note the impact value of the specimen using the dial and check the same by computing the energy absorbed by the specimen using the relevant angles.

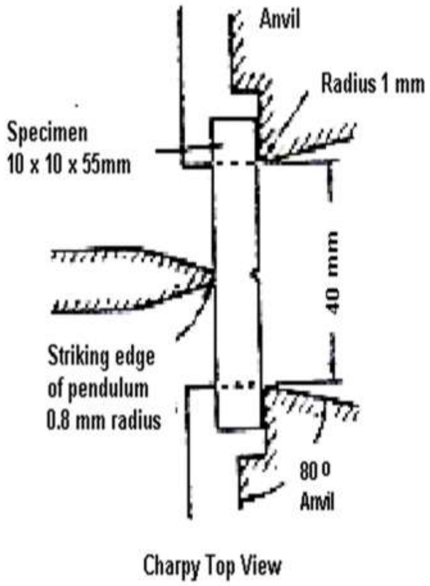
RESULT:-

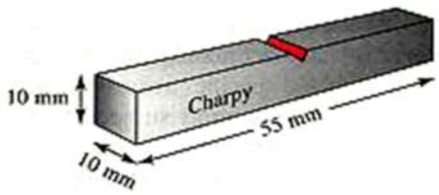
Impact value of the specimen
Izod test =

ANGLE FROM GRAPH
Izod test =

DISCUSSION:-

The materials ability to absorb energy up to fracture is called its toughness or in other words toughness defines the ability of the material to absorb energy prior to fracture. The larger the total area under the stress-strain graph the tougher is the material. Toughness indicates the resistance of the material to impact loading.





Position of the Charpy test specimen on the impact test machine

EXPT. NO: 9

Date:

IMPACT TEST-CHARPY

AIM:-

To determine the impact strength of the material of the standard specimen.

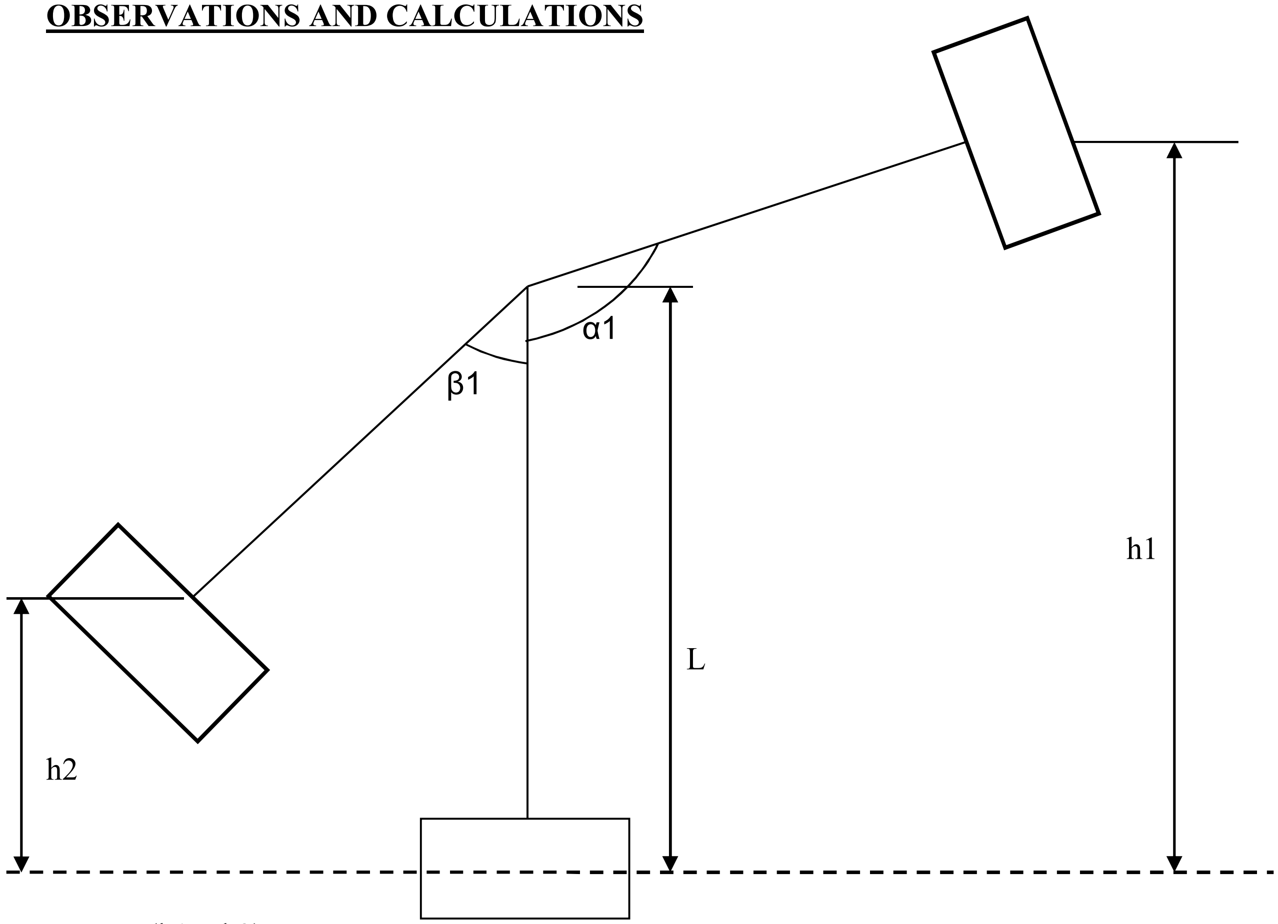
GENERAL:-

The strengths, ductility and toughness of materials are modified when impact loads are used instead of static loads. The mechanical property of toughness is a measure of the energy that the material absorbs during plastic deformation before its failure under impact loading. The material properties influencing toughness are the strength of the material and its ductility. Ductile materials, therefore, have large toughness values whereas brittle materials have low toughness. The impact test is carried out to obtain a measure of the toughness of material in terms of the energy required to fracture the specimen under dynamic loading.

The toughness of the material as determined by the impact test is dependent on the temperature, the velocity of the impact, the size of the specimen and the method of fixing. Depending upon the type of impact, impact testing may be classified as tensile impact test and impact bending test. The most widely used test in laboratories is impact bending test which is further classified into Izod and Charpy impact tests.

In Charpy test, the standard specimen as simply supported beam and the impact load is applied at the centre, while in the Izod test, the specimen is held firmly in a vice as a cantilever and the load is applied at the free end. In either case, the energy expended when the specimen fracture is taken as the measure of the impact value.

OBSERVATIONS AND CALCULATIONS



$E = wg\,(h1 - h2)$

$h = L + y$

$= L + L \sin(\alpha 1 - 90°)$

$= L + L(\sin\alpha 1 \cos 90° - \cos\alpha 1 \sin 90°)$

$h1 = L - L \cos\alpha 1$

$h2 = L - L \sin(90° - \beta 1)$

$= L - L(\sin 90° \cos\beta 1 - \cos 90° \sin\beta 1)$

$= L - L\cos\beta 1$

$E = wg\,(L - L\cos\alpha 1 - L + L\cos\beta 1)$

$E = wgL\,(\cos\beta 1 - \cos\alpha 1)$

A triaxial state of stress is produced at the base of the notch during the impact test. The brittleness of the material under this state is greater than for a simple uniaxial

stress, and hence the notch-bar test provides a most sensitive means of evaluating tri axial stress brittleness or notch sensitivity.

The impact value viz. the energy Ea absorbed in the fracture of the specimen can be determined as follows:

If the initial height to which the pendulum is raised is h1(corresponding to α1) and the highest position the pendulum reaches after breaking the specimen is h2 (corresponding to β1), then

$E_L = Wg\,(h1 - h2)$ or

$E_L = Wgl\,(\cos\beta 1 - \cos\alpha 1)$

The value of Wl is obtained from the known value of the energy E_L recorded in the hammer corresponding to the maximum position of the hammer.

APPARATUS:-

Impact testing machine, specimens, gauge etc.

The impact testing machine consists of a heavy pendulum which can be initially set at a specified height. The specimen is placed properly at the base of the machine to suit either the charpy or Izod test. On releasing, the pendulum swings giving a hammer blow to the specimen, thereby breaking it. In the process, the specimen absorbs some part of the energy of the pendulum and the pendulum further swings back to the opposite side. From the initial energy stored in the pendulum and the

final energy after breaking the specimen, the energy absorbed by the specimen can be obtained. This value is directly given in the calibrated dial.

Generally, the range of the machine is fixed at 160J and 300J. this is achieved by changing the weight of the hammer by adding or removing necessary counterweights.

Initial energy of the pendulum, E_L = ………………J
W = 21.035.kg
L = 0.814m
$\beta 1$ =……………..
$E = wgL (\cos \beta 1 - \cos \alpha 1) =$
Initial angle, $\alpha 1$ = 141.7^0
The value, WL =

Sl.No.	**Angle (β)**	**Charpy Test (J)**
1	0	
2	10	
3	20	
4	30	
5	40	
6	50	
7	60	
8	70	
9	80	
10	90	
11	100	
12	110	
13	120	
14	130	
15	140	

PROCEDURE:-

Prepare the calibration chart for the machine. Note down the dimension of the test specimen. Raise the pendulum to its maximum position and lock it. Place the specimen on the props of the test base so that the notch is directly opposite to the striking edge (charpy test).

Release the lock of the pendulum allowing it to swing breaking the test piece and swing in the opposite direction. Apply the handbrake to stop the pendulum. Note the impact value of the specimen using the dial and check the same by computing the energy absorbed by the specimen using the relevant angles.

CHARPY TEST

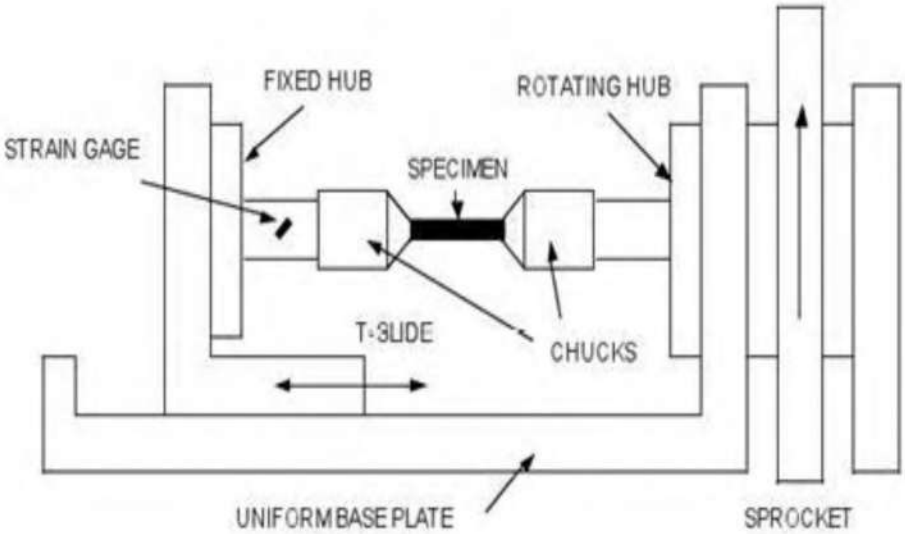
Length of the specimen =

Cross sectional area =

Depth of the notch =

DISCUSSION:-

The materials ability to absorb energy up to fracture is called its toughness or in other words toughness defines the ability of the material to absorb energy prior to fracture. The larger the total area under the stress-strain graph the tougher is the material. Toughness indicates the resistance of the material to impact loading.



TORSION TESTING MACHINE(LINE SKETCH)

EXPT. NO: 10
Date:

TORSION TEST ON MILD STEEL BAR

AIM

Torsion test on mild steel is to be conducted to find its modulus of rigidity

APPARATUS REQUIRED

A torsion testing apparatus, standard specimen of mild steel, twist meter for measuring angles of twist, a steel rule & calipers.

THEORY

Whenever a rod is subjected to torsion, shear stresses are developed on the planes perpendicular to the axis of the specimen. Then the shear strength (ability to withstand the developed shear stress) of the material becomes very important. If the shear strength is less than the compressive /tensile strength then the material may fail in compression or tension depending upon the smaller of the strengths.

A torsion test is quite instrumental in determining the value of the rigidity (ratio of shear stress to shear strain) of a metallic specimen. The value of modulus of rigidity can be found out through observations made during the experiment by using the torsion equation.

From the theory of pure torsion,

$$T/J = Fs/R = G\,\theta/L$$

Formulas for bars of non - circular section.

Bars of non -circular section tend to behave non-symmetrically when under torque and plane sections to not remain plane. Also the distribution of stress in a section is not necessarily linear. For the circular section J' = J.

$$\theta = \frac{T.l}{J'.G}$$

T = torque (Nm)
l = length of bar (m)
J = Polar moment of inertia.(Circular Sections) (m4)
J' = Polar moment of inertia.(Non circluar sections) (m4)
K = Factor replacing J for non-circular sections.(m4)

OBSERVATION AND TABULATION

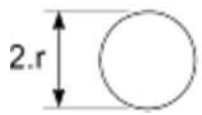
Length of the specimen,l : m

Side length of specimen, a: mm

Polar moment of inertia, J: mm

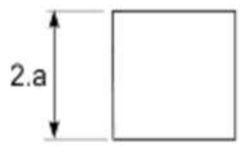
Sl.no	Torque ,T		Angle of twist, θ	
	Kgf	NM	In degree	In radian
1				
2				
3				
4				
5				
6				
7				
8				
9				

Solid Circular Section



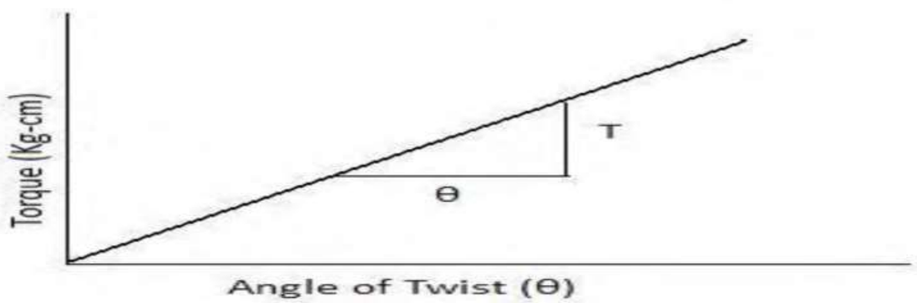
$J' = \frac{1}{2}\pi.r^4$ $\tau_{max} = \frac{2.T}{\pi.r^3}$

Solid Square Section



$J' = 2,25.a^4$ $\tau_{max} = \frac{0,601.T}{a^3}$

At midpoint of each side



Modulus of rigidity G=(TL)/(Jθ)= N/mm

PROCEDURE

1. Prepare the testing machine by fixing the two twist meters at some constants lengths from fixed support.
2. Measure the diameter of the pulley.
3. Measure the side length (a) of the specimen and measure the length(l) of the specimen between the heads.
4. Select suitable scale of loading on the machine and adjust initial torque and angle of twist reading to zero.
5. The specimen is gripped in between the two chucks.
6. Slacken the knurled headed screws on the flange of the straining holder and rotate the protractor until it reads zero
7. Apply the torque slowly and continuously at a uniform rate by turning the hand wheel in the same direction as before.
8. Note the readings of torque for every 10 degree increment of angle of twist till the material fails.
9. Plot a graph between the angle of twist and applied torque and compute the optimum torsion and of twist.
10. Compute the rigidity modulus using the optimized values of angles of twist and torque.

RESULT

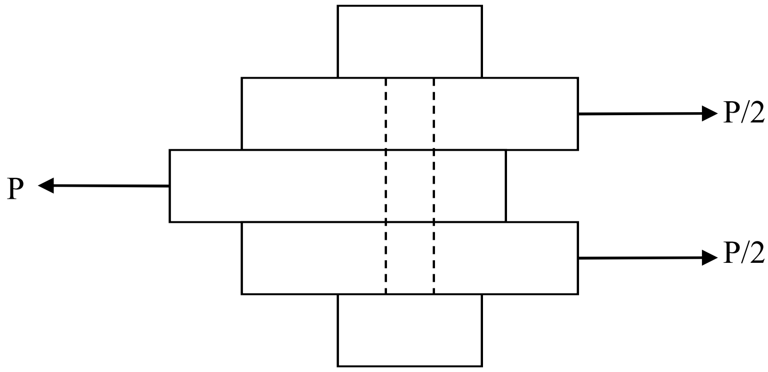
Modulus of rigidity of the shaft is = N/mm^2

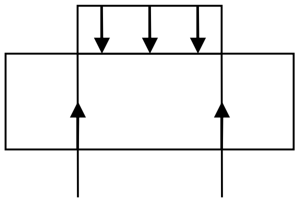
DISCUSSION

The obtained value for modulus of rigidity of steel is

Hence the given material of close coiled spring is

Material	**Modulus of Rigidity (*GPa*)**
Aluminum, 6061-T6	24
Aluminum, 2024-T4	28
Brass	40
Carbon Steel	77
Cast Iron	41
Copper	45
Structural Steel	79.3
Stainless Steel	77.2
Steel, Cold-rolled	75
Wood	13





OBSERVATIONS AND CALCULATIONS

Diameter of the rod, d = mm

Cross sectional area of the rod, A = $2\frac{\pi}{4}d^2$ = mm^2

Load taken by the specimen at the time of failure, W = N

Ultimate shear strength, f = $\frac{W}{A}$ = N/mm^2

EXPT. NO: 11

Date:

SHEAR TEST

AIM:-

To determine the shear strength of the given material by subjecting the specimen to failure under double shear.

PRINCIPLE:-

The test consists of subjecting a suitable length of mild steel specimen in full cross section to double shear using a suitable testing machine under a compressive load or a tensile pull and recording the maximum load F causing fracture. The shear strength can be calculated from the formula,

$$Rs = (F/2) / (\pi D^2/4)$$

$$= 2F / \pi D^2$$

Where D is the actual diameter of the specimen

APPARATUS:-

Universal testing machine, shear shackle, vernier calipers etc.

PROCEDURE:-

1. Measure the diameter, D of the rod and calculate the area of cross section, A of the specimen.
2. Assuming the ultimate shear strength of the material, determine the approximate load that the specimen will carry and select the range of the machine accordingly.
3. Fix the specimen in the shear shackle.
4. Apply the load after adjusting the machine for zero error.
5. Load the specimen till failure and note down the failure load.

RESULT:-

Shear strength of the given mild steel specimen =

DISCUSSION:-

Double Shear: - it is the one to which the specimen will have the tendency to get shear across 2 sections. In the case of double shear, shear force at each section is equal to P/2. The average shear stress on the cross section is given by $I_{avg} = P/2A$

Ex: - shear stress in a bolted connection.

EXPT. NO: 12
Date:

BENDING TEST ON MILDSTEEL (I-SECTION)

AIM:-

To observe the behaviour of I-section under bending to evaluate its modulus of elasticity

PRINCIPLE:-

If forces acting on a piece of material in such a way that they tend to induce compressive stresses over one part of a cross section of the piece and tensile stresses over the remaining part, the piece is said to be in bending.

In structures and machines in service bending may be accompanied by direct stress transverse shear, or torsional shear. For convenience, however, bending stresses may be considered separately, and in tests to determine the behavior of the materials in bending, attention is usually confined to beams.

It is assumed that the loads are applied so that they act in a plane of symmetry, so that deflections are parallel to the plane of the loads. It is also assumed that no longitudinal forces are induced by the loads or by the supports.

The flexural formula is given by,

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

Where,

M = Bending moment at a section (N-mm)

I = Moment of inertia of the section about the neutral axis (mm^2)

f = Bending stress in a fiber located at a distance 'y' above or below the neutral axis (N/mm^2)

E = Young's modulus of the material of the beam (N/mm^2)

R = Radius of curvature (mm)

In this experiment we apply central point load.

OBSERVATIONS AND CALCULATIONS:-

1. Effective length of the specimen l = mm
2. Breadth of flange b_f = mm
3. Thickness of flange t_f = mm
4. Depth of the specimen D = mm
5. Moment of inertia of the specimen about neutral axis I = mm^4

Least count of proving ring reading 1 div = kg

S. no	PROVING RING READING		DEFLECTOMETER READING			DEFLECTION (mm)
	DIV	LOAD (N)	TRIAL 1	TRIAL 2	TRIAL 3	

1. Stiffness of the beam = load/ deflection (from graph)

2. Young's modulus (E) = E = $\frac{wL^3}{48I\delta}$

   = N/mm^2

APPARATUS:-

The following equipment's are used for the experiment:

1) UTM or universal testing machine
2) Deflectometer
3) Beam supports
4) Vernier caliper
5) Wood specimen

PROCEDURE:-

1. Measure the dimensions the specimen
2. The specimen is placed above the roller support placed on the bending attachment such that the load will be acting at the center of the specimen.
3. The dial gauge deflectometer is fixed at the midspan to measure the deflection
4. Load is applied at a constant rate and continuously at a rate of 5mm/min.
5. Note down the deflectometer at regular interval of loading, upto failure.
6. Plot a graph pf load vs. deflection. Slope of tis graph gives the stiffness of the beam.

RESULT:-

1. Stiffness of the beam =
2. Young's modulus =

EXPT. NO: 13

Date:

BENDING TEST ON TIMBER

AIM:-

To observe the behaviour of timber under bending to evaluate its modulus of elasticity and modulus of rupture.

PRINCIPLE:-

If forces acting on a piece of material in such a way that they tend to induce compressive stresses over one part of a cross section of the piece and tensile stresses over the remaining part, the piece is said to be in bending. The common illustration of bending action is a beam acted on by transverse or couple such as may result , for example, from eccentric loads parallel to the longitudinal axis of a piece.

In structures and machines in service bending may be accompanied by direct stress transverse shear, or torsional shear. For convenience, however, bending stresses may be considered separately, and in tests to determine the behavior of the materials in bending, attention is usually confined to beams.

It is assumed that the loads are applied so that they act in a plane of symmetry, so that deflections are parallel to the plane of the loads. It is also assumed that no longitudinal forces are induced by the loads or by the supports.

The flexural formula is given by,

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

Where,

M = Bending moment at a section (N-mm)

I = Moment of inertia of the section about the neutral axis (mm^2)

f = Bending stress in a fiber located at a distance 'y' above or below the neutral axis (N/mm^2)

E = Young's modulus of the material of the beam (N/mm^2)

R = Radius of curvature (mm)

In this experiment we apply central point load.

OBSERVATIONS AND CALCULATIONS:-

6. Effective length of the specimen l = mm
7. Breadth of the specimen b = mm
8. Depth of the specimen d = mm
9. Moment of inertia of the

   specimen about neutral axis I = $\frac{bd^3}{12}$

   = mm^4

Least count of proving ring reading 1 div = kg

S. no	PROVING RING READING		DEFLECTOMETER READING			DEFLECTION (mm)
	DIV	LOAD (N)	TRIAL 1	TRIAL 2	TRIAL 3	

3. Modulus of rupture = f = $\frac{3W_{max}L}{2bd^2}$

   = N/mm^2

4. Young's modulus (E) = E = $\frac{wL^3}{48I\delta}$

   = N/mm^2

APPARATUS:-

The following equipment's are used for the experiment:

1) UTM or universal testing machine
2) Deflectometer
3) Beam supports
4) Vernier caliper
5) Wood specimen

PROCEDURE:-

1. Measure the length l, breadth b, depth d of the specimen
2. The specimen is placed above the roller support placed on the bending attachment such that the load will be acting at the center of the specimen.
3. The dial gauge deflectometer is fixed at the midspan to measure the deflection
4. Load is applied at a constant rate and continuously at a rate of 5mm/min.
5. Note down the deflectometer at regular interval of loading, upto failure.
6. Plot a graph pf load vs. deflection. Slope of tis graph gives the stiffness of the beam.

RESULT:-

Modulus of rupture =

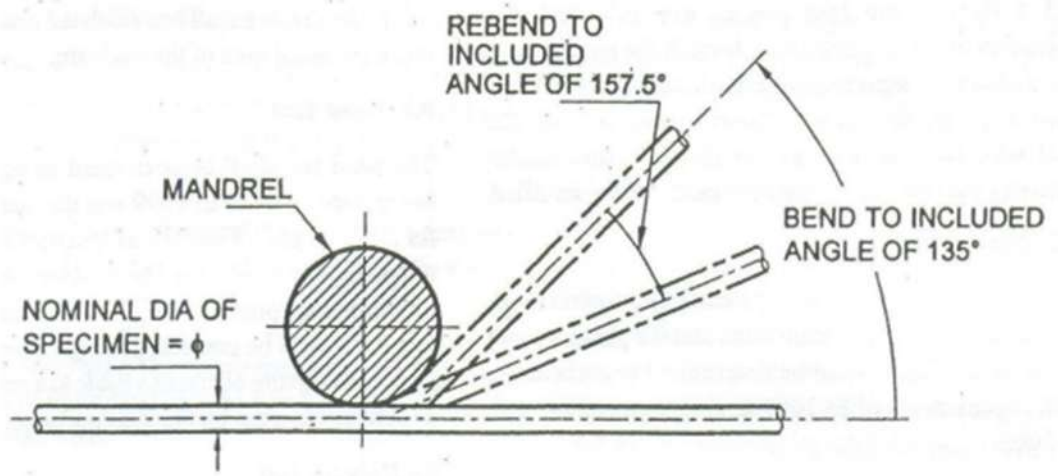
Young's modulus =

DISCUSSION

As per IS 883-1994 timber is classified on the basis of modulus of elasticity as follows.

Strength of characteristics	Modulus of elasticity
Group A	> 12.6×10^3 N/mm^2
Group B	9.8×10^3 to 12.6×10^3 N/mm^2
Group C	5.6×10^3 to 9.8×10^3 N/mm^2

Here the obtained value of modulus of elasticity is ______________N/mm^2. So timber belongs to group _____ as obtained from the test.



NOTE—ϕ Represents the nominal size in mm of the test piece.

Sr. No.	Nominal Size mm	Mandrel Diameter for Different Grades						
		Fe 415	Fe 415D	Fe 500	Fe 500D	Fe 550	Fe 550D	Fe 600
i	Up to and including 20	3Ø	2Ø	4Ø	3Ø	5Ø	4Ø	5Ø
ii	Over 20	4Ø	3Ø	5Ø	4Ø	6Ø	5Ø	6Ø

Where Ø is the nominal size of the test piece, in mm.

Sr. No	Nominal Size of Specimen	Dia of Mandrel Fe415 and Fe500	Dia of Mandrel Fe415D and Fe500D	Dia of Mandrel Fe550 and Fe600	Dia of Mandrel Fe550D
i	Up to and including 10mm	5Ø	4Ø	7Ø	6Ø
ii	Over 10mm	7Ø	6Ø	8Ø	7Ø

EXPT. NO: 14

Date:

BEND AND REBEND TEST - STUDY

AIM:

To observe the development of transverse cracks in reinforcing steel

MATERIALS:

Reinforcing bars 400mm long.

THEORY:

Ductility and brittleness are the two important properties of reinforcing bar apart from its tensile strength. The properties of the bar are dependent of its chemical composition as the carbon content increases, strength increases but ductility decreases. In reinforced concrete structures, bars are reinforced to take up the tensile stresses because concrete is weak in tension. The brittle material fails suddenly without giving prior information which is not same in case of the ductile material. Thus high strength bars because of their higher carbon content can carry more loads but may fail in shear by developing cracks on tension side. Thus to know the behavior of a bar under transverse load bend and rebend test are conducted on it.

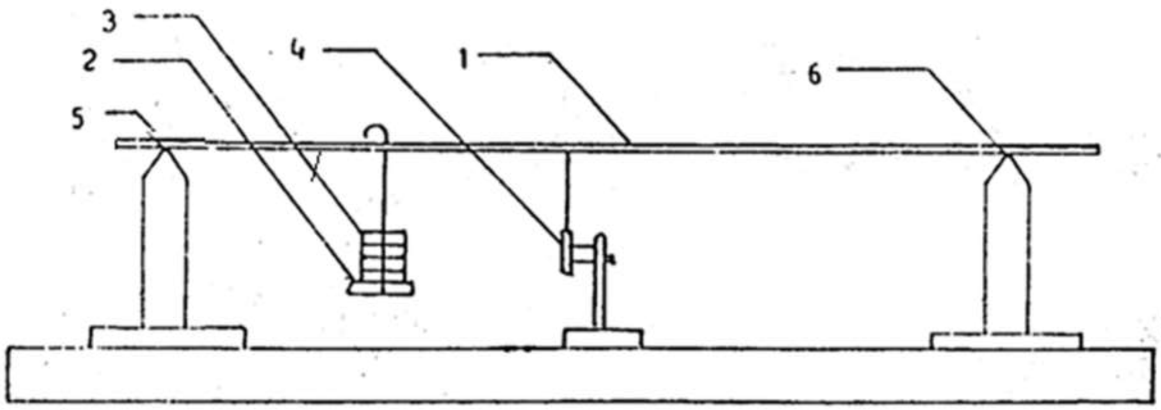
PROCEDURE:

1.Bend test: In this bar need to be tested is supported as shown in fig 1.b.1 and force is applied through mandrel till the included angle between two arms of the bar is 135^0. The bar is carefully observed for the cracks if any.

2.Rebend test: The specimen so bent shall be aged by keeping in boiling water [1000] for 30 minutes and then allowed to cool. The piece is then bent back to have an included angle of 157.5^0 . Again the bar is observed carefully for cracks of any.

RESULT:

The bend and rebend test was studied



1 SIMPLY SUPPORTED BEAM
2 LODIING PAN
3 WEIGHTS
4 DIAL GAUGE

5,6 FREELY SUPPORTED END

APPARATUS FOR CLERK MAXWELL'S
RECIPROCAL THEOREM

EXPT. NO: 15

Date:

VERIFICATION OF CLERK MAXWELL'S RECIPROCAL THEOREM

AIM:

To verify Clerk Maxwell's reciprocal deflection theorem and to determine young's modules.

THEOREM:

The theorem states that in any structure, the deflection at any point A, due to a load applied at B, will be equal to the deflection at B, when the same load is applied at A.

APPARATUS:

Two knife edge and one hinged support, steel beam, deflectometer, scale, Weights and Loading pan.

PROCEDURE:

Adjust the deflectometer and keep it under the mid span of the beam. Keep the weight hanger at quarter span of the beam and find out the deflection at the mid span. Repeat the same procedure for different loads and simultaneously measure the corresponding deflection at the mid span.

Shift the deflectometer to the quarter span point and the weight hanger to the mid span. Repeat the same loading and note the corresponding deflection at the quarter span.

EXPERIMENTAL OBSERVATIONS AND CALCULATIONS:

Span of the beam, L =

Breadth of the beam, b =

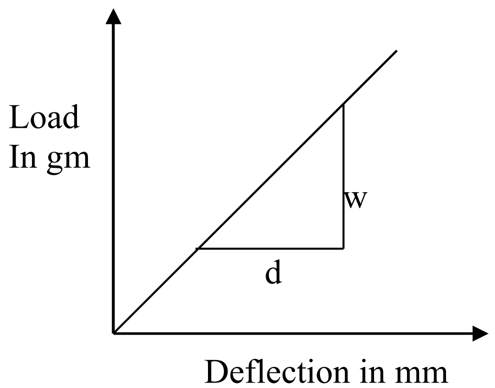
Depth of the beam, d =

Moment of inertia about neutral axis, $I = bd^3/12 =$

Sl No.	Load at mid span, deflection at quarter span					Load at quarter span, deflection at mid span				
	Load in gm	Deflectometer reading in div			Deflection In mm	Load in gm	Deflectometer reading in div			Deflection In mm
		Loading	Unloading	Average			Loading	Unloading	Average	
1										
2										
3										
4										
5										
6										
7										

GRAPH:

Load Vs Deflection graph



Note : Obtain a straight – line graph and it should coincide in both cases.

From the graph

Deflection, δ =

Load, W =

Young's modulus, $E = 11\ WL^3 / 768\ \delta I =$

RESULT:

Clerk Maxwell’s reciprocal deflection theorem is ……………………………….........

Young's Modulus for the material of the beam, E =

EXPT. NO: 16

Date:

DEMONSTRATION OF FATIGUE TEST

AIM:

To study the effect of fluctuating stress normally encountered in the cyclic loading of materials in service.

THEORY:

For this test, a number of identical test piece bars are made from the same material to be tested. First fix one piece in the space provided in the machine. Then apply some load. Allow electric motor to run so that it rotates the specimen also. Number of rotations, made will be automatically recorded by the cycle counter provided. After some time due to the continuous stress reversal the specimen will fail. By knowing the diameter of the specimen, stress applied in the material can be calculated. Note the number of rotations. Then repeating the test for the remaining specimen by decreasing the load. The corresponding stress as well as the number of rotations is noted. We can see as the load is decreasing, the number of rotations required to failing the specimens is increased. Then draw a graph with stress in the Y-axis and no: of rotations in the 'X-axis. From the graph we can see after some test, a limit is reached where the stress is not sufficient to break the material. This safe stress is known as endurance limit.

FATIGUE FAILURE

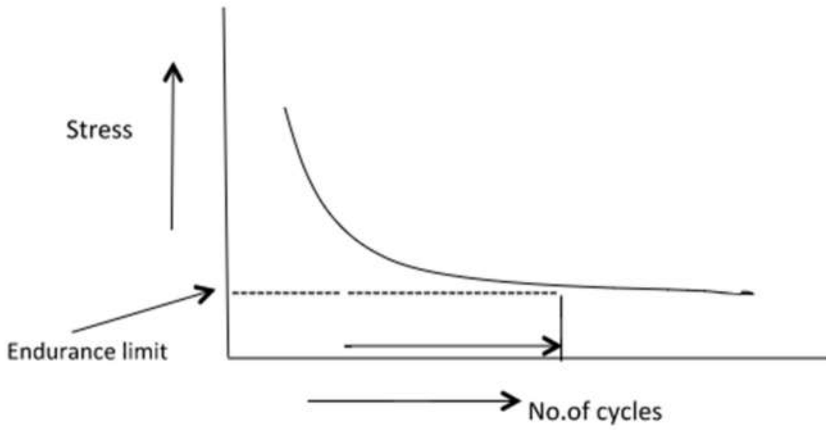
Most structural components are subjected to variation in applied loads and it causes in stress fluctuation. The failure induced in the metal due to this often stress fluctuation or stress repetition , even though the maximum applied stress may be considerably less than the static strength of the material is known as fatigue failure. It is also referred as progressive fractures.

FATIGUE STRENGTH

The stress at which a metal fails by fatigue after a certain number of cycle is termed the fatigue strength.

FATIGUE LIMIT

It is found that for most of the material there is a limiting stress below which a load may be repeatedly applied an indefinitely large number of times without causing failure. This limiting stress is called the endurance limit or fatigue limit. The ratio between the fatigue limit to static strength of the material is known as endurance ratio or fatigue ratio, it is normally varies from 0.2 to 0.6.



Stress VS No. of cycle graph

EQUIPMENTS

Machines for making fatigue test under cycles of repeated or reversed stress may be classified according to the type of stress produced

1. Machines for cycles of axial stress (tension and compression)
2. Machines for cycles of flexural stress
3. Machines for cycles of torsional shearing stress
4. Machines for cycles of axial, flexural, or torsional shearing or combination of them.

SELECTION OF TEST PARAMETERS BEFORE THE TEST IS STARTED

- Type of load variation
- Mean stress
- Alternative stress
- Frequency

PROCEDURE AND OBSERVATION

1. Preparation of identical specimen that are representative of the material.
2. Carefully measure the dimension of the specimen to obtain the cross sectional area.
3. Securely fasten the specimen in the chunks of the testing machine, verify that the grips are properly aligned.
4. The first specimen is tested at a relatively high stress to know about the repetitive stress applied on the specimen such that failure will occur after a small number of applications of stress. (To avoid the large number of cycles).
5. Set the load and frequency for the succeeding specimen, then tested at a lower stress of the above value with initial cycle counter as zero. Start the machine.
6. The number of repetitions required to produce failure increases as the stress decreases. It is normally ranging from 1,000,000 to 50,000,000 cycles.
7. Continue the test until the specimen fractures. Specimens stressed below the fatigue limit will not rupture.
8. In order to minimize the effect of random errors, usually many specimens are tested, at the same stress level.
9. Next an S-N diagram Is preapared.

RESULT

Fatigue testing was studied.

EXPT. NO: 17

Date:

STUDY OF STRAIN GAUGES AND LOAD CELLS

LOAD CELLS:

Load cell is a device for measurement of force through indirect method. Load cell utilize on elastic member as the primary transducer and the strain gauge may be called as secondary transducer. Load cells are steel rings which are used as force standard. There are particularly useful for the calibration of material testing M/C in situations where dead weight standard are impractical to use on account of bulk m/c. If load cell is a circular ring which may be subjected to tensile or compressive forces across its diameter. In fact it is a ring in which the forces show a deflection relationship. Load cell is mainly of three types:

Piezoelectric load cell:- Piezoelectric load cells work on the same principle of deformation as the strain gauge load cells, but a voltage output is generated by the basic piezoelectric material - proportional to the deformation of load cell. Useful for dynamic/frequent measurements of force. Most applications for piezo-based load cells are in the dynamic loading conditions, where strain gauge load cells can fail with high dynamic loading cycles. It must be remembered that the piezoelectric effect is dynamic, that is, the electrical output of a gauge is an impulse function and is not static. The voltage output is only useful when the strain is changing and does not measure static values.

Hydraulic load cell:- The cell uses conventional piston and cylinder arrangement. The piston is placed in a thin elastic diaphragm. The piston doesn't actually come in contact with the load cell. Mechanical stops are placed to prevent over strain of the diaphragm when the loads exceed certain limit. The load cell is completely filled with oil. When the load is applied on the piston, the movement of the piston and the diaphragm results in an increase of oil pressure which in turn produces a change in the pressure on a Bourdon tube connected with the load cells. Because this sensor has no electrical components, it is ideal for use in hazardous areas. Typical hydraulic load cell applications include tank, bin, and hopper weighing. By example, a hydraulic load cell is immune to transient voltages (lightning) so these type of load cells might be a more effective device in outdoor environments. This technology is more expensive than other types of load cells. It is a more costly technology and thus cannot effectively compete on a cost of purchase basis.

Pneumatic load cell:- The Load cell is designed to automatically regulate the balancing pressure. Air pressure is applied to one end of the diaphragm and it escapes through the nozzle placed at the bottom of the load cell. A pressure gauge is attached with the load cell to measure the pressure inside the cell. The deflection of the diaphragm affects the airflow through the nozzle as well as the pressure inside the chamber.

STRAIN GAUGES:- A strain Gauge may be defined as any instrument or device that is employed to measure the linear deformation over a given gauge length, occurring in the material of a structure during the loading of structures. This definition is quite broad. In fact it covers the range of instruments included between the linear scale & the precise optical & electrical gauges now available. The many types of strain gauges available are quite varied both in applications & in the principle invalid in their magnification, systems. Depending upon the magnification system the strain gauges may be classified as follows:

1) Mechanical

1. Wedge & screw
2. Lever – simple & compound
3 Rock & pinion
4 Combination of lever & rack & pinion
5 Dial indicators

2) Electrical

1. Inductance
2. Capacitance
3. Piezoelectric & piezoresiotue

Accuracy & repeatability -: Sensitive does not ensure accuracy. Usually the very sensitive instruments are quite prone to error unless they are employed with utmost care. Before selecting a particular type of gauge following factors must also be carefully evaluated.

1) Readalutity
2) Ease of mounting
3) Required operator skill
4) Weight
5) Frequency response
6) Cost.

1) Mechanical Strain Gauges:-

a) Wedge & screw orignification:- The wedge gauge is simply a triangular plate with its longer sides related at 1:10 slope when inserted between two shoulders dipped to the test

specimen, extension could be detected nearest 0.05 mm .A single screw extensometer which is one of the pioneer instruments used for measurement of strain. The magnification in this instrument is accomplished solely by a screw micrometer a measures the relative motion of two coaxial tubes.

1. Magnetic
2. Acoustical
3. Pneumatic
4. Scratch type
5. Photo stress gauge

Characteristic of a strain gauge:-

A strain gauge has the following four basic characteristics

1) Gauge length: - The gauge size for a mechanical strain gauge is characterized by the distance between two knife edges in contact with the specimen & by width of a movable knife edges non linear strum which should be as small as possible in that case.

2) Sensitivity :- It is the smallest value of strain which can be read on the scale associated with strain gauge .Sensitivity can be defined in two way :-

i) Deformation sensitivity = Smallest reading of scale/Multiplication factor

ii) Strain sensitivity = Deformation sensitivity/Base length

3) Range: - This represents the maximum strain which can be recorded without re-setting or replacing the strain gauge. The range & sensitivity are

1) Simple Mechanical lever magnification:- The simple lever strain gauge gains its magnification factors by a suitable positioning of fulcrum cap's multiplying divider is an important extensiomeus of this category. The magnification of this type of gauge is unlimited. The gauge length of cap's divider is 5cm & strain is magnified 10: 1 on graduated scale.

2) Compound Magnification System:- Two commercially available gauges which utilize the compound magnification are illustrated by Barry gauge & tinusis oisen strain gauge. The Barry strain gauge consists of frame a with two conically painted contact points. One point b is rigidly fixed to frame while other c is provided from a frame & is internal with a lever armed which alone magnifies the strain about 5.5. A screw micrometer or dial indicator is used to measure the motion of arm, thus permitting measurements of strain to nearest 0.005 m with a 0.025mm micrometer.

3) Compound lever Magnification:- Two gauges of this category are Huggen berger strain gauge & parter lipp strain gauge. In these instruments the magnification system is composed

of two or more simple levers in serus. They have relatively small size & high magnification factor.

4) Mechanical by rack & pinion:- The rack & pinion principle alone with various types of gear train is employed in gauge in which the magnification system is incorporated in an indicating dial. In general a dial indicator consists of an encased grain train actuated by a rack cut in spindle which follows the motion to be measured. A spring imposes sufficient spindle force to maintain a reasonably uniform &positive contact with the moving part. The gear train terminates with a light weight pointer which indicator spindle travel on a graduated dial. Lost motion in gear traum is minimized by +ve force of a small coul spring the dial gauge extensometer is the most popular gauge of this type used in a material testing laboratory. Dial gauge indicator are frequently attached permanently to a structure to indicate the deflection one deflection on deformation obtained under working condition.

3) Acoustical strain gauge:-

The vibrating wire or acoustical gauge consists essentially of a steel wire tensioned between two supports a predetermined distance apart. Vibration of the distance alters the natural frequency of vibration of the wire & thus change in frequency may be correlated with the change in strain causing An electro –magnet adjacent to the wire may be used to set the wire in vibration & this wire movement will then generate on oscillating electrical signal . The signal may be compared with the pitch adjustable standard wire , the degree of adjustment necessary to match of two signal frequencies being provided by a tensioning screw on the slandered wove calibration of this screw allows direct determination of change of length of a measuring gauge to be made once the standard gauge has been tuned to match the frequency of measuring wire. The visual display produced is a cko renders adjustment easier. Tuning is now more usually accomplished by feeding the two signal in to two pours of plates of an oscillogram & making use of the luscious figure formation to balance the frequencies. Matching of tones is simplified & made more accurate by tuning out the beats with results when the vibration frequencies of two were are nearly the lame.

CSL203 OBJECT ORIENTED PROGRAMMING LAB

INDEX

LIST OF EXPERIMENTS

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   Ex: MALAYALAM is palindrome.
2. Write a Java Program to find the frequency of a given character in a string. **
3. Write a Java program to multiply two given matrices. **
4. Write a Java program which creates a class named 'Employee' having the following members: Name, Age, Phone number, Address, Salary. It also has a method named 'print-Salary( )' which prints the salary of the Employee. Two classes 'Officer' and 'Manager inherits the 'Employee' class. The 'Officer' and 'Manager' classes have data members 'specialization' and 'department' respectively. Now, assign name, age, phone number, address and salary to an officer and a manager by making an object of both of these classes and print the same. (Exercise to understand inheritance). **
5. Write a java program to create an abstract class named Shape that contains an empty method named numberOfSides( ). Provide three classes named Rectangle, Triangle and Hexagon such that each one of the classes extends the class Shape. Each one of the classes contains only the method numberOfSides( ) that shows the number of sides in the given geometrical structures. (Exercise to understand polymorphism). **
6. Write a Java program to demonstrate the use of garbage collector.
7. Write a file handling program in Java with reader/writer.
8. Write a Java program that read from a file and write to file by handling all file related exceptions.**
9. Write a Java program that reads a line of integers, and then displays each integer, and the sum of all the integers (Use String Tokenizer class of java.util). **
10. Write a Java program that shows the usage of try, catch, throws and finally.**
11. Write a Java program that implements a multi-threaded program which has three threads. First thread generates a random integer every 1 second. If the value is even, second thread computes the square of the number and prints. If the value is odd the third thread will print the value of cube of the number.
12. Write a Java program that shows thread synchronization. **

13. Write a Java program that works as a simple calculator. Arrange Buttons for digits and the + - * % operations properly. Add a text field to display the result. Handle any possible exceptions like divide by zero. Use Java Swing. **
14. Write a Java program that simulates a traffic light. The program lets the user select one of three lights: red, yellow, or green. When a radio button is selected, the light is turned on, and only one light can be on at a time. No light is on when the program starts. **
15. Write a Java program to display all records from a table using Java Database Connectivity (JDBC).
16. Write a Java program for the following: **
    1) Create a doubly linked list of elements.
    2) Delete a given element from the above list.
    3) Display the contents of the list after deletion.
17. Write a Java program that implements Quick sort algorithm for sorting a list of names in ascending order. **
18. Write a Java program that implements the binary search algorithm.

OBJECT ORIENTED PROGRAMMING

In Object Oriented Programming, the data is a critical element in the program development and it does not flow freely around the system. Object oriented program allows decomposing a problem into a number of entities called object and then builds data and functions around these entities. Object, Class, Inheritance, Polymorphism, Dynamic binding, Overloading, Data abstraction, Encapsulation, Modularity are the basic concept of OOP.

GENERAL CONCEPTS OF OOPS: -

OBJECT

Objects are the basic run time entities in an Object Oriented Programming. They represent a person, a place or any item that the program handles. The Object Oriented approach views a problem in terms of object involved rather than procedure for doing it. Object is an identifiable entity with some characteristics and behavior. The characteristic of an object are represented by its data and its behavior is represented by its data function associated. Therefore in OOP Programming object represents an entity that can store data and has its interface through function.

CLASS

A class is a group of objects that share a common properties and relationship. ‘Object’ is an instance of class. A class is a way to bind the data and its associated function together. When defining a class, we are creating a new abstract data type that can be treated like any other built-in-data type. For e.g. Bird is a class but parrot is an object.

DATA ABSTRACTION

Abstraction is the concept of simplifying a real world concept into its essential element. Abstraction refers to act representing essential features without including the background details or explanations. It creates a new data type used encapsulation items that are suited to an application to be programmed is known as data abstraction. Data types created by the data abstraction process are known as abstract data types. For e.g. Switch board.

ENCAPSULATION

The wrapping up of data and function that operate on the data into a single unit called class is known as encapsulation. The data cannot be accessed directly. If you want to read a data, an item in an object (an instance of the class), you can call a member function in the object. It will read the item and return the value to you. The data is hidden so it is safe from accident alteration. Encapsulation is just a way to implement data abstraction class is the concept of data abstraction. They are known as abstract data type. Data types because; these can be used to create objects of its own type.

INHERITANCE

Inheritance is the capacity of one class of things to inherit capacities or properties from another class. One major reason behind this is the capability to express the inheritance relationship which makes it aware the closeness with the real world. Another reason is idea of reusability. One reason is the transitive nature. The principle behind this sort of diversion is that each subclass shares a common characteristic with the class from which it is derived. A subclass defines only those features that are unique to it.

POLYMORPHISM

Polymorphism is the ability for a message data to be processed more than one form. Polymorphism is the concept of which supports the capability of an object of a class to behave differentially in response to a message or action. Polymorphism is a property by which the same message can be sent to objects of several different classes and each object can respond in a different way depending on its class. Property by which the same message can be sent to objects of several different way depending on its class property by which the same message can be sent to objects of several different classes and each object can respond in a different way depending on its class property.

DYNAMIC BINDING

Binding refers to the tie up of a procedure call to the address code to be executed in response to the code. Dynamic binding is done at the time of execution.

OVERLOADING

Overloading allows a function or operator to be given more than one definition. A function name having several definitions that are differentiable by the number or type of their arrangements. This not only implements polymorphism but also reduces number of comparison in a program and thereby making the program run faster.

MODULARITY

Act of representing or partitioning a program into industrial components. It is the property of a system that has been decomposed into a set of cohesive and loosed coupled modules. For eg. A complete music system comprises of speakers, cassette players, and real player. Similarly, we can divide a complex program into various modules where each module is a complete unit in itself.

JAVA FEATURES

1. Simple
2. Object-Oriented
3. Platform independent
4. Secured
5. Robust
6. Architecture neutral
7. Portable
8. Dynamic
9. Interpreted
10. High Performance
11. Multithreaded
12. Distributed

SIMPLE

According to Sun, Java language is simple because: syntax is based on C++ (so easier for programmers to learn it after C++). Removed many confusing and/or rarely-used features e.g., explicit pointers, operator overloading etc. No need to remove unreferenced objects because there is Automatic Garbage Collection in Java.

OBJECT-ORIENTED

Object-oriented means we organize our software as a combination of different types of objects that incorporates both data and behavior. Object-oriented programming(OOPs) is a methodology that simplify software development and maintenance by providing some rules.

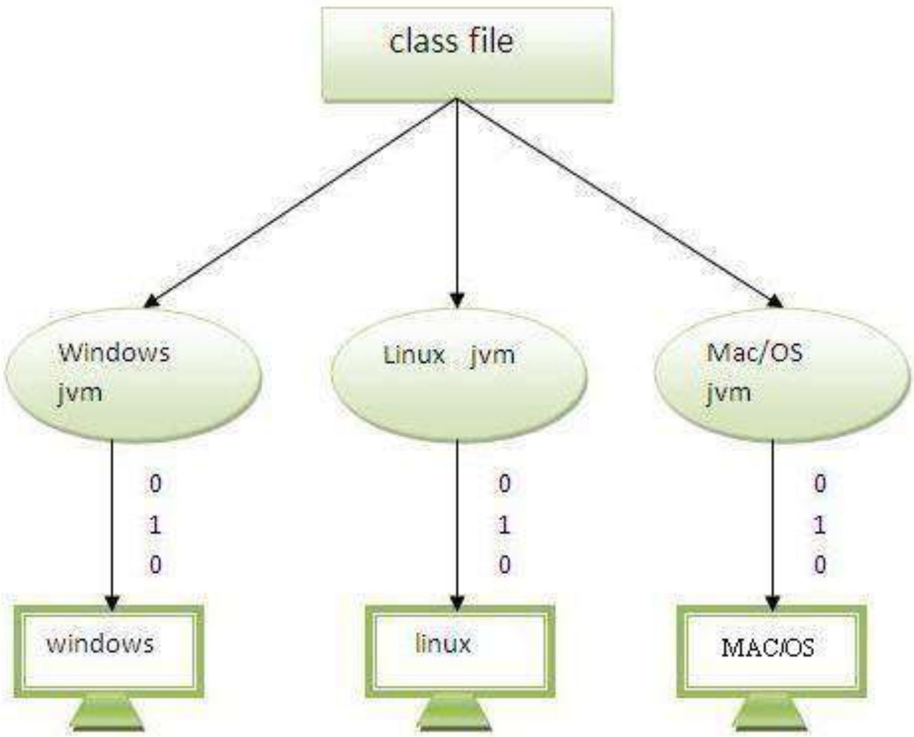
Basic concepts of OOPs are:

1. Object
2. Class
3. Inheritance
4. Polymorphism
5. Abstraction
6. Encapsulation

PLATFORM INDEPENDENT

A platform is the hardware or software environment in which a program runs. There are two types of platforms software-based and hardware-based. Java provides software-based platform. The Java platform differs from most other platforms in the sense that it's a software-based platform that runs on top of other hardware-based platforms. It has two components:

1. Runtime Environment
2. API(Application Programming Interface)

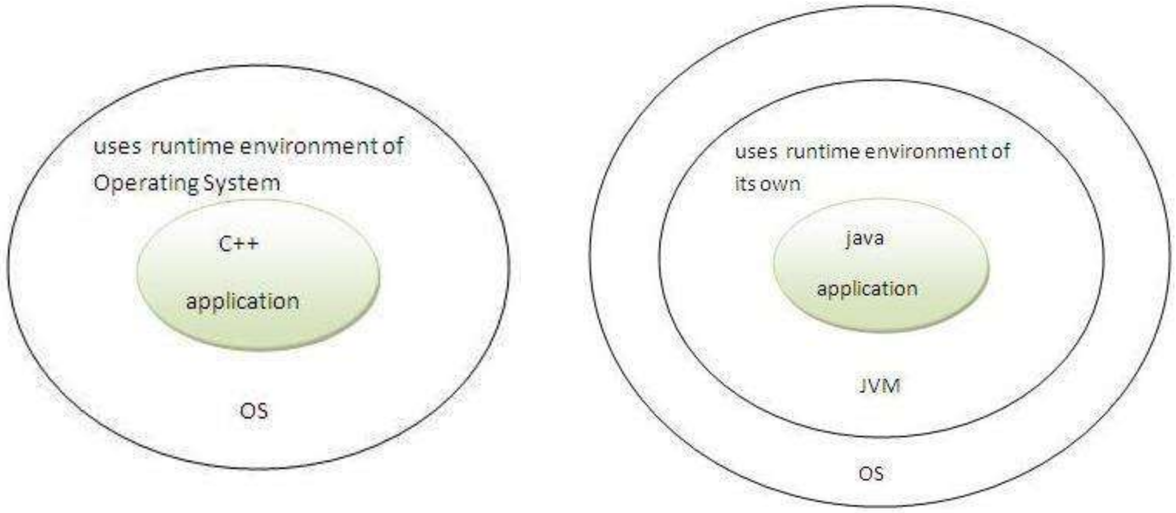


Java code can be run on multiple platforms e.g. Windows, Linux, Sun Solaris, Mac/OS etc. Java code is compiled by the compiler and converted into bytecode. This bytecode is a platform independent code because it can be run on multiple platforms i.e. Write Once and Run Anywhere(WORA).

SECURED

Java is secured because:

- No explicit pointer
- Programs run inside virtual machine sandbox.



- **Class loader-** adds security by separating the package for the classes of the local file system from those that are imported from network sources.
- **Bytecode Verifier-** checks the code fragments for illegal code that can violate access right to objects.
- **Security Manager-** determines what resources a class can access such as reading and writing to the local disk.

These securities are provided by Java language. Some security can also be provided by application developer through SSL, JAAS, cryptography etc.

ROBUST

Robust simply means strong. Java uses strong memory management. There are lack of pointers that avoids security problem. There is automatic garbage collection in Java. There is exception handling and type checking mechanism in Java. All these points makes Java robust.

ARCHITECTURE-NEUTRAL

There is no implementation dependent features e.g. size of primitive types is set.

PORTABLE

We may carry the Java bytecode to any platform.

HIGH-PERFORMANCE

Java is faster than traditional interpretation since byte code is "close" to native code still somewhat slower than a compiled language (e.g., C++)

DISTRIBUTED

We can create distributed applications in Java. RMI and EJB are used for creating distributed applications. We may access files by calling the methods from any machine on the internet.

MULTI-THREADED

A thread is like a separate program, executing concurrently. We can write Java programs that deal with many tasks at once by defining multiple threads. The main advantage of multi-threading is that it shares the same memory. Threads are important for multi-media, Web applications etc.

1. PALINDROME

AIM:

Write a Java program that checks whether a given string is a palindrome or not. Ex: MALAYALAM is palindrome

PROGRAM:

```
import java.util.Scanner;
class Test{

    public static void main(String args[]){
        Scanner sc = new Scanner(System.in);
        System.out.print("Enter the String:");
        String str = sc.nextLine();

        int flag = 0;
        int len = str.length();
        for(int i=0;i<len/2;i++){
            if(str.charAt(i) != str.charAt(len-i-1)){
                flag = 1;
                break;
            }
        }
        if(flag == 0){
            System.out.println("Palindrome");
        }
        else{
            System.out.println("Not Palindrome");
        }
    }
}
```

OUTPUT:

```
Enter the String: MALAYALAM
Palindrome.
```

2.FREQUENCY OF A GIVEN CHARACTER IN A STRING.

AIM:

Write a Java Program to find the frequency of a given character in a string

PROGRAM:

```
import java.util.Scanner;
class Test{

public static void main(String args[]){
Scanner sc = new Scanner(System.in);
System.out.print("Enter the String:");
String str = sc.nextLine();
System.out.print("Enter the character:");
char ch = sc.nextLine().charAt(0);
int count = 0;
for(int i=0;i<str.length();i++){
        if(str.charAt(i) ==  ch){
                count++;
        }
}
System.out.println("Count of occurence of "+ ch +"="+count);
}
}
```

OUTPUT:

Enter the String: java
Enter the character :a
Count of occurrence of a =2

3.MULTIPLY TWO GIVEN MATRICES.

AIM:

Write a Java program to multiply two given matrices

PROGRAM:

```
import java.util.Scanner;
class Test{

        public static void main(String args[]){
                Scanner sc = new Scanner(System.in);
                System.out.print("Enter the order - m1:");
                int m1 = sc.nextInt();
                System.out.print("Enter the order - n1:");
                int n1 = sc.nextInt();
                System.out.print("Enter the order - m2:");
                int m2 = sc.nextInt();
                System.out.print("Enter the order - n2:");
                int n2 = sc.nextInt();
                if(n1 != m2){
                        System.out.println("Matrix Multiplication not Possible");
                        return;
                }
                int A[][] = new int[m1][n1];
                int B[][] = new int[m2][n2];
                int C[][] = new int[m1][n2];
                System.out.println("Read Matrix A");
                for(int i=0;i<m1;i++){
                        for(int j=0;j<n1;j++){
                                System.out.print("A["+i+"]["+j+"]=");
                                A[i][j] = sc.nextInt();
                        }
                }
                System.out.println("Read Matrix B");
                for(int i=0;i<m2;i++){
                        for(int j=0;j<n1;j++){
                                System.out.print("B["+i+"]["+j+"]=");
                                B[i][j] = sc.nextInt();
                        }
                }
                for(int i=0;i<m1;i++){
                        for(int j=0;j<n2;j++){
                                C[i][j]=0;
                                for(int k=0;k<n1;k++){
                                        C[i][j] += A[i][k] * B[k][j];
```

```
                }
            }
        }
        System.out.println("Matrix A");
        for(int i=0;i<m1;i++){
            for(int j=0;j<n1;j++){
                System.out.print(A[i][j]+"\t");
            }
            System.out.println();
        }
        System.out.println("Matrix B");
        for(int i=0;i<m2;i++){
            for(int j=0;j<n2;j++){
                System.out.print(B[i][j]+"\t");
            }
            System.out.println();
        }
        System.out.println("Matrix C");
        for(int i=0;i<m1;i++){
            for(int j=0;j<n2;j++){
                System.out.print(C[i][j]+"\t");
            }
            System.out.println();
        }
    }
}
```

OUTPUT:

```
Enter the order - m1 2
Enter the order - n1 2
Enter the order - m2 2
Enter the order - n2 2
Read Matrix A: 2
2
2
2
Matrix A   2   2
           2   2
Read Matrix B: 2
2
2
2
Matrix B    2  2
            2  2

Matrix C       8
               8
```

4.EMPLOYEE DETAILS

AIM:

Write a Java program which creates a class named 'Employee' having the following members: Name, Age, Phone number, Address, Salary. It also has a method named 'print- Salary( )' which prints the salary of the Employee. Two classes 'Officer' and 'Manager' inherits the 'Employee' class. The 'Officer' and 'Manager' classes have data members 'specialization' and 'department' respectively. Now, assign name, age, phone number, address and salary to an officer and a manager by making an object of both of these classes and print the same.

PROGRAM:

```
import java.util.Scanner;
class Employee{
	private String name;
	private int	age;
	private long phoneNumber;
	private String address;
	private double salary;

	public void setName(String name){
		this.name = name;
	}
	public void setAge(int age){
		this.age=age;
	}
	public void setPhoneNumber(long phoneNumber){
		this.phoneNumber = phoneNumber;
	}
	public void setAddress(String address){
		this.address = address;
	}
	public void setSalary(double salary){
		this.salary = salary;
	}
	public double printSalary(){
		return salary;
	}
	public String getName(){
		return name;
	}
	public int getAge(){
		return age;
	}
	public String getAddress(){
		return address;
	}
	public long getPhoneNumber(){
		return phoneNumber;
	}
```

```
}

class Officer extends Employee{
	private String specialization;
	private String department;

	public void setSpecialization(String specialization){
		this.specialization = specialization;
	}
	public void setDepartment(String department){
		this.department = department;
	}

	public String getDepartment(){
		return department;
	}
	public String getSpecialization(){
		return specialization;
	}

}
class Manager extends Employee{
	private String specialization;
	private String department;

	public void setSpecialization(String specialization){
		this.specialization = specialization;
	}
	public void setDepartment(String department){
		this.department = department;
	}

	public String getDepartment(){
		return department;
	}
	public String getSpecialization(){
		return specialization;
	}

}

class Test{
	public static void main(String args[]){
		Scanner sc = new Scanner(System.in);
		Officer o = new Officer();
		System.out.println("Enter the officer's Detail");
		System.out.print("Name:");
		o.setName(sc.nextLine());
		System.out.print("Address:");
		o.setAddress(sc.nextLine());
		System.out.print("Specialization:");
		o.setSpecialization(sc.nextLine());
```

```
        System.out.print("Department:");
        o.setDepartment(sc.nextLine());
        System.out.print("Age:");
        o.setAge(sc.nextInt());
        System.out.print("Number:");
        o.setPhoneNumber(sc.nextLong());
        System.out.print("Salary:");
        o.setSalary(sc.nextDouble());
        sc.nextLine(); // to skip new Line
        System.out.println("The officer Detail");
        System.out.println("Name:"+o.getName());
        System.out.println("Age:"+o.getAge());
        System.out.println("Number:"+o.getPhoneNumber());
        System.out.println("Address:"+o.getPhoneNumber());
        System.out.println("Salary:"+o.printSalary());
        System.out.println("Specialization:"+o.getSpecialization());
        System.out.println("Department:"+o.getDepartment());

        Manager m = new Manager();
        System.out.println("Enter the manager's Detail");
        System.out.print("Name:");
        m.setName(sc.nextLine());
        System.out.print("Address:");
        m.setAddress(sc.nextLine());
        System.out.print("Specialization:");
        m.setSpecialization(sc.nextLine());
        System.out.print("Department:");
        m.setDepartment(sc.nextLine());
        System.out.print("Age:");
        m.setAge(sc.nextInt());
        System.out.print("Number:");
        m.setPhoneNumber(sc.nextLong());
        System.out.print("Salary:");
        m.setSalary(sc.nextDouble());
        sc.nextLine(); // to skip new Line
        System.out.println("The manager's Detail");
        System.out.println("Name:"+m.getName());
        System.out.println("Age:"+m.getAge());
        System.out.println("Number:"+m.getPhoneNumber());
        System.out.println("Address:"+m.getPhoneNumber());
        System.out.println("Salary:"+m.printSalary());
        System.out.println("Specialization:"+m.getSpecialization());
        System.out.println("Department:"+m.getDepartment());
    }
}
```

OUTPUT:

```
Enter the officer's Detail
Name:Sangeeth
Address:Trivandrum
Specialization:Computer Science
Department:CSE
Age:32
Number:9633566474
Salary:10000
The officer Detail
Name:Sangeeth
Age:32
Number:9633566474
Address:9633566474
Salary:10000.0
Specialization:Computer Science
Department:CSE
Enter the manager's Detail
Name:Manu
Address:Kochi
Specialization:CSE
Department:Computer Science
Age:30
Number:9895881182
Salary:67000
The manager's Detail
Name:Manu
Age:30
Number:9895881182
Address:9895881182
Salary:67000.0
Specialization:CSE
Department:Computer Science
```

5.FIND NUMBER OF SIDES IN A GIVEN GEOMETRICAL STRUCTURE

AIM:

Write a java program to create an abstract class named Shape that contains an empty method named numberOfSides( ). Provide three classes named Rectangle, Triangle and Hexagon such that each one of the classes extends the class Shape. Each one of the classes contains only the method numberOfSides( ) that shows the number of sides in the given geometrical structures. (Exercise to understand polymorphism).

```
abstract class Shape{
        public abstract void numberOfSides();
}

class Rectangle extends Shape{
        public void numberOfSides(){
                System.out.println("Number of Sides of Recta   ngle = 4");
        }
}
class Triangle extends Shape{
        public void numberOfSides(){
                System.out.println("Number of Sides of Triangle = 3");
        }
}
class Hexagon extends Shape{
        public void numberOfSides(){
                System.out.println("Number of Sides of Hexagon = 6");
        }
}
class Test{
        public static void main(String args[]){
                Rectangle r = new Rectangle();
                Triangle t = new Triangle();
                Hexagon h = new Hexagon();
                r.numberOfSides();
                t.numberOfSides();
                h.numberOfSides();
        }
}
```

OUTPUT:

```
Number of Sides of Rectangle = 4
Number of Sides of Triangle = 3
Number of Sides of Hexagon = 6
```

6.GARBAGE COLLECTER

AIM:

Write a Java program to demonstrate the use of garbage collector.

PROGRAM:

```
public class Test
{
   public static void main(String[] args) throws InterruptedException
   {
      Test t1 = new Test();
      Test t2 = new Test();

      // Nullifying the reference variable
      t1 = null;

      // requesting JVM for running Garbage Collector
      System.gc();

      // Nullifying the reference variable
      t2 = null;

      // requesting JVM for running Garbage Collector
      Runtime.getRuntime().gc();

   }

   @Override
   // finalize method is called on object once
   // before garbage collecting it
   protected void finalize() throws Throwable
   {
        System.out.println("Garbage collector called");
        System.out.println("Object garbage collected : " + this);
        }
}
```

OUTPUT:

Garbage collector called
Object garbage collected : Test@46d08f12
Garbage collector called
Object garbage collected : Test@481779b8

7.READ WRITE PROGRAM

AIM:

Write a file handling program in Java with reader/writer.

PROGRAM:

```
import java.io.*;
import java.lang.*;
class contol
{
        static boolean flag = false;
        void read (int a)
        {
        System.out.println ("Reading ...");
        try
        {
        Thread.sleep (3000);
        }
        catch (InterruptedException e)
        {
        e.printStackTrace ();
        }
        System.out.println ("Reading completed");
  }
  synchronized void read ()
  {
        System.out.println ("Reading ...");
        try
        {
        Thread.sleep (3000);
        }
        catch (InterruptedException e)
        {
        e.printStackTrace ();
        }
        System.out.println ("Reading completed");
}
synchronized void write ()
{
flag = true;
        System.out.println ("Writing... ");
        try
        {
        Thread.sleep (50);
        }
        catch (InterruptedException e)
        {
```

```
        e.printStackTrace ();
        }
System.out.println ("Writing completed");
        flag = false;
        }
 }

class Read extends Thread
{
        contol  ob;
        Read (contol d)
        {
        this.ob = d;
        start ();
        }
        public void run ()
        {
        if (!contol.flag)
        ob.read (1);
        else
        ob.read ();
        }
 }

class Write extends Thread
{
contol ob;
        Write (contol c)
        {
        this.ob = c;
        start ();
        }
        public void run ()
        {
        ob.write ();
        }
        }

 public class Rwproblem
 {
        public static void main (String args[]) throws Exception
        {
        int ch = 0;
        contol ob = new contol ();
        InputStreamReader in= new InputStreamReader (System.in);
        BufferedReader br = new BufferedReader (in);
        do
        {
                System.out.println
("\n MENU \n1.Read \n2.Write \n3.Exit \n\nEnter your choice:");
                ch = Integer.parseInt (br.readLine ());
                switch (ch)
```

```
                {
                case 1:
                        new Read (ob);
                        break;
                case 2:
new Write (ob);
                        break;
                case 3:
break;
                default:
System.out.println ("Wrong Choice");
                }
        }
        while (ch != 3);
        }
}
```

OUTPUT:

```
  MENU
1.Read
2.Write
3.Exit

Enter your choice:
1

Reading....
Reading completed

  MENU
1.Read
2.Write
3.Exit

Enter your choice:
2
Writing....
Writing completed
```

8. FILE HANDLING

AIM:

Java program that read from a file and write to file by handling all file related exceptions.

PROGRAM:

```
import java.io.FileWriter;
import java.io.FileReader;
import java.io.IOException;

class ReadWriteFile
{
   public static void main(String[] args) throws IOException
   {
      // variable declaration
                  int ch;

                  // check if File exists or not
                  FileReader fr=new FileReader("sample.txt");
                  FileWriter fw=new FileWriter("new sample.txt");
                  // read from FileReader till the end of file, print the content and write to another file
                  while ((ch=fr.read())!=-1) {
                  System.out.print((char)ch);
                          fw.write((char)ch);
                          }
                  // close the file

                  fr.close();
                  fw.close();
             }
}
```

OUTPUT:

We already created a file sample.txt with content “Hello world ”

after execution of program a new file is generated with name new sample.txt with contents readed rom sample.txt.

“Hello world”

9. STRING TOKENIZER

AIM:

Java program that read from a file and write to file by handling all file related exceptions.

PROGRAM:

```
import java.util.*;
class StringTokenizerDemo {
public static void main(String args[]) {
int n;
int sum = 0;
Scanner sc = new Scanner(System.in);
System.out.println("Enter integers with one space gap:");
String s = sc.nextLine();
StringTokenizer st = new StringTokenizer(s, " ");
while (st.hasMoreTokens()) {
    String temp = st.nextToken();
    n = Integer.parseInt(temp);
    System.out.println(n);
    sum = sum + n;
}
System.out.println("sum of the integers is: " + sum);
sc.close();
}
}
```

OUTPUT:

```
Enter integers with one space gap:
10 20 30 40 50
10
20
30
40
50
sum of the integers is: 150
```

10. SHOW THE USAGE OF TRY CATCH THROWS AND FINALLY

AIM:

Write a Java program that shows the usage of try, catch, throws and finally.

PROGRAM:

```
import java.util.Scanner;
class Test{
	public static void main(String args[]){
		Scanner sc = new Scanner(System.in);
		try{
			System.out.println("Program to perform Division");
			System.out.print("Enter Number-1:");
			int a = sc.nextInt();
			System.out.print("Enter Number-2:");
			int b = sc.nextInt();
			int c = a/b;
			System.out.println("Result="+c);
		}
		catch(ArithmeticException e){
			System.out.println(e.getMessage());
		}
		finally{
			System.out.println("End of Operation");
		}
	}
}
```

OUTPUT:

```
Program to perform Division
Enter Number-120
Enter Number-20
/ by zero
End of Operation
```

11. MULTI-THREADING

AIM:
Write a Java program that implements a multi-threaded program which has three threads. First thread generates a random integer every 1 second. If the value is even, second thread computes the square of the number and prints. If the value is odd the third thread will print the value of cube of the number

PROGRAM:

```
import java.util.Random;
class EvenThread extends Thread{
        private int num;
        public EvenThread(int num){
                this.num = num;
        }
        public void run(){
                System.out.println("Square of"+ num+"="+num*num);
        }
}
class OddThread extends Thread{
        private int num;
        public OddThread(int num){
                this.num = num;
        }
        public void run(){
                System.out.println("Cube of "+num+"="+ num*num*num);
        }
}
class RandomThread extends Thread{

        public void run(){
                Random r = new Random();
                for(int i =0;i<10;i++){
                        int num = r.nextInt(100);
                        if(num % 2 == 0){
                                new EvenThread(num).start();
                        }
                        else{
                                new OddThread(num).start();
                        }
                }

        }
}

class Test{
        public static void main(String args[]){
                RandomThread r = new RandomThread();
```

```
            r.start();
        }
    }
```

OUTPUT:

```
Square of 30=900
Cube of 49=117649
Square of 36=1296
Cube of 33=35937
Cube of 53=148877
Square of 78=6084
Square of 46=2116
Square of 84=7056
Square of 94=8836
Cube of 63=250047
```

12. THREAD SYNCHRONIZATION.

AIM:
Write a Java program that shows thread synchronization.

PROGRAM:

```
class Display{

        public synchronized void print(String msg){
                System.out.print("["+msg);
                try{
                        Thread.sleep(1000);
                }
                catch(Exception e){
                        System.out.println(e.getMessage());
                }
                System.out.println("]");
        }
}
class SyncThread extends Thread{

        private Display d;
        private String msg;
        public SyncThread(Display d,String msg){
                this.d=d;
                this.msg = msg;
        }
        public void run(){
                d.print(msg);
        }
}
class Test{
        public static void main(String args[]){
                Display d = new Display();
                SyncThread t1 = new SyncThread(d,"Hello");
                SyncThread t2 = new SyncThread(d,"World");
                t1.start();
                t2.start();
        }
}
```

OUTPUT:

```
[Hello]
[World]
```

13. CALCULATOR

AIM:
Write a Java program that works as a simple calculator. Arrange Buttons for digits and the + - * % operations properly. Add a text field to display the result. Handle any possible exceptions like divide by zero. Use Java Swing.

PROGRAM:

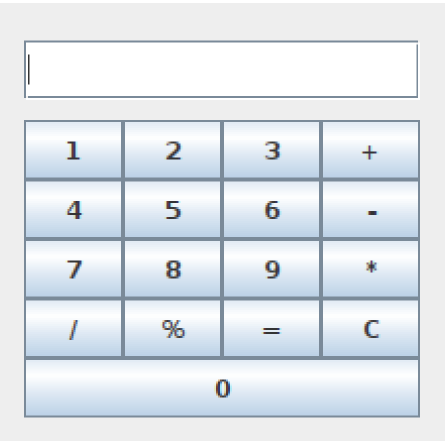
```
import javax.swing.*;
import java.awt.event.*;
class Calculator extends JFrame implements ActionListener{
	private JTextField t1;
	private JButton b1;
	private JButton b2;
	private JButton b3;
	private JButton b4;
	private JButton b5;
	private JButton b6;
	private JButton b7;
	private JButton b8;
	private JButton b9;
	private JButton b10;
	private JButton b11;
	private JButton b12;
	private JButton b13;
	private JButton b14;
	private JButton b15;
	private JButton b16;
	private JButton b17;
	private Integer res;
	private String operation;
	public Calculator(){
		setLayout(null);
		setSize(680,480);
		t1 = new JTextField();
		t1.setBounds(100,100,200,30);


		b1 = new JButton("1");
		b1.setBounds(100,140,50,30);
		b2 = new JButton("2");
		b2.setBounds(150,140,50,30);
		b3 = new JButton("3");
		b3.setBounds(200,140,50,30);
		b4 = new JButton("+");
		b4.setBounds(250,140,50,30);
		// Third Row
		b5 = new JButton("4");
		b5.setBounds(100,170,50,30);
```

```
        b6 = new JButton("5");
        b6.setBounds(150,170,50,30);
        b7 = new JButton("6");
        b7.setBounds(200,170,50,30);
        b8 = new JButton("-");
        b8.setBounds(250,170,50,30);


        // Fourth Row
        b9 = new JButton("7");
        b9.setBounds(100,200,50,30);
        b10 = new JButton("8");
        b10.setBounds(150,200,50,30);
        b11 = new JButton("9");
        b11.setBounds(200,200,50,30);
        b12 = new JButton("*");
        b12.setBounds(250,200,50,30);

                // Fourth Row
        b13 = new JButton("/");
        b13.setBounds(100,230,50,30);
        b14 = new JButton("%");
        b14.setBounds(150,230,50,30);
        b15 = new JButton("=");
        b15.setBounds(200,230,50,30);
        b16 = new JButton("C");
        b16.setBounds(250,230,50,30);
        b17 = new JButton("0");
        b17.setBounds(100,260,200,30);
        add(t1);add(b1);add(b2);
        add(b3);add(b4);add(b5);
        add(b6);add(b7);add(b8);
        add(b9);add(b10);add(b11);
        add(b12);add(b13);add(b14);
        add(b15);add(b16);add(b17);

        b1.addActionListener(this);b2.addActionListener(this);
        b3.addActionListener(this);b4.addActionListener(this);
        b5.addActionListener(this);b6.addActionListener(this);
        b7.addActionListener(this);b8.addActionListener(this);
        b9.addActionListener(this);b10.addActionListener(this);
        b11.addActionListener(this);b12.addActionListener(this);
        b13.addActionListener(this);b14.addActionListener(this);
        b15.addActionListener(this);b16.addActionListener(this);
        b17.addActionListener(this);
    }
    public void doAction(String op){
        if(operation == null){
            operation = op;
            res = Integer.parseInt(t1.getText());
            t1.setText("");
        }
```

```
		else{
			switch(operation){
				case "+": res = res + Integer.parseInt(t1.getText());
						break;
				case "-": res = res - Integer.parseInt(t1.getText());
						break;
				case "/": try{
							if(t1.getText().equals("0")){
								throw new
	ArithmeticException("Divide by Zero");
							}
							res = res / Integer.parseInt(t1.getText());
						}
						catch(ArithmeticException e){
							t1.setText(e.getMessage());
							operation = null;
							res = 0;
						}
						break;
				case "*": res = res * Integer.parseInt(t1.getText());
						break;
				case "%": res = res % Integer.parseInt(t1.getText());
						break;
			}
			if(op.equals("=")){
				t1.setText(res.toString());
				res = 0;
				operation = null;
			}
			else{
				operation = op;
				t1.setText("");
			}
		}

	}
	public void actionPerformed(ActionEvent e){
		if(e.getSource()== b1)
			t1.setText(t1.getText()+"1");
		else if(e.getSource()== b2)
			t1.setText(t1.getText()+"2");
		else if(e.getSource()==  b3)
			t1.setText(t1.getText()+"3");
		else if(e.getSource()==  b5)
			t1.setText(t1.getText()+"4");
		else if(e.getSource()==  b6)
			t1.setText(t1.getText()+"5");
		else if(e.getSource()==  b7)
			t1.setText(t1.getText()+"6");
		else if(e.getSource()==  b9)
			t1.setText(t1.getText()+"7");
		else if(e.getSource()==  b10)
```

```
                    t1.setText(t1.getText()+"8");
            else if(e.getSource()==  b11)
                    t1.setText(t1.getText()+"9");
            else if(e.getSource()==  b17)
                    t1.setText(t1.getText()+"0");
            else if(e.getSource()==  b16){
                    t1.setText("");
                    res =0;
                    operation = null;
            }
            else if(e.getSource()== b4){
                    doAction("+");
            }
            else if(e.getSource()== b8)
                    doAction("-");
            else if(e.getSource()== b12)
                    doAction("*");
            else if(e.getSource()== b13)
                    doAction("/");
            else if(e.getSource()== b14)
                    doAction("%");
            else if(e.getSource()== b15)
                    doAction("=");

        }
        public static void main(String args[]){
            new Calculator().setVisible(true);
        }

}
```

OUTPUT:



14. TRAFFIC LIGHT PROGRAM

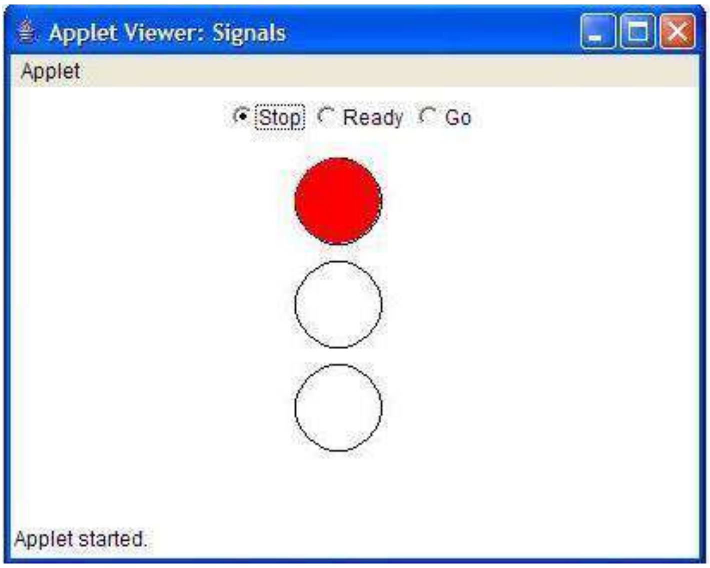
AIM:
Write a Java program that simulates a traffic light. The program lets the user select one of three lights: red, yellow, or green. When a radio button is selected, the light is turned on, and only one light can be on at a time. No light is on when the program starts.

PROGRAM:

```
import java.applet.*;
import java.awt.*;
import java.awt.event.*;
/*<applet code="Signals" width=400 height=250></applet>*/
public class Signals extends Applet implements ItemListener
{
String msg="";
Checkbox stop,ready,go;
CheckboxGroup cbg;
public void init()
{
cbg = new CheckboxGroup();
stop = new Checkbox("Stop", cbg, false);
ready = new Checkbox("Ready", cbg, false);
go= new Checkbox("Go", cbg, false);
add(stop);
add(ready);
add(go);
stop.addItemListener(this);
ready.addItemListener(this);
go.addItemListener(this);

}

public void itemStateChanged(ItemEvent ie)
{
repaint();
}

public void paint(Graphics g)
{

msg=cbg.getSelectedCheckbox().getLabel();
g.drawOval(165,40,50,50);
g.drawOval(165,100,50,50);
g.drawOval(165,160,50,50);
```

```
if(msg.equals("Stop"))
        {
        g.setColor(Color.red);
        g.fillOval(165,40,50,50);
        }
        else if(msg.equals("Ready"))
        {
        g.setColor(Color.yellow);
        g.fillOval(165,100,50,50);
        }
        else
        {
        g.setColor(Color.green);
        g.fillOval(165,160,50,50);
        }

        }
        }
```

OUTPUT:



16. QUICK SORT USING JAVA

AIM:
Write a Java program that implements Quick sort algorithm for sorting a list of names in ascending order.

PROGRAM:

```
public class QuickSortOnStrings {

   String names[];
   int length;

    public static void main(String[] args) {
        QuickSortOnStrings obj = new QuickSortOnStrings();
        String stringsList[] = {"Raja", "Gouthu", "Rani", "Gouthami", "Honey", "Heyaansh",
"Hello"};
        obj.sort(stringsList);

        for (String i : stringsList) {
            System.out.print(i);
            System.out.print(" ");
        }
    }

    void sort(String array[]) {
        if (array == null || array.length == 0) {
            return;
        }
        this.names = array;
        this.length = array.length;
        quickSort(0, length - 1);
    }

    void quickSort(int lowerIndex, int higherIndex) {
        int i = lowerIndex;
        int j = higherIndex;
        String pivot = this.names[lowerIndex + (higherIndex - lowerIndex) / 2];

        while (i <= j) {
            while (this.names[i].compareToIgnoreCase(pivot) < 0) {
                i++;
            }

            while (this.names[j].compareToIgnoreCase(pivot) > 0) {
                j--;
            }
```

```
            if (i <= j) {
                exchangeNames(i, j);
                i++;
                j--;
            }
        }
        if (lowerIndex < j) {
            quickSort(lowerIndex, j);
        }
        if (i < higherIndex) {
            quickSort(i, higherIndex);
        }
    }

    void exchangeNames(int i, int j) {
        String temp = this.names[i];
        this.names[i] = this.names[j];
        this.names[j] = temp;
    }
}
```

OUTPUT:

Gouthami
Gouthu
Hello
Heyaansh
Honey
Raja
Rani

17. BINARY SEARCH USING JAVA

AIM:
Write a Java program that implements the binary search algorithm.

PROGRAM:

```
import java.util.Scanner;

// Binary Search in Java

class Main {
  int binarySearch(int array[], int element, int low, int high) {

    // Repeat until the pointers low and high meet each other
    while (low <= high) {

      // get index of mid element
      int mid = low + (high - low) / 2;

      // if element to be searched is the mid element
      if (array[mid] == element)
        return mid;

      // if element is less than mid element
      // search only the left side of mid
      if (array[mid] < element)
        low = mid + 1;

      // if element is greater than mid element
      // search only the right side of mid
      else
        high = mid - 1;
    }

    return -1;
  }

  public static void main(String args[]) {

    // create an object of Main class
    Main obj = new Main();

    // create a sorted array
    int[] array = { 3, 4, 5, 6, 7, 8, 9 };
    int n = array.length;

    // get input from user for element to be searched
```

```
    Scanner input = new Scanner(System.in);

    System.out.println("Enter element to be searched:");

    // element to be searched
    int element = input.nextInt();
    input.close();

    // call the binary search method
    // pass arguments: array, element, index of first and last element
    int result = obj.binarySearch(array, element, 0, n - 1);
    if (result == -1)
    System.out.println("Not found");
    else
      System.out.println("Element found at index " + result);
  }
}
```

OUTPUT:

```
Enter element to be searched:
6

Element found at index 3
```

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DEPARTMENT OF MECHANICAL ENGINEERING

ESL 120 CIVIL AND MECHANICAL WORKSHOP

LABORATORY MANUAL

PART II MECHANICAL

REGULATION 2019

ACADEMIC YEAR 2019-2020

MANUAL PREPARED BY

SATHISH KUMAR RK

ASSISTANT PROFESSOR

DEPARTMENT OF MECHANICAL ENGINEERING

ASET

ESL 120	CIVIL & MECHANICAL WORKSHOP	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
			0	0	2	1	2019

SYLLABUS

PART II

MECHANICAL WORKSHOP

LIST OF EXERCISES

(Minimum EIGHT units mandatory and FIVE models from Units 2 to 8 mandatory)

UNIT 1:- General : Introduction to workshop practice, Safety precautions, Shop floor ethics, Basic First Aid knowledge.

Study of mechanical tools, components and their applications: (a) Tools: screw drivers, spanners, Allen keys, cutting pliers etc and accessories (b) bearings, seals, O-rings, circlips, keys etc.

UNIT 2:- Carpentry : Understanding of carpentry tools

Minimum any one model

1. T –Lap joint 2. Cross lap joint 3. Dovetail joint 4. Mortise joints

UNIT 3:- Foundry : Understanding of foundry tools

Minimum any one model

1. Bench Molding 2. Floor Molding 3. Core making 4. Pattern making

UNIT 4: - Sheet Metal : Understanding of sheet metal working tools

Minimum any one model

1. Cylindrical shape
2. Conical shape
3. Prismatic shaped job from sheet metal

UNIT 5: - Fitting : Understanding of tools used for fitting

Minimum any one model

1. Square Joint
2. V- Joint
3. Male and female fitting

UNIT 6: - Plumbing : Understanding of plumbing tools, pipe joints

Any one exercise on joining of pipes making use of minimum three types of pipe joints

UNIT 7: - Smithy: Understanding of tools used for smithy.

Demonstrating the forge-ability of different materials (MS, Al, alloy steel and cast steels) in cold and hot states.

Observing the qualitative difference in the hardness of these materials

Minimum any one exercise on smithy

1. Square prism
2. Hexagonal headed bolt
3. Hexagonal prism
4. Octagonal prism

UNIT 8: -Welding: Understanding of welding equipment
Minimum any one welding practice
Making Joints using electric arc welding. bead formation in horizontal, vertical and over head positions

UNIT 9: - Assembly: Demonstration only
Dissembling and assembling of

1. Cylinder and piston assembly
2. Tail stock assembly
3. Bicycle
4. Pump or any other machine

UNIT 10: - Machines: Demonstration and applications of the following machines
Shaping and slotting machine; Milling machine; Grinding Machine; Lathe; Drilling Machine.

UNIT 11: - Modern manufacturing methods: Power tools, CNC machine tools, 3D printing, Glass cutting.

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	70	30	1 hour

Assessment Procedure: Total marks allotted for the course is 100 marks. CIE shall be conducted for 70 marks and ESE for 30 marks. CIE should be done for the work done by the student and also viva voce based on the work done on each practical session. ESE shall be evaluated by written examination of one hour duration conducted internally by the institute.

Continuous Internal Evaluation Pattern:

Attendance : 20 marks
Class work/ Assessment /Viva-voce : 50 marks
End semester examination (Internally by college) : 30 marks

End Semester Examination Pattern: Written Objective Examination of one hour

CYCLE OF EXERCISES

CYCLE 1

1. **GENERAL(-** Workshop practice, shop floor precautions, ethics and First Aid knowledge. Studies of mechanical tools, components and their applications: (a) Tools: screw drivers, spanners, Allen keys, cutting pliers etc and accessories (b) bearings, seals, O-rings, circlips, keys etc
2. **CARPENTRY**
   T-lap joint practice
3. **FITTING**
   "V" joint practice
4. **WELDING**
   Butt Joint making practice
5. **SHEET METAL**
   Rectangular tray making
6. **FOUNDRY**
   Cone Pulley making
7. **SMITHY**
   Square rod making practice

CYCLE 2

8. **PLUMBING**
   Understanding of plumbing tools, pipe joints
9. **ASSEMBLY**
   Demonstration of assembly and disassembling of multiple parts components
10. **MACHINES**
    Demonstration of machine tools lathe, shaper, drilling, grinding
11. **MODERN MANUFACTURING METHODS**
    Demonstration of CNC Machine, Power Hacksaw

(AS PER SYLLABUS ANY 5 EXERCISES FROM 2 TO 8 ARE MANDATORY)

CARPENTRY

CARPENTRY

Introduction:

Carpentry is the process of working with wood for applications such as floor works, roofs and partitions in a building. Preparation of other wood works such as windows, stairs, cupboards, etc., is called as joinery.

Types of wood:

Wood is generally classified into three types.

(a) Soft wood
(b) Hard wood
(c) Ply wood

Soft wood:

It has straight fibers and is comparatively weaker. It is easy to work on the soft wood. Weight and durability are less for soft wood. Soft wood catches fire soon. Eg. Deodar, Kail, chir.

Hard wood:

Hard wood has closed structure, heavy in weight, dark in colour, more durable. It is difficult to work on hard wood. So it is very strong. Eg. Teek, Shirham, Sal, Mango, Oak.

Ply wood:

Ply wood consists of three layers.

(a) Top face plys layer
(b) Core layer
(c) Bottom face ply layer

The top and bottom layers are called face ply laters. These two layers are bonded to the centre core, which is thick and not of good quality.

Structure of wood:

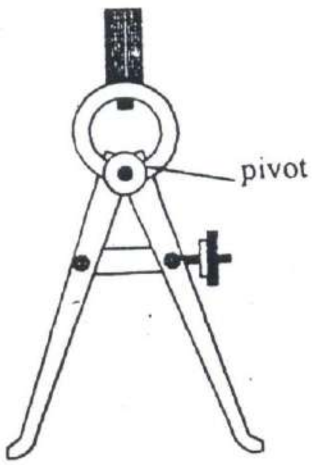
The following are the main parts of the wood.

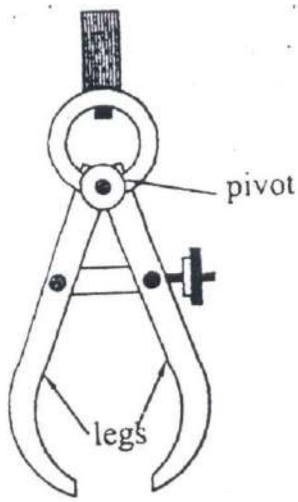
(a) Medulla: Medulla or Pith is the centre part of the tree. Medulla feeds the sap from the roots to the leaves. It is dark in colour.
(b) Heart wood: It is the portion surrounding the medulla. The percentage of moisture is less than the central part.
(c) Sap wood: Sap wood is the portion between cambium layer and heart wood. Sap wood is light in weight and softer and consists of high percentage of moisture.
(d) Cambium layer: Cambium layer is the rings adjacent to the bark.
(e) Bark: Bark is the outer surface of the tree. It acts as the cover for inner portion of the tree.
(f) Medullary rays: Medullary rays are radial layer starting from pith up to the cambium layer.
(g) Annual rings: It is the concentric layer of the wood around the pith. In every year, one such layer is added to the trees.

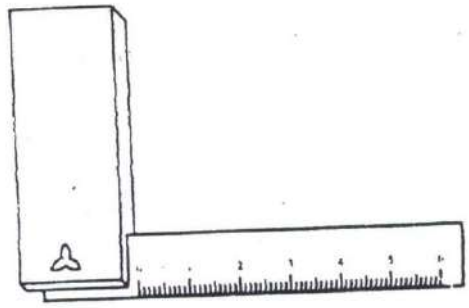
Carpentry tools:

Large numbers of tools are used in carpentry. Following are the types of tools used in carpentry.

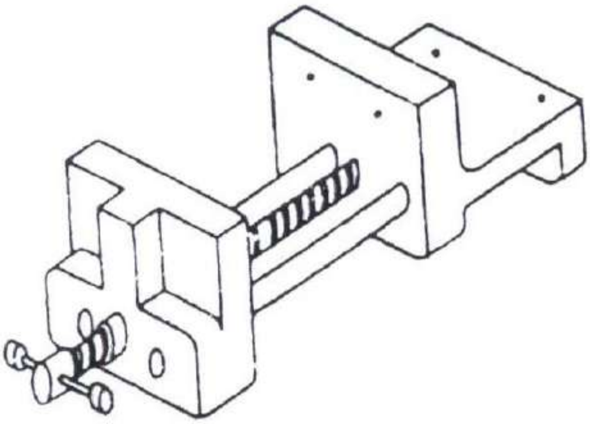
(1) Marking and measuring tools.
(2) Cutting tools.
(3) Planning tools.
(4) Boring tools.
(5) Striking tools and Holding tools and Power tools.



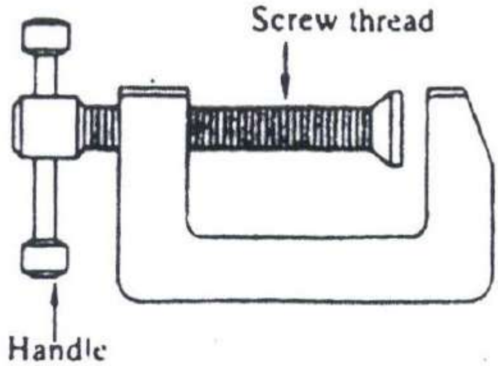




Try Square



Bench Vice



C - Clamps

Cross Cut Saw

Holding tools:

During the wood working job is shacked, so marking accuracy is tough. To maintain accuracy the wood is to be held rigidly.

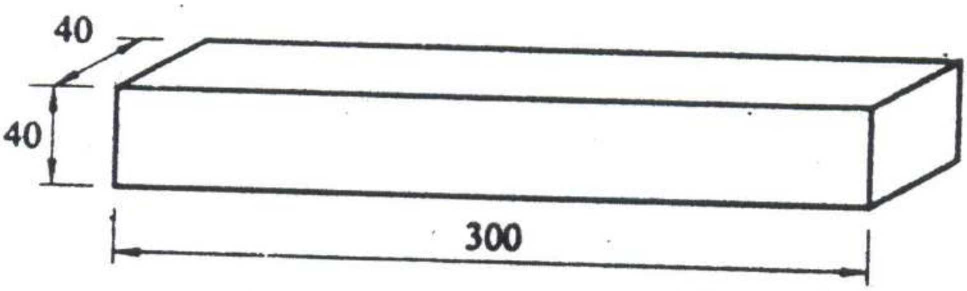
(a) **Bench vice:**

It is the most common work holding device. It consists of one fixed jaw and one movable jaw. The fixed jaw is fastened to the work bench. The gap between the jaws are adjusted using the screw rod.

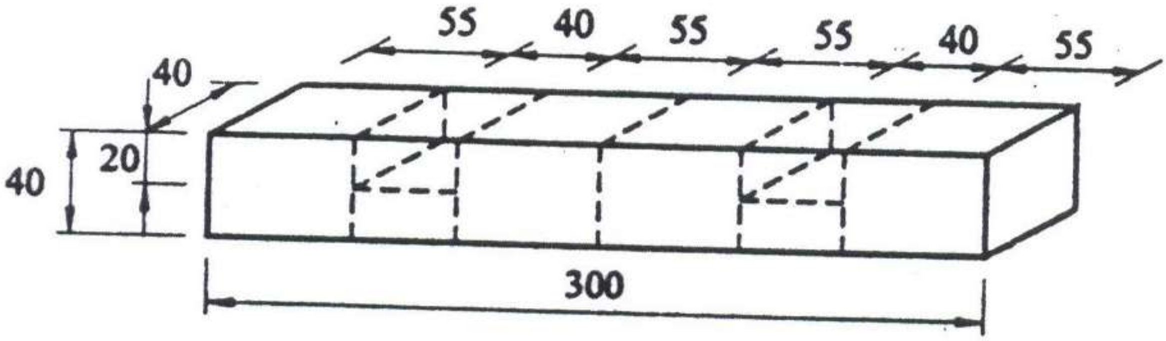
(b) C-clamps:

It is made up of malleable iron. The operating capacity rates from 50 to 350mm. it can be used for clamping small work. The swivel shoe allows to fix angled work.

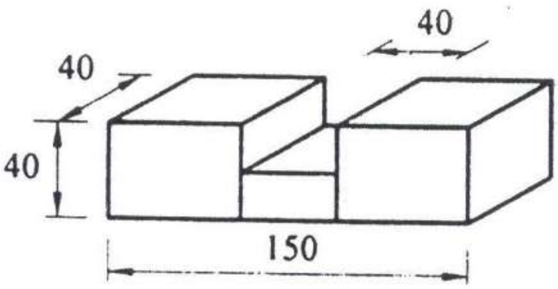
1. PLANING



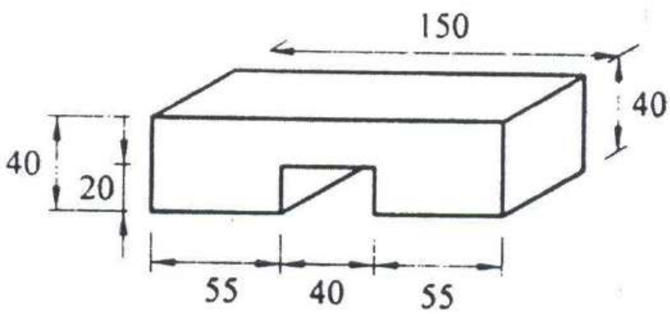
2. MARKING



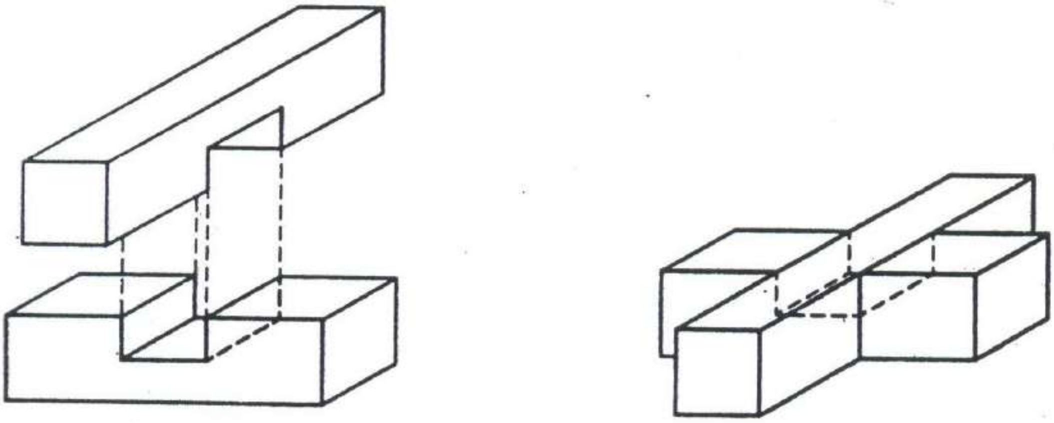
3. CUTTING



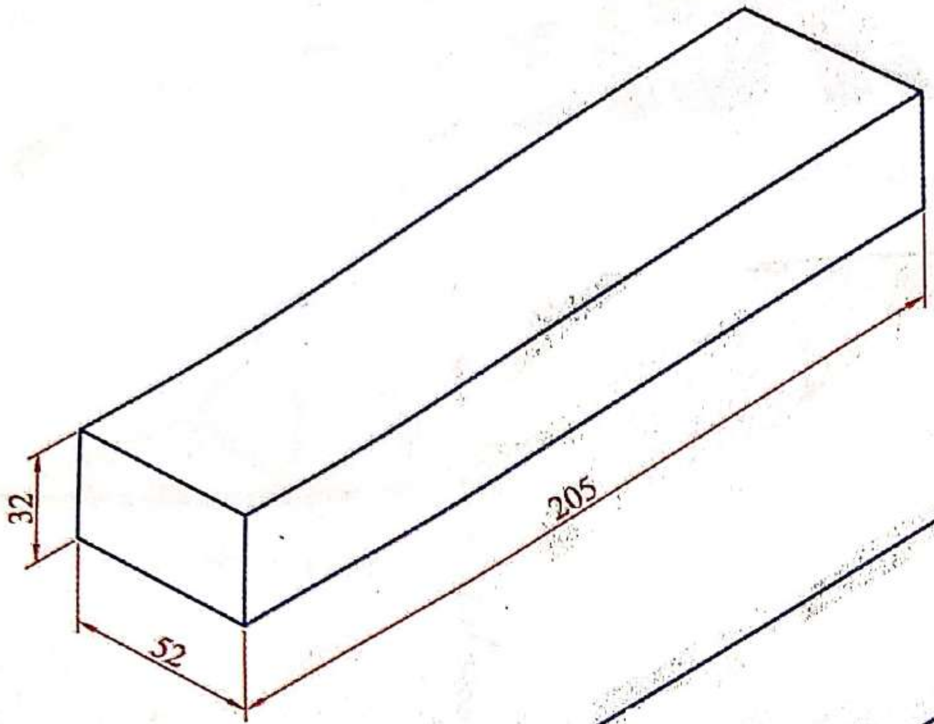
4. CHISELING

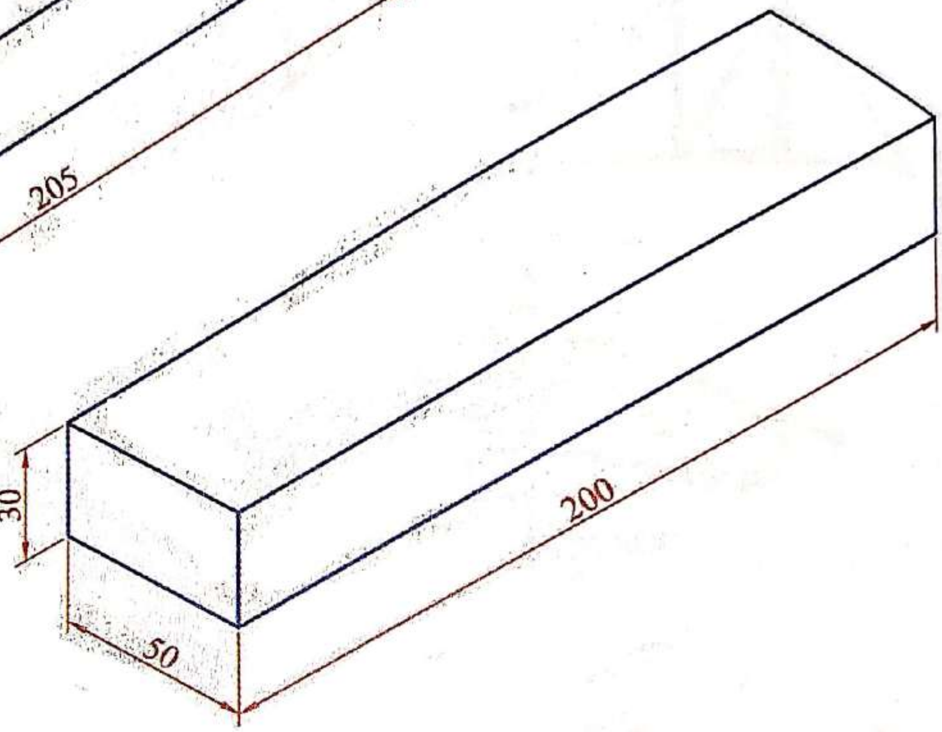


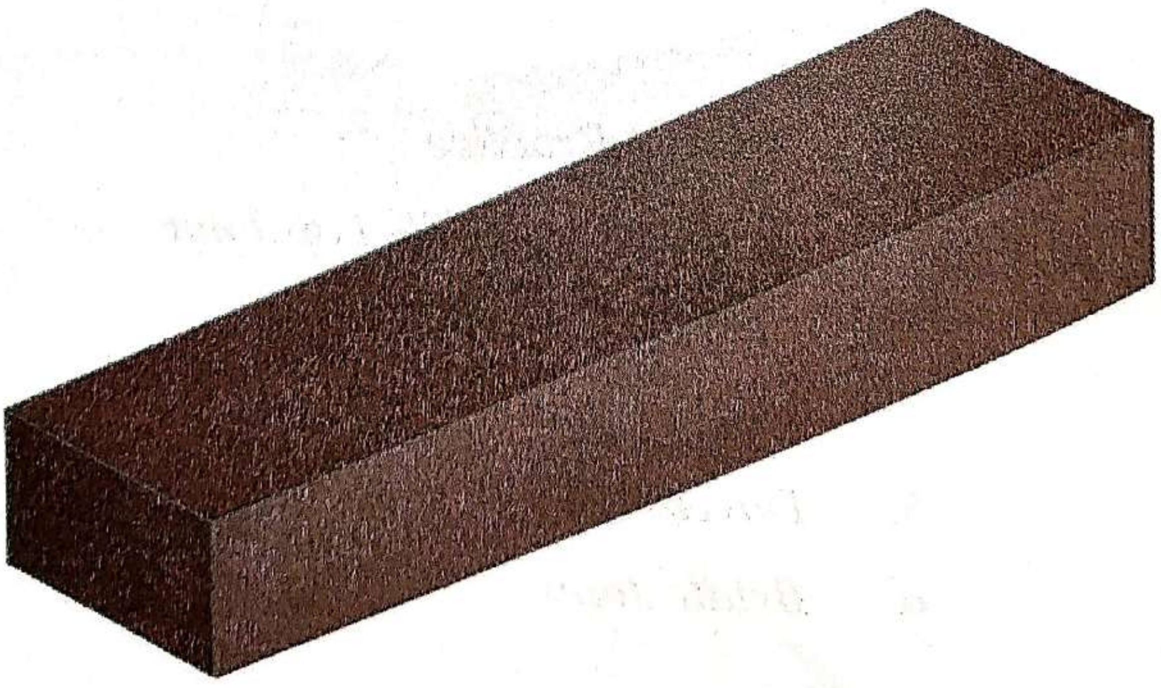
5. FINISHING



PLANING PRACTICE







All Dimensions are in mm

Ex. No. 1

Date: ____________

PLANING PRACTICE

AIM

To plane the given work piece for the given dimensions.

MATERIAL SUPPLIED

A soft wooden piece of size, l.b.t = 205 × 52 × 32 mm.

TOOLS REQUIRED

1. Machine Planer
2. Mallet
3. Tenon
4. Try Square
5. Firmer Chisel
6. Marking Gauge
7. Calipers
8. Jack Plane
9. Steel Rule and Carpentry Vice

SEQUENCE OF OPERATIONS

1. Rough Planing
2. Marking
3. Cutting or Sawing
4. Finish Planing

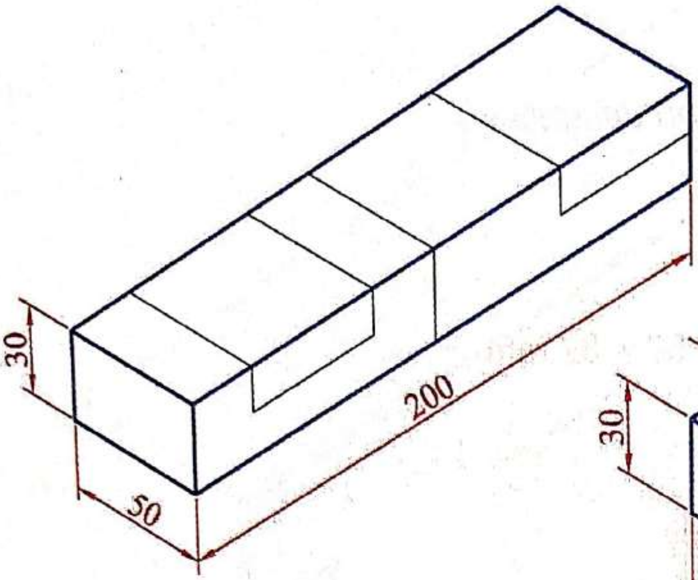
PROCEDURE

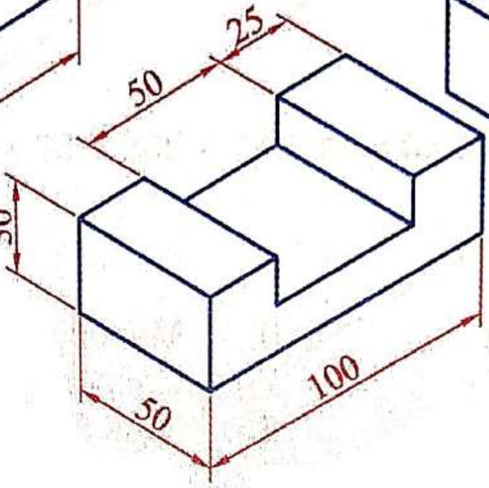
1. The given work piece is clamped in the carpentry vice and two adjacent faces are planed to get right angles, using machine planer.
2. The right angle of the work piece is then checked by using try square.
3. With the finished face as reference the required size is marked on the work piece by means of steel rule and marking gauge.
4. The other two faces of the work piece are planed to the marked dimensions by using thickness planer.
5. Finally, the accuracy and proper dimensions are verified by using steel rule and try square.
6. Finally, the length of the job is marked in the planed wood and the excess portion is removed from the job using tenon saw.

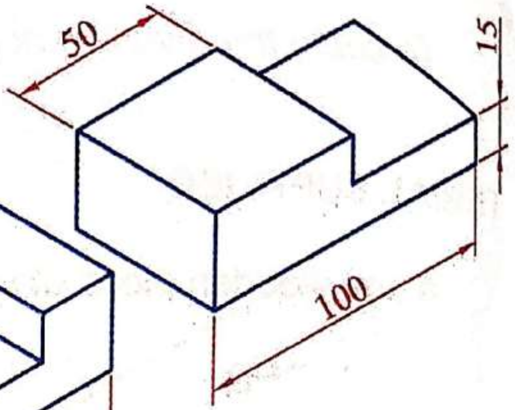
RESULT

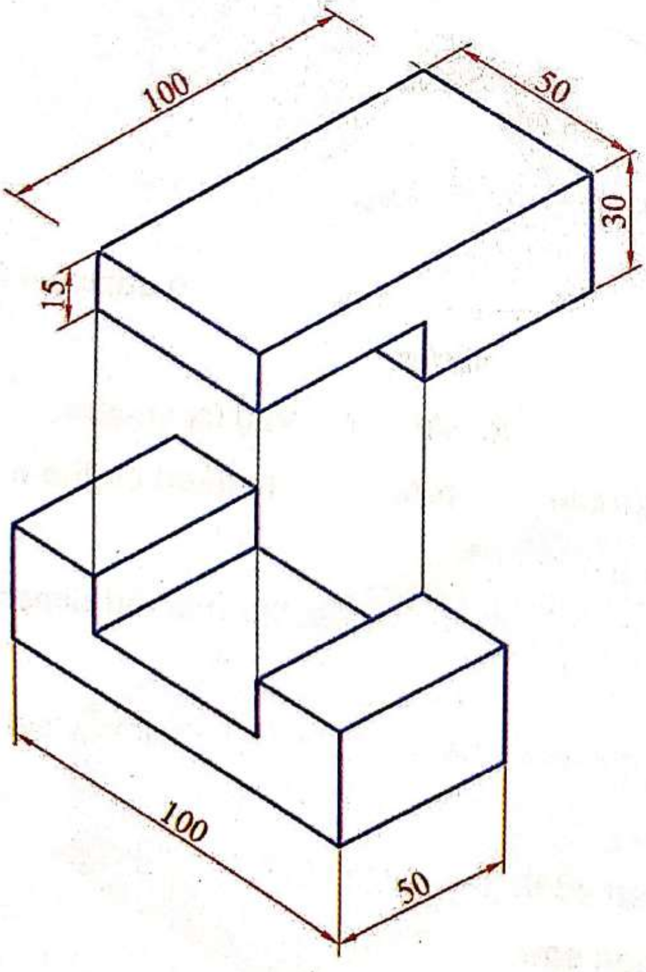
Thus, the given work piece is planed to the required dimensions and the size and shape are obtained.

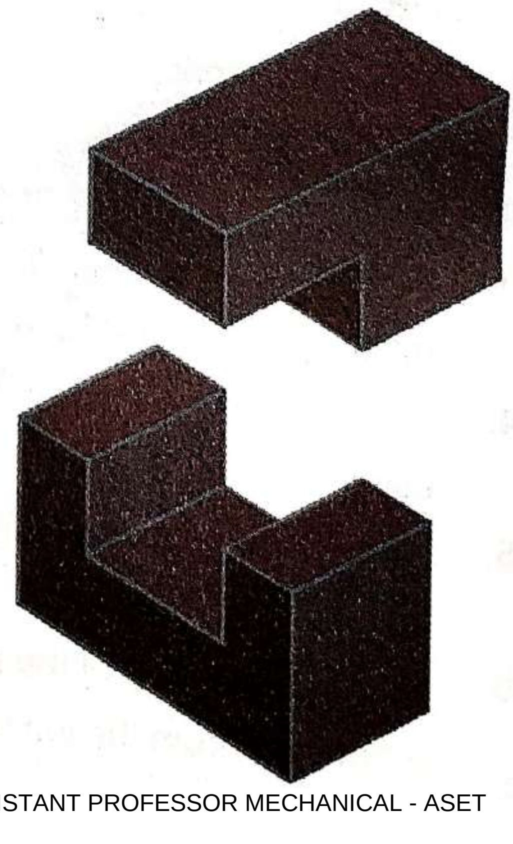
T - JOINT OR MIDDLE LAP JOINT











Ex. No. 2

Date: ________

T - JOINT OR MIDDLE LAP JOINT

AIM

To make a T - joint to the required dimensions from the given workpiece.

MATERIAL SUPPLIED

A soft wooden piece of size, l.b.t = 205 × 52 × 32 mm.

TOOLS REQUIRED

1. Machine Planer
2. Mallet
3. Rip Saw
4. Try Square
5. Marking Gauge
6. Calipers
7. Circular Saw

SEQUENCE OF OPERATIONS

1. Planing
2. Marking
3. Sawing
4. Chiseling
5. Fitting

PROCEDURE

1. The given work piece is clamped in the carpentry vice and two adjacent faces are planed to get right angles, using machine planer.
2. The work piece is cut into two halves using rip saw.
3. With the finished face as reference the required size is marked on the work piece by means of steel rule and marking gauge.
4. In one half of the workpiece, the unnecessary portions are removed using mitre saw and firmer chisel.
5. Similarly the unwanted portions are removed in the other half of the work piece using circular saw and firmer chisel.
6. Now the two pieces are assembled to check proper fitting.
7. Finally, the accuracy and proper dimensions are verified by using steel rule and try square.

RESULT

Thus, the T - joint is obtained to the required size and shape from the given workpiece.

VIVA QUESTIONS in Carpentry

1. Name the carpentry process?

   (i) Marking (ii) Sawing (iii) Planning (iv) Chiselling (v) Grooving

2. Name four Indian timbers used to manufacture furniture.

   Mahogany, Teak wood, Jack wood, pin goda etc

3. What is the purpose of marking gauge?

   To mark parallel line with respect to an edge

4. Names the type of chisels used in the carpentry shop.

   Firmer chisel, parring chisel mortice chisel and dove tail chisel, curved chisel called gouge is also used to cut circular hole or discs

5. Name the work holding devices in the carpentry shop.

   Carpenters vice, 'C' Clamp, Sash clamp, hand screw

6. What are the difference between carpenters vice and Bench vice?

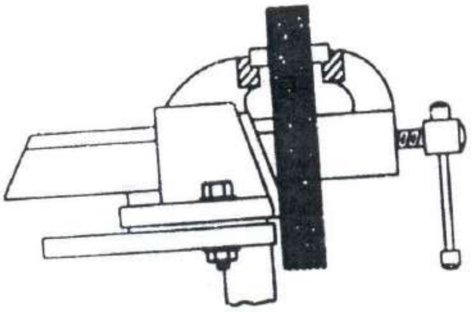
   Carpenters vice is a light duty vice and its jaw does not have any serration or grip line as provided in the bench vice

7. What is the purpose of gouges in carpentry shop?

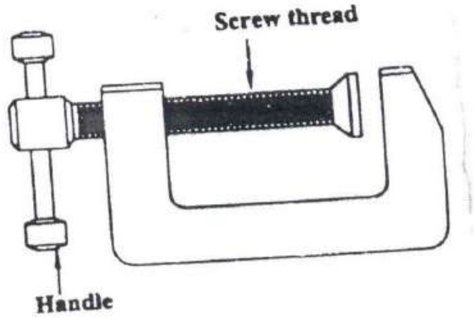
   To cut curved path

FITTING

Work holding Tools

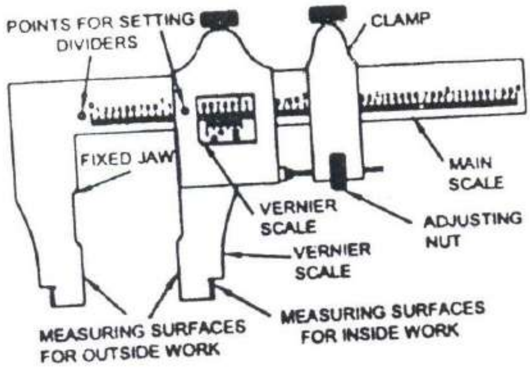


Bench Vice



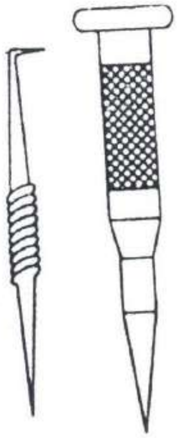
C Clamp

Marking and Measuring Tools

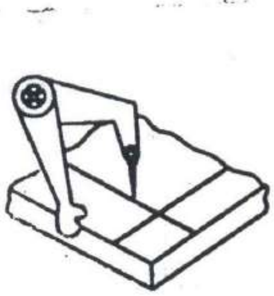


Vernier Caliper

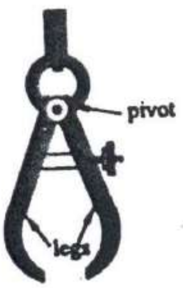
Divider



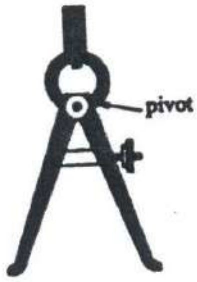
Scribers



Jenny Caliper



Outside Caliper



Inside Caliper

Flat Cold Chisel

Roundnose Chisel

Cape Chisel

Diamond Point Chisel

FITTINGS

Introduction:

Fitting is the assembling together of parts and removing metals to secure the necessary fit and it may or may not be carried out at the bench. An operator who does the fitting job is called **fitter** and the work done by him is **fitting.** There are various group of fitters such as bench fitter, assemble fitter and erection fitter etc.

Fitting tools

The fitting tools are classified into following groups

1) Work holding tools
2) Marking and Measuring tools
3) Cutting tools
4) Finishing tools
5) Other tools

1) Work holding tools:

a. Bench Vice
b. C- clamp
c. V- block with clamp

2) Marking and Measuring tools:

a. Steel rule
b. Caliper
c. Vernier Caliper
d. Vernier height guage
e. Jenney Caliper (or) Hermaphrodite
f. Scriber
g. Divider
h. Try Square
i. Trammel
j. Dot punch
k. Surface plate
l. Angle plate
m. Surface gauge

3) Cutting tools:

a. Hacksaw Frame
    - Solid frame (length cannot be changed)
    - Adjustable frame (length can be changed)
b. Chisel

4) Finishing tools:

File

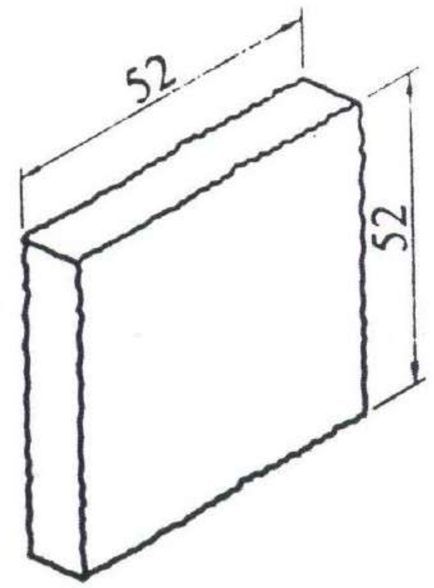
- It is principal hand tool used by fitter.
- It has several teeths to remove fine chips of materials.

a. Flat file
b. Square file
c. Round file
d. Half round file
e. Triangular file (or) three square file
f. Knife edge file

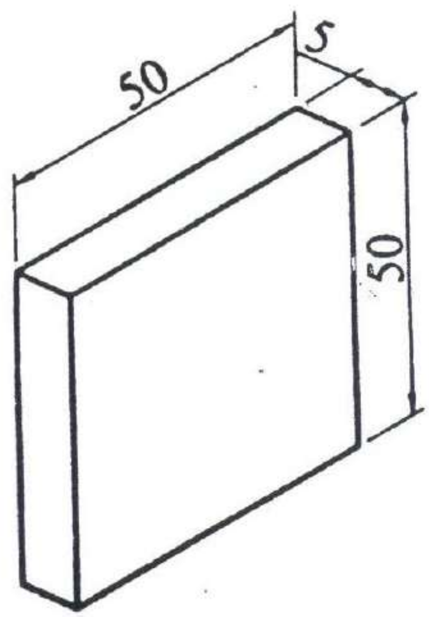
5) Other tools

a. Ball- peen hammer
b. Screw driver

Before filing



After filing



SQUARE FITTING

Aim :

To file the given workpiece (mild steel) into square shape.

Material Supplied :

Moulding sand, Parting sand, Facing sand, Stepped cone pulley .

Tools required :

1. Showel
2. Steel rule
3. Standard set of filing tools
4. Try square
5. Vernier height gauge
6. Surface plate
7. Dot punch

Sequence of operations:

1. Checking.
2. Marking.
3. Punching.
4. Rough filing.
5. Finish filing.

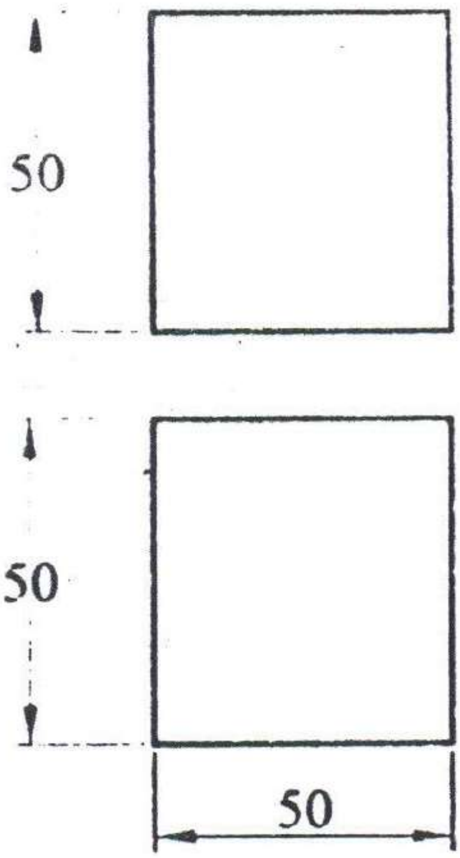
Working steps:

1. The dimension of the given work piece (job) is checked using steel rule.
2. Job is rigidly fixed on a bench vice and the two adjacent sides are filed using a flat file so that they at right angles.
3. Then chalk is applied uniformly on the surface of the work piece.
4. The given dimensions are marked by using vernier height gauge with reference to the datum.
5. Then using dot punch, dots are punched along the marked line.
6. The work piece is again fitted on the bench vice and the other two sides are filed in the same manner.
7. Finally the required square shape is obtained by filing repeatedly using smooth and triangular file so that the given dimension is obtained.

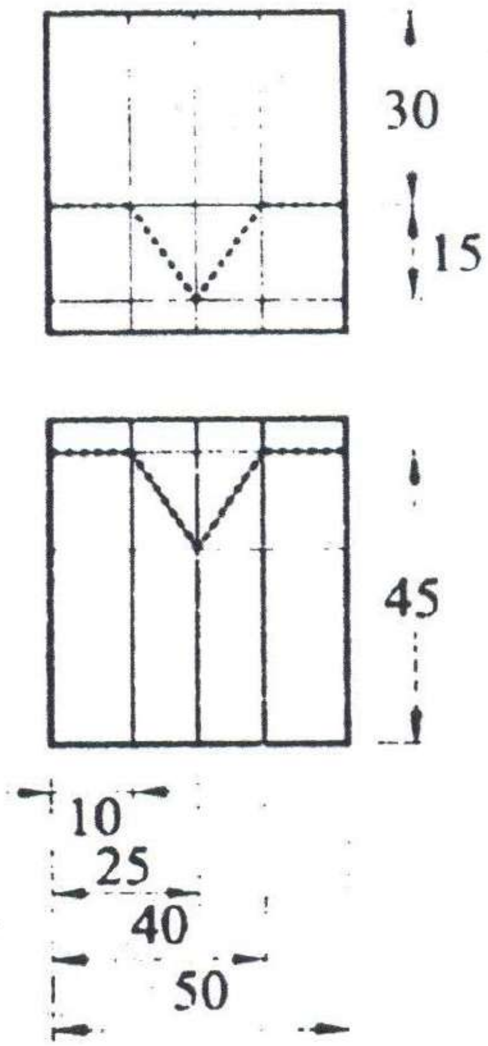
Result :

Thus the **Square filing** is done on the given work piece.

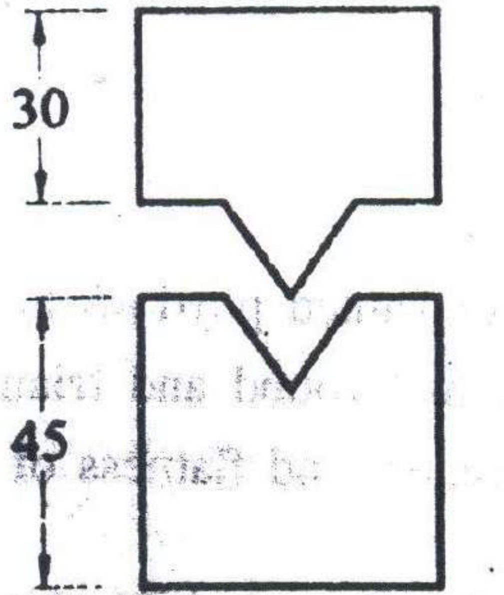
1. FILING



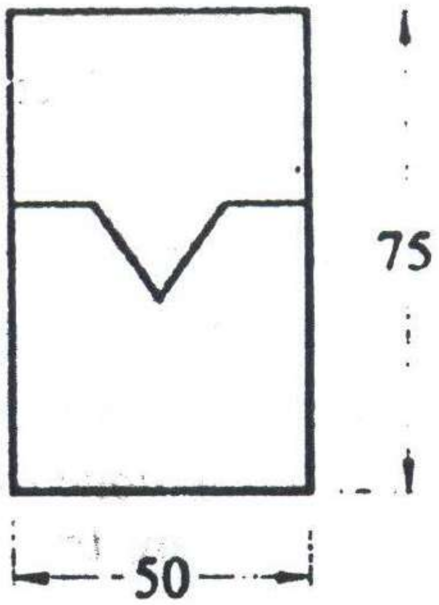
2. MARKING AND PUNCHING



3. SAWING



4. FINISHING



Vee- JOINT

Aim :

To make a **V- Joint** on the given workpieces.

Material Supplied :

50 * 50 * 50 mm Mild steel plate - 2 Nos

Tools required :

1. Bench vice
2. Steel rule
3. Standard set of filling tools
4. Try square
5. Scriber
6. Vernier height gauge
7. Surface plate
8. Angle plate
9. Dot punch
10. Fixed hacksaw

Sequence of operations :

1. Checking 2. Rough filling 3. Marking
4. Punching 5. Sawing 6. Rough Filling
7. Finish Filling

Working steps :

8. The raw material is checked for its size 50*50*5 mm after deburring.
9. A given pieces are fixed rigidly on the vice separately and all edges are filed using flat file so that they are at right angles.
10. Then chalk is applied uniformly on the surface of the work pieces.
11. The work piece is marked to given dimensions as per drawing with reference to the datum using surface plate and vernier height gauge.
12. Now using dot punch, dots are punched along the marked line.
13. Using hacksaw frame, the unwanted portions are removed.
14. Cutting edges are filed by half round and triangular files.
15. Finally the assembly is checked for the required class of fit.

Result :

Thus the required **V- Joint** is obtained from the given work piece.

VIVA QUESTIONS in Fitting

1. What is meant by fitting

    Fitting is the process of assembling the item after bringing the components to the exact size and geometrical shape and tolerance

2. Which material is used to make the fitting file? - High carbon steel

3. What is the name of material used in fitting shop? - M S Flat of size 50x10 mm

4. What is the least count of the vernier caliper used in fitting shop?

    0.02 mm - Least count = one main scale division - one Vernier scale division in Vernier caliper

5. Name of hammers used in the fitting shop?

    Ball peen hammer straight peen hammer and cross peen hammer

Viva Questions for Drilling and Power tools (DEMO)

6. What is meant by drilling?
    Making hole in the any item using the tool drill bit

7. What is the name of tool used to make holes in thick materials? - drill bit

8. What is the name of tool used to cut thread inside a hole - Threading tap

9. How to specify a hack saw blade?

    By the Number of teeth per 2.5 cm and the width and length of the blade. 18 and 24 are the standard No of teeth per inch (25.4)

10. What is meant by a combination set? What are the uses of it? –

    It consists of a try square, a MITRE square and a provision to find out the centre of a cylindrical item

SHEET METAL

SHEET METAL

Introduction

Sheet metal is simply metal formed into thin and flat pieces. It is one of the fundamental forms used in metalworking, and can be cut and bent into a variety of different shapes. Countless everyday objects are constructed of the material. Thicknesses can vary significantly, although extremely thin thicknesses are considered foil or leaf, and pieces thicker than 6 mm (0.25 in) are considered plate.

Sheet metal is available as flat pieces or as a coiled strip. The coils are formed by running a continuous sheet of metal through a roll slitter.

The thickness of the sheet metal is called its gauge. The gauge of sheet metal ranges from 30 gauge to about 8 gauge. The higher the gauge, the thinner the metal is.

There are many different metals that can be made into sheet metal, such as aluminum, brass, copper, steel, tin, nickel and titanium. For decorative uses, important sheet metals include silver, gold, and platinum (platinum sheet metal is also utilized as a catalyst.)

Sheet metal has applications in car bodies, airplane wings, medical tables, roofs for building and many other things. Sheet metal of iron and other materials with high magnetic permeability, also known as laminated steel cores, has applications in transformers and electric machines. Historically, an important use of sheet metal was in plate armor worn by cavalry, and sheet metal continues to have many decorative uses, including in horse tack.

Sheet metal processing

The raw material for sheet metal manufacturing processes is the output of the rolling process. Typically, sheets of metal are sold as flat, rectangular sheets of standard size. If the sheets are thin and very long, they may be in the form of rolls. Therefore the first step in any sheet metal process is to cut the correct shape and sized ‘blank’ from larger sheet.

Sheet metal processes

Sheet metal processes can be broken down into two major classifications and one minor classification

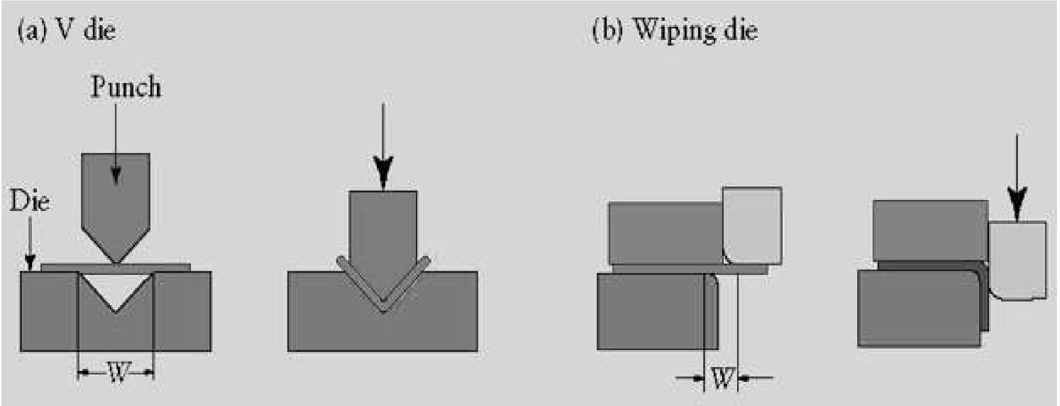
- **Shearing processes** - processes which apply shearing forces to cut, fracture, or separate the material.
- **Forming processes** - processes which cause the metal to undergo desired shape changes without failure, excessive thinning, or cracking. This includes bending and stretching.
- **Finishing processes** - processes which are used to improve the final surface characteristics.

Shearing Process

1. Punching: shearing process using a die and punch where the interior portion of the sheared sheet is to be discarded.
2. Blanking: shearing process using a die and punch where the exterior portion of the shearing operation is to be discarded.
3. Perforating: punching a number of holes in a sheet
4. Parting: shearing the sheet into two or more pieces
5. Notching: removing pieces from the edges
6. Lancing: leaving a tab without removing any material

Forming Processes

- **Bending:** forming process causes the sheet metal to undergo the desired shape change by bending without failure. Ref fig.
- **Stretching:** forming process causes the sheet metal to undergo the desired shape change by stretching without failure.
- **Drawing:** forming process causes the sheet metal to undergo the desired shape change by drawing without failure.
- **Roll forming:** Roll forming is a process by which a metal strip is progressively bent as it passes through a series of forming rolls.



Common Die – Bending operations

Finishing processes

Material properties, geometry of the starting material, and the geometry of the desired final product play important roles in determining the best process

Equipments

Basic sheet forming operations involve a press, punch, or ram and a set of dies

Presses

- **Mechanical Press** - The ram is actuated using a flywheel. Stroke motion is not uniform.
- **Hydraulic Press** - Longer strokes than mechanical presses, and develop full force throughout the stroke. Stroke motion is of uniform speed, especially adapted to deep drawing operations.

Dies and Punches

- **Simple**- single operation with a single stroke
- **Compound**- two operations with a single stroke
- **Combination**- two operations at two stations
- **Progressive**- two or more operations at two or more stations with each press stroke, creates what is called a strip development

Tools and Accessories

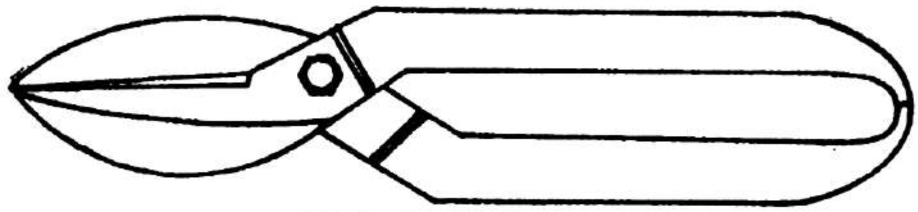
The various operations such as cutting, shearing, bending, folding etc. are performed by these tools.

Marking and measuring tools

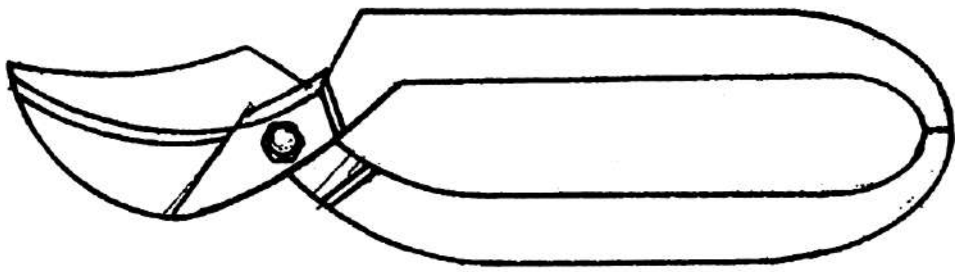
- **Steel Rule** - It is used to set out dimensions.
- **Try Square** - Try square is used for making and testing angles of 90degree
- **Scriber** – It used to scribe or mark lines on metal work pieces.
- **Divider** - This is used for marking circles, arcs, laying out perpendicular lines, bisecting lines, etc

Cutting Tools

- **Straight snip** - They have straight jaws and used for straight line cutting. Ref fig.
- **Curved snip** - They have curved blades for making circular cuts. Ref fig.



STRAIGHT SNIP

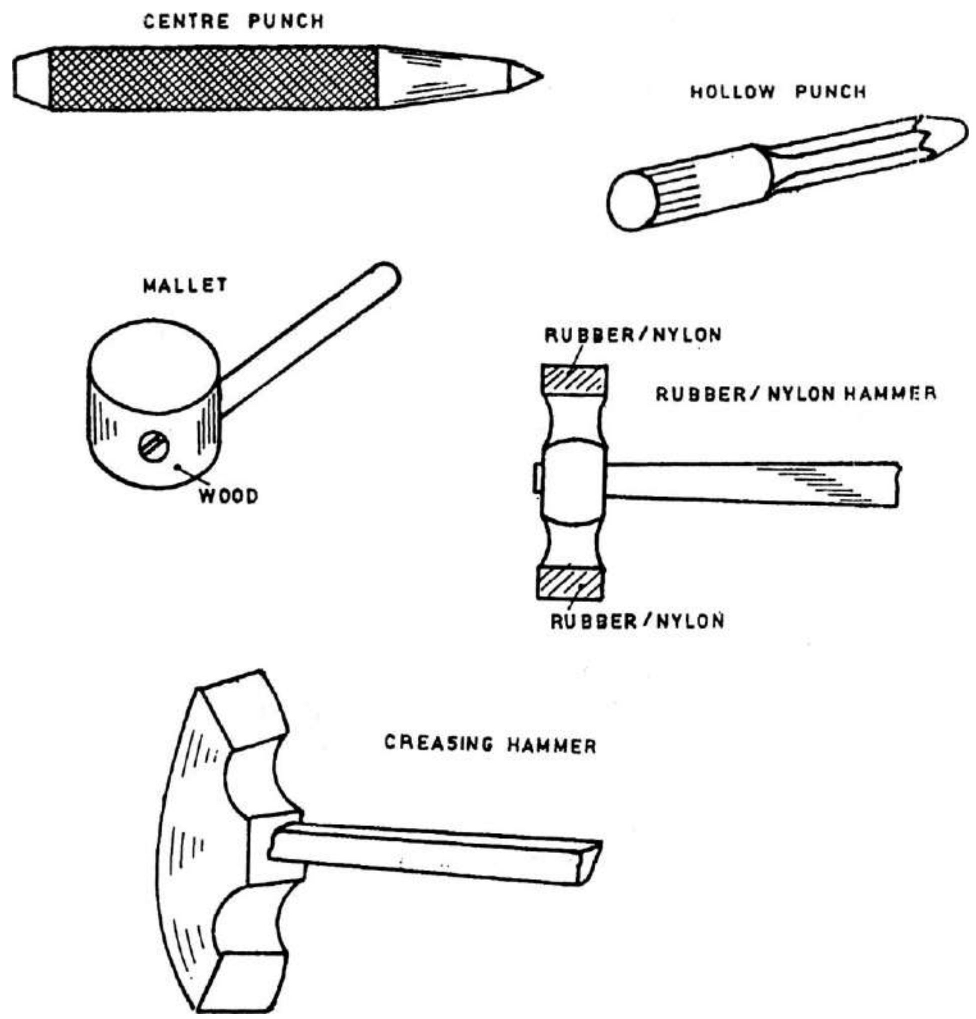


CURVED SNIP

Striking Tools

Mallet - It is wooden-headed hammer of round or rectangular cross section. The striking face is made flat to the work. A mallet is used to give light blows to the Sheet metal in bending and finishing. Ref fig.

Hammers – Hammers are also used in sheet metal work for forming shapes. Commonly used hammers are rubber / nylon hammers and creasing hammer.



Merits

High strength

Good dimensional accuracy and surface finish

Relatively low cost

Demerits

Wrinkling and tearing are typical limits to drawing operations

Different techniques can be used to overcome these limitations

- Draw beads
- Vertical projections and matching grooves in the die and blank holder

Trimming may be used to reach final dimensions

Applications

Roofings

Ductings

Vehicles body buildings like 3 wheelers, 4 wheelers, ships, aircrafts etc.

Furnitures, House hold articles and Railway equipment

VIVA QUESTIONS AND ANSWERS

1. What is sheet metal work?

   Sheet metal work is used for making, Cutting and bending of sheet metals to desired shape.

2. Which are the materials used for sheet metals?

   (i) Galvanized iron (ii) Stainless steel (iii) Copper (iv) Aluminium

3. Name the sheet metal hand tools.

   (i) Steel rule (ii) Vernier calliper (iii) Micrometer (iv) Scriber (v) Divider (vi) hammer (viii) mallet(ix) Shears

4. What is G.I.?

   G.I. is galvanized iron

5. What is shearing?

   Shearing means sheet metal cutting

6. What is the name of vice used in fitting shop?

   Bench vice

7. Name the different files?

   (i)Flat file (ii) Square file (iii) Round file (iv) Triangular file (v) Half round file

8. What are the metals that can be used for sheet metal work?

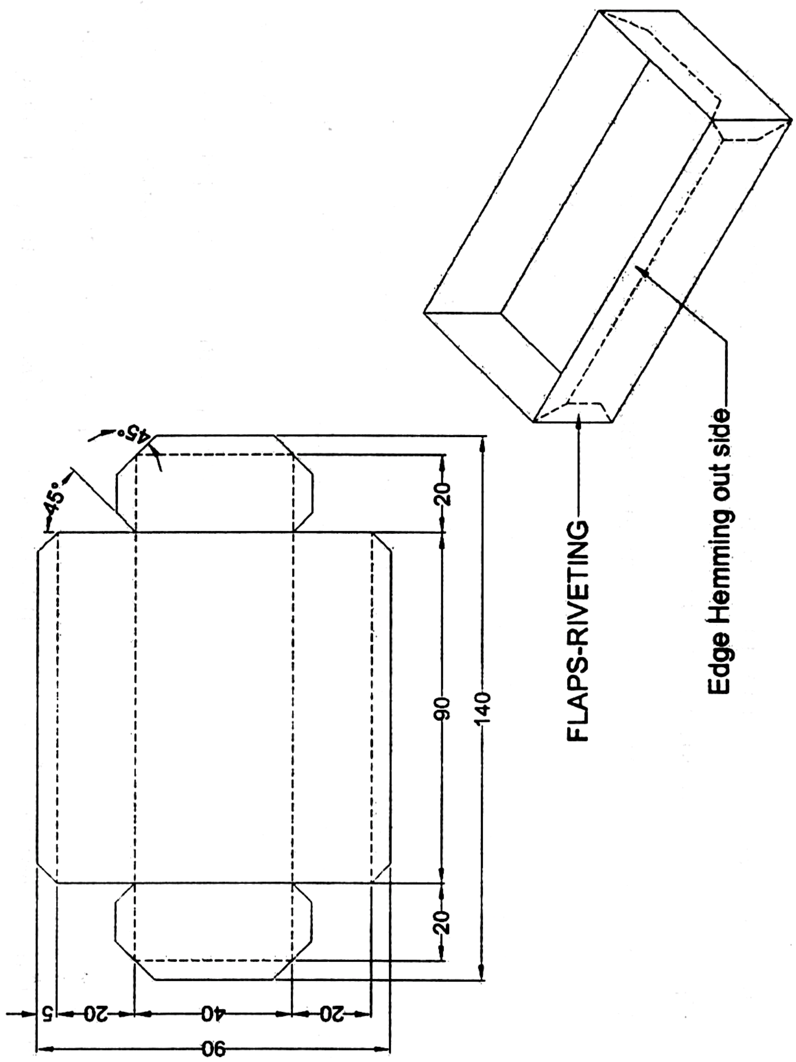
   Aluminium, Brass, Copper and steel.

9. What are the cutting tools?

   Straight snip and Curved snip

10. What is Curved snip?

    Curved blades are used for making circular cuts.


FLAPS-RIVETING
Edge Hemming out side
45°
45°
20
90
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40
20
90

2. TRAY MAKING

Aim: To make a rectangular tray out of the given sheet with specified dimensions.

Tools required:

1. Sheet metal	2. Anvil	3. Try square	4. Steel rule
5. Divider	6. Snip	7. Scriber	
8. Mallet	9. File	10. Hand shearing machine	
11. Protractor etc.			

Materials required:

Tin or mild steel of suitable size.

Procedure:

1. Development of the rectangular tray for the given dimensions is drawn on the provided sheet metal using steel rule, protractor and scriber as shown in fig.
2. Assume some joining allowance on all sides of the development for locking the tray.
3. The sheet metal is exactly cut as per the markings made on it using a hand shearing machine or snip. The burrs are removed using a file.
4. Single hemming is made on the four sides of the tray as shown in fig.
5. Four sides are bent to 90° using stake / anvil.
6. Then the edges are bent for the length of joining allowance and the edges are made to overlap each other and are struck with a mallet to get the required joint.

Result:

Thus the rectangular tray of given dimension is fabricated with the given sheet metal.

VIVA QUESTIONS AND ANSWERS

1. What is a try square?

   Try square is used for making and testing angles of 90degree

2. What is a Scriber?

   It used to scribe or mark lines on metal work pieces.

3. What is a Divider?

   This is used for marking circles, arcs, laying out perpendicular lines, bisecting lines, etc

4. What is a straight snip?

   They have straight jaws and used for straight line cutting.

5. What is a Mallet?

It is wooden-headed hammer of round or rectangular cross section. The striking face is made flat to the work.

6. What is a Hammer?

Hammer is also used in sheet metal work for forming shapes. Commonly used hammers are rubber / nylon hammers and creasing hammer.

7. What is punching?

   It is the shearing process using a die and punch where the interior portion of the sheared sheet is to be discarded.

8. What is Blanking?

   Shearing process using a die and punch where the exterior portion of the shearing operation is to be discarded.

9. What is Perforating?

   Punching a number of holes in a sheet

10. What is parting?

    Shearing the sheet into two or more pieces

WELDING

WELDING

Welding is a fabrication process that joins materials, usually metals or thermoplastics, by causing coalescence. This is often done by melting the work pieces and adding a filler material to form a pool of molten material (the weld puddle) that cools to become a strong joint, with pressure sometimes used in conjunction with heat, or by itself, to produce the weld. This is in contrast with soldering and brazing, which involve melting a lower-melting-point material between the work pieces to form a bond between them, without melting the work pieces.

Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding can be done in many different environments, including open air, underwater and in space. Regardless of location, however, welding remains dangerous, and precautions must be taken to avoid burns, electric shock, eye damage, poisonous fumes, and overexposure to ultraviolet light.

TYPES OF WELDING

Arc Welding

Arc welding is a process utilizing the concentrated heat of an electric arc to join metal by fusion of the parent metal and the addition of metal to joint usually provided by a consumable electrode. Either direct or alternating current may be used for the arc, depending upon the material to be welded and the electrode used.

Gas Welding

It is a metal joining process in which the ends of pieces to be joined are heated at their interface by producing coalescence with one or more gas flames (such as oxygen and acetylene), with or without the use of a filler metal.

Welding Safety

Welding hazards pose an unusual combination of safety and health risks. By its nature, welding produces fumes and noise, gives off radiation, involves electricity or gases, and has the potential for burns, shock, fire, and explosions.

Some hazards are common to both electric arc and oxygen-fuel gas welding. If you work with or near a welding operation, the following general precautions should help you to work more safely.

- Weld only in designated areas.
- Only operate welding equipment you have been trained to use.
- Know what the substance is that’s being welded and any coating on it.
- Wear protective clothing to cover all exposed areas of the body for protection sparks, hot spatter, and radiation.
- Protective clothing should be dry and free of holes, grease, oil, and other substances which may burn.
- Wear flameproof gauntlet gloves, a leather or asbestos apron, and high-top shoes to provide good protection against sparks and spatter.
- Wear specifically designed, leak-proof helmets equipped with filter plates to protect against ultraviolet, infrared, and visible radiation.
- Never look at a flash, even for an instant.

- Keep your head away from the plume by staying back and to the side of the work.
- Use your helmet and head position to minimize fume inhalation in your breathing zone.
- Make sure there is good local exhaust ventilation to keep the air in your breathing zone clear.
- Don’t weld in a confined space without adequate ventilation and a NIOSH-approved respirator.
- Don’t weld in wet areas, wear wet or damp clothing or weld with wet hands.
- Don’t weld on containers which have held combustible materials or on drums, barrels or tanks until proper safety precautions have been taken to prevent explosions.
- If others are working in the area be sure they are warned and protected against arcs, fumes, sparks, and other welding hazards.
- Don’t coil the electrode cable around your body.
- Ground both the frame of the welding equipment and metal being welded.
- Check for leaks in gas hoses using an inert gas.
- Check area around you before welding to be sure no flammable material or degreasing solvents are in the welding area.
- Keep a fire watch in the area during and after welding to be sure there are no smoldering materials, hot slag or live sparks which could start a fire.
- Locate the nearest fire extinguisher before welding.
- Deposit all scraps and electrode butts in proper waste container to avoid fire and toxic fumes.

Types of arc welding

Different types of arc welding are.

1. Carbon arc welding
2. Metal arc welding
3. Metal inert gas welding
4. Submerged arc welding
5. Plasma arc welding etc.

Electric Arc Welding,

Electric arc welding is the most widely used of the various arc welding processes. Welding is performed with the heat of an electric arc that is maintained between the end of a coated metal electrode and the work piece (See Figure 1). The heat produced by the arc melts the base metal, the electrode core rod, and the coating. As the molten metal droplets are transferred across the arc and into the molten weld puddle, they are shielded from the atmosphere by the gases produced from the decomposition of the flux coating. The molten slag floats to the top of the weld puddle where it protects the weld metal from the atmosphere during solidification. Other functions of the coating are to provide arc stability and control bead shape. More information on coating functions will be covered in subsequent lessons.

Welding Power Sources: Shielded metal arc welding may utilize either alternating current (AC) or direct current (DC), but in either case, the power source selected must be of the constant current type. This type of power source will deliver relatively constant amperage or welding current regardless of arc length variations by the operator the amperage determines the amount of heat at the arc and since it will remain relatively constant, the weld beads produced will be uniform in size and shape.

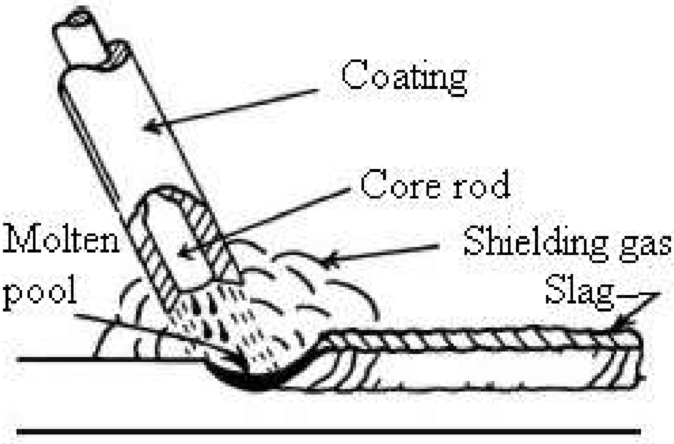
Whether to use an AC, DC, or AC/DC power source depends on the type of welding to be done and the electrodes used. The following factors should be considered: 1**. Electrode Selection -** Using a DC power source allows the use of a greater range of electrode types. While most of the electrodes are designed to be used on AC or DC, some will work properly only on DC.

2. Metal Thickness - DC power sources may be used for welding both heavy sections and light gauge work. Sheet metal is more easily welded with DC because it is easier to strike and maintain the DC arc at low currents.

3. Distance from Work - If the distance from the work to the power source is great, AC is the best choice since the voltage drop through the cables is lower than with DC. Even though welding cables are made of copper or aluminum (both good conductors), the resistance in the cables becomes greater as the cable length increases. In other words, a voltage reading taken between the electrode and the work will be somewhat lower than a reading taken at the output terminals of the power source. This is known as voltage drop.

4. Welding Position - Because DC may be operated at lower welding currents, it is more suitable for overhead and vertical welding than AC. AC can successfully be used for out-of-position work if proper electrodes are selected.

5. Arc Blow - When welding with DC, magnetic fields are set up throughout the weldment. In weldments that have varying thickness and protrusions, this magnetic field can affect the arc by making it stray or fluctuate in direction. This condition is especially troublesome when welding in corners. AC seldom causes this problem because of the rapidly reversing magnetic field produced.



Oxy-Acetylene gas Welding

Oxyacetylene welding, commonly referred to as gas welding, is a process which relies on combustion of oxygen and acetylene. When mixed together in correct proportions within a hand-held torch or blowpipe, a relatively hot flame is produced with a temperature of about 3,200˚C. The chemical action of the oxyacetylene flame can be adjusted by changing the ratio of the volume of oxygen to acetylene.

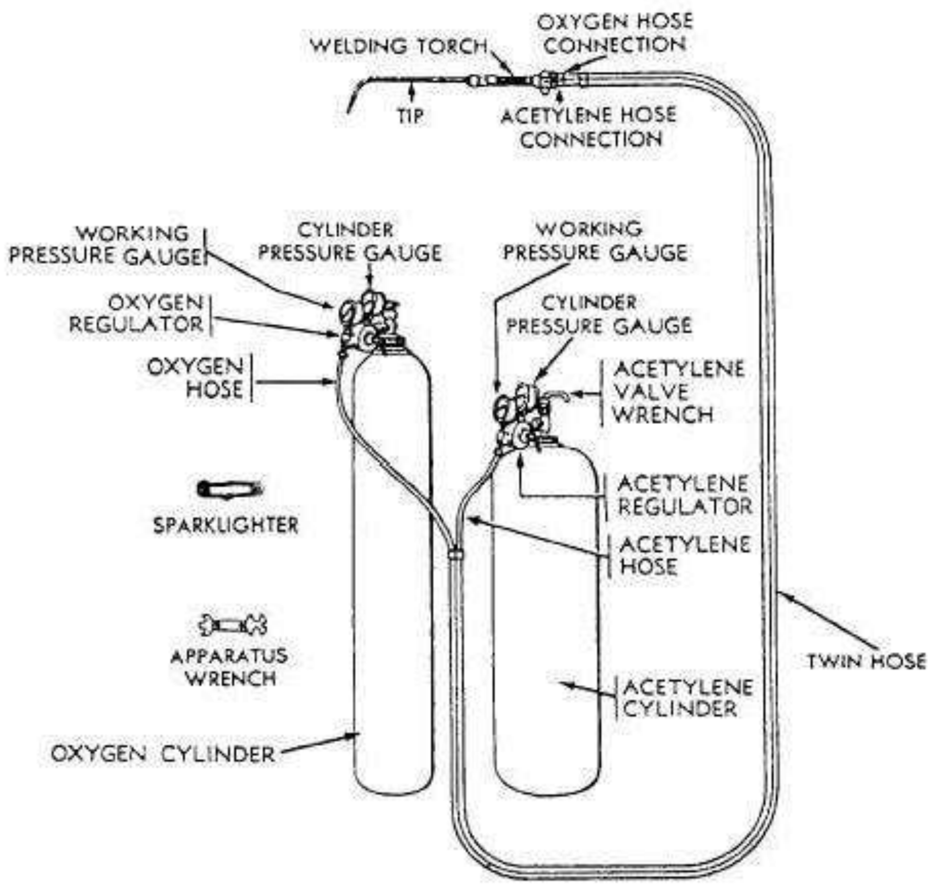
Three distinct flame settings are used, neutral, oxidising and carburizing. Welding is generally carried out using the neutral flame setting which has equal quantities of oxygen and acetylene. The oxidising flame is obtained by increasing just the oxygen flow rate while the carburising flame is achieved by increasing acetylene flow in relation to oxygen flow. Because steel melts at a temperature above

1,500˚C, the mixture of oxygen and acetylene is used as it is the only gas combination with enough heat to weld steel. However, other gases such as propane, hydrogen and coal gas can be used for joining lower melting point non-ferrous metals, and for brazing and silver soldering.

Equipment

Oxyacetylene equipment is portable and easy to use. It comprises oxygen and acetylene gases stored under pressure in steel cylinders. The cylinders are fitted with regulators and flexible hoses which lead to the blowpipe. Specially designed safety devices such as flame traps are fitted between the hoses and the cylinder regulators. The flame trap prevents flames generated by a 'flashback' from reaching the cylinders; principal causes of flashbacks are the failure to purge the hoses and overheating of the blowpipe nozzle.

When welding, the operator must wear protective clothing and tinted coloured goggles. As the flame is less intense than an arc and very little UV is emitted, general-purpose tinted goggles provide sufficient protection



Neutral Flame

As the supply of oxygen to the blowpipe is further increased; the flame contracts and the white cone become clearly defined, assuming a definite rounded shape. At this stage approximately equal quantities of acetylene and oxygen are being used and the combustion is complete, all the carbon supplied by the acetylene is being consumed and the maximum heat given out. The flame is now neutral, and this type of flame is the one most extensively used by the welder, who should make himself thoroughly familiar with its appearance and characteristics.

Carburising Flame

This is a flame in which an excess of acetylene is burning, i.e. combustion is incomplete and unconsumed carbon is present. When lighting the blowpipe the acetylene is turned on first and ignited, giving a very smoky yellow flame of abnormal size, showing two cones of flame in addition to an outer envelope; this is an exaggerated form of the carburising flame, but gives out comparatively little heat and is of little use for welding.

Oxidising Flame

A further increase in the oxygen supply will produce an oxidising flame in which there is more oxygen than is required for complete combustion. The inner cone will become shorter and sharper, the flame will turn a deeper purple colour and emit a characteristic slight "hiss", while the molten metal will be less fluid and tranquil during welding and excessive sparking will occur. An oxidising flame is only used for special applications, and should never be used for welding

Welding Tools and Safety Equipments

Goggles

Goggles are forms of protective eyewear that usually enclose or protect the eye area in order to prevent particulates, infectious fluids, or chemicals from striking.

Face Shield

Face shield is used to protect the eyes of the welder from the little sparks produced during welding. It is normally held in hand.

Hand Gloves

Hand gloves are used to protect the hands from electrical shock, arc radiation and hot spatters.

Tongs

Tongs are used to handle the hot metal – welding job while cleaning. They are also used to hold the metal for hammering.

Chipping Hammer

Chipping hammer is a chisel shaped tool and is used to remove the slag from the weld bead.

Wire brush

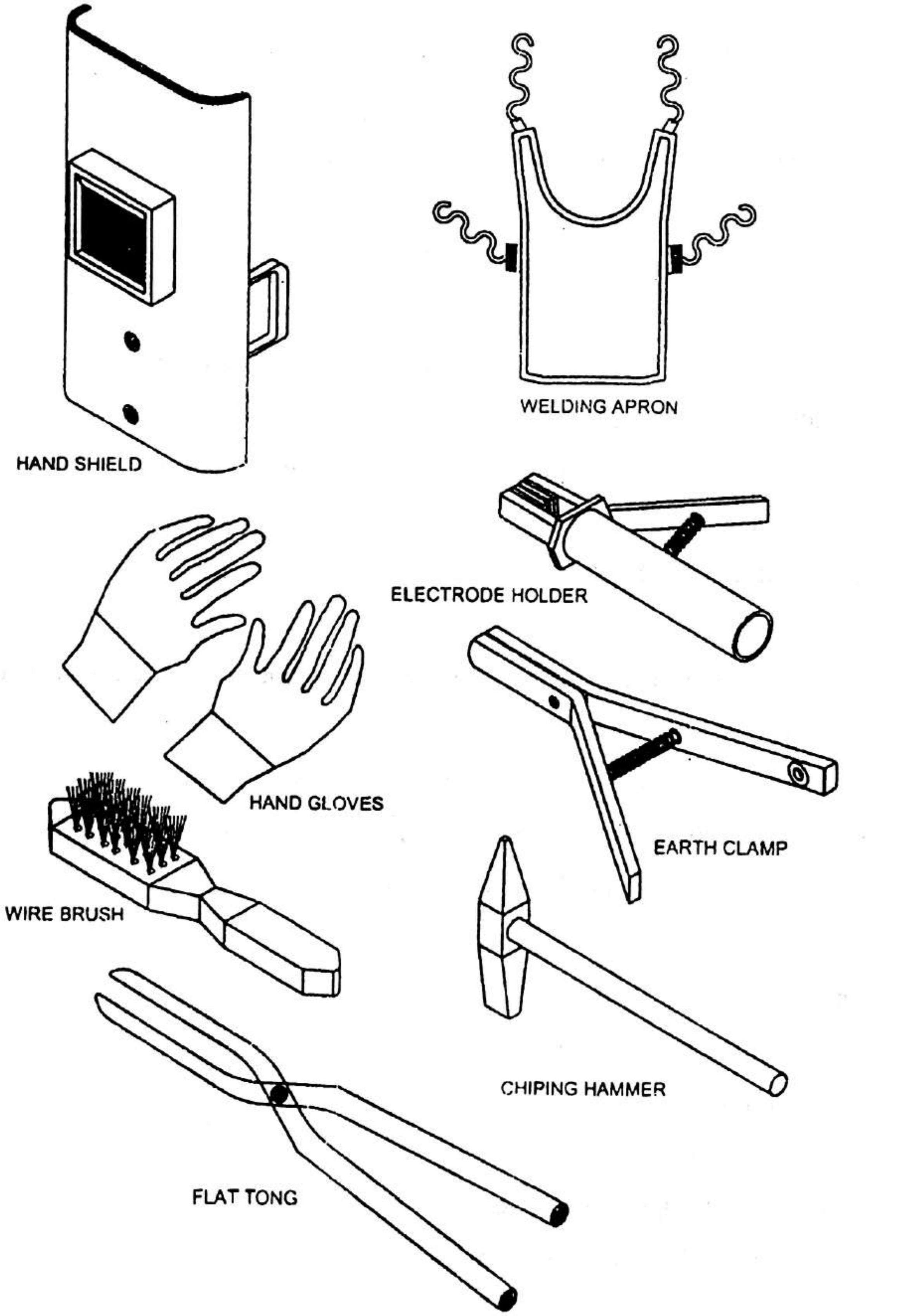
A wire brush is made up of stiff steel wire embedded in a wooden piece. It removes small particles of slag from the weld bead after the chipping hammer has done its job.

Welding Helmet

Welding helmets are headgear used when performing certain types of welding to protect the eyes , face and neck from flash burn, ultraviolet light, sparks and heat. Welding helmets can also prevent retina burns, which can lead to a loss of vision.

Ground Clamp

It is connected to the end of the ground cable. It is normally clamped to the welding table or the job itself to complete the electric circuit.


HAND SHIELD
WELDING APRON
HAND GLOVES
ELECTRODE HOLDER
EARTH CLAMP
WIRE BRUSH
CHIPING HAMMER
FLAT TONG

Advantages of Arc Welding

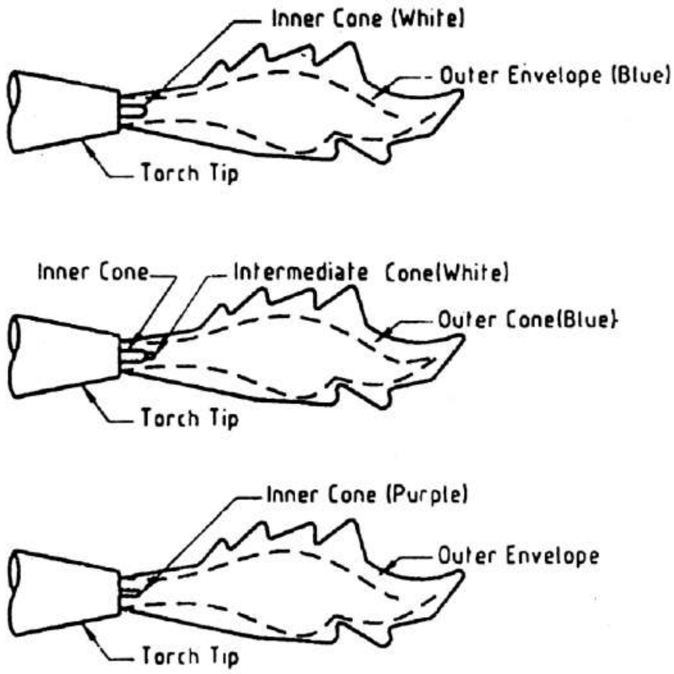
1. A big range of metals and their alloys can be welded
2. Welding equipment is portable and the cost is fairly low
3. Flux shielded manual metal arc welding is the simplest of all the arc welding processes.
4. The applications of the arc welding are innumerable, because of the availability of wide variety of electrodes.
5. Welding can be carried out in any position with highest weld quality.

Disadvantages of arc welding

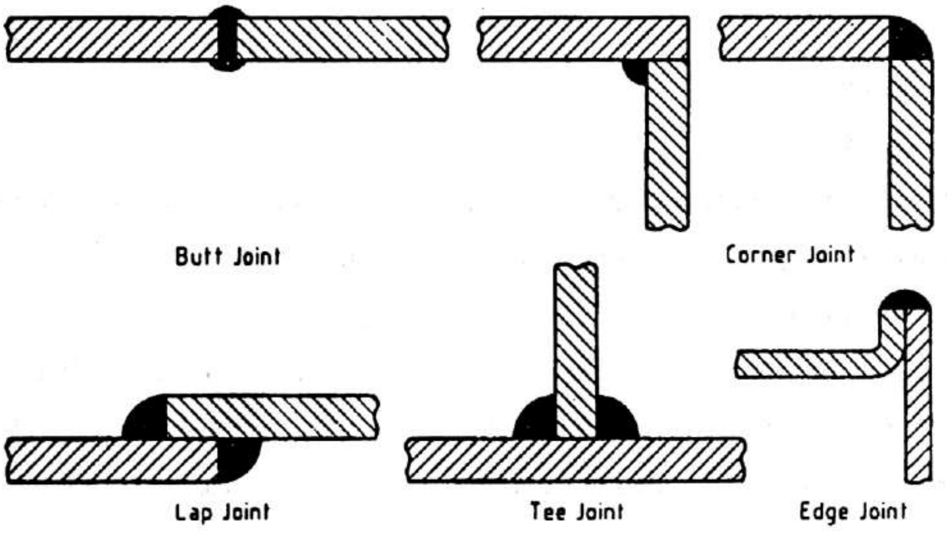
1. Because of the limited length of each electrode and brittle flux coating on it, mechanization is difficult.
2. In welding long joints, as one electrode finishes, the weld is to be progressed with the next electrode. A defect may occur at the place where welding is restarted with the new electrode.

Applications

1. In reservoir tank, boiler and pressure vessel fabrications
2. Ship building
3. Pipes and pen stock joining
4. Building and bridge construction
5. Automotive and air craft industry



TYPES OF OXY-ACETYLENE FLAME



BASIC TYPES OF WELDED JOINTS

Types of Joints

The joints used in welding are

1. Butt joint   2. Lap joint   3. Edge joint

4. T – joint   5. Corner joint

1. Butt joint

It is used to join the ends or edges of plates lying in the same plane. Plates having thickness less than 5mm do not require edge preparation but plates having thickness more than 5mm require edge preparation on both sides.

2. Lap joint

It is used to join two over lapping pieces so that the edges of each piece are welded to the surface of the other. It is used on plates less than 3mm thickness. Common types are single lap and double lap joint. Edge preparation is not required for these joints.

3. Edge joint

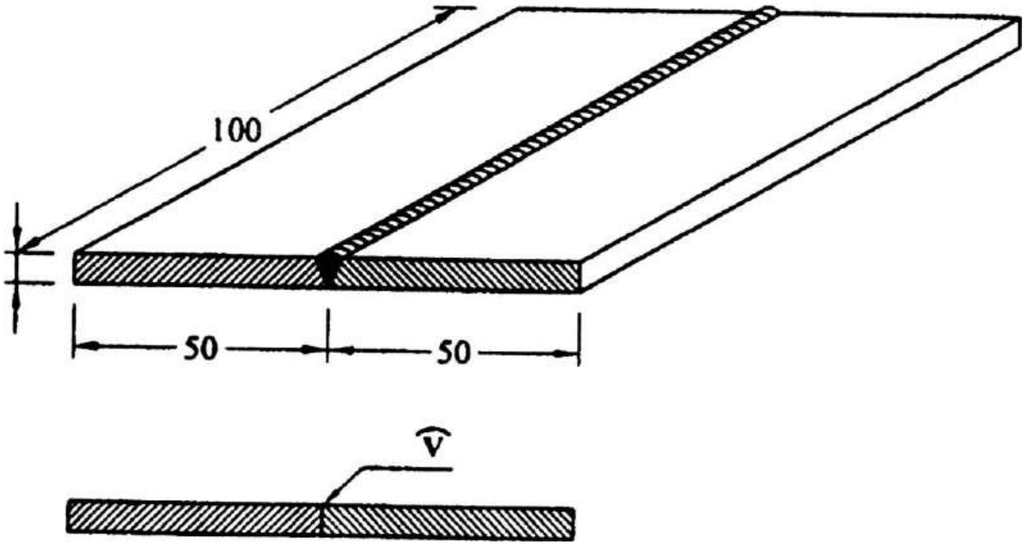
It is used to weld two parallel plates. This is economical for joining thin plates up to 6mm. This joint is often used in sheet metal work. It is suitable for severe loading.

4. T – joint

It is used to weld two perpendicular plates. This is economical for joining thin plates up to 3mm. This joint is often used in structures.

5. Corner joint

It is used to join the edges of two pieces whose surfaces are approximately at right angles to each other. It is common in the construction of boxes, tanks, frames and other similar items. Edge preparation is not necessary for these joints.


100
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BUTT JOINT PRACTICE

Aim:

To make a butt joint on the given work pieces using arc welding.

Apparatus required:

Work pieces, Welding electrodes, Welding machine, Tongs, Wire brush, chipping hammer, Gloves and Goggles.

Procedure:

1. The given work pieces are cleaned with the wire brush to remove the rust, scale and other impurities.
2. Edges are prepared suitably to the given dimension and positioned for the butt joint.
3. Depending upon the thickness of the parent metal, the amperage and correct voltage is selected.
4. With goggles covering the eyes and gloves on hands, an arc is struck on the work piece and tacks are made at the extreme ends.
5. Welding process is progressed along the seam at a constant speed and keeping uniform distance between the electrode and the work piece.
6. Using chipping hammer the flux in the form of slag is chipped off and then cleaned.
7. After welding, the work pieces should be handles only using the tongs.

Result:

Thus the required butt joint is obtained as per the given dimensions.

VIVA QUESTIONS AND ANSWERS

1. Name the types of welding.

(i) Arc welding (ii) Argon welding (Iii) Gas welding (iv) Tig welding (v) Mig welding (vi) Spot welding

2. Which is are the types of joint?

Butt joint, T - joint, Lap joint.

3. What is welding?

Joining of two similar metals

4. Name the welding tools used in workshop.

Welding holder, welding rod, hand shield, hand gloves, chipping hammer, wire brush

5. Which outer cover is on the welding rod?

Silicon

6. What is the use of welding holder?

It hold the electrode firmly.

7. What is the use of hand shield?

It protects the face from sparks.

8. What is the use of hand gloves?

It protects the hands from sparks.

9. What is the use of chipping hammer?

It is used to remove the waste material from welded metal.

10. What is the use of wire brush?

It is used to clean the outer surface of welded metal.

VIVA QUESTIONS AND ANSWERS

1. Which welding process uses non-consumable electrodes?

   TIG welding

2. What is gas welding?

   Mixture of gases is used to produce high temperature flame.

3. What is filler material?

   It is the material added to the weld pool to assist in filling the gap.

4. What is flux?

   Flux avoids oxidation in welding flame by giving a cover.

5. What are the advantages of using LPG over acetylene for cutting?

   LPG fuel produces rich flame for cutting process.

6. Which equipment is used to supply power for welding?

   Welding transformer

7. What is over head welding?

   Welding done at the top of welding booth is called overhead welding.

8. What are the applications of welding?

   Fabrication of steel windows and rods.

9. What is flux change in welding?

   Flux change is done to switch from one type of welding to other.

10. What are the advantages of using electric arc welding?

    EAW can be done without the use of oxygen cylinder.

VIVA QUESTIONS AND ANSWERS

1. What is arc welding?

Electric arc is produced between carbon electrode and work piece to produce heat.

2. What is electrode?

Filler rods used in arc welding are called electrodes.

3. Name the materials used for coating on electrodes.

Copper, Carbon and Graphite.

4. What are the types of resistance welding?

Spot welding, Projection welding and Butt welding.

5. What are the welding defects?

Undercut, Cracking and Incomplete penetration.

6. What is coating done on electrode surface?

Coating is done to avoid melting of electrode.

7. What is butt joint?

Work pieces are welded to either sides.

8. What is lap joint?

Work pieces are welded one over other.

9. What is T- joint?

Work pieces are welded at perpendicular to each other.

10. What is corner joint?

Work pieces are welded at the corners.

FOUNDRY
&
SMITHY

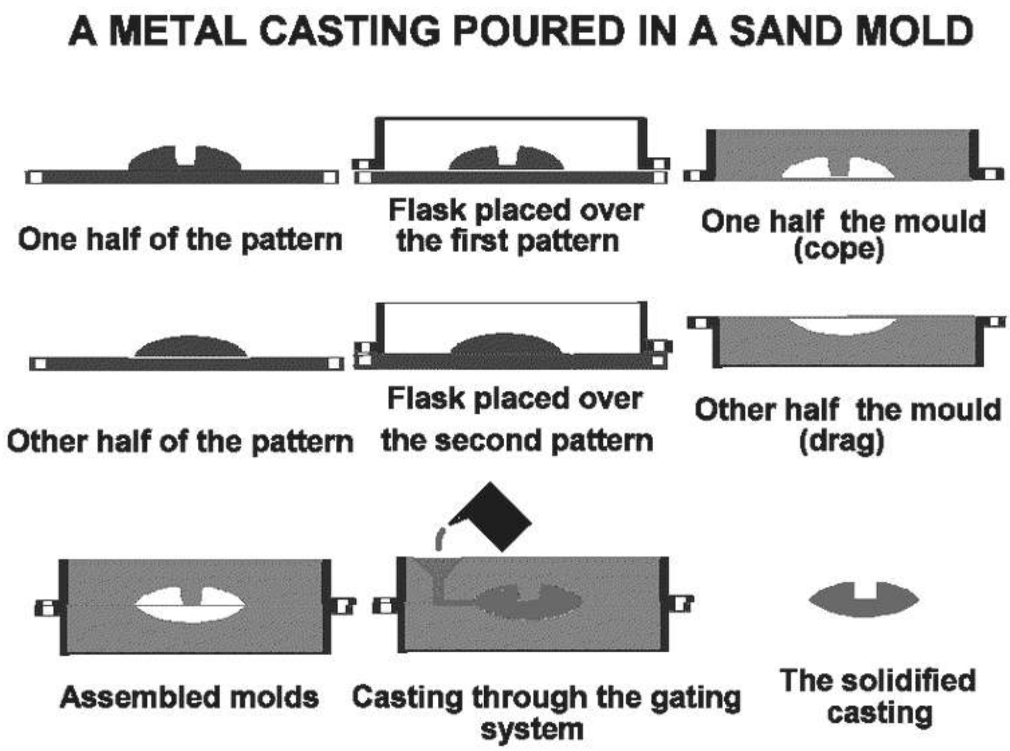
FOUNDRY

A foundry is a factory which produces metal castings from either ferrous or non-ferrous alloys. Metals are turned into parts by melting the metal into a liquid, pouring the metal in a mold, and then removing the mold material or casting. The most common metal alloys produced are aluminum and cast iron. However, other metals, such as steel, magnesium, copper, tin, and zinc, can be processed.

A sand casting or a sand molded casting is a cast part produced by forming a mold from a sand mixture and pouring molten liquid metal into the cavity in the mold. The mold is then cooled until the metal has solidified. In the last stage the casting is separated from the mold. There are six steps in this process:

1. Place a pattern in sand to create a mold.
2. Incorporate a gating system.
3. Remove the pattern.
4. Fill the mold cavity with molten metal.
5. Allow the metal to cool.
6. Break away the sand mold and remove the casting.

There are two main types of sand used for molding. "Green sand" is a mixture of silica sand, clay, moisture and other additives. The "air set" method uses dry sand bonded to materials other than clay, using a fast curing adhesive. When these are used, they are collectively called "air set" sand castings to distinguish these from "green sand" castings. Two types of molding sand are natural bonded (bank sand) and synthetic (lake sand), which is generally preferred due to its more consistent composition.



Foundry hand tools

The hand tools commonly used in foundry are as follows.

1. **Shovel**

It is used for mixing molding sand and for filling molding sand into the flask. A shovel is shown in fig. (a)

2. **Riddle**

Riddle is used for removing foreign materials from the moulding sand. It is shown in fig. (b)

3. **Rammer**

This is used for packing or ramming the sand into the mould. Hand rammers are shown in fig. (c) For large moulds, machine rammers are used.

4. **Trowel**

A trowel is used for smoothening the surfaces of the mould. It is shown in fig.(d)

5. **Sprue pin**

It is a conical wooden pin, which is used while making the mould, for making an opening to pour the molten material into the cavity. A sprue pin is shown in fig. (e).

6. Vent rod

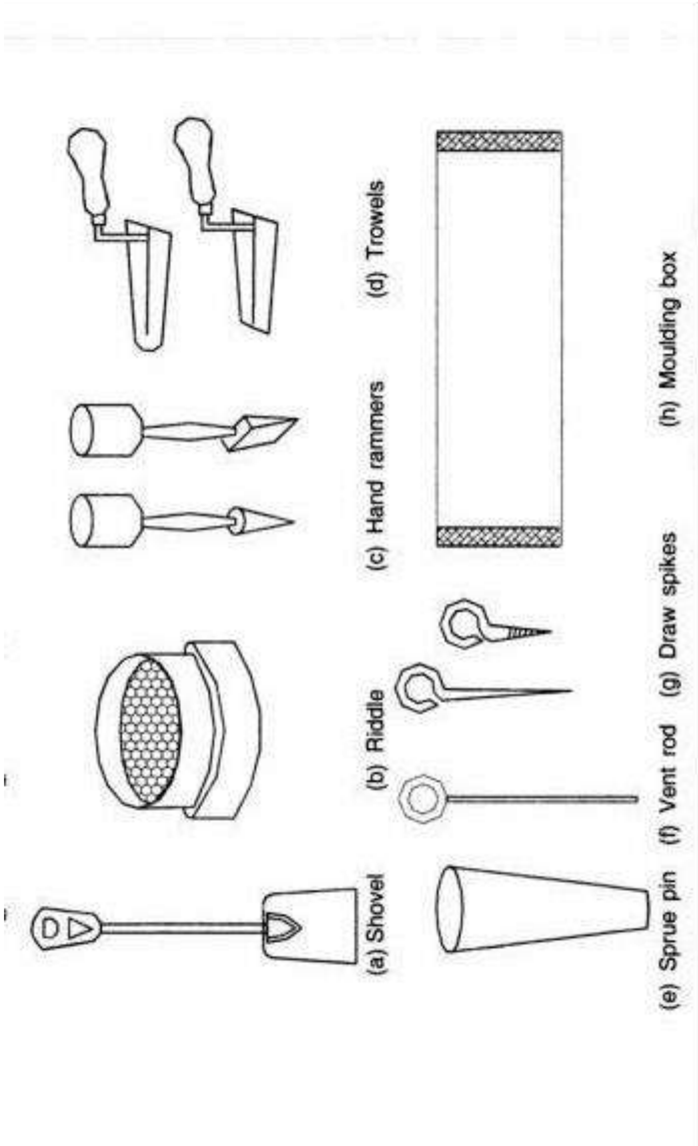
Vent rod is used for making small holes to permit gases to escape while the molten material is being poured. Fig. (f) shows a vent rod.

7. Draw spike

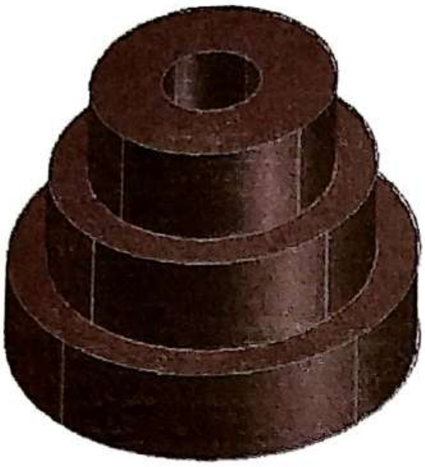
This is used for drawing patterns from the sand. It has a loop at one end for pulling up the pattern from the mould. Draw spike is shown in fig. (g)

8. Moulding boxes

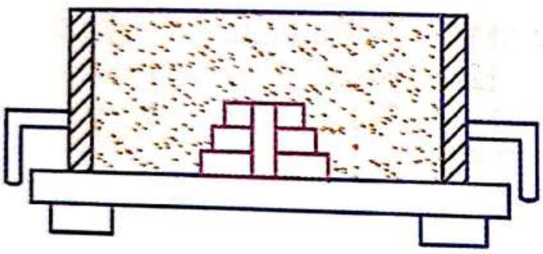
These are also known as moulding flasks. Moulding boxes are rigid frames made of iron or wood to hold the sand. The purpose of the flask is to impart necessary rigidity and strength to the rammed sand. Complete process of moulding is done in the moulding boxes. They are usually made in two parts, which are assembled with each other by pins on either side of the flasks. The top flask is called cope and the bottom flask is called drag. If the boxes are made in three sections then the middle one is called as cheek.

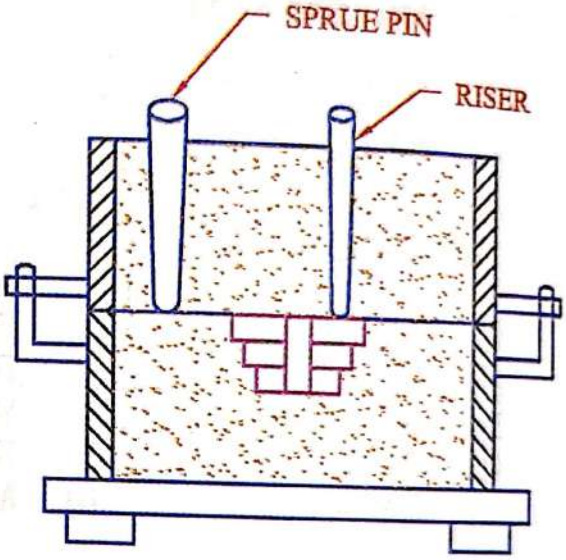

(a) Shovel
(b) Riddle
(c) Hand rammers
(d) Trowels
(e) Sprue pin
(f) Vent rod
(g) Draw spikes
(h) Moulding box

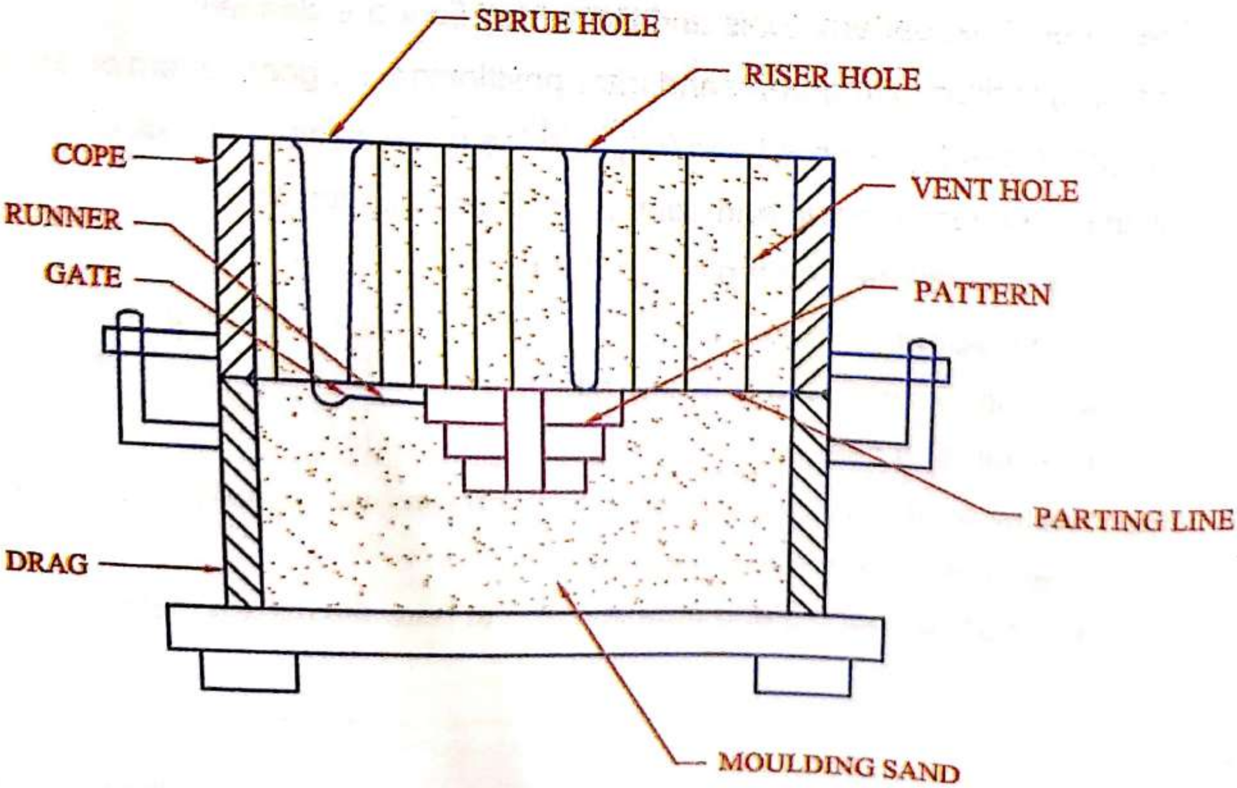
STEPPED CONE PULLEY



PATTERN







Ex. No. 2

Date: ________

STEPPED CONE PULLEY

AIM

To make the mould for the given stepped cone pulley pattern.

MATERIALS REQUIRED

1. Moulding Sand
2. Parting Sand
3. Facing Sand

TOOLS REQUIRED

1. Trowel
2. Lifter
3. Gate Cutter
4. Swab
5. Bellow
6. Rammer
7. Runner
8. Vent Wire
9. Riddle
10. Moulding Box
11. Strike off bar
12. Riser
13. Draw Spike
14. Sprue Pin

PROCEDURE

1. The mould box, pattern, tools and the table / floor are cleaned.
2. A suitable core is prepared with the help of core box.
3. The drag box is placed above the moulding board. Now the pattern is kept at center of the drag.
4. Now parting sand is sprinkled before we keep the pattern.
5. Facing sand is sprinkled over the pattern to a depth of **5 mm**. Then green sand filled over it.
6. Proper ramming is done on the green sand to get a air tight packing. Excess sand is removed by strike off bar.
7. The drag box is inverted upside down. The cope box is placed over the drag box and locked.
8. The riser pin and sprue pin is placed at right position and green sand is filled over the pattern.
9. Proper ramming is done on the green sand to get air tight packing, with strike off bar levelling is done.
10. The pattern is removed by draw spike tool.
11. Gate is prepared using gate cutter and core is placed vertically inside the cavity.
12. The vent holes are made with vent wire on the cope.

RESULT

Thus, the mould for the given stepped cone pulley pattern is developed.

SMITHY

Black smithy or forging is an ancient trade. It consists of heating a metal stock till it acquires sufficient plasticity, followed by hand forging, involving hammering, bending, pressing etc., till the desired shape is attained.

Hand forging is the term used when the process is carried out by hand tools. The hand forging process is generally employed for relatively small components. If power operated machines are used for the purpose, it is known as machine forging.

Advantages of forging

1. Strength and toughness is high
2. Strength to weight ratio is high
3. Internal defects are eliminated.

A blacksmith is a person who creates objects from iron or steel by "forging" the metal; i.e., by using tools to hammer, bend, cut, and otherwise shape it in its non-liquid form. Usually the metal is heated until it glows red or orange as part of the forging process. Blacksmiths produce things like wrought iron gates, grills, railings, light fixtures, furniture, sculpture, tools, agricultural implements, decorative and religious items, cooking utensils etc.

Forging Operations

There are five basic operations or techniques employed in forging: drawing, shrinking, bending, upsetting, and punching.

These operations generally employ hammer and anvil at a minimum, but smiths will also make use of other tools and techniques to accommodate odd-sized or repetitive jobs.

Drawing

Drawing lengthens the metal by reducing one or both of the other two dimensions. As the depth is reduced, the width narrowed, or both the piece is lengthened or "drawn out". As an example of drawing, a smith making a wood chisel might flatten a square bar of steel, lengthening the metal, reducing its depth but keeping its width consistent.

Upsetting

Upsetting is the process of making metal thicker in one dimension through shortening in the other. One form is by heating the end of a rod and then hammering on it as one would drive a nail: the rod gets shorter, and the hot part widens. An alternative to hammering on the hot end would be to place the hot end on the anvil and hammer on the cold end, or to drop the rod, hot end down, onto a piece of steel at floor level.

Shrinking

Shrinking, while similar to upsetting, is essentially the opposite process as drawing. As the edge of a flat piece is curved,—as in the making of a bowl shape—the edge will become wavy as the material bunches up in a shorter radius. At this point the wavy portion is heated and the waves are gently pounded flat to conform to the desired shape.

Bending

Heating steel to an orange heat allows bending. Bending can be done with the hammer over the horn or edge of the anvil, or by inserting the work into one of the holes in the top of the anvil and swinging the free end to one side. Bends can be dressed and tightened or widened by hammering them over the appropriately-shaped part of the anvil.

Punching

Punching may be done to create a decorative pattern, or to make a hole. For example, in preparation for making a hammerhead, a smith would punch a hole in a heavy bar or rod for the hammer handle. Punching is not limited to depressions and holes. It also includes cutting, or slitting and drifting: these are done with a chisel.

Hand Forging Tools

All a smith needs is something to heat the metal, [something to hold the hot metal with,] something to hit the metal on, and something to hit the metal with."

Anvil

The anvil at its simplest is a large block of iron or steel. Over time this has been refined to provide a rounded horn to facilitate drawing and bending, a face for drawing and upsetting and bending, and one or more holes to hold special tools (swages or hardies) and facilitate punching. Often the flat surface of an anvil will be hardened steel, and the body made from tougher iron.

Tongs

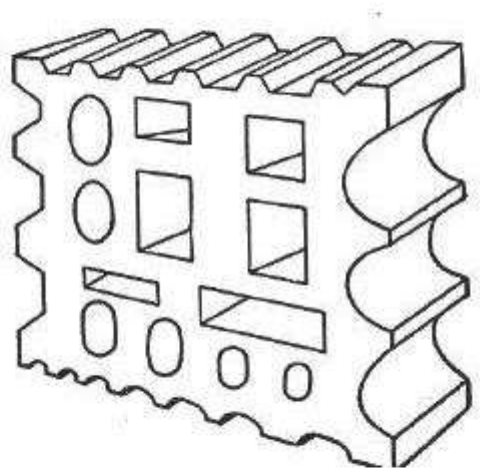
Tongs are used to hold the hot metal. They come in a range of shapes and sizes. Intriguingly, while tongs are needed for a great deal of blacksmithing, much work can be done by merely holding the cold end with one's bare hand: steel is a fairly poor conductor of heat, and orange-hot steel at one end would be cold to the touch a foot away or so.

Hammers

Blacksmiths' hammers tend to have one face and a peen. The peen is typically either a ball or a blunt wedge (cross or straight peen depending on the orientation of the wedge to the handle) and is used when drawing.

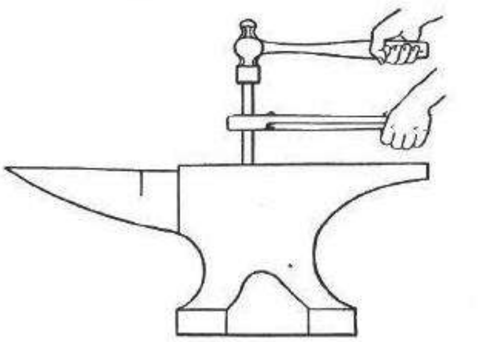
Swage block

Swages (hardies) and fullers are shaping tools. Swages are either stand alone tools or fit the "hardie hole" on the face of the anvil. The metal is shaped by being driven into the form of the swage. Opposite to the swage in some respects is the fuller which may take a number of shapes and is driven into the metal with a hammer. Swages and fullers are often paired to bring a piece of metal to shape in a single operation, essentially a set of dies. A fuller and swage pair might be spoon shaped, for example, the swage dished to form the bowl and the fuller the convex mirror of the swage. Together they will quickly stamp a spoon shape on the end of a bar.

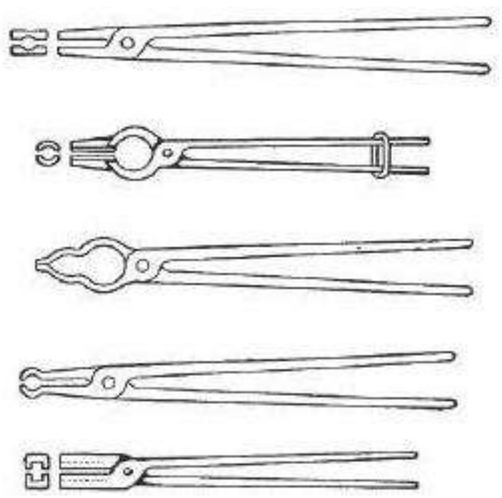


SWAGE BLOCK

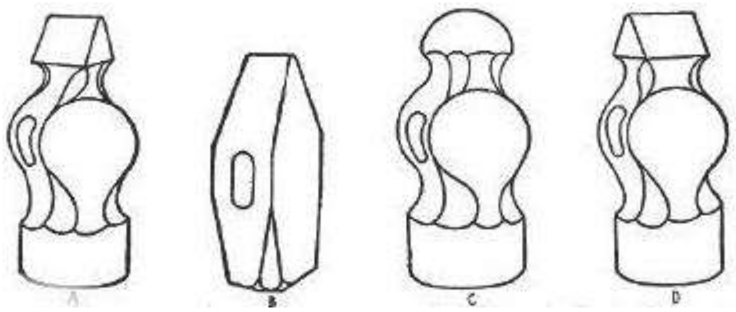
FULLER



ANVIL



TONGS

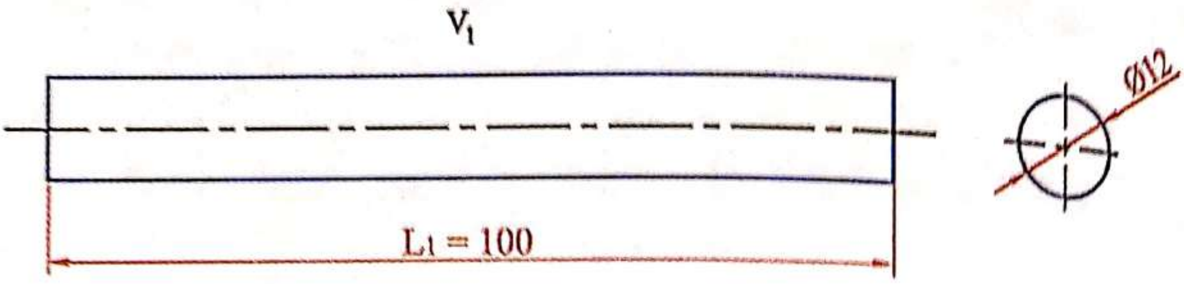


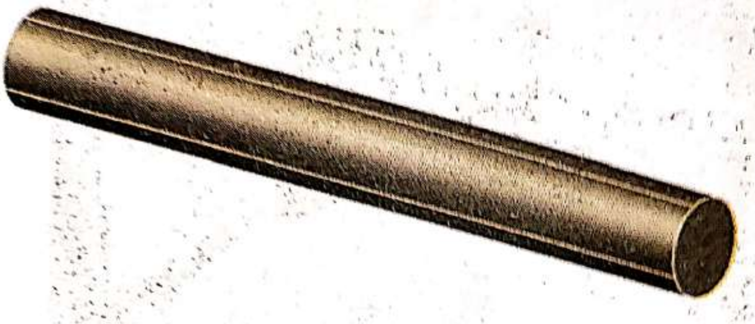
A & B - CROSS PEEN HAMMER

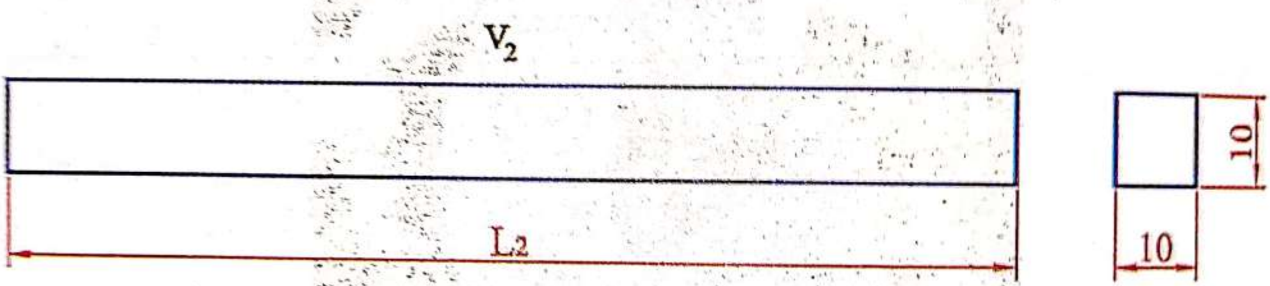
C – BALL PEEN HAMMER

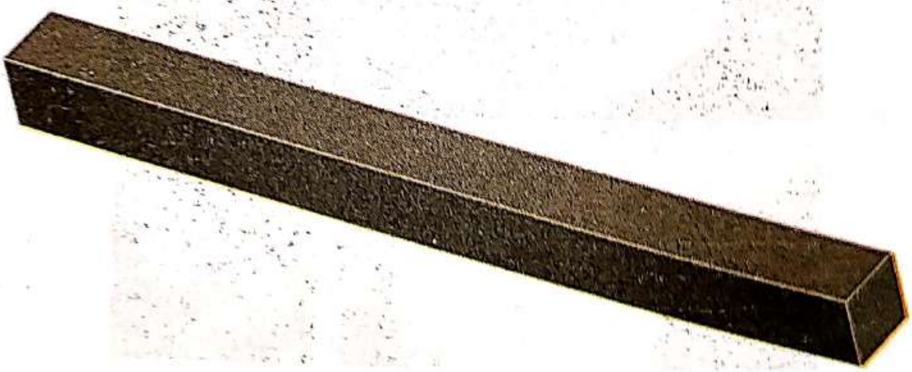
D – STRAIGHT PEEN HAMMER

ROUND ROD TO SQUARE ROD









Volume of round rod = Volume of square rod

$V_1 = V_2$

$$\frac{\pi}{4} d_1^2 . l_1 = a^2 . l_2$$

$$\frac{\pi}{4} \times 12^2 \times 100 = 10^2 \times l_2$$

$$l_2 = 113 \text{ mm}$$

Ex. No. 1

Date: ____________

ROUND ROD TO SQUARE ROD

AIM

To make a 10 mm square rod from a given round rod.

MATERIAL SUPPLIED

Mild Steel rod of diameter **12 mm** and length **100 mm.**

TOOLS REQUIRED

1. Anvil
2. Hand Hammer
3. Tongs
4. Flatter
5. Furnace, etc.

SEQUENCE OF OPERATIONS

1. Heating
2. Hammering
3. Flattening
4. Squareness Checking
5. Cooling

PROCEDURE

1. One end of the given round rod is heated in the furnace.
2. When the job is red hot, place it on the anvil using the tong.
3. Hit the job hard using the hammer and hold the job carefully using the tong while hammering.
4. Change the position of the job and repeat hammering to change the rod from round to square.
5. Repeat heating and hammering until the required square shape is obtained.
6. Heat the other end of the rod by reversing it.
7. Also repeat hammering and heating to get the required size and shape.
8. The flatter is used to obtain a fine finish on the job.
9. Finally, the job is cooled by dipping it in water.

RESULT

Thus, the given round rod is transformed to a square rod for the required dimensions.

PLUMBING

Plumbing is a skilled trade of working with pipes or tubes and plumbing fixtures. The process is mainly used for the supply of drinking water and the drainage of waste water, sometimes mixed with waste floating materials in a living or working place. A plumber is someone who installs or repairs piping systems, plumbing fixtures and equipment such as valves, washbasins, water heaters, water closests, etc. Thus it usually refers to a system of pipes and fixtures installed in a building for the distribution of water and the removal of waterborne wastes.

The latin word plumbum, means metal lead pipe, is the origin for developing the term plumbing. Plumbing process was originated during the ancient civilizations such as the greek, Roman, Persian, Indian and Chinese civilizations as they developed public baths and needed to provide potable water, and drainage of wastes carried by water.

PIPES AND THEIR JOINTS:

Pipes are manufactured by using different types of materials like steel, cast iron, galvanized iron, brass, copper, aluminum, lead, plastic, concrete, asbestos, etc. They are usually classified according to the material. They are also grouped as cast, welded, seamless, extruded, etc. For conveying large quantity of water, cast iron, steel or concrete pipes having large diameter are usually used. Galvanized iron pipes (GI pipes) are popular for medium and low pressure water supply lines.

Plastic pipes are preferred for household uses at low pressure. Pipes are generally specified by their inner diameter (Nominal diameter specified in inches). Hence, the pipe fitting size is also based on this dimension. But for plastic pipes, this rule is not strictly followed because threading is not usually required for them. For engineering uses, along with the nominal diameter, the pipe thickness is also specified as light, medium or heavy.

Types of pipe joints:

According to the pipe material, size and application, different methods are used to join pipes. The most common types of pipe joints are:

1. Screwed pipe joint – For GI Pipes
2. Welded pipe joint – for steel, copper, aluminum and lead pipes
3. Flanged pipe joint – for cast iron and steel pipes
4. Soldered pipe joint – for brass and copper tubes
5. Glued or cemented pipe joint – for PVC pipes

Pipes made of iron (GI Pipes) and brass of small and medium diameters (10 mm to 100 mm) are usually joined by screwing the pipe specials with internal or external threads. Welding is used to make permanent joint of medium and large diameter steel pipes. Flanged pipe joints are common in medium and large diameter pipes of cast iron and steel, along with rubber/CAF (Compressed asbestos fibre) gaskets. The flanged are screwed to the pipe for smaller diameter but made integral for large diameters. Pipes of copper and brass are usually joined by soldering.

PVC (poly Vinyl Chloride) pipe is the most popular choice in plastic group. It is rigid and uses thread and solvent weld (glue) connections. It also can be heat fused. PVC pipes are available in various pressure ratings for water supply, and is a very choice for landscape irrigation. The reasons for the popularity are the economy, no corrosion and easiness to work. CPVC is a different type of plastic, which has an extra chlorine atom in the compound, can be used for the hot water supply, and in industry.

To join plastic pipes, gluing or cementing method is used. Solvent cement is the gluing material and it partially melts the surface of the plastic pipe to make the joint. As the glue evaporates within two minutes, a strong joint is obtained.

Screwed pipe fittings, (pipe specials) are removable or temporary pipe connections which permit necessary dismantling or reassembly for the purpose of installation, maintenance, cleaning, repair, etc. The functions of pipe fittings can be broadly classified as:

1. To join two or more pipe lines together
2. To effect change in diameter or direction
3. To close the end of a pipe line

The most common types of screwed pipe fittings used in galvanized iron (GI) pipe lines and plastic (PVC) pipe lines are shown in Figure 1 (I to 17). A brief description of these fittings is given below

1. **Coupler (coupling):** Two pipe lines of equal diameter and in axial alignment can be joined by a coupler (coupling). It is a short sleeve with internal thread.
2. **Reducer coupler** (Reducer coupling): This is a coupler to join two pipe lines of different diameters in axial alignment.
3. **90^0 Elbow:** This is a pipe special used or effecting abrupt change in direction through 90°. Internal threads are provided on both ends. An elbow brings twice the head loss than a bend.
4. **90^0 Reducer elbow:** This is an elbow with outlet diameter less than that of inlet diameter It is used to join two pipe lines having different diameters and meeting at right angle.
5.**Bend:** This is a pipe special used to effect gradual change in direction (usually 90°).The two ends of the bend are externally threaded.
6. **Return hand:** This bend is used to return the direction of pipe line through 180°.The ends are internally threaded for fitting the pipe lines.
1. **Tee:** This pipe special is used to make a branch connection of same diameter to the main pipe line at right angle. A Tee is internally threaded and it connects three ends of pipes.
8. **Reducer Tee:** This is a pipe special similar to Tee used to take a branch connection of reduced diameter from the main pipe line.
9, **Cross:** This pipe special is used to take two branch connections at right angles to the main pipe line. The threads are provided internally,
10. **Close nipple:** A nipple is a short straight piece of pipe with external thread on both ends. A close nipple is the shortest one of this category with external thread for the full length. They are used to join two internally threaded pipe specials and valves.
11. **Short nipple:** A short nipple has the same shape and function of a close nipple, but it has a short unthreaded portion at the middle of its length for gripping.
12. **Short nipple with hexagonal grip:** This nipple has an additional hexagonal nut shape at the middle portion for easy screwing with spanner. It is similar to an ordinary short nipple, except that difference.
13. **Hose nipple:** A hose nipple is used to connect a hose (flexible pipe-usually plastic or rubber) to a pipe line. One end of the hose-nipple has a stepped taper to fit the hose, while other end has thread. A hexagonal nut shape is given to the middle portion for gripping with a spanner.

14. **Male plug:** A male plug is used to close an internally threaded end of a pipe line or pipe special. It has external thread and a grip of square shape at the end.
15. **Female plug (cap):** A female plug is used to close an externally thread end of a pipe or pipe special. It has internal thread and a grip of square shape at the end.
16. **Screwed union:** II consists of three pieces as shown in the drawing. The two end pieces have internal threads at their ends which are connected to the pipe ends. The central hexagonal (or octagonal) piece (union nut) has internal thread at one end and a collar at the other end. After the end pieces are screwed on to the pipes, the central piece (union nut) is tightened to draw the end pieces together to get a water tight joint.
17. **Flange:** This is a disc type pipe special having threaded hole at the centre for screwing to the externally threaded end of a pipe line. It will have holes around the central hole at equal angular spacing (3, 4, 6f or 8 Nos.) for joining to another similar flange or flat surface using bolt or stud. Example for the use of various pipe fittings in pipe line is given in Figure 9.2

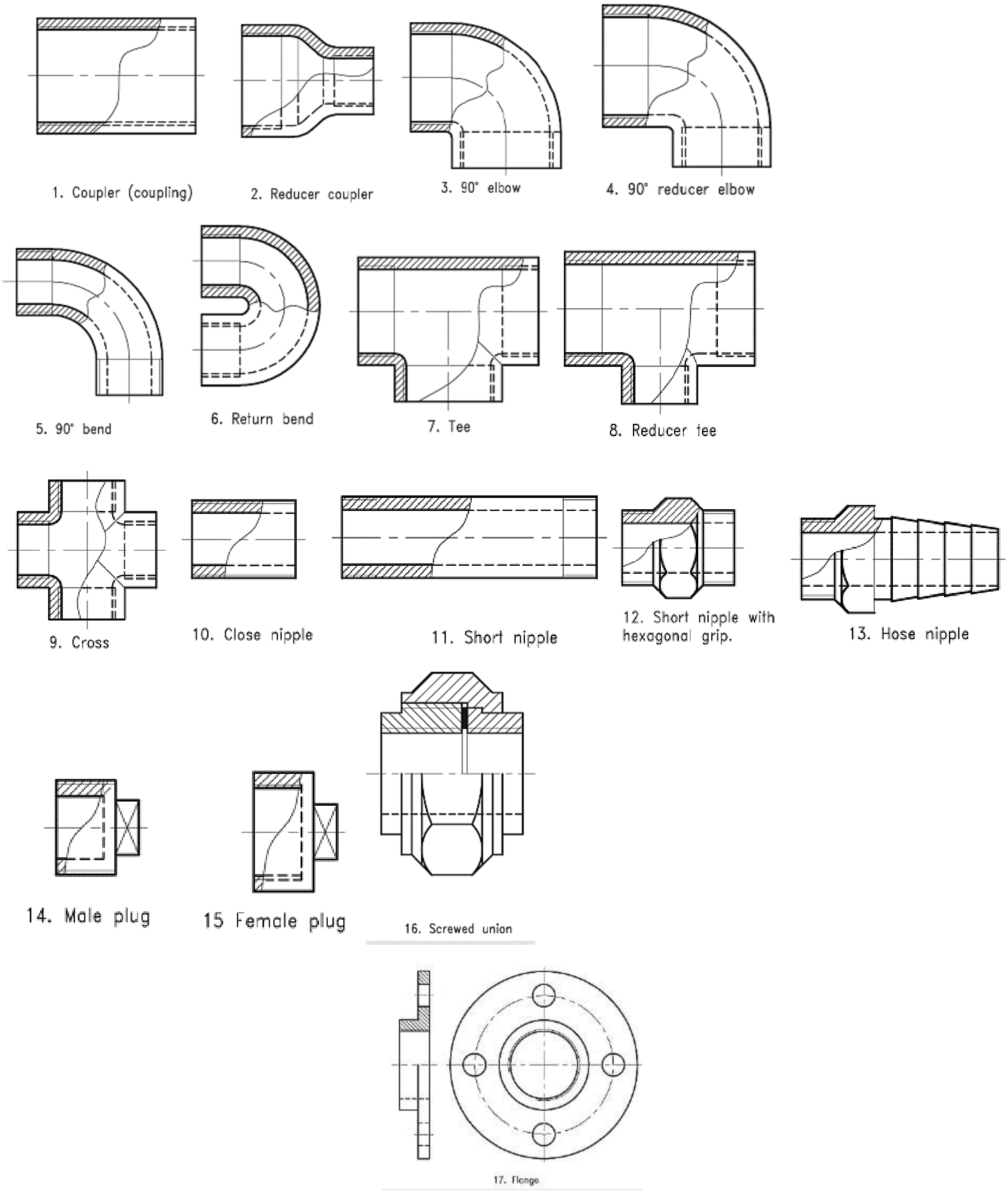


Figure 1: Various pipe joints.

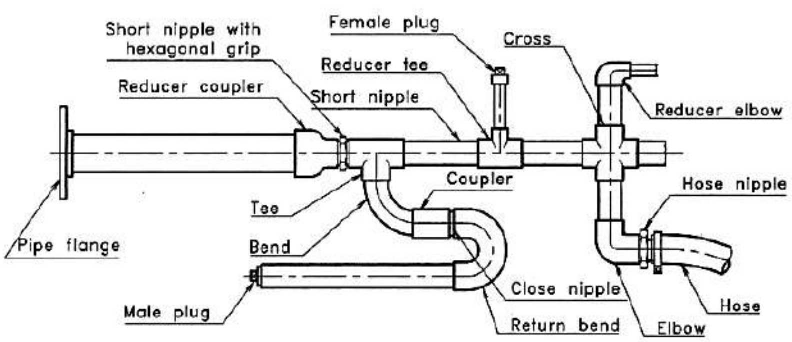


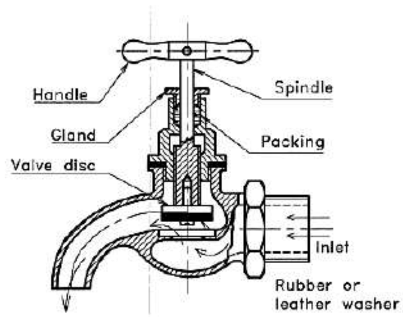
Figure 2: Application of various joints in the pipe fittings

Valves and Meters

Valves are used in piping systems to control or stop the flow of liquid or gas. The most common types of valves used in low pressure water pipe line are:

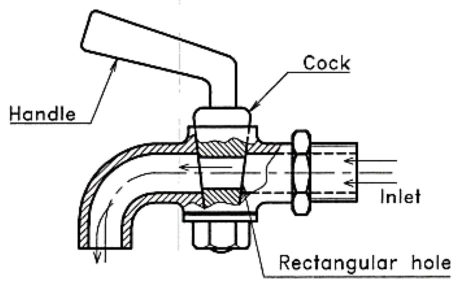
1. Water tap
2. Water cock
3. Globe valve
4. Gate valve
5. Ball valve
6. Non-return valve
7. Foot valve

Water tap



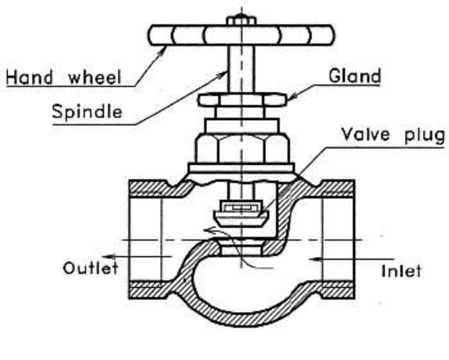
To collect water from low pressure pipe line, water tap (screw-down valve) is commonly used. Figure gives the cross section of the tap. Its leather or rubber faced valve disc is lifted or lowered by rotating the spindle. Brass or gun-metal is the material used for the valve body and the size is specified by the pipe to which it is fitted, usually ranging from 10 mm to 25 mm.

Water cock



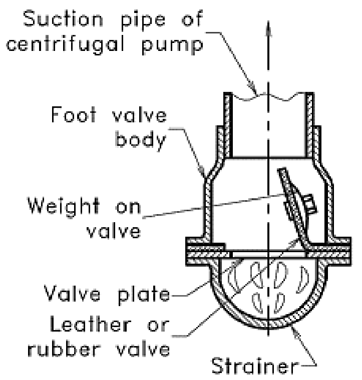
This is the simplest and smallest form of a valve in which a conical plug called cock is inserted into a conical hole having a matching taper. A rectangular hole is provided at the centre across the conical potion so that, in one position it permits flow of water as shown in Figure. A half turn of the handle will bring the solid portion of the cock to the water ways preventing the flow. Cocks are used for low rate of water flow' or for tapping pressure line to a manometer etc.

Globe valve



Globe valves are used as control valves in fluid (gas and liquid) pipe lines. Figure shows the simplest and smallest type of globe valve used in water pipe lines. Basically, the valve is a variable opening flow device. The design of a globe valve also creates a slight retardation to the flow because the fluid is forced to make a double turn and passes through the opening at 90° to the axis of the pipe. The valve plug is raised or lowered to stop or regulate the flow through a circular opening. A globe valve can be identified by the spherical body and the arrow mark for the direction of flow. These valves are used in water pipe lines from 12 mm to 100 mm or even larger diameter for the flow control purpose.

Gate valve: A gate valve is on-off type valve. It allows a straight-line movement of fluid and offer very little resistance to the flow in fully opened position. The central disc moves completely out of the passage and leaves a full opening. Figure shows a simple type of gate valve partially opened in position. These valves are very widely used in water pipe lines of diameter ranging from 12 mm to higher values. A gate valve can be identified by its slim body. It is to be noted that there will be no arrow mark or the body of valve because it can be used in both ways



Foot valve: Foot valve is a kind of non-return valve used in centrifugal pumps. It is fitted at the bottom most end of the suction pipe (Foot) to stop flow in the downward direction for priming purpose. The strainer restricts the entry of floating materials to the pipe line. Figure gives the details of the foot valve. The material used may be cast iron, brass, or PVC.

POWER TOOLS

INTRODUCTION:

Power tool is a powered by an electric motor, a compressed air motor, or a gasoline engine. Power tools are classified as either stationary or portable, where portable means handheld. They are used in industry, in construction, and around the house for cutting, shapping, drilling, sanding, painting, grinding, and polishing.

Stationary power tools for metalworking are usually called Machine tools.

The lathe is the oldest power tool, being known to the ancient Egyptians. Early industrial revolution-era factories had batteries of power tools driven by belts from overhead shafts. The prime power source was a water wheel or a steam engine.

Stationary power tools are prized not only for their speed, but for their accuracy. A table saw not only cuts faster than a hand saw, but the cuts are smoother, straighter and more square than even the most skilled man can co with a handsaw. Lathes produce truly round objects that cannot be made in any other way.

An electric motor is the universal choice to power stationary tools. Portable electric tools may be either corded or battery-powered.

Common power tools include the drill, various types of saws, the router, the electric sander, and the lathe.

The term power tool is also used in a more general sense, meaning a technique for greatly simplifying a complex or difficult task.

1. POWER HACKSAW:

A power hacksaw is a type of hacksaw that is powered either by its own electric motor (also known as electric hacksaw) or connected to a stationary engine. Most power hacksaw are stationary machines but some portable models do exist. Stationary models usually have a mechanism to lift up the saw blade on the return stroke and some have a coolant pump to prevent the saw blade from overheating.

While stationary electric hacksaw are reasonably uncommon they are still produced but saws powered by a stationary engines have gone out of fashion. The reason for using one is that they provide a cleaner cut than an angle grinder or other types of saw.

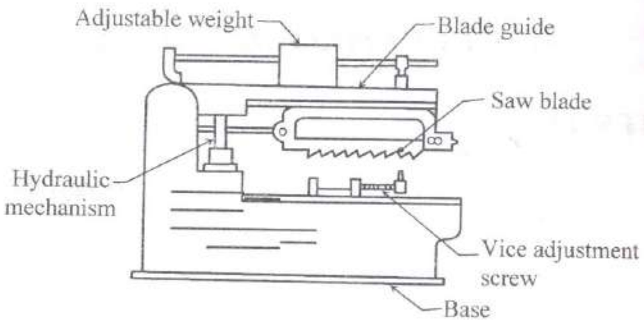


Fig. Power Hacksaw

Hand-Held circular saws:

The term circular saw is most commonly used to refer to a hand-held electric circular saw designed for cutting wood, which may be used less optimally for cutting other materials with the exchange of specific blades. Circular saws can be either left or right handed, depending on the side of the blade where the motor sits and which hand the operator uses when holding a saw.

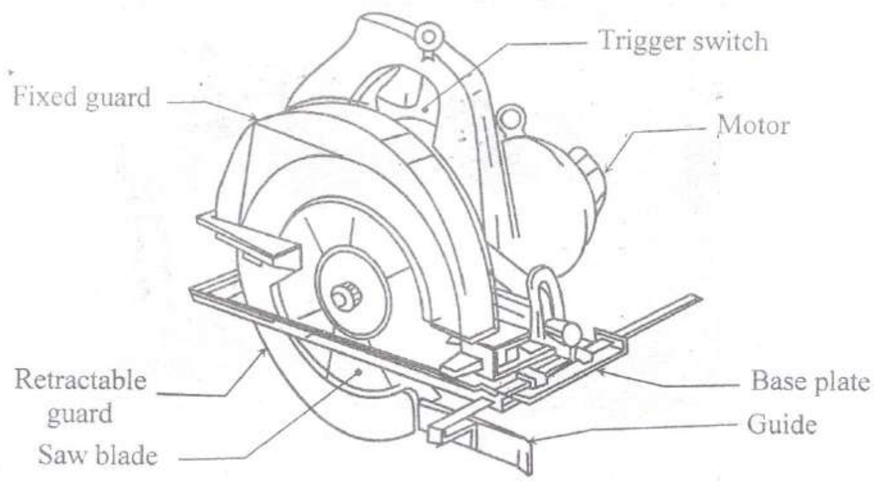


Fig. Circular saw (Portable)

5. DRILL:

A drill is a tool with a rotating drill bit used for drilling holes in various materials. Drills are commonly used in woodworking, metalworking. Special designed drills are also used in medical and other applications such as in space missions.

The drill bit is gripped by a chuck at one end of the drill and rotated while pressed against the target material. The tip of the drill bit does the work of cutting into the target material, either slicing off thin shavings (twist drills or auger bits), grinding of small particles (oil drilling), or crushing and removing pieces of the work piece (masonry drill).

8. BENCH GRINDER:

A bench grinder or pedestal grinder is a machine used to drive an abrasive wheel (or wheels).

Depending on the grade of the grinding wheel it may be used for sharpening cutting tools such as lathe tools or drill bits. Alternatively it may be used to roughly shape metal prior to welding or fitting.

A wire brush wheel or buffing wheel can be interchanged with the grinding wheels in order to clean or polish work-pieces.

MACHINES

Demonstration of lathe, shaper drilling and grinding

LATHE

The lathe is used for producing cylindrical work. The work piece is rotated while the cutting tool movement is controlled by the machine. The lathe is primarily used for cylindrical work. The lathe may also be used for: Boring, drilling, tapping, turning, facing, threading, polishing, grooving, knurling etc.

The purpose of a lathe is to rotate a part against a tool whose position it controls. It is useful for fabricating parts and/or features that have a circular cross section. The spindle is the part of the lathe that rotates. Various work holding attachments such as three jaw chucks, collets, and centers can be held in the spindle. The spindle is driven by an electric motor through a system of belt drives and/or gear trains. Spindle speed is controlled by varying the geometry of the drive train.

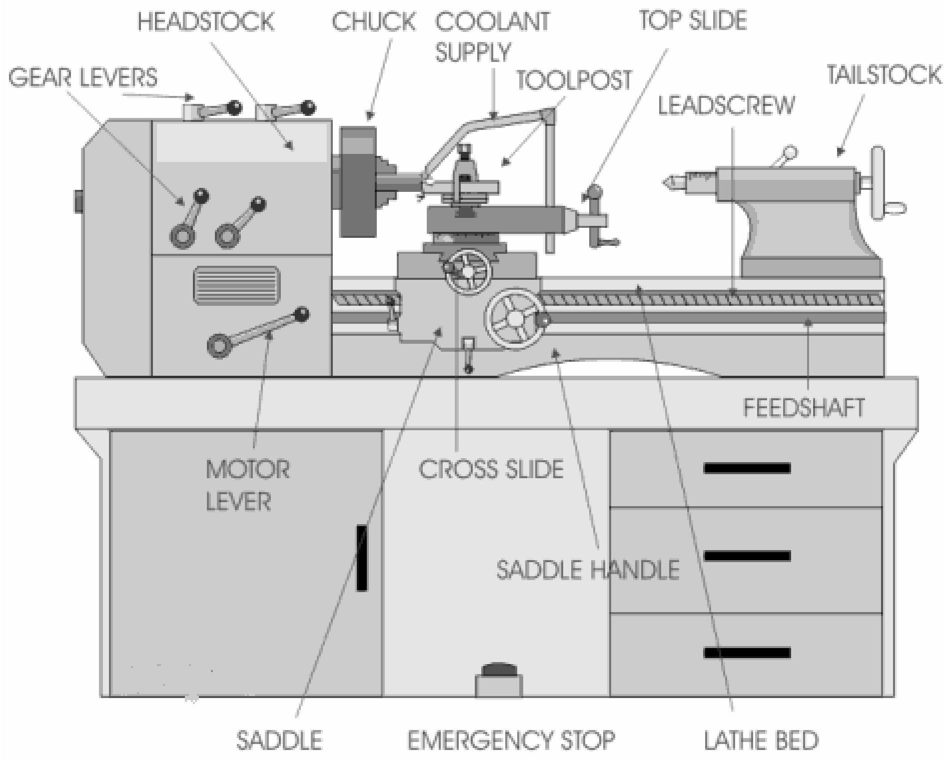
The tailstock can be used to support the end of the work piece with a center, or to hold tools for drilling, reaming, threading, or cutting tapers. It can be adjusted in position along the ways to accommodate different length work pieces. The ram can be fed along the axis of rotation with the tailstock hand wheel.

The carriage controls and supports the cutting tool. It consists of: A saddle that mates with and slides along the ways, an apron that controls the feed mechanisms, a cross slide that controls transverse motion of the tool (toward or away from the operator), a tool compound that adjusts to permit angular tool movement and a tool post T-slot that holds the tool post.

Feed, Speed, And Depth of Cut

Cutting speed is defined as the speed at which the work moves with respect to the tool. Feed rate is defined as the distance the tool travels during one revolution of the part. Cutting speed and feed determines the surface finish, power requirements, and material removal rate. The primary factor in choosing feed and speed is the material to be cut. However, one should also consider material of the tool, rigidity of the work piece, size and condition of the lathe, and depth of cut. To calculate the proper spindle speed, divide the desired cutting speed by the circumference of the work.

Parts of Lathe



Head Stock

The headstock houses the main spindle , speed change mechanism , and change gears The headstock is required to be made as robust as possible due to the cutting forces involved, which can distort a lightly built housing, and induce harmonic vibrations that will transfer through to the work piece, reducing the quality of the finished work piece

Bed

The bed is a robust base that connects to the headstock and permits the carriage and tailstock to be aligned parallel with the axis of the spindle. This is facilitated by hardened and ground ways which restrain the carriage and tailstock in a set track. The carriage travels by means of a rack and pinion system, leads crew of accurate pitch, or feed screw.

Feed and lead screws

The feed screw is a long driveshaft that allows a series of gears to drive the carriage mechanisms. These gears are located in the apron of the carriage. Both the feed screw and lead screw are driven by either the change gears or an intermediate gearbox known as a quick change gearbox or Norton gearbox. These intermediate gears allow the correct ratio and direction to be set for cutting threads or worm gears. Tumbler gears are provided between the spindle and gear train that enables the gear train of the correct ratio and direction to be introduced. This provides a constant relationship between the number of turns the spindle makes, to the number of turns the lead screw makes. This ratio allows screw threads to be cut on the work piece without the aid of a die.

Carriage

In its simplest form the carriage holds the tool bit and moves it longitudinally (turning) or perpendicularly (facing) under the control of the operator. The operator moves the carriage manually via the hand wheel or automatically by engaging the feed screw with the carriage feed mechanism, this provides some relief for the operator as the movement of the carriage becomes power assisted. The hand wheels on the carriage and its related slides are usually calibrated both for ease of use and to assist in making reproducible cuts.

Cross-slide

The cross-slide stands atop the carriage and has a lead screw that travels perpendicular to the main spindle axis, this permit facing operations to be performed. This lead screw can be engaged with the feed screw (mentioned previously) to provide automated movement to the cross-slide; only one direction can be engaged at a time as an interlock mechanism will shut out the second gear train.

Compound rest

The compound rest is the part of the machine where the tool post is mounted. It provides a smaller amount of movement along its axis via another lead screw. The compound rest axis can be adjusted independently of the carriage or cross-slide. It is utilized when turning tapers, when screw cutting or to obtain finer feeds than the lead screw normally permits.

Tool post

The tool bit is mounted in the tool post which may be of the American lantern style, traditional 4 sided square styles, or in a quick change style. The advantage of a quick change set-up is to allow an unlimited number of tools to be used (up to the number of holders available) rather than being limited to 1 tool with the lantern style, or 3 to 4 tools with the 4 sided type.

Tail Stock

The tailstock is a tool holder directly mounted on the spindle axis, opposite the headstock. The spindle does not rotate but does travel longitudinally under the action of a lead screw and hand wheel. The spindle includes a taper to hold drill bits, centers and other tooling. The tailstock can be positioned along the bed and clamped in position as required. There is also provision to offset the tailstock from the spindles axis; this is useful for turning small tapers.

Lathe Operations

Turning

Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface:

- with the work piece rotating,
- with a single-point cutting tool, and
- with the cutting tool feeding parallel to the axis of the work piece and at a distance that will remove the outer surface of the work.

Taper turning is practically the same, except that the cutter path is at an angle to the work axis. Similarly, in contour turning, the distance of the cutter from the work axis is varied to produce the desired shape

Facing

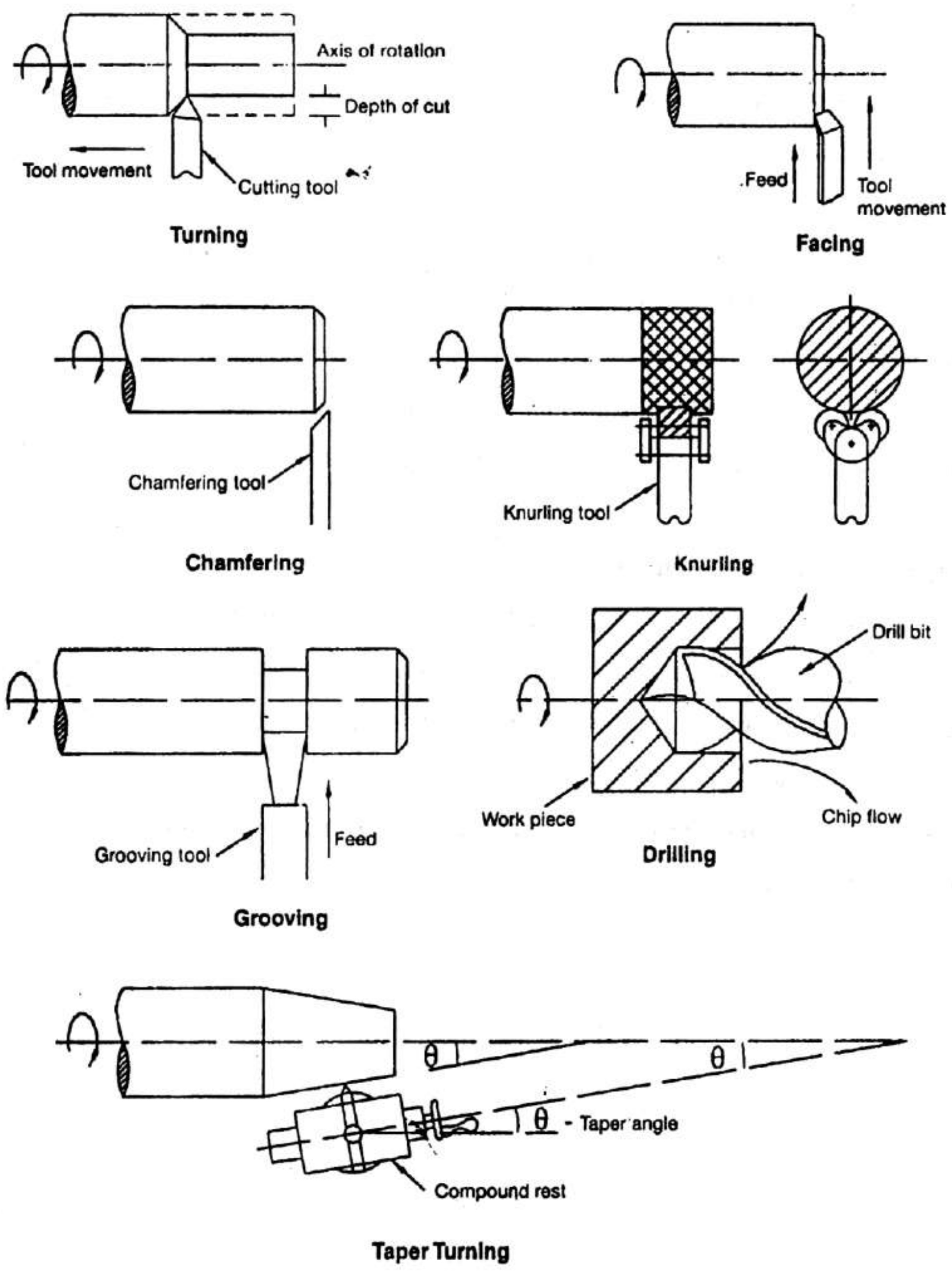
Facing is the producing of a flat surface as the result of a tool's being fed across the end of the rotating work piece. Unless the work is held on a mandrel, if both ends of the work are to be faced, it must be turned end for end after the first end is completed and the facing operation repeated. The cutting speed should be determined from the largest diameter of the surface to be faced. Facing may be done either from the outside inward or from the center outward. In either case, the point of the tool must be set exactly at the height of the center of rotation.

Parting

Parting is the operation by which one section of a work piece is severed from the remainder by means of a cutoff tool. Because cutting tools are quite thin and must have considerable overhang, this process is less accurate and more difficult. The tool should be set exactly at the height of the axis of rotation, be kept sharp, have proper clearance angles, and be fed into the work piece at a proper and uniform feed rate.

Drilling

A lathe can also be used to drill holes accurately concentric with the centerline of a cylindrical part. First, install a drill chuck into the tail stock. Make certain that the tang on the back of the drill chuck seats properly in the tail stock. Withdraw the jaws of the chuck and tap the chuck in place with a soft hammer.



Move the saddle forward to make room for the tailstock. Move the tailstock into position, and lock the bit in place. Before starting the machine, turn the spindle by hand. Just move the saddle forward, so it could interfere with the rotation of the lathe chuck. Always use a center drill to start the hole. .

Boring

Boring is an operation in which a hole is enlarged with a single point cutting tool. A boring bar is used to support the cutting tool as it extends into the hole. Because of the extension of the boring bar, the tool is supported less rigidly and is more likely to chatter. This can be corrected by using slower spindle speeds or by grinding a smaller radius on the nose of the tool.

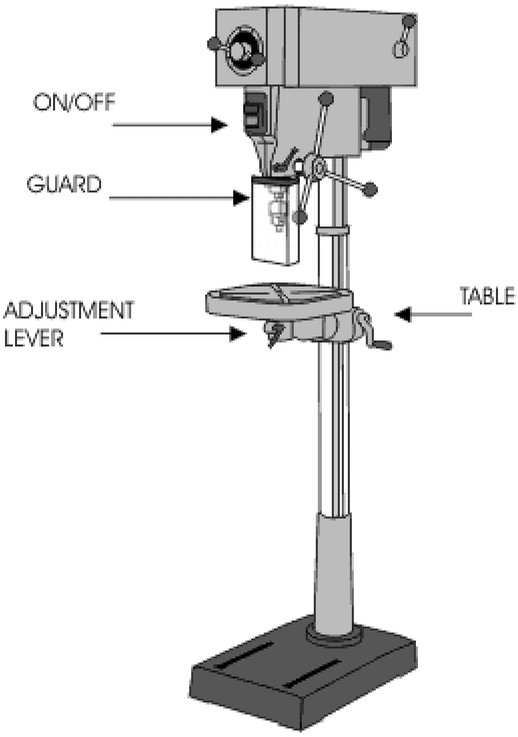
Single Point Thread Turning

External threads can be cut with a die and internal threads can be cut with a tap. But for some diameters, no die or tap is available. In these cases, threads can be cut on a lathe. A special cutting tool should be used, typically with a 60 degree nose angle. To form threads with a specified number of threads per inch, the spindle is mechanically coupled to the carriage lead screw. Procedures vary for different machines

Drilling Machine

The machine which performs the drilling operation is known as drilling machine. There are two types of machine drill, the bench drill and the pillar drill. The bench drill is used for drilling holes through materials including a range of woods, plastics and metals. It is normally bolted to a bench so that it cannot be pushed over and that larger pieces of material can be drilled safely.

The larger version of the machine drill is called the pillar drill. This has a long column which stands on the floor. This can do exactly the same work as the bench drill but because of its larger size it is capable of being used to drill larger pieces of materials and produce larger holes.



SAFETY MEASURES

1. Always use the guard.
2. Wear goggles when drilling materials.
3. Clamp the materials down or use a machine vice.

4. Never hold materials by hand while drilling.

5. Always allow the ‘chippings’ to clear the drill by drilling a small amount at a time.

6. Follow all teacher instructions carefully.

TYPES OF DRILLING MACHINE

1. Portable drilling machine
2. Sensitive drilling machine
3. Upright drilling machine
4. Radial drilling machine
5. Gang drilling machine
6. Multi spindle drilling machine

Bench Drill

The bench drill is a smaller version of the pillar drill. This type of machine drill is used for drilling light weight pieces of material. The work piece is held safely in a hand vice which is held in the hand. NEVER hold work directly in the hand when drilling. The on and off buttons are found on the left hand side of the machine and the handle controlling the movement of the drill on the right. Most bench drills will also have a foot switch for turning off the drill. The hand vice is one safe way of holding material whilst drilling. It has two jaws that are closed by turning a wing nut.

Drilling Operations

1. Drilling

It is the operation by which circular holes can be produced by rotating a tool called drill bit against the work piece. Using centre punch the centre of the hole is marked before drilling. The hole produced by drilling will be rough and of less accuracy.

2. Reaming

It is the operation of finishing and sizing the already drilled hole. The tool used is called reamer. It removes very little amount of metal to finish the hole.

3. Boring

The operation to enlarge the drilled hole is called boring. For boring, the cutter is held in a boring bar and is fixed to the spindle. It gives good surface finish.

4. Counter boring

To seat the heads of socket, screw and studs, a drilled hole is enlarged to a given depth. This operation is called counter boring.

5. Counter sinking

The operation of machining a conical enlargement at the top of a drilled hole is called counter sinking.

VIVA QUESTIONS AND ANSWERS

1. What is a lathe?

   Lathe is a machine, which removes the metal from a piece of work to the required shape and size.

2. What is the various operations can be performed on a lathe?
   Turning, Facing, Chamfering, Drilling, Thread cutting, Grooving, Knurling and Tapping

3. What are principle parts of lathe?

   Red, headstock, tailstock, carriage, cross slide, tool post

4. What are the types of headstock?

   Back geared type, all geared type

5. State the various parts mounted on the carriage.
   Saddle, compound rest, cross slide, tool Post

6. What are the four types of tool post?
   1. Single screw
   2. Open side
   3. Four bolt
   4. Four way

7. What is a Chamfering?

   A cut that is made on the edge of work piece at 45degrees angle to the adjacent principal faces.

8. State any two specification of lathe.

   1. The height of centers from the bed
   2. The maximum length of the bed

9. List any three types of lathe.
   1. Engine lathe
   2. Bench lathe
   3. Tool room lathe

10. What is a semi-automatic lathe?

The lathe in which all the machining operations are performed automatically and loading and unloading of work piece, coolant on or off is performed manually

VIVA QUESTIONS AND ANSWERS

1. What is copying lathe?

   The tool of the lathe follows a template or master through a stylus or tracer

2. State the various feed mechanisms used for obtaining automatic feed.

   a. Tumbler gear mechanism
   b. Quick change gearbox
   c. Tumbler gear- Quick change gearbox

3. List any four holding devices.

   d. Chucks
   e. Centers
   f. Face plate
   g. Angle plate

4. What are the different operations performed on the lathe?
Centering, straight turning, rough turning, finish turning, shoulder turning, facing, chamfering, knurling, etc

5. Define the term ‘Conicity’.

   The ratio of the difference in diameters of taper to its length k = (D-d)/l

   d-smallerdia D-bigger dia
   l-length of the work piece.

6. What is the use of chuck?

   Chuck is used to hold the work piece firmly.

7. What are the types of chuck based on numbering?

   Three jaw and four jaw Chuck.

8. What is the use of tail stock?

   Tail stock is used to support the rear end of work piece.

9. Where is the motor located in lathe?

   It is adjacent to the head stock.

10. What is the use of knurling?

    It is to provide grip to the work piece.

VIVA QUESTIONS AND ANSWERS

1. What is the use of drilling machine?

   It used to makes holes of required size in work pieces.

2. What are the drilling operations?

   Drilling, reaming, boring, counter boring and counter sinking.

3. What is Reaming?

It is the operation of finishing and sizing the already drilled hole. The tool used is called reamer. It removes very little amount of metal to finish the hole.

4. What is Boring?

The operation to enlarge the drilled hole is called boring. For boring, the cutter is held in a boring bar and is fixed to the spindle. It gives good surface finish.

5. What is counter boring?

To seat the heads of socket, screw and studs, a drilled hole is enlarged to a given depth. This operation is called counter boring.

6. What is counter sinking?

The operation of machining a conical enlargement at the top of a drilled hole is called counter sinking.

7. What is the use of a guard?

   It is used to protect the face from chips.

8. What is radial drilling machine?

   The work piece is drilled at right angles to the drill bit.

9. Why is boring operation preferred?

   Varying size of holes can be made from standard sizes.

10. Mention few applications of drilling.

    Building construction, tool fabrication etc.

AHALIA SCHOOL OF ENGINEERING & TECHNOLOGY

(Approved by AICTE & Affiliated to A. P. J. Abdul Kalam Technological University and University of Calicut)

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Physics Laboratory Record

PHL120 -ENGINEERING PHYSICS LAB

Department of Science & Humanities

Instructions for Laboratory

- The objective of the laboratory is learning. The experiments are designed to illustrate phenomena in different areas of Physics and to expose you to measuring instruments. Conduct the experiments with interest and an attitude of learning.
- You need to come well prepared for the experiment
- Work quietly and carefully (the whole purpose of experimentation is to make reliable measurements!) and equally share the work with your partners.
- Be honest in recording and representing your data. Never make up readings or doctor them to get a better fit for a graph. If a particular reading appears wrong repeat the measurement carefully. In any event all the data recorded in the tables have to be faithfully displayed on the graph.
- All presentations of data, tables and graphs calculations should be neatly and carefully done.
- Bring necessary graph papers for each of experiment. Graphs should be neatly drawn with pencil. Always label graphs and the axes and display units.
- If you finish early, spend the remaining time to complete the calculations and drawing graphs. Come equipped with calculator, scales, pencils etc.
- Do not fiddle idly with apparatus. Handle instruments with care. Report any breakage to the Instructor. Return all the equipment you have signed out for the purpose of your experiment.

INDEX

Sl. No.	Date	Title of the Experiment	Page No.	Marks			Staff Signature
				50 (Expt.)	20 (Viva)	30 (Written)	
1		Newton's Rings- Wavelength measurement of a monochromatic light.					
2		Laser – Measurement of wavelength of Diode laser using diffraction grating and spectrometer.					
3		Air Wedge-Measurement of diameter of a given thin wire.					
4		Spectrometer-Dispersive power and resolving power of a plane transmission grating arranged for normal incidence.					
5		Melde's Experiment- Measurement of frequency of tuning fork in the transverse and longitudinal mode					
6		Wavelength of Laser using Grating					

7		Numerical aperture and acceptance angle of a given Optical Fibre					
8		Ultrasonic Diffractometer- Wavelength & velocity measurement of ultrasonic waves in liquid					
9		Determintion of Particle size of Lycopodium Powder using semiconductor laser					
10		CRO- Measurement of Amplitude and Frequency					
11		Determination of resonant frequency and quality factor of LCR circuit					
12		Solar Cell - I-V characteristics					
		Total					

*viva marks

Date **Lab Course In-charge**

Expt. No.1 Date:

Newton’s Rings

AIM:

To determine the wavelength of given sodium light by Newton’s Rings method.

APPARATUS:

Glass plate, 45^0 angle set up, sodium vapour lamp, vernier microscope, a convex lens of large focal length (about 1 m) etc…

PRINCIPLE:

The diameter of the n^{th} dark ring is given by,

$D_n^2 = 4nR\lambda$………(1)Where R is the radius of curvature of the lower surface of the convex lens and λ is the wavelength of light used.

The diameter of the $(n+k)^{th}$ dark ring is given by

$$[D_{(n+k)}]^2 = 4(n+k)R\lambda \quad \text{……………}(2)$$

Then $$[D_{(n+k)}]^2 – D_{(n)}{}^2 = 4kR\lambda$$

$$\lambda = D_{n+k}^2 - D_n^2 / 4KR \text{…………..}(3)$$

PROCEDURE:

The Newton’s ring apparatus consists of an optically plane glass plate ‘G’ on which a long-focus convex lens L is placed. There is a glass plate ‘P’ inclined at 45^0 to the horizontal. Light from a sodium lamp is rendered parallel by a short focus convex lens L_1.These parallel rays fall on the glass plate P and get reflected vertically downward and fall on the system of the lens Land the glass plate G. The light reflected from the lower surface of the lens L and the upper surface of the glass plate G interfere and a number of concentric dark and bright rings formed. These rings are observed through a microscope arranged vertically above the glass-plate P. The microscope is focused well so that the rings are clearly seen. The center of the ring system is dark. Then by working the tangential screw, the point of intersection of the cross-wire is kept at the central dark spot. Then the microscope is moved to the left and to the right in order to ensure that about 25 dark rings are clearly seen. Then again starting from the central dark spot, the microscope is moved to the left by working the tangential screw so that the cross-wire is tangential to the 22^{nd} dark ring on the left.

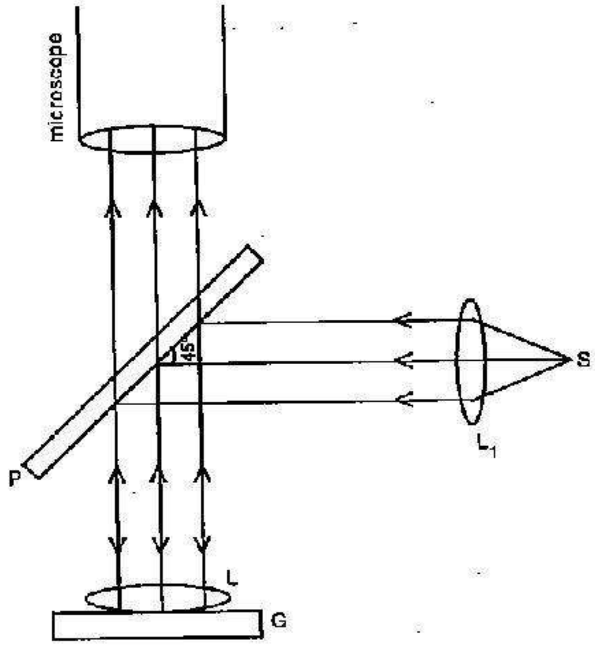
The tangential screw is then slowly adjusted so that the cross-wire is tangential to the 20^{th} dark ring. The microscope reading on the horizontal scale is taken. Then by working the tangential screw the cross wire is kept tangential to the 18^{th}, 16^{th},14^{th}, etc., dark ring up to the second dark ring on the left and the reading corresponding to each ring is taken. Then by working the tangential screw, the microscope is moved in the same direction until the cross wire is tangential to the second dark ring on the right. The corresponding reading is taken. Similarly the cross-wire is kept tangential to the 4th, 6th, 8th, etc., dark rings up to the 20^{th} dark ring on the right. The reading corresponding to each ring is taken. The tangential screw should be worked only in one direction from the position of the 20^{th} ring on the left to the position of the 20th ring on the right. This is to avoid back lash error). The difference in readings on the left and right of each ring gives its Diameter D. The value of D^2 is calculated. The values of $Dn_{+k}^2 - D_n^2$ are calculated, for a value of k=10. Then the mean value of $(D_{n+k}^2 - D_n^2)$ is found.. If the radius of curvature of the convex lens for the marked surface is R,

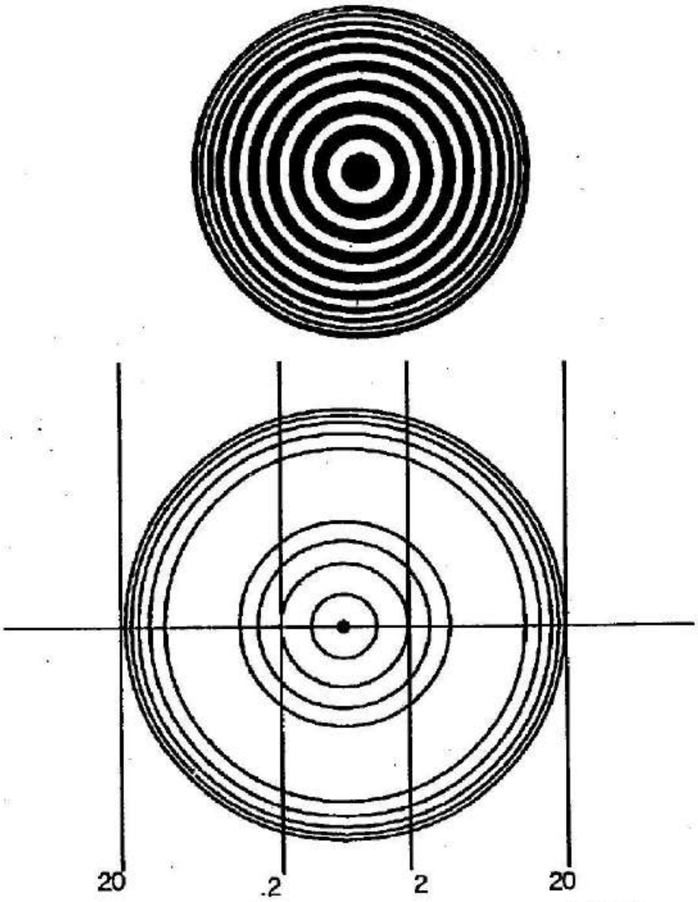
The wavelength of sodium light is λ can be determined using the equation

$$\lambda = D_{n+k}^2 - D_n^2 / 4KR \text{ where } k=10$$

RESULT:

Wave length of given Sodium light = ……………………nm.





Newton's rings

Fig. 2

OBSERVATIONS:

Value of 1 msd =…………………..cm

No. of divisions on the vernier n = ……………….

Least Count (LC) = 1msd/n =………………cm

Order of the ring	Microscope Reading						Diameter (D)	D^2	$D_{n+k}^2 - D_n^2$
	Left			Right					
	MSR (x)	VSR (y)	TOTAL x+(y xLC)	MSR (x)	VSR (y)	TOTAL x+(yxLC)			
	cm	div	cm	cm	div	cm	cm	cm^2	cm^2

$\lambda = D_{n+k}^2 - D_n^2 / 4KR$ where, k=10

Expt. No.2 Date :

Laser – Diffraction of Diode laser using diffraction grating and spectrometer

AIM:

To Determine the wavelength λ of Diode laser using diffraction grating.

APPARATUS:

Spectrometer, The given grating, Diode Laser etc.

PRINCIPLE:

When a parallel beam of monochromatic light is incident normally on a grating , the transmitted light gives rise to primary maxima in certain specific direction .

At normal incidence,

$\sin\Theta = Nn\lambda$ where,

θ = the angle of diffraction

N = the number of lines per meter of the grating

n =the order of the spectrum and

λ = the wavelength of light used in m.

$$\lambda = \frac{\sin\theta}{Nn}$$

.

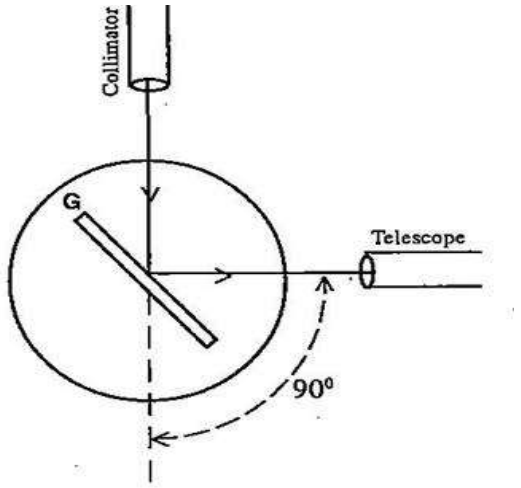
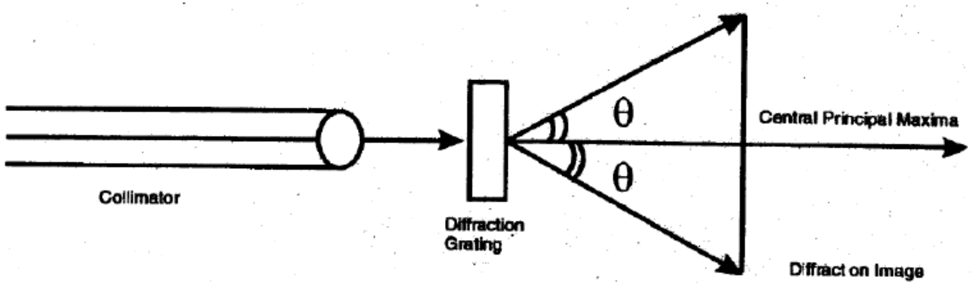

Collimator
G
Telescope
90⁰

FiG .01


Collimator
Diffraction Grating
θ
θ
Central Principal Maxima
Diffract on Image

OBSERVATIONS:

$$(a+b)\sin\theta = n\lambda$$

Where, a is the width of transparency

b is the width of opacity.

(a+b) is called width of grating element

θ is the angle of diffraction.

λ is the wavelength of light used.

No. of lines on grating per m,   N= 1/ (a+ b)

Order of Spectrum	Vernier Scale	Telescope Reading						2θ	Mean 2θ	θ	λ
		Left			Right						
		MSR	VSR	TOTAL	MSR	VSR	TOTAL				
	V1										
	V2										
	V1										
	V2										

PROCEDURE:

Preliminary adjustments of the spectrometer are done:

I. Focusing of the eye - piece

The telescope is turned towards a white wall.

The eye- piece is gently pushed in or pulled out until the cross- wires are clearly seen.

II. Adjustments of telescope

The telescope is turned towards a distant object.

The rack and pinion arrangement on it, the telescope is adjusted to get a clear image of the distant object at the cross- wires, without parallax.

The telescope is now ready to receive parallel rays. .

III. Adjustment of collimator

The slit of the collimator is opened slightly

The slit is illuminated with light from a mercury lamp

The telescope is then brought in line with the collimator.

The image of the slit is observed through the telescope.

Looking through the telescope, the rack and pinion arrangement of the collimator is adjusted so that a well defined image of the slit is obtained at the cross – wires.

IV. Leveling of the prism table

The prism table can be leveled looking through the telescope.The grating is fixed on the table, telescope is arranged to get the reflected image from grating.

The screws are adjusted so that the vertical cross wire bisects the reflected image.

V. To arrange the grating for normal incidence

The preliminary adjustments of the spectrometer are made.

The slit is made narrow.

The telescope is brought in line with the collimator.

The telescope is adjusted so that the point of intersection of the cross wires coincides with the fixed edge of the image of the slit. The telescope is then clamped. The vernier table is unclamped and adjusted so that the reading of vernier I is 0^0 and the reading of vernier II is 180^0 .The vernier table is then clamped. The telescope is then unclamped and rotated exactly through 90^0 and then clamped.

The grating is then mounted on the grating table with its ruled surface facing the collimator. The grating table alone is rotated so that the reflected image of the slit coincides with the point of intersection of the cross wires.

The reflected image will be RED in colour. (There may be two reflected images. The brighter one is chosen.) Now the angle of incidence is 45^0 .

The vernier table is now unclamped and rotated exactly through 45^0 in such a direction that the ruled surface of the grating faces the collimator.

The vernier table is then clamped. The grating is now in the normal incidence position. The telescope is unclamped and brought in the line with the collimator.

The direct image of the slit is observed.

The telescope is slowly rotated towards left.

The first order spectrum of LASER light is observed.

The telescope is adjusted so that the cross wire coincides with the lines of spectrum. The readings of vernier I and vernier II are noted.

The telescope is then rotated to the right of the direct image and adjusted so that the cross wire coincides with the lines of the first order spectrum in the right. The readings of vernier I and vernier II are noted.

The difference in readings of the corresponding verniers on the left and right sides is determined. The average value of the difference gives 2θ. Then angle of diffraction for the first order line θ is found.

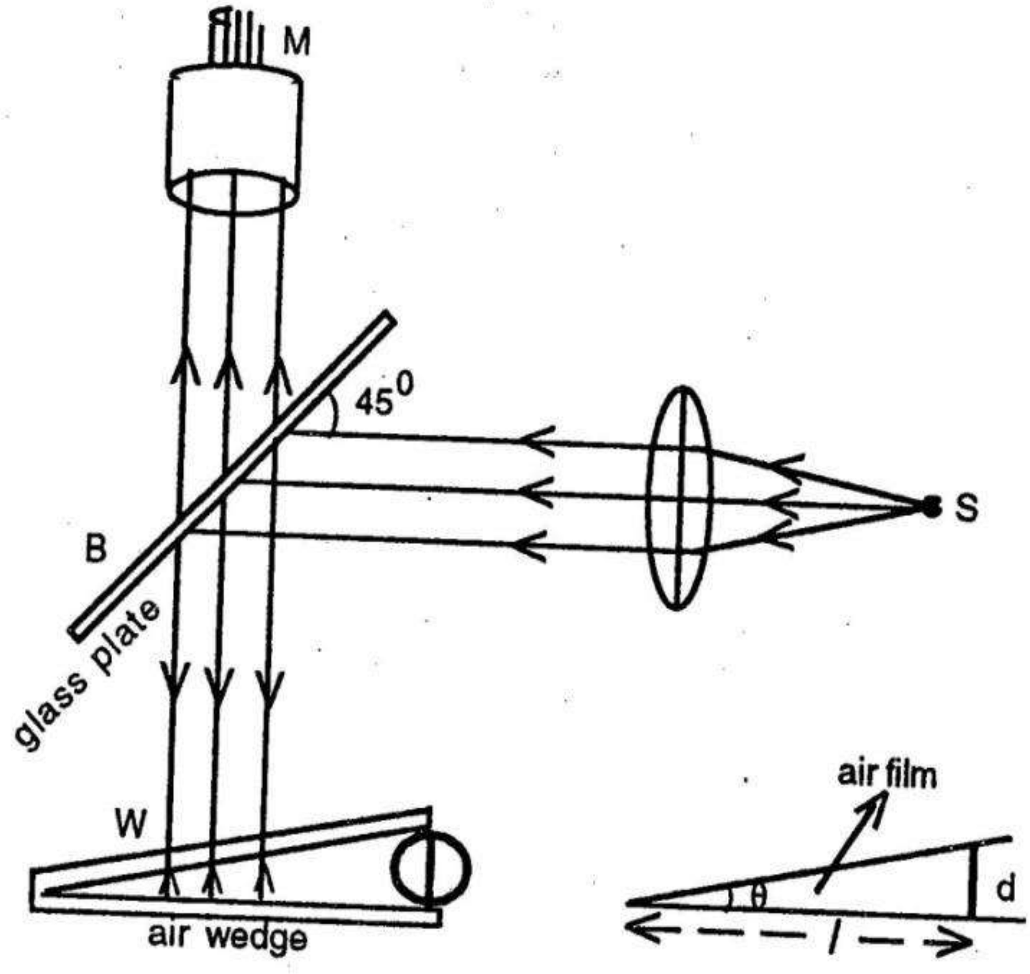
Using the formula;

$$\lambda = \frac{Sin\ \theta}{n\ N}$$

.

RESULT:

Wavelength of given LASER light source is = ………..A^0


M
45⁰
S
B
glass plate
W
air wedge
air film
θ
d
l

Expt. No.3 Date:

Air Wedge - Diameter of a Given thin wire or thickness of a paper.

AIM:

To determine the diameter of a thin wire or thickness of a paper by measuring the width of the interference bands formed by the air wedge arrangement and also the angle of wedge.

APPARATUS:

Two optically plane rectangular glass plates, the given wire, sodium vapour lamp, travelling microscope etc.

PRINCIPAL:

Air wedge is formed by placing two optically plane glass plates one above the other and keep the wire in between the plates. One end of the plates is held tight by a rubber band so that it becomes the line of contact and put another rubber band loosely on the other end so that it forms the open edge..

The diameter of the wire used to form the air wedge is given by $d = \frac{l\lambda}{2\beta}$ where l is the distance of the wire from the edge at which plates are in contact (tight end), λ the wave length of light used and β the band width.

PROCEDURE:

Light from the sodium lamp is rendered parallel by a short focus convex lens(lamp should be placed at a large distance) and is allowed to fall on a glass plate inclined at 45^0 to the horizontal(fig1).

Place the air wedge such that light reflected from the glass plate B is incident normally on the air wedge.

Adjust the travelling microscope which is placed vertically above the glass plate B to view clearly the interference bands.

Bands are formed by the light reflected from the top and bottom surfaces of air film enclosed between the two glass plates of air wedge.) Using the tangential screw, one of the cross wires is made to coincide with a dark band Count the number of clear bands obtained (20 or above) so that tangential screw is free to move on either side.

Make the cross wire to coincide with a dark band either on extreme right or extreme left and take the reading on the horizontal scale.

Move the cross wire to n+5 th,n+10th,……………n+65th band and note the microscope readings in each case.

From these readings width of 10 bands is calculated (X) and band width β is also found (X/10).

Distance ‘l’ between the wire and line of contact of the plates is measured. Knowing the wavelength of sodium light (589.3nm) diameter of the wire is calculated.

RESULTS:

Diameter of the wire = ………………m.
Angle of wedge = ……………….radians.
………………degrees

OBSERVATIONS:

Value of 1 main scale division = …………….cm

Number of divisions on the vernier n =…………….

L.C. of microscope = 1 msd/n =………………cm

Distance of wire from the line of contact of the plates,

l =………………..cm

Wavelength of sodium light =589.3nm

Diameter of the wire $d = \frac{l\lambda}{2\beta}$ m

Angle of wedge $\Theta = \frac{\lambda}{2\beta}$ radians

Number of bands	Microscope Readings			Width of 10 bands (X cms)	Mean (X cms)	Band width β = mean X/10 cms
	MSR	VSR	Total=MSR+VSR x LC			
n n+5 n+10 n+15 n+20 n+25 n+30 n+35 n+40 n+45 n+50 n+55 n+60 n+65						

Expt.No.4 Date :

Spectrometer-Dispersive power and resolving power of plane transmission grating arranged for normal incidence.

AIM:

To determine the dispersive power and resolving power of grating arranged for normal incidence.

APPARATUS:

Spectrometer, The given grating, mercury vapour lamp etc.

PRINCIPLE:

The dispersive power of grating is the ratio of change in angle of diffraction to the corresponding change in wavelength of any two neighbouring lines. Let two wavelengths λ and $\lambda+d\lambda$ be diffracted through θ and $\theta+d\theta$.

Dispersive power of grating $=d\theta/d\lambda$

For a grating, for normal incidence,

$$\sin\theta = Nn\lambda \ldots\ldots\ldots\ldots(1)$$

Where θ is the angle of diffraction, nis the order of spectrum is the number of lines per unit length and $\lambda$is the wavelength of light.

Differentiating, $\cos\theta d\theta = Nnd\lambda$

$$d\theta/d\lambda = Nn / \cos\theta \ldots\ldots\ldots\ldots(2).$$

The resolving power of a grating is its ability to show two neighbouring spectral lines in spectrums seperate.

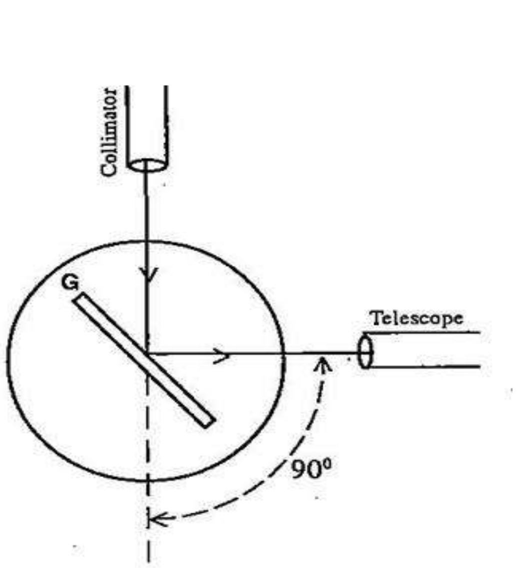

Collimator
G
Telescope
90⁰

FiG .01

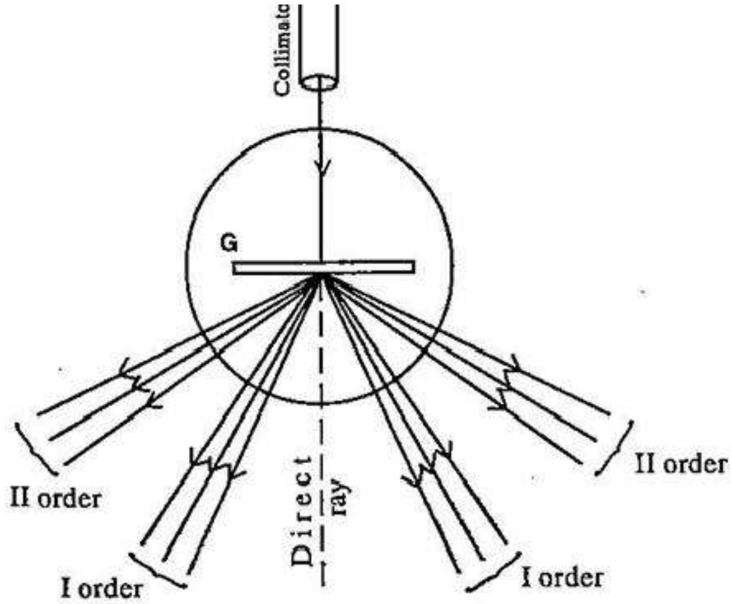

Collimato
G
II order
I order
Direct ray
I order
II order

FIG. 02

If λ and $\lambda+d\lambda$ are wavelegths of two neighbouring spectral lines, the resolving power of the grating is the ratio λ / $d\lambda$. By Rayleigh's criterion for resolution, when the two spectral lines are just resolved.

Resolving powerof grating $\lambda/d\lambda$.=nN where n is the order of spectrum is the number of lines per unit length in the given grating and λ is the wavelength of light.

PROCEDURE:

Preliminary adjustments of the spectrometer are done:

I. Focusing of the eye - piece

The telescope is turned towards a white wall.The eye- piece is gently pushed in or pulled out until the cross- wires are clearly seen.

II. Adjustments of telescope

The telescope is turned towards a distant object.The rack and pinion arrangement on it, the telescope is adjusted to get a clear image of the distant object at the cross- wires, without parallax. The telescope is now ready to receive parallel rays.

III. Adjustment of collimator

The slit of the collimator is opened slightly. The slit is illuminated with light from a mercury lamp. The telescope is then brought in line with the collimator. The image of the slit is observed through the telescope.

Looking through the telescope, the rack and pinion arrangement of the collimator is adjusted so that a well-defined image of the slit is obtained at the cross wires.

IV. Levelling of the prism table

The prism table can be leveled looking through the telescope.

The grating is fixed on the table, telescope is arranged to get the reflected image from grating.The screws are adjusted so that the vertical cross wire bisects the reflected image.

V. To arrange the grating for normal incidence

The preliminary adjustments of the spectrometer are made. The slit is made narrow. The telescope is brought in line with the collimator. The telescope is adjusted so that the point of intersection of the cross wires coincides with the fixed edge of the image of the slit. The telescope is then clamped. The vernier table is unclamped and adjusted so that the reading of vernier I is 0^0 and the reading of vernier II is 180^0 .The vernier table is then clamped. The telescope is then unclamped and rotated exactly through 90^0 and then clamped. The grating is then mounted on the grating table with its ruled surface facing the collimator.

The grating table alone is rotated so that the reflected image of the slit coincides with the point of intersection of the cross wires.

The reflected image will be white in colour. (There may be two reflected images. The brighter one is chosen.) Now the angle of incidence is 45^0 .The vernier table is now unclamped and rotated exactly through 45^0 in sucha direction that the ruled surface of the grating faces the collimator.The vernier table is then clamped. The grating is now in the normal incidence position.

VI. To standardize the grating

The telescope is unclamped and brought in the line with the collimator. The direct image of the slit is observed. The telescope is slowly rotated towards left. The first order spectrum of mercury light is observed. The telescope is adjusted so that the cross wire coincides with the lines of spectrum. The readings of vernier I and vernier II are noted. The telescope is then rotated to the right of the direct image and adjusted so that the cross wire coincides with the lines of the first order spectrum in the right.

The readings of vernier I and vernier II are noted. The difference in readings of the corresponding verniers on the left and right sides is determined. The average value of the difference gives 2θ. Then angle of diffraction for the first order line θ is found. Using the value of θ the wavelength of lines can be calculated. The wavelength of green line, λ_g is given and the number of rulings per meter, N of the grating is calculated using the formula, $N = \frac{\sin \theta g}{n\lambda_g}$where n =1 for the first order image.UsingthisvalueofNwe can calculate the wavelengths of other lines.

VII Calculation of Dispersive power and Resolving power.

Dispersivepower dθ/dλ for violet region is calculated as follows:

Θ_1 is the angle of diffraction of violetI whose wavelength is λ_1.Similarly Θ_2 is the angle of diffraction of violetI whose wavelength is λ_2 .

$d\theta=\theta_1 - \theta_2$ and $d\lambda=\lambda_1 - \lambda_2$. Then dθ/dλ can be determined.

Mean angle of diffraction $\theta = (\theta_1 + \theta_2)/2$ is calculated. Then Dispersive power= Nn / cosθ.

The mean value is calculated. Similarly for yellow region the dispersive power is found for yellow in yellow lines.The experiment is repeated for the second order spectrum also. If λ and λ+dλ are wavelegths of two neighbouring spectral lines, the resolving power of the grating is the ratio λ / dλ . By Rayleigh's criterion for resolution, when the two spectral linesare just resolved. Resolving power of grating λ / dλ.= nN_1 where n is the order of spectrum,N_1 is the total number of lines in the given grating and λ is the wavelength of light.

RESULT:

Dispersive power of given grating =……………..

Resolving power of given grating =………………

OBSERVATIONS:

	VernierI	Vernier II
Direct Reading		
Reading after the telescope is turned through 90^0		
Reading after rotating the vernier through 45^0		

To standardize the grating to find N

Value of 1 m.s.d =………………degree

=…………….minutes

No.of divisions on the vernier , n =………………

Least count of vernier =1 m.s.d/n =…………..

=……………minutes

Total Reading =Main Scale Reading +(Vernier Scale reading x LC)

Wavelength of mercury green λ_g =5461 x10^{-10} m

$$N = \frac{Sin\,\theta g}{n\,\lambda\,g}$$

The value of N =………………lines/m

Determination of wavelengths

Order (n)	Line	Vernier	Diffracted reading						Difference 2θ	Mean θ	λ= Sinθ/nN
			Left			Right					
			MSR	VSR	Total	MSR	VSR	Total			
1	Violet I	V1 V2									
	Violet II	V1 V2									
	Green	V1 V2									
	Yellow I	V1 V2									
	Yellow II	V1 V2									

Dispersive power for violet region:

θ_1 = λ_1 =

θ_2 = λ_2 =

$d\theta = \theta_1 - \theta_2$ and $d\lambda = \lambda_1 - \lambda_2$

Dispersive power = $d\theta / d\lambda$ =………………degree/m.

Mean angle of diffraction θ == $(\theta_1 + \theta_2)$ /2=……………

Dispersive power = $Nn / \cos\theta$=………………

Mean Dispersive power = …………………

Dispersive power for yellow region:

θ_1 = λ_1 =

θ_2 = λ_2 =

$d\theta = \theta_1 - \theta_2$ and $d\lambda = \lambda_1 - \lambda_2$

Dispersive power = $d\theta/d\lambda$ =………………degree/m.

Mean angle of diffraction θ == $(\theta_1 + \theta_2)$ /2=……………

Dispersive power = $Nn / \cos\theta$=………………

Mean Dispersive power = ………………

To calculate resolving power of grating

Resolving power of grating, $\lambda/d\lambda = Nn$

Expt No.5 Date :

Melde's Experiment-Measurement of frequency in the transverse and longitudinal mode

AIM:

To determine the frequency of a tuning fork by Melde's arrangement, using the transverse mode of vibration andusing the longitudinal mode of vibration

APPARATUS:

Electrically maintained tuning fork, fine thread, scale pan, weight box, balance etc.

The arrangement consists of an electrically maintained tuning fork. One end of a string is attached to one of the prongs of the fork. The other end of the string carrying a scale pan is passed over a pulley.

PRINCIPLE:

Transverse mode of vibration

The frequency 'n' of the fork is calculated using the formula

$$n = \sqrt{\frac{g}{4m}}\sqrt{\left(\frac{M}{l^2}\right)} \ldots\ldots\ldots(1)$$

Longitudinal mode of vibration

$$n = \sqrt{\frac{g}{m}}\sqrt{\left(\frac{M}{l^2}\right)} \ldots\ldots\ldots\ldots\ldots(2)$$

Where , m = linear density of string

M = total mass at the end of the string

L = average length of one loop

g =acceleration due to gravity

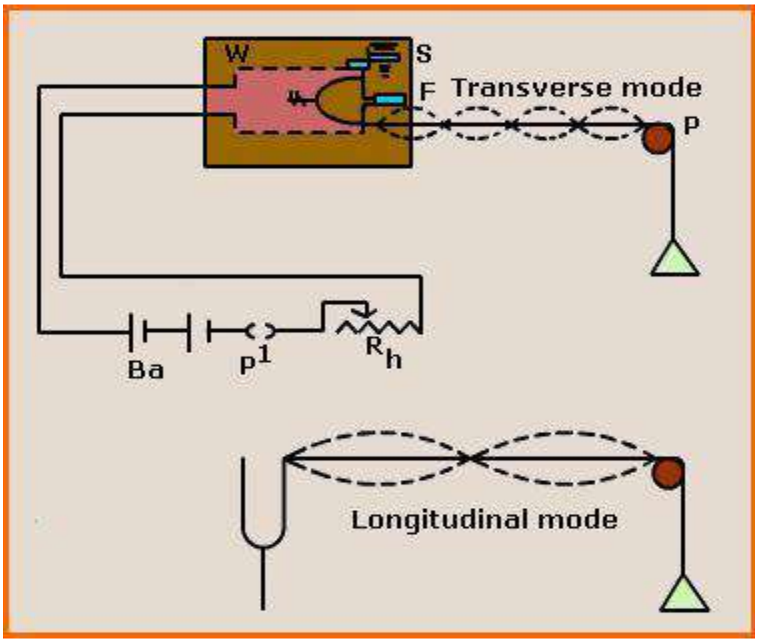


Fig.1

PROCEDURE:

The weights of the 10m thread and pan are determined.

Transverse mode of vibration

The mass of the scale pan is determined correct to a milligram.
10 meters of the given string is weighed accurately. Hence its linear density (mass per unit length), 'm' is found.The electrical connections are made as shown in the diagram. The string is arranged horizontally with its length parallel to the prong of the fork. The fork vibrates in a direction perpendicular to the length of the string.
A mass of about 2 or 3 gm is placed in the scale pan.The circuit is closed.The fork vibrates. Transverse stationary waves are formed in the string.
The length of the string between the prong and the pulley is carefully adjusted by moving the fork, so that a number of well defined loops are formed in the string.
Leaving the loops at the two ends, the length of a definite number of loops are measured. Then the average length of a loop is found (l). The total mass M at the end of the string (mass of scale pan + mass placed in the pan) is noted. The value of M/l^2 is found.The experiment is repeated for different masses in the scale pan and the mean value of M/l^2 is calculated.
Then the frequency of the fork is calculated using the formula,

$$n = \sqrt{\frac{g}{4m}}\sqrt{\left(\frac{M}{l^2}\right)}$$

Longitudinal mode of vibration

The apparatus is arranged as shown in the diagram, with the prongs perpendicular to the string.
Then the fork vibrates in a direction parallel to the string or string vibration in the longitudinal mode.
The experiment is performed exactly as before for different masses and the mean value of M/l^2 is found.
The frequency of the fork is calculated using the formula,

$$n = \sqrt{\frac{g}{m}}\sqrt{\left(\frac{M}{l^2}\right)}$$

RESULT:

The mean frequency of the tuning fork =…………….Hz.

OBSERVATIONS:

Longitudinal Mode

Trial No	Mass in the scale pan	Total mass including the mass of pan (M)	Number of loops X	Length of X loops L	Length of one loop l=L/X	M/l^2
	g	10^{-3}kg		cm	cm	Kg/m^2
1						
2						
3						
4						

Mean M/l^2 =………

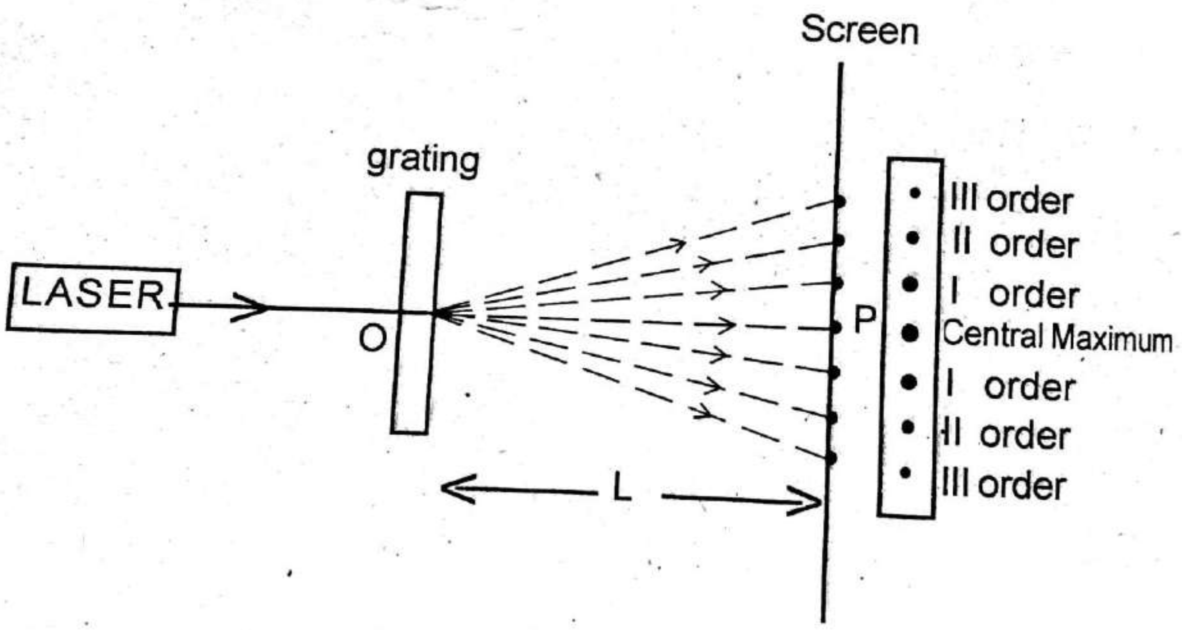
The frequency of the fork $n = \sqrt{\frac{g}{m}}\sqrt{\left(\frac{M}{l^2}\right)}$ =………………Hz

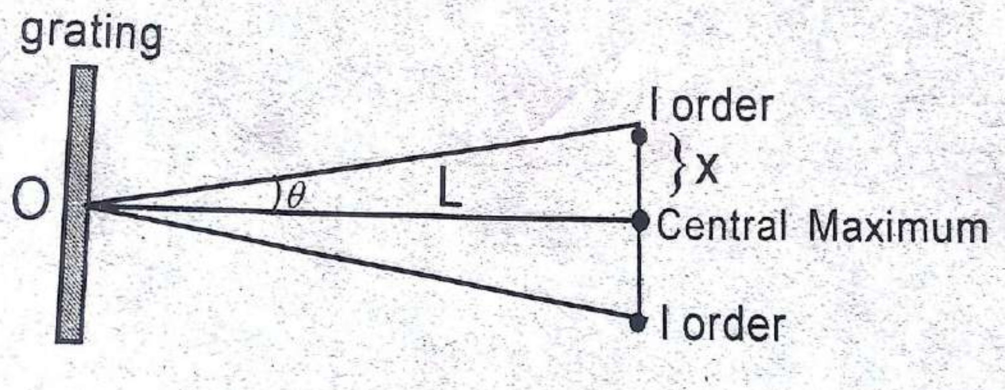
Transverse Mode

Trial No	Mass in the scale pan	Total mass including the mass of pan (M)	Number of loops X	Length of X loops L	Length of one loop l=L/X	M/l^2
	g	10^{-3}kg		cm	cm	Kg/m^2
1						
2						
3						
4						

Mean M/l^2 =………

Frequency of the fork, $n = \sqrt{\frac{g}{4m}}\sqrt{\left(\frac{M}{l^2}\right)}$ =………………Hz


Screen
grating
LASER
O
P
III order
II order
I order
Central Maximum
I order
II order
III order
L


grating
O
θ
L
I order
X
Central Maximum
I order

Expt.No: 6 Date:

DTERMINATION OF WAVELENGTH OF LASER USING GRATING

AIM:

To Determine the wavelength λ of laser beam using diffraction grating.

APPARATUS:

The given grating, Diode Laser etc.

PRINCIPLE:

For a plane transmission grating, the equation is given by

$\sin\theta = Nn\lambda$ where

λ =Wavelength of laser beam

θ = the angle of diffraction

N = the number of lines per meter of the grating

n =the order of the spectrum

N =1/d where d = a+b and a+b is called grating element or grating constant. From this, wavelength λ of laser beam can be determined.

PROCEDURE:

A .5mW laser is mounted horizontally so that it produces horizontal lser beam. The given plane transmission grating is held vertically on an upright at a distance (about 50cms) from the laser. A screen is placed at a distance L from the grating (1 meter).

When current is switched on, the most dominant laser beam is produced from it. This beam is incident normally on the transmission grating. The laser beam is diffracted into different angles and hence we get clear, well defined and bright images (spots) on the screen. The screen is moved slowly towards or away from the laser so that seven or nine spots are obtained. The central larger bright spot is due to the diffracted rays passing through the incident direction (Angle of diffraction θ=0). This is the central maximum. On either side of this central maximum we get I order, II order, III order etc. spots. The intensity and size of these spots get decreased for higher orders. The positions of these spots are marked on the screen. The distance between the grating and the center of the screen is measured as L. Angle of diffraction θ is found out from

$\tan\theta = x/L$

Now λ for the first order (m=1) can be found out from the grating equation

$$\sin\theta = Nn\lambda$$

Where N is the number of lines per lines per unit length. N is calculated from a same type of experiment using a sodium vapour lamp with a beam of wavelength of 5893Å. Similarly distances x for the second order, third order etc. are measured. λ is calculated for each order of the image. From these sets of orders mean value of λ is determined.

OBSERVATIONS:

Number of lines per cm=

Distance between screen and grating L cm	Order m	Distance 2x cms between left & right spots	x cms	$\tan\theta = x/L$	θ	. $\lambda = \sin\theta/Nn$ (Å)
	1 2 3					
	1 2 3					

Mean λ=…………..(Å)

RESULT:

Wavelength of Laser beam λ =………………

Expt.No.7 Date:

Numerical aperture and acceptance angle of a given Optical Fibre

AIM:

To determine the numerical aperture of a given optical fibre.

APPARATUS:

Step index fibre optic cable 1 or 2 m length, light source ,N.A measuring jig.

PRINCIPLE:

The schematic diagram of the fibre optic trainer module is shown in figure1.

The numerical aperture of an optical system is a measure of the light collected by an optical system. It is the product of the refractive index of the incident medium and the sine of the maximum angle.

Numerical Aperture (NA)= $n_1 \sin\theta_{max}$ …..(1)

For step index fibre, the NA is given by;

NA=$(n^2_{core} – n^2_{cladding})^{1/2}$ ……..(2)

For small differences in refractive indices between the core and cladding, equation (2) reduces to

NA=$n_{core}\ (2\Delta)^{1/2}$ …………….(3)

Where Δ is the fractional difference in the refractive indices of the core and cladding i.e.

$\Delta =[n_{core} – n_{cladding}]/ n_{core}$

Light from the fibre end 'A' falls on the screen BD. Let the distance between the fibre end the screen=AO=L

From the AOB $\sin\theta$ =OB/AB

OB=r AB=$[r^2 +L^2]^{1/2}$

NA=$\sin\theta$ =r / $[r^2 +L^2]^{1/2}$

Knowing r and L, the NA can be calculated. Substituting this value of NA in equation(1), the acceptance angle can be calculated.

PROCEDURE:

1. LED is made of glow by applying about 1.5 V DC power supply.
2. Light is allowed to propagated through an optical fibre cable whose NA is to be determined.
3. The output is screened on a concentric circles of known diameter is placed at a distance of 1,2,3,4, and 5 cm and corresponding radius of the concentric circles is noted.
4. The experiment is repeated for different lights.

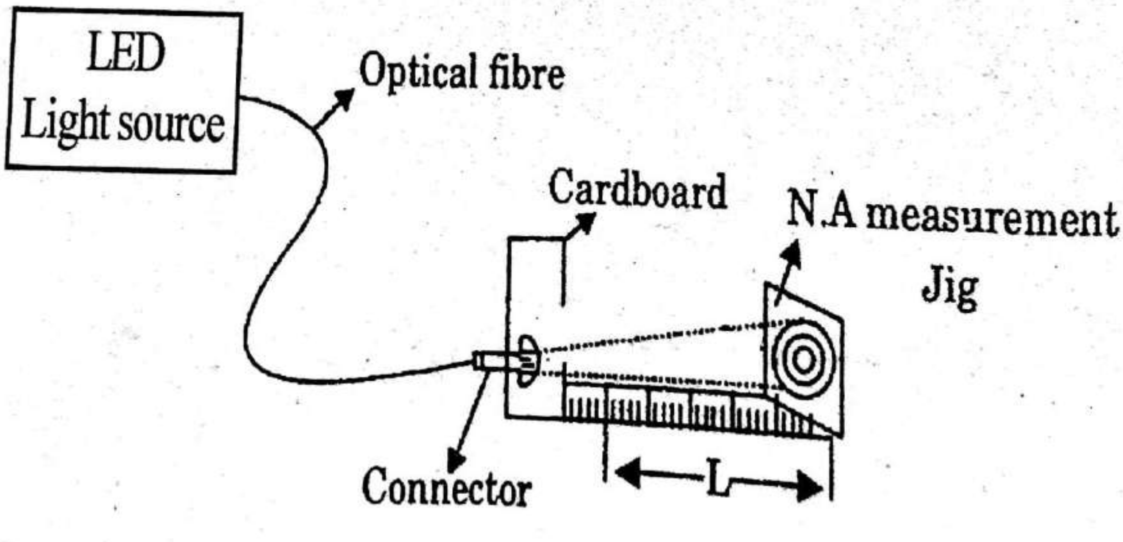
OBSERVATIONS:

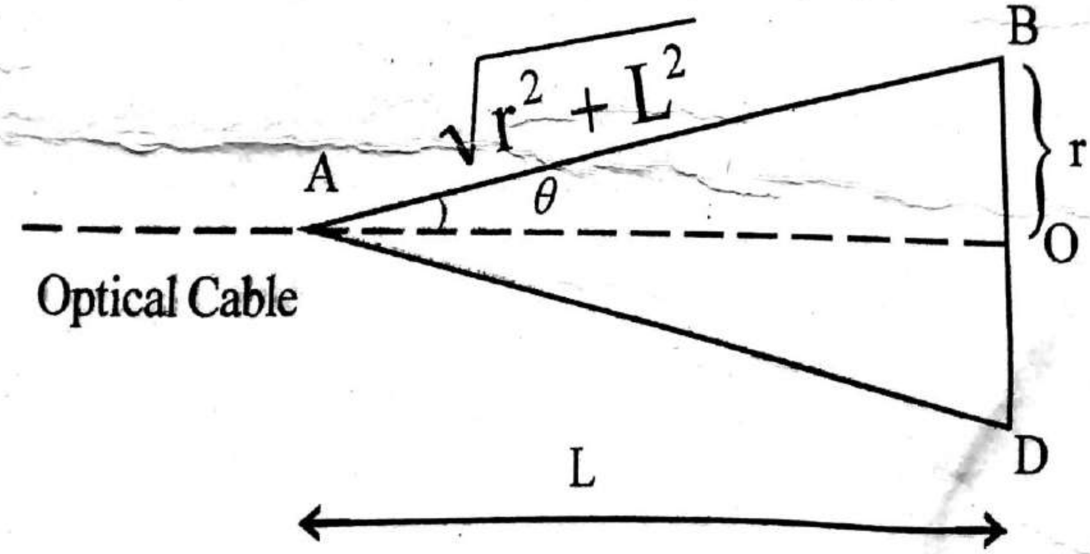
Sl.No	L(mm)	r (mm)	$N.A=r/(r^2+L^2)^{1/2}$	θ (degrees)

RESULT:

The Numerical Aperture of the Optical Fibre =…………..

The Acceptance angle θ =…………….


LED
Light source
Optical fibre
Cardboard
N.A measurement
Jig
Connector
L


B
$\sqrt{r^2 + L^2}$
r
A
θ
O
Optical Cable
D
L

Expt.No.8 Date:

Ultrasonic Diffractometer- Wavelength & velocity measurement of ultrasonic waves in liquid

AIM:

To determine the wavelength and velocity of ultrasonic waves in kerosene using Ultrasonic diffractometer..

APPARATUS:

High resolving spectrometer, sodium vapour lamp, reading lens, quartz crystal, high frequency oscillator, glass through with cubical shape containing test liquid.

PRINCIPLE:

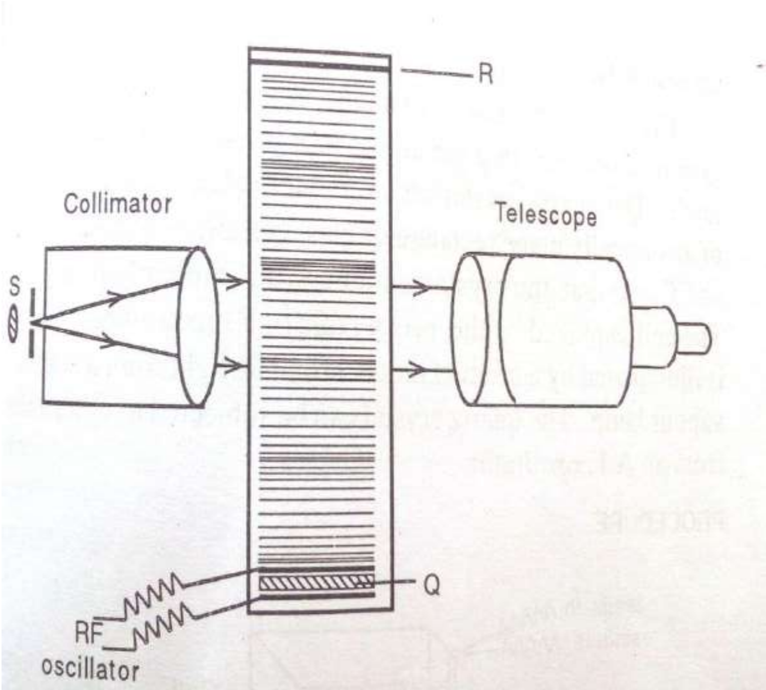
The velocity of ultrasonic waves in the experimental liquid

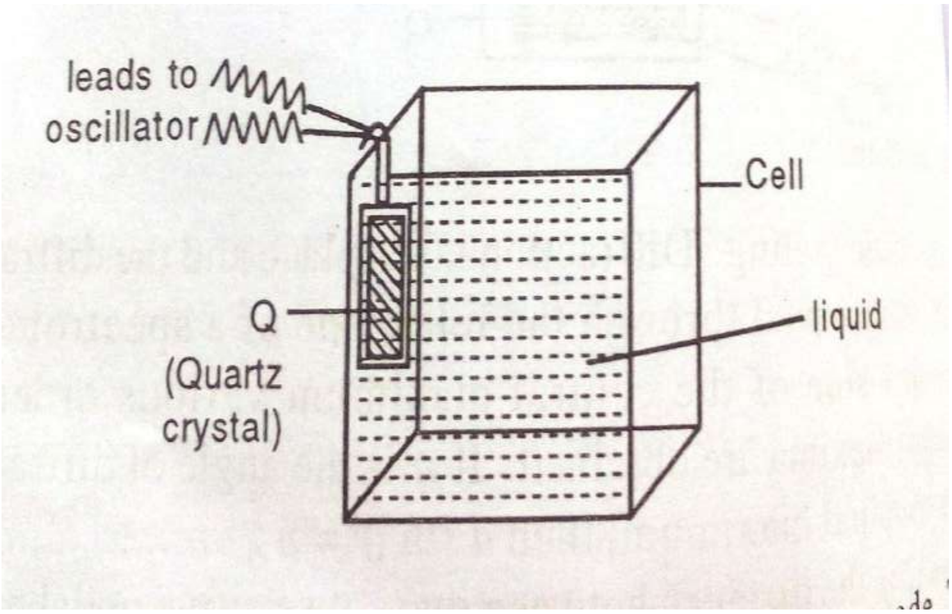
$$v=\upsilon\lambda$$

where υ is frequency of oscillator of the crystal, λ is wavelength of ultrasonic waves in the experimental liquid.

When an ultrasonic transducer (quartz crystal) is placed inside a glass through containing a test liquid, stationary waves are produced due to interference of direct and reflected waves. The nodal ad anti-nodal regions so formed acts like opaque and open spaces to form an grating with monochromatic light of wavelength λ diffraction takes place and the diffraction pattern consists of central maximum and principal maxima on either side. The position of principal maxima on either side is given by the relation,

$$d \sin\theta = n\lambda$$


R
Collimator
Telescope
S
Q
RF
oscillator


leads to
oscillator
Cell
Q
liquid
(Quartz
crystal)

where,

d- Distance between 2 consecutive nodal and antinodal planes,

n- Order of spectrum,

λ –wavelength of sodium light =589.3nm

The angle θ is determined experimentally for an order n and corresponding value of d can be calculated using the relation , $d \sin\theta = n\lambda$.

If λ is the wavelength of ultrasonic waves through the medium then,

$d=\lambda/2$ or $\lambda = 2d$. For practical purposes ; $\lambda = d$.

knowing the value of λ, the velocity of ultrasonic waves can be calculated using the relation, $v=\upsilon\lambda$

PROCEDURE:

Preliminary adjustments of the spectrometer are done which includes distant object focusing, adjusting the eyepiece and collimator. Slit is illuminated by light from sodium vapour lamp.

Carefully balance the prism table with the help of a spirit level and place the trough containing experimental liquid on the prism table.

Fix the crystal such that it is placed inside the trough containing test liquid and connect the leads to the terminals of the high frequency oscillator.

Slide the crystal in such a way that it sends waves in the test liquid and connect the leads to the terminals of the high frequency oscillator.

Energise the crystal by switching on the oscillator vary the oscillator frequency to match with that of the crystal so that maximum power from oscillator is transferred to the crystal. You will see distinct diffracted spectral lines in the telescope.

OBSERVATIONS:

Value of 1 m.s.d	=………………degree
	=…………….minutes
No. of divisions on the vernier n	=………………
Least count of vernier	= 1m.s.d/n =…………..
	=……………minute
.	
Frequency of oscillator	=……………Hz.
Order of spectrum	=………….
Wavelength of light λ	=…………………m

	Position of diffracted image						2θ	θ	d
	Left (a)			Right (b)					
	MSR (degree)	VSR (div)	TOTAL	MSR (degree)	VSR (div)	TOTAL			
V1									
V2									
V1									
V2									

Mean d = ………

Measurement of θ by spectrometer:

Set up the vertical cross wire of the telescope in line with first order and note the vernier and main scale reading.\

Rotate the telescope to the other side and set the telescope on the readings as above.

Find the difference between the above 2 readings. It gives 2θ for the first order. Half of this value gives the angle of diffraction θ and substitute this value in the relation $d = \lambda/\sin\theta$ to calculate the value odd.

The procedure may be repeated for second order and average value of d may be calculated.

Using the value of d, λ can be calculated and velocity can be obtained using the relation, $v = \upsilon\lambda$

RESULT:

Wavelength of ultrasonic waves in kerosene=……………….m.

Velocity of ultrasonic waves in kerosene =………………….m/s.

Fig. 1.4 1, 2 and 3 orders of diffraction pattern

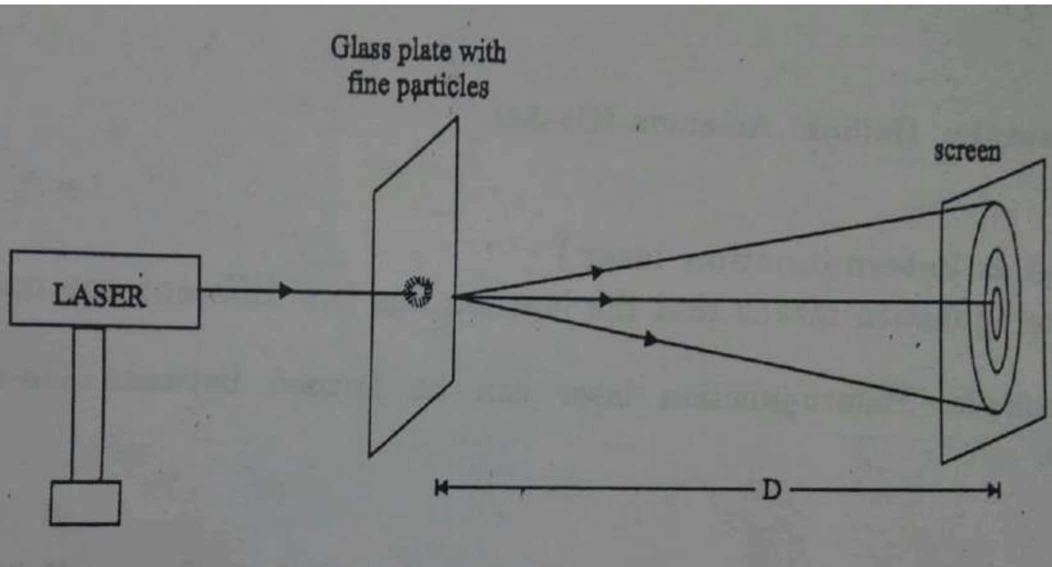


Fig 1.3 Particle size determination by LASER

Expt. No. 9   Date:

Determination of particle size of Lycopodium Powder using Semiconductor Laser

AIM:

To determine the size of the given micro paricles(lycopodium powder) using laser.

APPARATUS:

Diode laser, Fine particles having nearly same size (lycopodium powder), glass plate, screen, meter scale.

PRINCIPLE:

Particle size (diameter) d is given by $d= n\lambda D / X_n$ metre

n order of spectrum

λ Wavelength of laser light used

D Distance between glass plate and the screen

X_n Distance between central bright spot and the n^{th} ring

PRINCIPLE:

A glass plate is taken and a fine powder of the particle size in the range of micrometer is sprinkled on the glass plate. This glass plate is kept between laser light and screen. Now laser beam gets diffracted by the particles present in the glass plate.

By adjusting the distance between the glass plate and the screen, (D) a circular fringe pattern is seen on the screen. The bright fringes of different orders are seen on the screen and the distance between the central bright point and n^{th} fringe X_n for various orders of diffraction is measured .Using the formula , the particle size is determined. The experiment is repeated for different D values.

RESULT:

Average size of the particle =………………..m.

OBSERVATIONS:

Sl.no	Distance between screen and glass plate (D)	Order of Diffraction n	Distance between the central bright point and n^{th} fringe X_n	Particle size $d = n\lambda D / X_n$
Unit	cm		cm	cm
		1		
		2		
		3		
		1		
		2		
		3		
		1		
		2		
		3		

Mean =……………

Wavelength of laser source λ =6900 Å =6900 X 10^{-10} m.

Expt. No. 10 Date:

FAMILIARISATION OF CRO

AIM:

To familiarize with cathode ray oscilloscope and to study its functions.

COMPONENTS AND EQUIPMENTS REQUIRED:

Cathode ray oscilloscope, Function generator, connecting probes.

THEORY:

Cathode ray oscilloscope is an instrument which gives the visual representation of electrical signals. It is one among the most versatile tools used for the research and study of electronic circuits and systems. It displays the signal on a screen in X and Y axes which is used in conventional graph constructions. X-axis represents the time and Y-axis the amplitude of the signal. Oscilloscope is capable of displaying voltage variation which takes place over a period of microseconds and nanoseconds.

Cathode ray tube is the heart of a CRO. It is a vacuum tube which generates a narrow electron beam and made fall on a fluorescent screen at one end of the tube. The electron beam is deflected by horizontal and vertical deflection plates respectively. The waveform to be observed is fed across the vertical deflection plates while the horizontal deflection plates elongate the waveform in the time axis. The controls and sockets in front panel of a typical CRO are explained below in three categories.

1. **POWER CONTROLS:**

   (a) **OFF/INTENS:** Turns power on. A pilot LED indicates the status whether it is on or off, the intensity of the displayed electron bean can be varied using this knob.

   (b) **FOCUS:** Using this, the beam can be made sharply defined. This helps to take the readings more accurately.

2. **VERTICAL DEFLECTION:**

(a) **Y- POSITION:** Controls the vertical shifting of the trace.

(b) **AMP/DIV:** Enlarges the signal in vertical direction. Knob can be set in ranges from 2mV/div to 10V/div usually.

(c) **ON/OFF :** Turns the channel ON or OFF

(d) **AC/DC:** In AC position, DC component of the signal is blocked by a blocking capacitors. In DC position, the signal is directly coupled.

3. **TIME BASE AND HORIZONTAL DEFLECTION:**

(a) **X-POSITION:** Controls the horizontal shifting of the trace.

(b) **LEVEL:** Helps the signal to remain still.

(c) **MAGN x n:** Allows the magnification of horizontal deflection by a factor of n.

(d) **TIME/DIV:** Enlarges the signal in X-direction. In combination with s/ms select the time coefficients.

(e) **X via A:** Horizontal deflection is determined by the input signal to channel A.

(f) **CAL:** Knob should be turned to CAL position to take readings.

(g) **INT/EXT:** An external triggering signal for time base can be given through EXT socket.

(h) **NORM/TV:** In NORM position, normal triggering is obtained. In TV position, TV line or TV frame synchronization is obtained.

PROCEDURE:

To measure the amplitude of a signal

1. Switch on the CRO. Obtain a sharply defined trace of a horizontal line on the screen by adjusting INTENS and FOCUS knob.
2. Adjusting the Y- position knob to make the trace to coincide with the centre line on the screen by keeping the AC-DC switch in GND position.
3. Connect the function generator with CRO using a probe and switch on the function generator.
4. Count the number of divisions occupied by the signal from peak to peak.
5. Multiply this by the scale indicated by the AMP/DIV knob. This gives the peak to peak amplitude of the signal. Half of this will give the maximum value of the voltage.
6. Repeat the above step for various settings of AMP/DIV knob.

To measure the frequency of a signal

1. Obtain a sharply defined trace of horizontal line on the screen by adjusting INTENS and FOCUS knob. Feed the signal (sine or square) whose frequency is to be measured, to either of the channels using a probe and observe the signal on CRO.
2. Adjust the TIME/DIV knob so as to see two or three cycles of the waveform.
3. Count the number of divisions in one cycle of the waveform. Multiply this by the time base setting. This is the time period of the signal.
4. Reciprocal of time period will give frequency of the signal.
5. Repeat the above steps for various settings of TIME/DIV knob.

RESULT:

Familiarized with the CRO and its knob. Also studied how to measure amplitude, frequency and phase difference of a signal.

Expt. No. 11 Date:

Determination of resonant frequency and quality factor of LCR circuit

AIM:-

To determine the resonant frequency and quality factor of an LCR circuit

APPARATUS :

LCR circuit, CRO, connecting wires, etc

THEORY

Consider the LCR circuit shown in the figure,

If the applied voltage is $V_{in} = V_0 \cos(\omega t)$, the output voltage V_R is given by

$$V_R = \frac{V_{in}R}{R+X_c+X_L} = \frac{V_{in}R}{R+\left(\frac{1}{j\omega C}\right)+j\omega L} = \frac{V_o \exp(j\omega t)R}{R+j\left(\omega L-\frac{1}{\omega C}\right)}$$

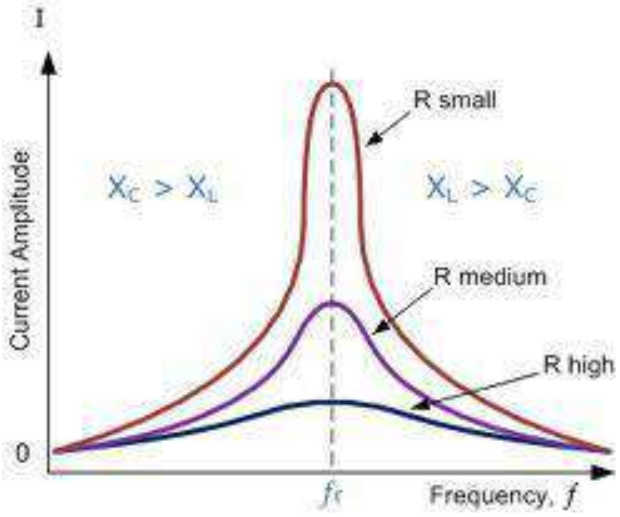
The magnitude of V_R is given by,

$$V_R = V_0 R/\sqrt{(R^2+(\omega L-1/\omega C)^2}$$

The phase of V_R with respect to V_{in} is defined as $V_R = V_R \exp j(\omega t-\varphi)$, where the phase angle φ is defined as,

$$\tan\varphi = \text{Imaginary } X/\text{ Real } X = (\omega L-1/\omega C)/R$$

Depending on L,C and ω, the phase angle could be positive or negative.



The current amplitude I= | V_R/ R is plotted against the frequency = ω/2π in Fig. for different values of R. The current becomes maximum at the resonant frequency for all R. The maximum current amplitude decreases with increasing R. For a given R, when i ω is small the reactance $X_L = \omega L$ is small and the reactance $X_C = 1/\omega C$ is large. Thus the current is mainly capacitive and the impedance is dominated by X_C , which keeps the current low. As ω increases, X_C decreases and X_L increases. The decrease in X_C reduces the impedance and allowing the current to increase. The current becomes maximum when $X_C = X_L$ corresponding to the resonant frequency. If the frequency ω is further increased beyond ω_R, X_L will dominate over X_C and cause increase in the impedance which will keep the current low again.

There is an exact analogy between a LCR circuit and a forced damped harmonic oscillator.

The equation for the charge oscillation in the LCR circuit considered here is given by,

$$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C} = V_0 \cos\omega t$$

With natural frequency $\omega_0 = 1/\sqrt{(LC)}$ on the other hand if a particle of mass m is subject to an external periodic force $F(t) = F_0 \cos(\omega t)$, The equation of motion is given by,

$$m\frac{d^2x}{dt^2} + \gamma\frac{dq}{dt} + kx = F_0 \cos\omega t$$

Where γ is damping force constant, k is the restoring force constant with natural frequency $\omega_0 = \sqrt{(k/m)}$. One finds both the equations are exactly same with the equivalent quantities, x=q, m= L, γ= R and k= 1/C. in both the cases resonance occurs when the driving frequency ω is equal to the natural frequency ω_0.

Resonant frequency ω_R

At resonance, the imaginary part of the impedance vanishes. For the series LCR circuit considered here, the impedance is given by

$$Z=R+X_L+X_C=R+j(\omega L - (1/\omega C))$$

Hence at resonance one has $\omega_R L = 1/\omega_R C$ or $\omega_R = 1/\sqrt{(LC)}$

Quality factor Q of a circuit

Q determines how well the LCR circuit stores energy and it is defined by

$$Q=2\pi(\text{Energy stored /average power dissipated})$$

per cycle.

The maximum energy stored in the inductor is $LI^2/2$ with $I=I_{max}$. There is no energy stored in the capacitor, at this instant because I and V_c are 90° out of phase.

The expression for Q is given by $\mathbf{Q= \omega_R/\Delta\omega}$

Where $\mathbf{\Delta\omega}$ is the bandwidth τ of the resonance curve. τ corresponds to the width where V_R drops to $1/\sqrt{2}$ of its maximum value. Q can be measured from the resonance curve itself, regardless of L, C and R.

PROCEDURE

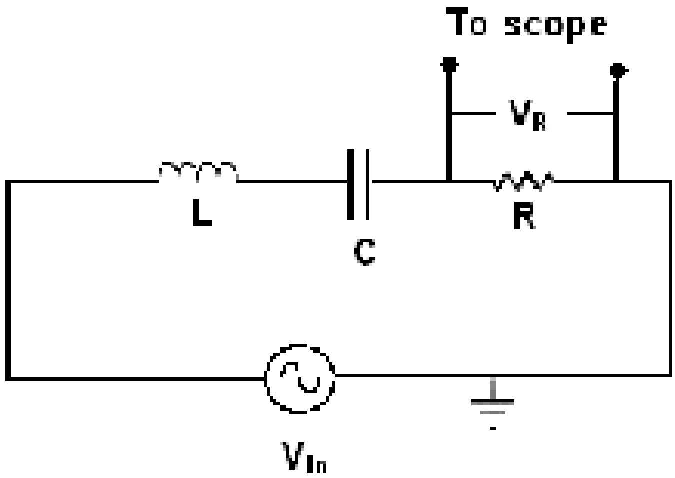
1. Assemble the circuit as shown in Figure
2. Set the function generator for sinusoidal signal and adjust the peak to peak amplitude of the signal to some suitable value (around 1 to 2V) and keep it constant throughout the experiment.
3. Record the voltage drop across the resistance *R* as a function of frequency in a suitable step. Make sure that you have sufficient data point on either side of the resonance frequency (so as to measure the value of τ).
4. Plot the amplitude of voltage *VR* against the frequency ω.
5. Obtain the resonant frequency ω_R and measure the bandwidth τ from the plot. Estimate *Q* factor.
6. Compare the values of ω_R and *Q* with theoretical values.
7. Estimate the maximum possible error in the measurement of Q.

RESULT

Resonant frequency of given LCR circuit = ……

Q- factor of the given LCR circuit = ……

CIRCIUT DIAGRAM

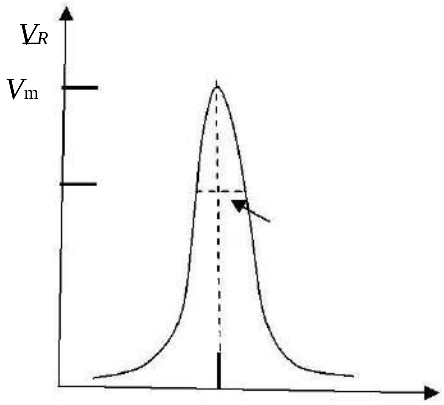


OBSERVATION TABLE

L=
C=

Sl.No.	frequency	ω=2πf	Input voltage	Output voltage across R in mV

MODEL GRAPH



Expt. No. 12 Date:

Solar Cell - I-V characteristics

Aim ***:*** To plot I-V characteristics of Solar Cell and calculate Fill Factor and efficiency.

Apparatu*s:*

Solar cell characteristics kit.

Theory ***:***

A solar cell is a semiconductor PN junction diode as shown in figure 1. The large surface area indicated in light blue is exposed to incident light energy. Solar cells are usually coated with anti-reflective materials so that they absorb the maximum amount of light energy. Normally no external bias is applied to the cell. When a photon of light is absorbed near the PN junction a hole / electron pair is produced. This occurs when the energy of the photon is higher than the energy band-gap of the semiconductor. The built in electric field of the junction cause the pair to separate and head toward the respective + and - terminals. The energy from the light causes a current to flow in an external load when the cell is illuminated.

A typical voltage vs. current characteristic, known as an I/V curve, of a PN diode without illumination is shown in green in figure 2. The applied voltage is in the forward bias direction. The curve shows the turn-on and the buildup of the forward bias current in the diode. Without illumination, no current flows through the diode unless there is external potential applied. With incident sunlight, the I/V curve shifts up showing that there is external current flow from the solar cell to a resistive load as shown with the red curve.

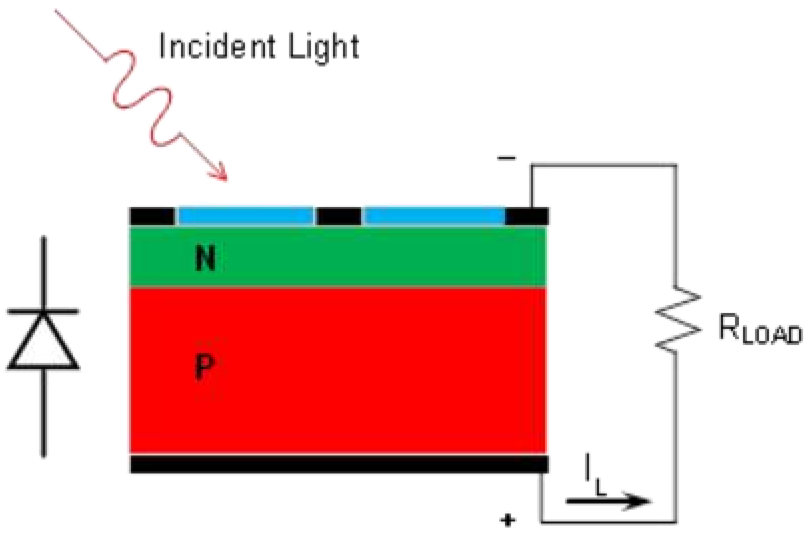


Figure 1 Structure of a basic solar cell.

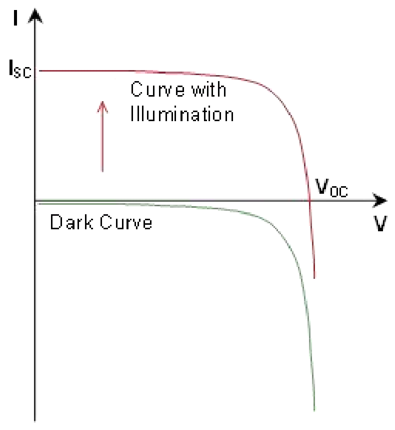


Figure 2 Shift of the solar cell I/V curve with increasing incident light.

Short circuit current, I_{SC}, flows when the external resistance is zero (V = 0) and is the maximum current delivered by the solar cell at a given illumination level. The short circuit current is a function of the PN junction area collecting the light. Similarly, the open circuit voltage, V_{OC}, is the potential that develops across the terminals of the solar cell when the external load resistance is very large, $R_{LOAD} = \infty$. For silicon based cells a single PN junction produces a voltage near 0.5V. Multiple PN junctions are connected in series in a larger solar panel to produce higher voltages. Photovoltaic cells can be arranged in a series configuration to form small modules, and modules can then be connected in parallel-series configurations to form larger arrays. When connecting cells or modules in series to produce higher output voltages, they must have the same current rating (if not the cell with the lowest current specification will limit the ultimate current of the module), and similarly, modules must have the same voltage specification when connected in parallel to generate larger currents. The power delivered to the load is of course zero at both extremes of the I/V curve and reaches a maximum (P_{MAX}) at a single load resistance value. In figure 3, P_{MAX} is shown as the area of the shaded rectangle.

A commonly used parameter that characterizes a solar cell is the fill factor, FF, which is defined as the ratio of P_{MAX} to the area of the rectangle formed by V_{OC} and I_{SC}.

$$FF = \frac{P_{MAX}}{V_{OC} I_{SC}}$$

The efficiency of a solar cell is the ratio of the electrical power it delivers to the load, to the optical power incident on the cell. Maximum efficiency is when power delivered to the load is P_{MAX}. Incident optical power is normally specified as the power from sunlight on the surface of the earth which is approximately 1mW/mm^2. Spectral distribution of sunlight is close to a blackbody spectrum at 6000º C minus the atmospheric absorption spectrum. The maximum efficiency $?_{MAX}$ may be written as:

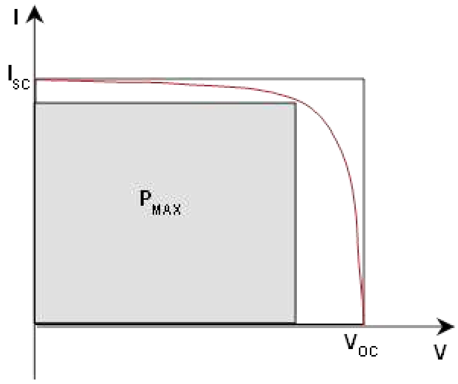


Figure 3 The maximum power delivered by a solar cell, P_{MAX}, is the area of the largest rectangle under the I/V curve.

Equations:

$$FF = \frac{P_{MAX}}{V_{OC} I_{SC}}$$

$$\eta_{MAX} = \frac{P_{MAX}}{P_{IN}} = \frac{V_{OC} I_{SC} FF}{P_{IN}}$$

For a cell of a certain size, I_{SC} is directly proportional to the incident optical power P_{IN}. However, V_{OC} increases logarithmically with the incident power. So, we would expect the overall efficiency of the solar cell to also increase logarithmically with incident power. However, thermal effects at high sunlight concentrations and electrical losses in the series resistance of the solar cell limit the enhancement in efficiency that can be achieved. So the efficiency of practical solar cells peaks at some finite light concentration level.

Procedure*:*

- Connect Solar Cell as per shown in Mimic diagram in front panel.
- Make connection between Solar cell and iv setup using D9 cable provided
- Switch on Light source and adjust intensity to max value.
- Wait few minutes to warm up Solar cell.
- Switch on IV trainer kit.
- To measure V_{OC} (open circuit voltage) disconnect ammeter terminal from circuit and note down V_{oc} in voltmeter.
- Now connect ammeter terminals and note down reading of voltmeter and current meter at various positions of load.
- Now to measure I_{sc} (short circuit current) remove load and short terminal.
- Take I_{sc} reading and plot IV graph between measured voltage and current
- Now by using formulas calculate FF and η

Result:

Fill factor=……………..

Efficiency=…………….

TABULAR COLUMN

VOLTAGE	CURRENT
V_{OC}	0
0	I_{SC}

LABORATORY MANUAL

EEL 332 – POWER SYSTM LAB

AHALIA SCHOOL OF ENGINEERING & TECHNOLOGY

(ISO 9001:2015 Certified Institution)

Approved by AICTE & Affilated to A. P. J. Abdul Kalam Technological University

Ahalia Health, Heritage & Knowledge Village, Palakkad - 678557. Ph: 04923-226666, www.ahalia.ac.in

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

AHALIA SCHOOL OF ENGINEERING AND TECHNOLOGY

PALAKKAD - 678557

CODE	COURSE	CATEGORY	L	T	P	CREDIT
EEL332	POWER SYSTEMS LAB	PCC	0	0	3	2

Preamble : This Laboratory Course will provide a perfect platform for the students to do hands-on practise with hardware and software in Power Systems. The experiments include simulation of power system analysis in steady state and transient state. The Hardware experiments cover Protective Relaying and High Voltage Testing. Successful completion of this lab will certainly make the students equipped for any Power Industry.

Prerequisite : EET301Power Systems I

Course Outcomes : After the completion of the course the student will be able to:

CO 1	Develop mathematical models and conduct steady state and transient analysis of power system networks using standard software.
CO 2	Develop a frequency domain model of power system networks and conduct the stability analysis.
CO 3	Conduct appropriate tests for any power system component as per standards.
CO 4	Conduct site inspection and evaluate performance ratio of solar power plant.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	3	3			3	2	3		3
CO 2	3	2	1	3	3			1	2	3		2
CO 3	3	1	1	3	3	3	1	3	3	3		3
CO 4	3	1	1	3	3	3	3	3	3	3	2	3

ASSESSMENT PATTERN:

Mark distribution :

Total Marks	CIE	ESE	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation (CIE) Pattern:

Attendance	Regular Lab work	Internal Test	Course Project	Total
15	30	25	5	75

Internal Test Evaluation (Immediately before the second series test)

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks:

(a) Preliminary work (Type of Test, circuit diagram and diagram for simulation): 15 Marks
(b) Simulation in software and Conducting the experiment (Procedure) : 10 Marks
(c) Performance, result and inference (usage of equipment and troubleshooting): 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

General instructions : Practical examination to be conducted immediately after the second series test covering the entire syllabus given. Each student has to do both software and hardware parts for the examination. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

LIST OF EXPERIMENTS:

Part A: POWER SYSTEM SIMULATION EXPERIMENTS

1. Y-Bus Formulation(Basic Programming): Effect of change in topology
2. Transmission Line Modelling (Basic Programming): ABCD constants
3. Load Flow Analysis –Gauss-Siedel Method, Newton-Raphson Method,Fast Decoupled Method – Effect of change in load/generation schedule
4. Load Flow Analysis –Gauss-Siedel Method, Newton-Raphson Method,Fast Decoupled Method – Effect of change in real power/reactive power limits
5. Short Circuit Analysis – Symmetrical Faults and Unsymmetrical Faults
6. Contingency Ranking
7. Transient Stability Analysis
8. Automatic Generation Control – Single Area, Two Area
9. Distribution Systems with Solar PV units
10. Reactive Power Control.
11. Ferranti Effect and Reactive Power Compensation.
12. Plot the IV characteristics of a PV module and determine Maximum Power Point.

Part B: POWER SYSTEM COMPONENT TESTING (Hardware experiments)

1. High voltage testing -Power frequency/Impulse
2. High voltage testing -DC
3. Smart metering
4. Relay Testing **-** Over current relay /Earth fault(Electromechanical/Static/Numerical)
5. Relay Testing –Voltage relay/ Impedance Relay (Electromechanical/Static/Numerical)
6. Insulation Testing – LT & HT Cable
7. Earth Resistance
8. Testing of CT and PT
9. Testing of transformer oil
10. Testing of dielectric strength of solid insulating materials
11. Testing of dielectric strength of air
12. Power factor improvement

Instructions:

Both software and hardware experiments are included. **At least 12 experiments (4 hardware experiments are mandatory) and one Mini Project.** Any additional experiment can be treated as Beyond the Syllabus. **Students have to do software simulation and a hardware testing for the End semester examination.**

Mandatory Course Project:

Design a solar power plant (rooftop or ground mounted).Conduct site inspection and feasibility study. Design the components to be used and calculate the performance ratio. Prepare a concise project report giving justifications to the choices made and the economic analysis.

Students have to do a mandatory course project (group size not more than 4 students-individual may be preferred).A report isalso to be submitted. Performance can be evaluated along with the internal test and a maximum of 5 marks shall be awarded.

Reference Books:

1. HadiSaadat, *Power System Analysis*, 2/e, McGraw Hill, 2002.
2. Kothari D. P. and I. J. Nagrath, *Modern Power System Analysis*, 2/e, TMH, 2009
3. M. S. Naidu, V. Kamaraju, *High Voltage Engineering*, Tata McGraw-Hill Education, 2004
4. Wadhwa C. L., *Electrical Power Systems*, 3/e, New Age International, 2009.
5. IEC 61850.
6. IEEE 1547 and 2030 Standards.
7. IS Codes for Testing of Power System components.
8. IEC 61724-1:2017Performance of Solar Power Plants.

SYLLABUS

LIST OF EXPERIMENTS

Part A: POWER SYSTEM SIMULATION EXPERIMENTS

1.Y-Bus Formulation(Basic Programming): Effect of change in topology

2. Transmission Line Modeling (Basic Programming): ABCD constants

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4. Load Flow Analysis –Gauss-Siedel Method, Newton-Raphson Method, Fast Decoupled Method – Effect of change in real power/reactive power limits

5. Short Circuit Analysis – Symmetrical Faults and Unsymmetrical Faults

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(Hardware experiments)

1. High voltage testing -Power frequency/Impulse
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7. Earth Resistance
8. Testing of CT and PT
9. Testing of transformer oil
10. Testing of dielectric strength of solid insulating materials
11. Testing of dielectric strength of air
12. Power factor improvement

LIST OF EXEPERIMENT

Sl.No	DATE	NAME OF EXPERIMENT	PAGE NO.	MAR K	SIG N
		PART A			
1		Y-Bus Formulation			
2		Transmission Line Modeling			
3a		Load Flow Analysis –Gauss-Siedel Method - Effect of change in load/generation schedule			
3b		Load Flow Analysis –Newton-Raphson – Effect of change in load/generation schedule			
3c		Load Flow Analysis – Fast Decoupled Method – Effect of change in load/generation schedule			
4a		Load Flow Analysis –Gauss-Siedel Method - Effect of change real power/reactive power limits			
4b		Load Flow Analysis –Newton-Raphson – Effect of change in real power/reactive power limits			
4c		Load Flow Analysis – Fast Decoupled Method – Effect of change in real power/reactive power limits			

5a.		Short Circuit Analysis – Symmetrical Faults			
5b.		Short Circuit Analysis –Unsymmetrical Faults			
6		Transient Stability Analysis			
7a		Automatic Generation Control – Single Area System			
7b		Automatic Generation Control – Two Area System			
8		Plot the IV characteristics of a PV module and determine Maximum Power Point			
PART - B					
9		Relay Testing - Over current relay			
10		Relay Testing –Voltage relay			
11		Earth Resistance			
12		Testing of CT and PT			
13		Testing of transformer oil			
14		Power factor improvement			

EXP.NO: 1

DATE:

Formation of Y - bus matrix

AIM:

To develop a program for formulate the Y –bus matrix for a given n-bus system by direct inspection method.

THEORY:

Y bus denotes the matrix of bus admittance and is known as bus admittance matrix. The dimension of Y bus matrix is (n x n).

Where n=number of buses.

$$\begin{bmatrix} I1 \\ I2 \\ I3 \end{bmatrix} = \begin{pmatrix} y_{11} & y_{12} & y_{13} \\ y_{21} & y_{22} & y_{23} \\ y_{31} & y_{32} & y_{33} \end{pmatrix} \begin{bmatrix} V1 \\ V2 \\ V3 \end{bmatrix}$$

Where

$y_{11}=y_{10}+y_{12}+y_{13}$;

$y_{22}=y_{20}+y_{21}+y_{23}$;

$y_{33}=y_{30}+y_{31}+y_{32}$;

$y_{12}=y_{21}=-Y_{12}$;

$y_{23}=y_{32}=-Y_{23}$;

$y_{31}=y_{13}=-Y_{13}$;

Each admittance matrix Y_{ij}(j=1,2,3,4) is called as self admittance or driving point admittance of node i and equals algebraic sum of all admittance terminating on the node. Each diagonal term is mutual admittance or transfer admittance between nodes i & j and equals negative sum of all admittance connected directly between these nodes.Y-bus of large networks is very sparse. It greatly reduces numerical computations in load flow studies and minimizes the memory requirements.

ALGORITHM:

STEP1: Create a new m-file.

STEP2: Get the number of buses in the system

STEP3: Read the self admittance of all the buses.

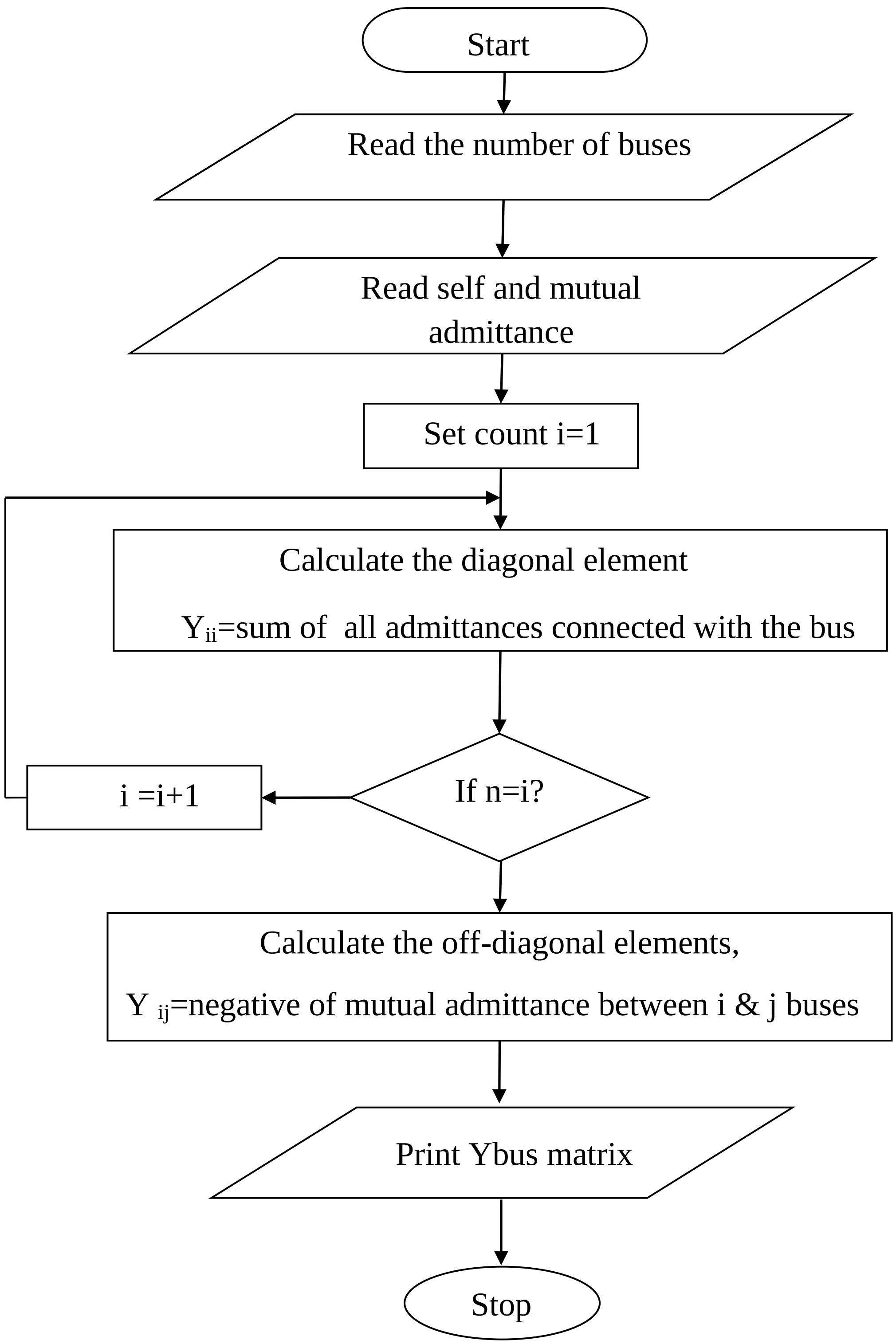
STEP4: Calculate the diagonal elements of bus matrix which is the sum of all admittances connected in single buses.

STEP5: Calculate the off-diagonal elements of bus matrix which are negative of mutual admittance.

STEP6: Print the computed admittance matrix y-bus.

STEP7: Stop the program.

FLOWCHART


Start
Read the number of buses
Read self and mutual admittance
Set count i=1
Calculate the diagonal element
Y_{ii}=sum of all admittances connected with the bus
If n=i?
i =i+1
Calculate the off-diagonal elements,
Y_{ij}=negative of mutual admittance between i & j buses
Print Ybus matrix
Stop

PROGRAM:

```
clear all;
clc;
n=input('enter  the  number  of  buses:');
for i=1:n
for j=i+1:n
y(i,j)=input(['enter the  line admittance y',num2str(i),num2str(j),':']);
y(j,i)=y(i,j);
end
end
for i=1:n
y1(i)=input(['enter the admittance to ground y',num2str(i),':']);
end
for i=1:n
for j=1:n
if i==j
ybus(i,j)=0;
for k=1:n
ybus(i,j)=ybus(i,j)+y(j,k);
end
else
ybus(i,j)=-1*y(i,j);
end
end
end
for i=1:n
ybus(i,i)=ybus(i,i)+y1(i);
end
disp('ybus matrix is:');
disp(ybus);
```

PROBLEM:

OUTPUT:

enter the number of buses: 4

enter line admittance y12: 0.2941-1.1764i

enter line admittance y13: 0.5882-2.3529i

enter line admittance y14: 0

enter line admittance y23: 0.3333-1i

enter line admittance y24: 0.2352-0.9411i

enter line admittance y34: 0.2941-1.1764i

enter the admittance to ground y1: 0.03i

enter the admittance to ground y2: 0.09i

enter the admittance to ground y3: 0.06i

enter the admittance to ground y4: 0.06i

Y-bus matrix is:

0.8823-3.4993i	-0.2941+1.1764i	-0.5882+2.3529i	0
-0.2941+1.1764i	0.8626-3.0275i	-0.3333+1.0000i	-0.2352+0.9411i
-0.5882+2.3529i	-0.3333+1.0000i	1.2156 -4.4693i	-0.2941+1.1764i
0	-0.2352+0.9411i	-0.2941+1.1764i	0.5293-2.0575i

RESULT:

Thus a Y-bus admittance matrix is formed from a given bus system by direct inspection method.

EXP.NO:2

DATE:

MODELLING OF TRANSMISSION LINES

AIM:

To understand modeling and performance of short, medium and long transmission lines.

SOFTWARE REQUIRED:

MATLABFORMULAE:

$V_s=AV_R+BI_R$

$I_s=CV_R+DI_R$

TYPE	METHOD	ABCD PARAMETERS
Short	-------------------	A=D=1; B=Z; C=0.
Medium	Nominal T Method	A=D=1+YZ/2; B=Z(1+YZ/4); C=Y;
	Nominal π Method	A=D=1+YZ/2; B=Z; C=Y(1+YZ/4);
Long	Rigorous Method	$A=D=\cosh(\gamma\ell)$; $B=Z_c \sinh(\gamma\ell)$; $C=1/Z_c \sinh(\gamma\ell)$; $\gamma=\sqrt{(ZY)}$; $Z_c=\sqrt{(Z/Y)}$;
	Equivalent π Method	A=D=1+YZ/2; B=Z; C=Y(1+YZ/A); $Z=Z \sinh(\gamma\ell)/ \gamma\ell$; $Y=Y \tanh(\gamma\ell/2)/ (\gamma\ell/2)$; $\gamma=\sqrt{(ZY)}$; $Z_c=\sqrt{(Z/Y)}$;
	Equivalent T Method	A=D=1+YZ/2; B=Z; C=Y(1+YZ/A); $Z=Z \tanh(\gamma\ell/2)/ (\gamma\ell/2)$; $Y=Y \sinh(\gamma\ell)/ \gamma\ell$; $\gamma=\sqrt{(ZY)}$; $Z_c=\sqrt{(Z/Y)}$;

PROCEDURE:

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File
3. Type and save the program in the editor window.
4. Execute the program by either pressing Tools – Run.

PROBLEM:

1. View the results an overhead 3 phase transmission line delivers 4000KW at 11 KV at 0.8 pf lagging. Theresistance and reactance of each conductor are 1.5Ω and 4Ω per phase. Determine the line performance.

Manual Calculation:

SHORT TRANSMISSION LINE

PROGRAM:

```
clc; clear all;
R=input('Resistance                          :');
XL=input('Inductive Reactance                    :');
XC=input('Capacitive Reactance                   :');
G=input('Conductance                          :');
length=input('Length of Transmission Line         :');
f=input('Frequency                            :');
Z1=    (R+j*XL)*length;    Y1=
(G+j*XC)*length;A = 1;
B = Z1;C = 0;
D =1;
TM = [ A B; C D ];
VRL=input('ENTER RECEIVEING END VOLTAGE                     :');
VRP=VRL/(sqrt(3));
PR = input('ENTER RECEIVING END LOAD IN MW                  :');
Pf=input('ENTER THE RECEIVING END LOAD POWER FACTOR          :');
h=acos(Pf);
SR=PR/Pf;
SR=SR*(cos(h)+j*sin(h));
QR=imag(SR);
IR=conj(SR)/(3*conj(VRP));
SM=TM*[VRP;IR]; VS=SM(1,1);
IS=SM(2,1);
Pfs=cos(angle(VS)-angle(IS));
SS=3*VS*conj(IS);
VSA=angle(VS)*(180/pi);
ISA=angle(IS)*(180/pi);
VS=sqrt(3)*abs(VS);
IS=abs(IS)*1000;
VREG=((VS/(abs(TM(1,1)))-VRL)/VRL)*100;
PS=real(SS);
QS=imag(SS);
eff=PR/PS*100;
PL=PS-PR;
QL=QS-QR;
Z1 Y1 TM
```

```
fprintf('SENDING END LINE VOLTAGE %g at %g degrees \n',VS,VSA);
fprintf('SENDING END LINE CURRENT %g at %g degrees \n',IS,ISA);
fprintf('SENDING END POWER FACTOR %g\n',Pfs);
fprintf('SENDING END  REAL POWER %g\n',PS); fprintf('SENDING END
REACTIVE POWER %g\n',QS); fprintf('PERCENTAGE VOLTAGE
REGULATION  %g\n',VREG);
fprintf('REAL POWER LOSS %g\n',PL);
fprintf('REACTIVE POWER LOSS %g\n',QL);
fprintf('EFFICIENCY %G', eff);
```

OUTPUT:

```
Resistance                     : 1.5
Inductive Reactance            : 4
Capacitive Reactance           : 0
Conductance                    : 0
Length of Transmission Line    : 1
Frequency                      : 50
ENTER RECEIVEING END VOLTAGE                11
ENTER RECEIVING END LOAD IN MW              4
ENTER THE RECEIVING END LOAD POWER FACTOR          : 0.8
Z1 = 1.5000 + 4.0000i

Y1 = 0
TM =

1.0000          1.5000 + 4.0000i
0               1.0000

SENDING END LINE VOLTAGE 12.6795 at 4.72953 degreesSENDING
END LINE CURRENT 262.432 at -36.8699 degreesSENDING END
POWER FACTOR 0.747805
SENDING END REAL POWER 4.30992 SENDING
END REACTIVE POWER 3.82645
PERCENTAGE VOLTAGE REGULATION 15.2685REAL
POWER LOSS 0.309917
REACTIVE POWER LOSS 0.826446
EFFICIENCY 92.8092
```

2. A balanced 3 phase load of 30 MW is supplied at 132KV, 50Hz and 0.85 pf lag by meansof a line. The series impedance is 20+j52Ω and total admittance is $315*10^{-6}$℧ .UsingNormal T method determine A,B,C,D parameters and regulation.

Manual Calculation:

MEDIUM TRANSMISSION LINE

NOMINAL T METHOD:

PROGRAM:

```
clc;
clear
all;
R=input('Resistance                              :');
XL=input('Inductive Reactance                    :');
XC=input('Capacitive Reactance                   :');
G=input('Conductance                             :');
length=input('Length of Transmission Line        :');
f=input('Frequency                               :');
Z1=
(R+j*XL)*length;
Y1=
(G+j*XC)*length;
m=menu('ENTER THE TYPE OF NETWORK','NOMINAL T', 'NOMINAL PI');
switch m
case {1}
A = 1+(Z1*Y1/2);
B=Z1*(1+(Z1*Y1/4));
C=Y1;
D=A;
otherwise
A = 1+(Z1*Y1/2); B=Z1;
C=Y1*(1+(Z1*Y1/4));
D=A;
end
TM = [ A B; C D ];
VRL=input('ENTER RECEIVEING END VOLTAGE                :');
VRP=VRL/(sqrt(3));
PR = input('ENTER RECEIVING END LOAD IN MW             :');
Pf=input('ENTER THE RECEIVING END LOAD POWER FACTOR    :');
h=acos(Pf);SR=PR/Pf;
SR=SR*(cos(h)+j*sin(h));
QR=imag(SR);
```

```
IR=conj(SR)/(3*conj(VRP));
SM=TM*[VRP;IR];
VS=SM(1,1);
IS=SM(2,1);
Pfs=cos(angle(VS)-angle(IS));
SS=3*VS*conj(IS);
VSA=angle(VS)*(180/pi);ISA=angle(IS)*(180/pi); VS=sqrt(3)*abs(VS);
IS=abs(IS)*1000;
VREG=((VS/(abs(TM(1,1)))-VRL)/VRL)*100;
PS=real(SS); QS=imag(SS); eff=PR/PS*100;
PL=PS-PR; QL=QS-QR;
Z1 Y1 TM
fprintf('SENDING END LINE VOLTAGE %g at %g degrees \n',VS,VSA);
fprintf('SENDING END LINE CURRENT %g at %g degrees \n',IS,ISA);
fprintf('SENDING END POWER FACTOR %g\n',Pfs);
fprintf('SENDING END REAL POWER %g\n',PS); fprintf('SENDING
END REACTIVE POWER %g\n',QS); fprintf('PERCENTAGE
VOLTAGE REGULATION  %g\n',VREG);
fprintf('REAL POWER LOSS %g\n',PL);
fprintf('REACTIVE POWER LOSS %g\n',QL);
fprintf('EFFICIENCY %G', eff);
```

OUTPUT:

Resistance	: 20
Inductive Reactance	: 52
Capacitive Reactance	: 315*10^(-6)
Conductance	: 0
Length of Transmission Line	: 1
Frequency	: 50

ENTER RECEIVEING END VOLTAGE 132

ENTER RECEIVING END LOAD IN MW 30

ENTER THE RECEIVING END LOAD POWER FACTOR : 0.85

Z1 = 20.0000 +52.0000i

Y1 =0 +3.1500e-004i

TM = 0.9918 + 0.0031i 19.8362 +51.8186i

0 + 0.0003i 0 .9918 0.0031i

SENDING END LINE VOLTAGE 143.035 at 3.76761degrees

SENDING END LINE CURRENT 142.007 at -23.3284 degrees

SENDING END POWER FACTOR 0.890244

SENDING END REAL POWER 31.3199

SENDING END REACTIVE POWER 16.0245

PERCENTAGE VOLTAGEREGULATION 9.25407

REAL POWER LOSS 1.31989

REACTIVE POWER LOSS -2.56785EFFICIENCY 95.7858

RESULT:

Thus the line modeling of different types of transmission lines was done by using MATLAB software

EXP.NO: 3a/4a

DATE:

LOAD FLOW ANALYSIS USING GAUSS SEIDAL METHOD

AIM:

To analyze the load flow studies - Gauss-Seidal method for the given three bus system using MATLAB programming technique by varying the following parameters

1. Effect of change in load/generation schedule
2. Effect of change in real power/reactive power limits

THEORY:

The Gauss-Seidal method is an iterative method for solving a set of non-linear algebraic equations. In this case, first we have to assume all buses as PQ buses instead of slack bus. The slack bus voltage is specified. Then there are (n-1) bus voltages starting values whose magnitude and angles are assumed. The process is then repeated for all the variables thereby completing one iteration. The iterative process is then repeated till the solution vector converges within prescribed accuracy. This equation used to find the bus voltages in all iteration is

$$\mathrm{Vi} = \frac{1}{\mathrm{Yii}}\left[\frac{\mathrm{Pi} - \mathrm{jQi}}{\mathrm{Vik}} - \Sigma Y_{ik} V_k\right]$$

Where k=1, 2, 3………….n, k≠i

Convergence in Gauss-Seidal method can sometimes be speeded up by the use of

acceleration factor having a recommended value of 1.6

ALGORITHM:

STEP 1: Read the value for number of buses,Y-bus, slack bus voltage, Pp and Qp for load buses and P_p,V_p,Q_{pmax},Q_{pmin} for generator buses and number of iterations.

STEP 2: Set the flat voltage profile 1+j0 for all the buses except slack bus.

STEP3: Calculate the value of Q for PV uses using

$$Qp^{k+1} = -\mathrm{imag}\{(Vp^{k}) * [\Sigma YpqVp^{k+1} + \Sigma YpqVq].$$

STEP4: Check for the limits,if $Qp^{k+1} < Qpmin$, then $Qp^{k+1} = Qpmin$,

if Qp^{k+1} >Qpmax, then $Qp^{k+1} = Qpmax$.

STEP5: Calculate the phase angle of P^{th} bus using

$$\delta p^{k+1} =< Vp^{k+1} =< (\frac{1}{Ypp}[\frac{Pp-jQp}{Vp*} - \Sigma YpqVp^{k+1} - \Sigma YpqVq^{k}]).$$

STEP 6: Set $Vp^{k+1} = |Vp|spec < \delta p^{k+1}$ and treat PV buses as PQ buses

STEP 7: Check whether all the PV buses are converted into PQ buses, if yes go to step 8 else go to step3

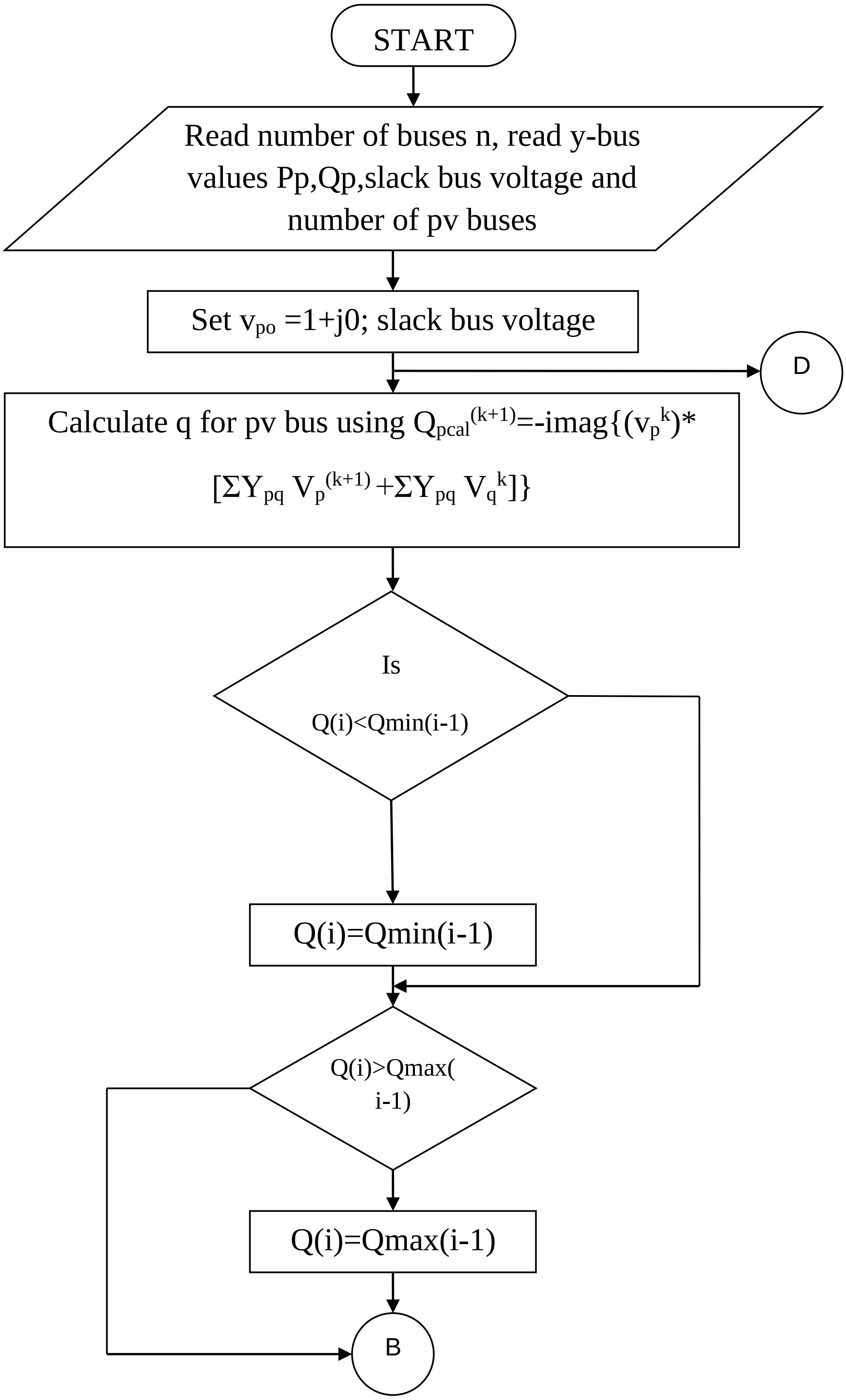
STEP 8: Initiate iteration for PQ buses and calculate Vp using:

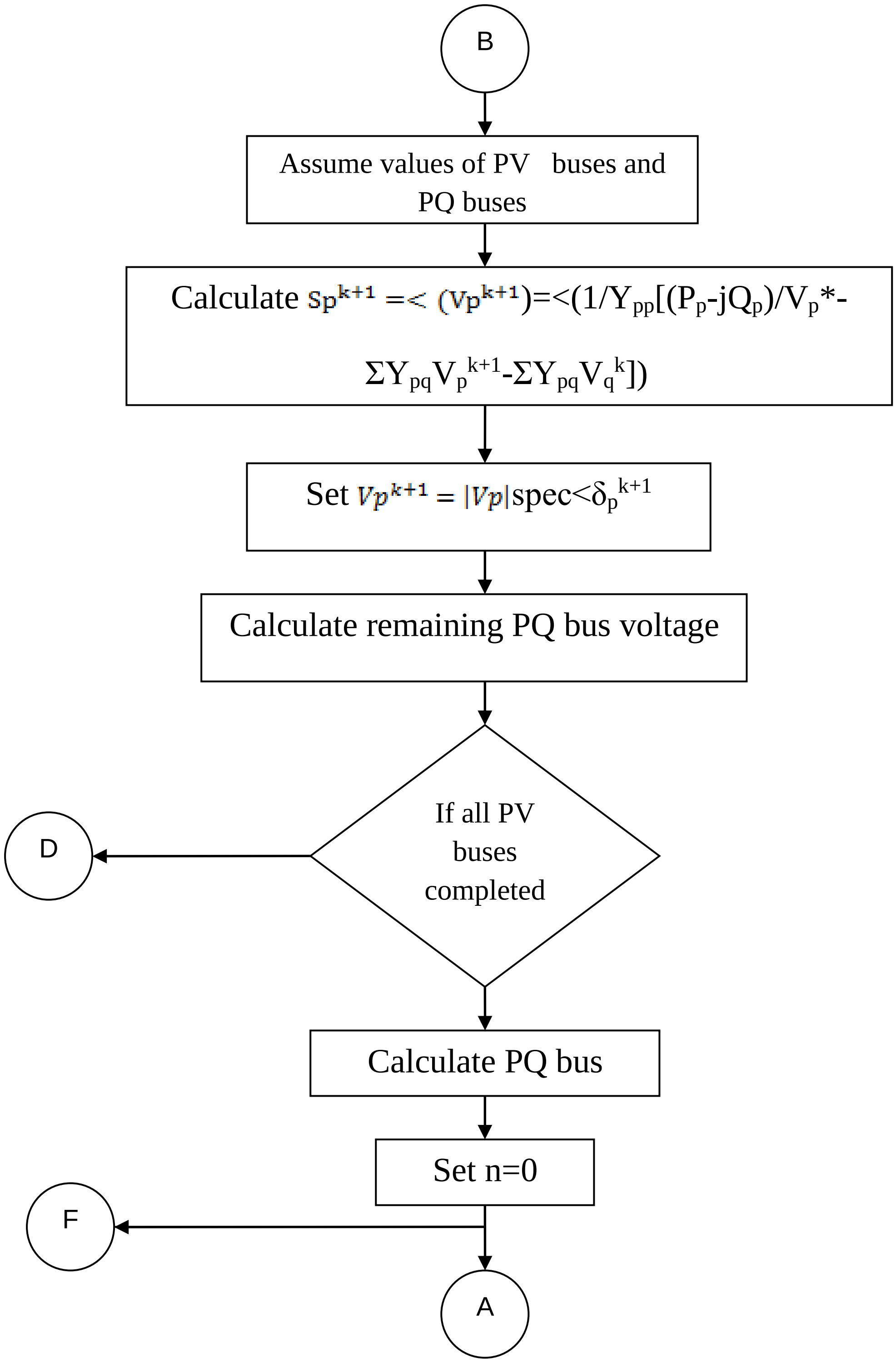
$$Vp^{k+1} = \frac{1}{Ypp}\left[\frac{(Pp-jQp)}{Vp *} - \sum Y_{pq} V_p^{k+1} - \sum Y_{pq} V_q^{k}\right]$$

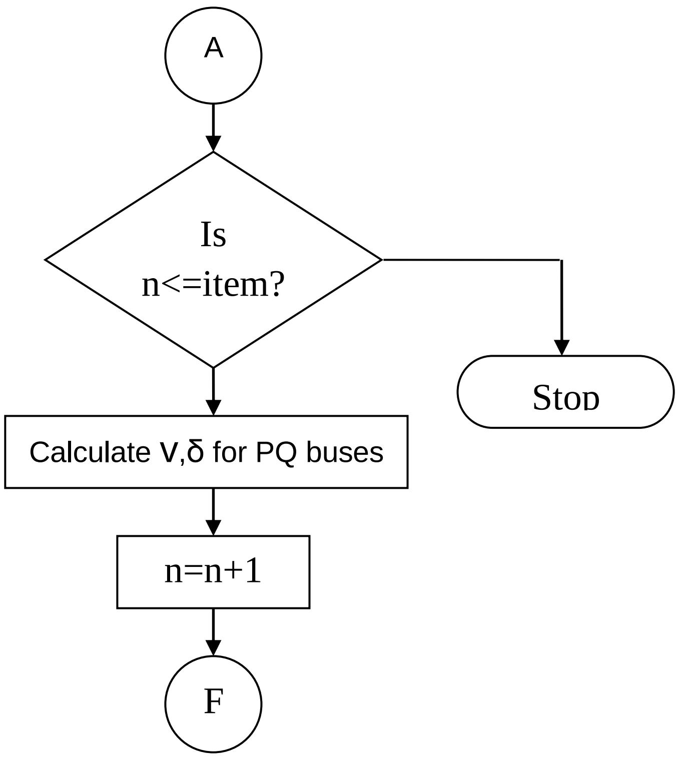
STEP 9: Check whether the iteration count is reached, if yes, go to step 10 else go to step 8.

STEP10: Print voltage values of all buses.

FLOWCHART:


START
Read number of buses n, read y-bus values Pp,Qp,slack bus voltage and number of pv buses
Set v_{po} =1+j0; slack bus voltage
D
Calculate q for pv bus using $Q_{pcal}^{(k+1)}$=-imag{(v_p^k)*
[$\Sigma Y_{pq}\ V_p^{(k+1)} + \Sigma Y_{pq}\ V_q^k$]}
Is
Q(i)<Qmin(i-1)
Q(i)=Qmin(i-1)
Q(i)>Qmax(
i-1)
Q(i)=Qmax(i-1)
B


B
Assume values of PV buses and PQ buses
Calculate $Sp^{k+1} = < (Vp^{k+1}) = <(1/Y_{pp}[(P_p - jQ_p)/V_p^* - \Sigma Y_{pq} V_p^{k+1} - \Sigma Y_{pq} V_q^{k}])$
Set $Vp^{k+1} = |Vp|spec<\delta_p^{k+1}$
Calculate remaining PQ bus voltage
If all PV buses completed
D
Calculate PQ bus
Set n=0
F
A



PROCEDURE:

1. Download the Power system Analysis by “Hadi Saddat” M file download and extract the zip file.
2. Open MATAB command window and go to “set path” and add extracted M file in the MATLAB directory then save the files.
3. Open CHP6 EX9.m M file and save as “LFAGAUSS.m”
4. Make the changes in the data as per given problem data “LFAGAUSS.m” file
5. Open “lfybus.m” file.
6. Open “lfgauss.m” file.
7. Open “busout.m” file.
8. Open “linefow.m” file
9. Open “LFAGAUSS.m” and run the m file.
10. Copy the result from the command window and save it.
11. Check the result up to first iteration by manual calculation.

PROBLEM:

Figure 6.12 shows the one-line diagram of a simple three-bus power system with generators at buses 1 and 3. The magnitude of voltage at bus 1 is adjusted to 1.05 pu. Voltage magnitude at bus 3 is fixed at 1.04 pu with a real power generation of 200 MW. A load consisting of 400 MW and 250 Mvar is taken from bus 2. Line impedances are marked in per unit on a 100 MVA base, and the line charging susceptances are neglected. Obtain the power flow solution by the Gauss-Seidel method including line flows and line losses.

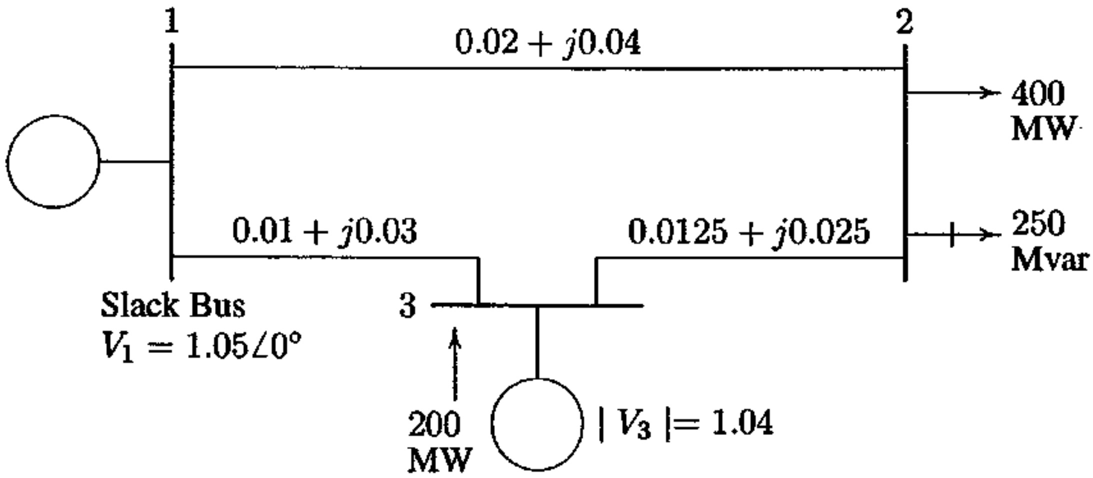


FIGURE 6.12
One-line diagram of Example 6.8 (impedances in pu on 100-MVA base).

CALCULATION:

RESULT:

Thus the load flow analysis – Gauss seidal method for the given problem is performed and verified manual calculation up to first iteration.

EXP.NO: 3b/4b

DATE:

LOAD FLOW ANALYSIS USING NEWTON RAPHSON METHOD

AIM:

To analyze the load flow studies – Newton Raphson method for the given three bus system using MATLAB programming technique by varying the following parameters

1. Effect of change in load/generation schedule
2. Effect of change in real power/reactive power limits

THEORY:

The Newton-Raphson method is a powerful method of solving non-linear algebraic equations. It works faster and is sure to converge in most of the cases. It includes the practical method of load flow solution of large power networks.

In order to solve non-linear algebraic equations through this method, need to calculate jacobian matrix. It is obtained by differentiating the function vector 'x' & evaluating it at x^0.

$J+jAx^{A}=0$

These set of linear algebraic equations can be solved effectively by triangulation and back substitution. Iteration one will be continued till

$|F_i(k^v) < \sum|$all specific values$|$

where i=1,2,3……n

ALGORITHM:

STEP 1: Input the total number of buses 'n'.

STEP 2: Input the Y-bus matrix of order n×n.

STEP 3: Assume all the bus voltage as 1p.u except stack bus.

STEP 4: Set the iteration count as k=0 & bus count as p=1.

STEP 5: Calculate the real & reactive power P_p & Q_p using the formula

$$\boxed{\begin{gathered} P_p=\sum V_p V_q Y_{pq}*\cos(\theta_{pq}+\delta_p-\delta_q) \\ Q_p=\sum V_p V_q Y_{pq}*\sin(\theta_{pq}+\delta_p-\delta_q) \end{gathered}}$$

STEP 6: Evaluate $P_p^k = P_{sp}-P_p^k$.

STEP 7: If the bus is the generator bus (PV), check the value of Q_p^k is within the limit. If violated the limit, then evaluate the violated limit as reactive power and treat it as per bus if the limits is not violated then calculate

$$|V_p|^v=|V_p|^v_{spec}-|V_p|^v$$

$$Q_p=Q_{spec}-Q_p^k$$

STEP 8: Advance the bus count by 1 and check if the buses have been accounted. If not go to step 5

STEP 9: Calculate voltage increment e_p^k & F_p^k

STEP 10: Calculate the bus voltage

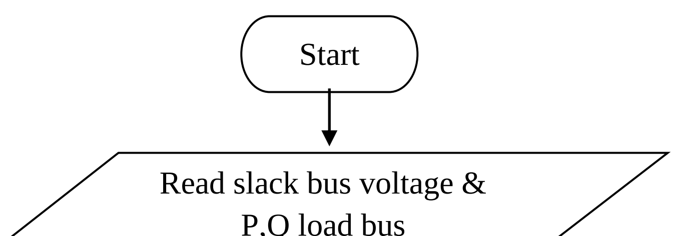
$$e_p^{k+1}=e_p^k+e_p^k \ \&$$

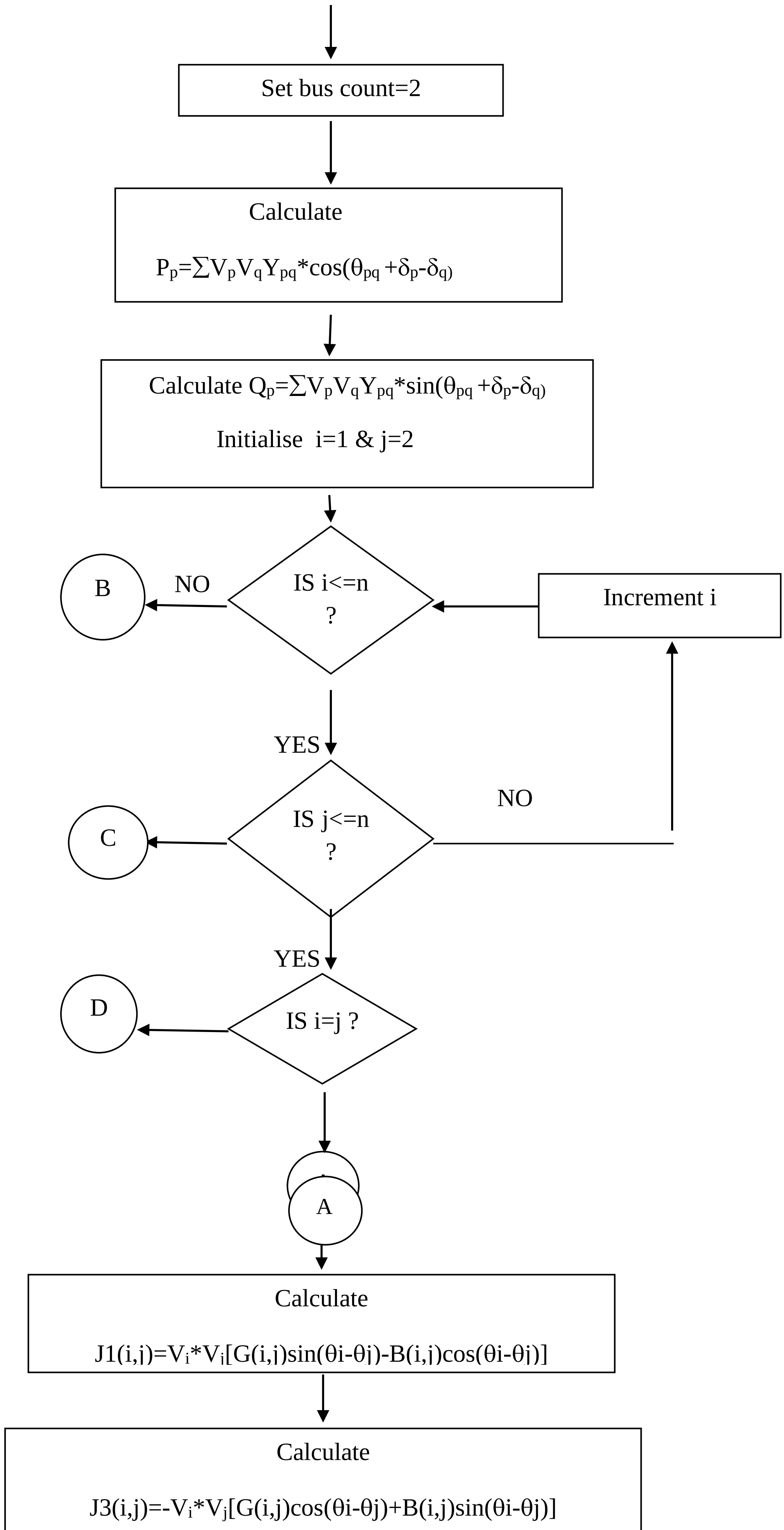
$$F_p^{k+1}=F_p^k+F_p^k$$

STEP 11: Advance iteration count by 1 and go to step 5

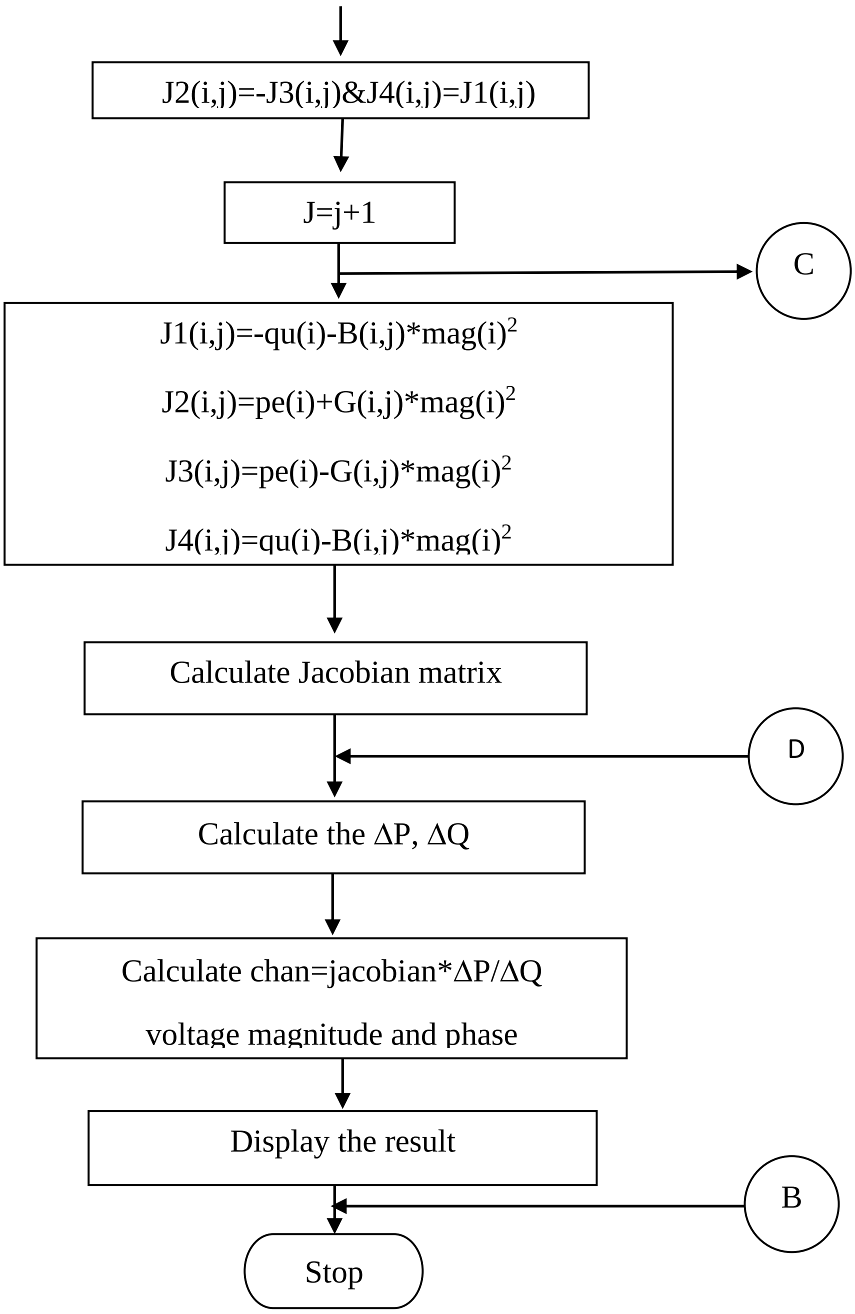
STEP 12: Evaluate bus voltage & power flow through line.

FLOWCHART:





Set bus count=2
Calculate
$P_p=\sum V_p V_q Y_{pq}*\cos(\theta_{pq}+\delta_p-\delta_q)$
Calculate $Q_p=\sum V_p V_q Y_{pq}*\sin(\theta_{pq}+\delta_p-\delta_q)$
Initialise i=1 & j=2
IS i<=n ?
NO
B
Increment i
YES
IS j<=n ?
NO
C
YES
IS i=j ?
D
A
Calculate
$J1(i,j)=V_i*V_j[G(i,j)\sin(\theta i-\theta j)-B(i,j)\cos(\theta i-\theta j)]$
Calculate
$J3(i,j)=-V_i*V_j[G(i,j)\cos(\theta i-\theta j)+B(i,j)\sin(\theta i-\theta j)]$



PROCEDURE:

1. Download the Power system Analysis by “Hadi Saddat” M file download and extract the zip file.
2. Open MATAB command window and go to “set path” and add extracted M file in the MATLAB directory then save the files.
3. Open CHP6 EX9.m M file and save as “LFANEWTON.m”
4. Make the changes in the data as per given problem data “LFANEWTON.m” file
5. Open “lfybus.m” file.
6. Open “lfnewton.m” file.
7. Open “busout.m” file.
8. Open “linefow.m” file
9. Open “LFNEWTON.m” and run the m file.
10. Copy the result from the command window and save it.

11. Check the result up to first iteration by manual calculation.

PROBLEM:

Figure 6.12 shows the one-line diagram of a simple three-bus power system with generators at buses 1 and 3. The magnitude of voltage at bus 1 is adjusted to 1.05 pu. Voltage magnitude at bus 3 is fixed at 1.04 pu with a real power generation of 200 MW. A load consisting of 400 MW and 250 Mvar is taken from bus 2. Line impedances are marked in per unit on a 100 MVA base, and the line charging susceptances are neglected. Obtain the power flow solution by the NR method including line flows and line losses.

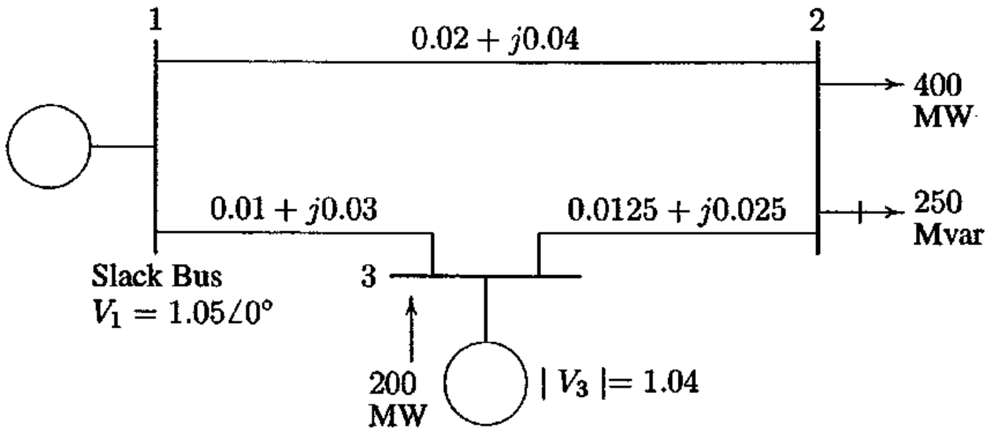


FIGURE 6.12
One-line diagram of Example 6.8 (impedances in pu on 100-MVA base).

CALCULATION:

RESULT:

Thus the load flow analysis – Newton Raphson method for the given problem is performed and verified manual calculation up to first iteration.

EXP.NO: 3c/4c

DATE:

LOAD FLOW ANALYSIS USING FAST DECOUPLED METHOD

AIM:

To analyze the load flow studies – Fast Decoupled method for the given three bus system using MATLAB programming technique by varying the following parameters

1. Effect of change in load/generation schedule
2. Effect of change in real power/reactive power limits

THEORY:

An important characteristic of any practical electric power transmission system operating in steady state is the strong interdependence between real powers and bus voltages angles and between reactive powers and voltage magnitudes. This interesting property of weak coupling between P- δ and Q-V variables gave the necessary motivation in developing the Fast Decoupled Load Flow, in which P- δ and Q-V problems are solved separately.

FLOW CHART:

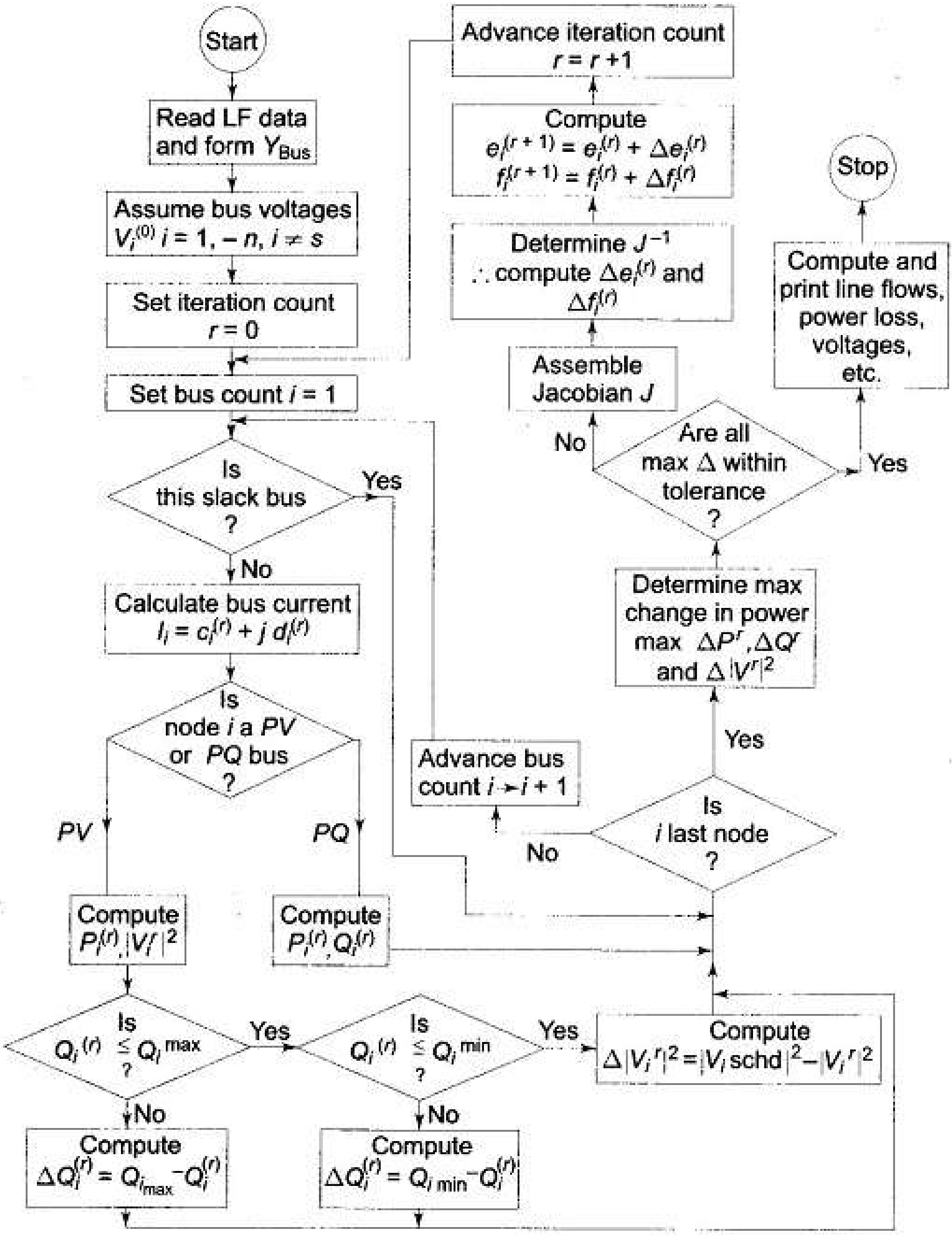

Start
Read LF data and form Y_{Bus}
Assume bus voltages $V_i^{(0)}$ $i = 1, -n, i \neq s$
Set iteration count $r = 0$
Set bus count $i = 1$
Is this slack bus ?
Yes
No
Calculate bus current $I_i = c_i^{(r)} + j\, d_i^{(r)}$
Is node i a PV or PQ bus ?
PV
PQ
Compute $P_i^{(r)}, |V_i^r|^2$
Compute $P_i^{(r)}, Q_i^{(r)}$
Is $Q_i^{(r)} \leq Q_i^{\max}$?
Yes
No
Is $Q_i^{(r)} \leq Q_i^{\min}$?
Yes
No
Compute $\Delta Q_i^{(r)} = Q_{i\max} - Q_i^{(r)}$
Compute $\Delta Q_i^{(r)} = Q_{i\min} - Q_i^{(r)}$
Compute $\Delta |V_i^r|^2 = |V_i \text{ schd}|^2 - |V_i^r|^2$
Is i last node ?
No
Yes
Advance bus count $i \to i + 1$
Determine max change in power max $\Delta P^r, \Delta Q^r$ and $\Delta |V^r|^2$
Are all max Δ within tolerance ?
No
Yes
Assemble Jacobian J
Determine J^{-1} $\therefore$ compute $\Delta e_i^{(r)}$ and $\Delta f_i^{(r)}$
Compute $e_i^{(r+1)} = e_i^{(r)} + \Delta e_i^{(r)}$ $f_i^{(r+1)} = f_i^{(r)} + \Delta f_i^{(r)}$
Advance iteration count $r = r + 1$
Compute and print line flows, power loss, voltages, etc.
Stop

Fig. 6.12

PROCEDURE:

1. Download the Power system Analysis by “Hadi Saddat” M file download and extract the zip file.
2. Open MATAB command window and go to “set path” and add extracted M file in the MATLAB directory then save the files.
3. Open CHP6 EX9.m M file and save as “LFAFDLF.m”
4. Make the changes in the data as per given problem data “LFAFDLF.m” file
5. Open “lfybus.m” file.
6. Open “decouple.m” file.
7. Open “busout.m” file.
8. Open “linefow.m” file
9. Open “LFAFDLF.m” and run the m file.
10. Copy the result from the command window and save it.
11. Check the result up to first iteration by manual calculation.

PROBLEM:

Figure 6.12 shows the one-line diagram of a simple three-bus power system with generators at buses 1 and 3. The magnitude of voltage at bus 1 is adjusted to 1.05 pu. Voltage magnitude at bus 3 is fixed at 1.04 pu with a real power generation of 200 MW. A load consisting of 400 MW and 250 Mvar is taken from bus 2. Line impedances are marked in per unit on a 100 MVA base, and the line charging susceptances are neglected. Obtain the power flow solution by the FDLF method including line flows and line losses.

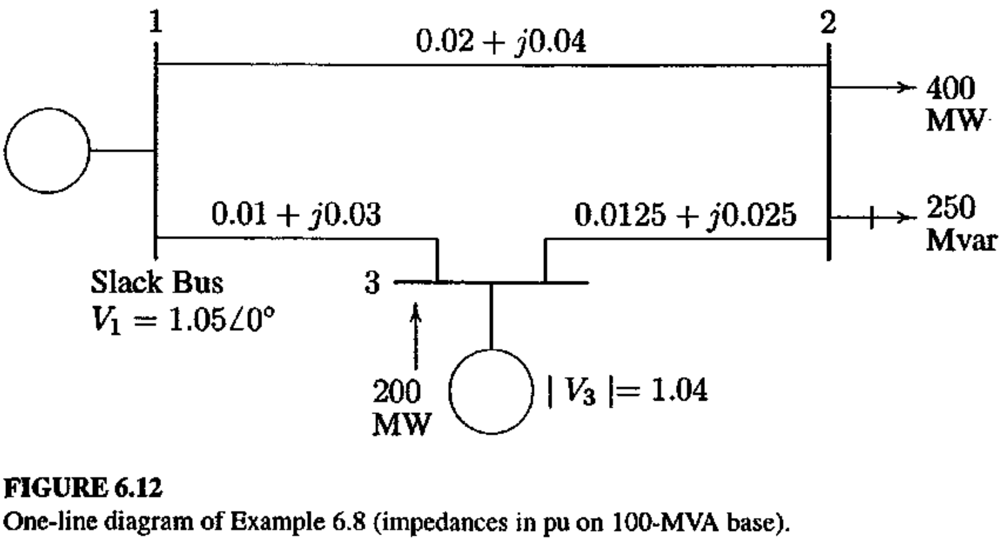


FIGURE 6.12
One-line diagram of Example 6.8 (impedances in pu on 100-MVA base).

CALCULATION:

RESULT:

Thus the load flow analysis – Fast Decoupled method for the given problem is performed and verified manual calculation up to first iteration.

EX.No.5a
DATE : **SHORT CIRCUIT ANALYSIS - SYMMETRICALS FAULT**

AIM:

To conduct the fault analysis of power system networks on power world simulator software platform to solve a symmetrical fault of the given system and verify by manual calculation.

THEORY:

Short circuit studies are performed to determine the magnitude of currents flowing throughout the power system at various time intervals after the occurrence of the fault. The magnitude of the current flowing through the power system after a fault varies with time until they reach steady state condition. This behavior is due to system characteristics and dynamics during this time, the protective is called to detect, interrupt and isolate these faults. The various types of faults occurring in a system in the order of frequency of occurrence are

- Single-line to ground
- Line-to-line
- Double line-to-ground
- Three phase faults.

Other types of faults include,

- One conductor open
- Two conductors open

The path for the fault current may have either zero impedance (dead short circuit) orimpedance.

Fault analysis consists of determining these currents for various type fault at various location in the system. The short circuit information is used to select fuses breakers and switchgear ratings in addition to setting protective relays. The short circuit program computes the steady state current for the impedance considered.

PROCEDURE:

1. Download and install the open source "Power World Simulator" software.
2. Open "Power World Simulator" software.
3. Open new modes
4. Go to "draw" header then select network icon.
5. By selecting the component from network icon, draw the one line diagram of given problem and fill the given data.
6. Go to run mode, select solve play button and select fault analysis header.
7. Select single fault, data window will be open then select type of fault.
8. Enter fault " impedance Zf" value if given.
9. Click "calculate" and save the result.

Problem :

The one-line diagram of a simple power system is shown in Figure 10.16. The neutral of each generator is grounded through a current-limiting reactor of 0.25/3 per unit on a 100-MVA base. The system data expressed in per unit on a common 100-MVA base is tabulated below. The generators are running on no-load at their rated voltage and rated frequency with their emfs in phase.

Determine the fault current for the following faults.

(a) A balanced three-phase fault at bus 3 through a fault impedance $Z_f = j0.1$ per unit.

(b) A single line-to-ground fault at bus 3 through a fault impedance $Z_f = j0.10$ per unit.

(c) A line-to-line fault at bus 3 through a fault impedance $Z_f = j0.1$ per unit.

(d) A double line-to-ground fault at bus 3 through a fault impedance $Z_f = j0.1$ per unit.

Item	Base MVA	Voltage Rating	X^1	X^2	X^0
G_1	100	20 kV	0.15	0.15	0.05
G_2	100	20 kV	0.15	0.15	0.05
T_1	100	20/220 kV	0.10	0.10	0.10
T_2	100	20/220 kV	0.10	0.10	0.10
L_{12}	100	220 kV	0.125	0.125	0.30
L_{13}	100	220 kV	0.15	0.15	0.35
L_{23}	100	220 kV	0.25	0.25	0.7125

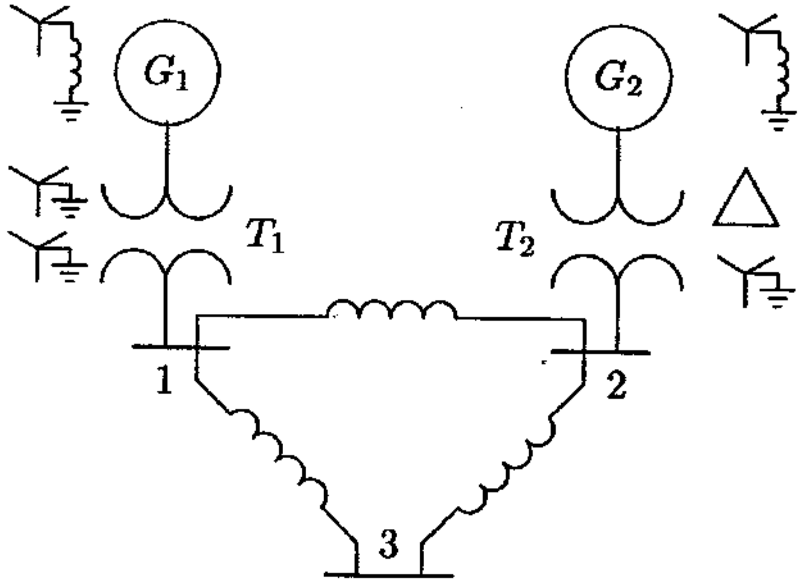


FIGURE 10.16
The one-line diagram for Example 10.5.

SIMULATION RESULT:

RESULT:

Thus the symmetrical fault analysis of given power system networks was analyzed on power world simulator software platform and were verified by manual calculation.

EX.No.5b
DATE : **SHORT CIRCUIT ANALYSIS - UNSYMMETRICALS FAULT**

AIM:

To conduct the fault analysis of power system networks on power world simulator software platform to solve a unsymmetrical fault of the given system and verify by manual calculation.

THEORY:

Short circuit studies are performed to determine the magnitude of currents flowing throughout the power system at various time intervals after the occurrence of the following faults

- Single-line to ground
- Line-to-line
- Double line-to-ground
- Three phase faults.

PROCEDURE:

1. Download and install the open source “Power World Simulator” software.
2. Open “Power World Simulator” software.
3. Open new modes
4. Go to “draw” header then select network icon.
5. By selecting the component from network icon, draw the one line diagram of given problem and fill the given data.
6. Go to run mode, select solve play button and select fault analysis header.
7. Select single fault, data window will be open then select type of fault.
8. Enter fault “ impedance Zf” value if given.
9. Click “calculate” and save the result.

Problem :

The one-line diagram of a simple power system is shown in Figure 10.16. The neutral of each generator is grounded through a current-limiting reactor of 0.25/3 per unit on a 100-MVA base. The system data expressed in per unit on a common 100-MVA base is tabulated below. The generators are running on no-load at their rated voltage and rated frequency with their emfs in phase.

Determine the fault current for the following faults.

(a) A balanced three-phase fault at bus 3 through a fault impedance $Z_f = j0.1$ per unit.

(b) A single line-to-ground fault at bus 3 through a fault impedance $Z_f = j0.10$ per unit.

(c) A line-to-line fault at bus 3 through a fault impedance $Z_f = j0.1$ per unit.

(d) A double line-to-ground fault at bus 3 through a fault impedance $Z_f = j0.1$ per unit.

Item	Base MVA	Voltage Rating	X^1	X^2	X^0
G_1	100	20 kV	0.15	0.15	0.05
G_2	100	20 kV	0.15	0.15	0.05
T_1	100	20/220 kV	0.10	0.10	0.10
T_2	100	20/220 kV	0.10	0.10	0.10
L_{12}	100	220 kV	0.125	0.125	0.30
L_{13}	100	220 kV	0.15	0.15	0.35
L_{23}	100	220 kV	0.25	0.25	0.7125

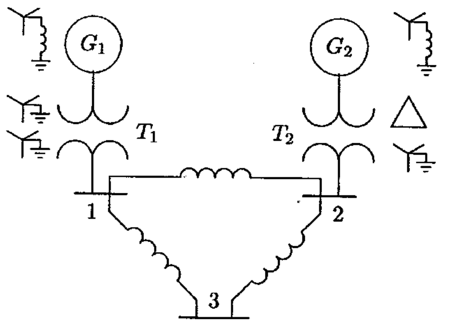


FIGURE 10.16
The one-line diagram for Example 10.5.

SIMULATION RESULT:

RESULT:

Thus the unsymmetrical fault analysis of given power system networks was analyzed on power world simulator software platform and were verified by manual calculation.

EXP. NO. 6 **TRANSIABILITY AND SMALL SIGNAL STABILITY ANALYSIS – SINGLE MACHINE INFINITE BUS SYSTEM**

DATE:

AIM:

To become familiar with various aspects of the transient and small signal stability analysis of Single-Machine-Infinite Bus (SMIB) system

SOFTWARE REQUIRED : MATLAB 10

THEORY :

Stability : Stability problem is concerned with the behaviour of power system when it is subjected to disturbance and is classified into small signal stability problem if the disturbances are small andtransient stability problem when the disturbances are large.

Transient stability: When a power system is under steady state, the load plus transmission loss equals to the generation in the system. The generating units run a synchronous speed and system frequency, voltage, current and power flows are steady. When a large disturbance such as three phase fault, loss of load, loss of generation etc., occurs the power balance is upset and the generating units rotors experience either acceleration or deceleration. The system may come backto a steady state condition maintaining synchronism or it may break into subsystems or one or more machines may pull out of synchronism. In the former case the system is said to be stable andin the later case it is said to be unstable.

Small signal stability: When a power system is under steady state, normal operating condition, the system may be subjected to small disturbances such as variation in load and generation, change in field voltage, change in mechanical toque etc., The nature of system response to small disturbance depends on the operating conditions, the transmission system strength, types of controllers etc. Instability that may result from small disturbance may be of two forms,

(i) Steady increase in rotor angle due to lack of synchronising torque.

(ii) Rotor oscillations of increasing magnitude due to lack of sufficient damping torque.

FORMULA :

Reactive power $Q_e = \sin(\cos^{-1}(p.f))$

$$\text{Stator Current } I_t = \frac{S^*}{E_t^*}$$

$$= \frac{P_e - jQ_e}{E_t^*}$$

Voltage behind transient condition

$$E^1 = E_t + j X_d^1 I_t$$

Voltage of infinite bus

$$E_B = E_t - j(X_3 + X_{tr}) I_t$$

$$\text{where, } X_3 = \frac{X_1 X_2}{X_1 + X_2}$$

Angular separation between E^1 and E_B

$$\delta o = \angle E^1 - \angle E_B$$

Prefault Operation:

$$X = j X_d^1 + jX_{tr} + \frac{X_1 X_2}{X_1 + X_2}$$

$$\text{Power } P_e = \frac{E^1 \text{ x } E_B}{X} \sin\delta_o$$

$$\delta_o = \sin^{-1}\left(\frac{P_e * X}{E^1 * E_B}\right)$$

During Fault Condition:

$$P_e = P_{Eii} = 0$$

Find out X from the equivalent circuit during fault condition

Post fault Condition:

Find out X from the equivalent circuit during post fault condition

$$\text{Power } P_e = \left\{ \frac{E^1 \text{ x } E_B}{X} \right\} \sin\delta_o$$

$$\delta_{max} = \pi - \delta_o$$

$$P_e = \frac{P_m}{\sin\delta_{max}}$$

Critical Clearing Angle:

$$\text{Cos}\delta_{cr} = \frac{P_m(\boldsymbol{\delta}_{\mathbf{max}} - \delta_o) + P_{3max}\cos\boldsymbol{\delta}_{\mathbf{max}} - P_{2max}\cos\boldsymbol{\delta}_{\mathbf{o}}}{\mathbf{P_{3max} - P_{2max}}}$$

Critical Clearing Time:

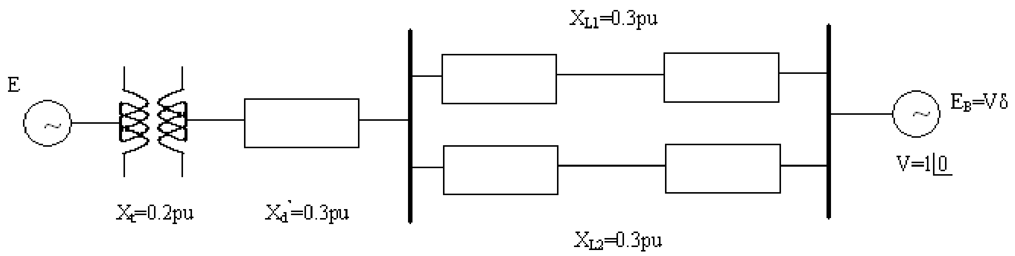
$$t_{cr} = \sqrt{\frac{2H\,(\delta_{cr} - \delta_o)}{\pi f_o\, P_m}} \text{ Sec}$$

PROCEDURE :

1. Enter the command window of the MATLAB.
2. Create a new M – file by selecting File - New – M – File
3. Type and save the program.
4. Execute the program by either pressing Tools – Run
5. View the results.

EXERCISE :

1. A 60Hz synchronous generator having inertia constant H = 5 MJ/MVA and a direct axis transient reactance X_d^1 = 0.3 per unit is connected to an infinite bus through a purely reactive circuit as shown in figure. Reactances are marked on the diagram on a common system base. The generator is delivering real power P_e = 0.8 per unit and Q = 0.074per unit to the infinite bus at a voltage of V = 1 per unit.



a) A temporary three-phase fault occurs at the sending end of the line at point F.When the fault is cleared, both lines are intact. Determine the critical clearing angle and the critical fault clearing time.

.

b) Verify the result using MATLAB program.

PROGRAM :

QUESTION a)

Pm = 0.8; E = 1.17; V = 1.0;

X1 = 0.65; X2 = inf; X3 = 0.65;

eacfault(Pm, E, V, X1, X2, X3)

QUESTION b)

Pm = 0.8; E = 1.17; V = 1.0;

X1 = 0.65; X2 = 1.8; X3 = 0.8;

eacfault(Pm, E, V, X1, X2, X3)

MANUAL CALCULATION:

RESULT:

Thus the critical clearing angle was calculated by applying equal area criterion for given power system network and verified the same using MATLAB software.

Exp. No. 7a.
DATE: **AUTOMATIC GENERATION CONTROL – SINGLE AREA NETWORK**

AIM:

To determine the change in speed, frequency and steady state error corresponding to a load disturbance in a single area power system, without supplementary control using MATLAB software.

SOFTWARE REQUIRED : MATLAB 10

THEORY:

SIMULINK is an interactive environment for modeling, analyzing and simulating a wide variety of dynamic systems. SIMULINK provides a graphical user interface for constructing block diagram models using drag and drop operations. A system is configured in terms of block diagram representation using library of standard components. A system in block diagram representation is built easily and simulation results are displayed quickly.

SINGE AREA SYSTEM:

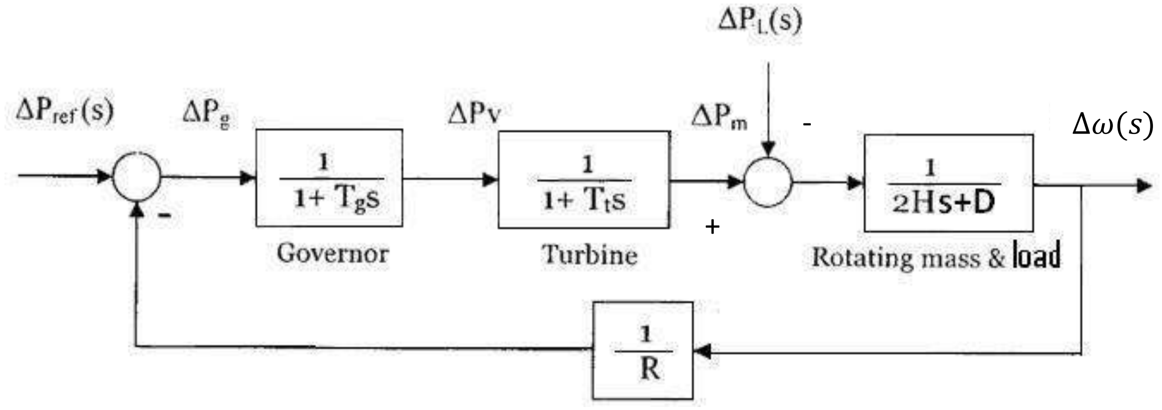


FIG: Load frequency control block diagram of an isolated power system

Problem 1:

An isolated power system has the following parameters:Turbine time constant, T_t = 0.5 Sec Governor time constant, T_g = 0.2 SecGenerator time constant, H = 5 Sec Governor Speed regulator, R = R pu.

The load varies by 0.8% for 1% change in frequency, i.e., D=0.8. The governor speed regulation is set to R= 0.05 pu. The turbine rated output is 250 MW. At normal frequency of 50 Hz a sudden load change of 50MW (ΔP_L= 0.2pu) occurs. Construct a SIMULINK block diagram-and obtain the frequency deviation response for the condition given above.

SIMULATION RESULT:

RESULT:

Exp. No. 7b
DATE:

AUTOMATIC GENERATION CONTROL – TWO AREA NETWORK

AIM:

To determine the change in speed, frequency and steady state error corresponding to a load disturbance in a two area power system, with and without supplementary control using software.

SOFTWARE REQUIRED : MATLAB 10

THEORY:

SIMULINK is an interactive environment for modelling, analyzing and simulating a wide variety of dynamic systems. SIMULINK provides a graphical user interface for constructing block diagram models using drag and drop operations. A system is configured in terms of block diagram representation using library of standard components. A system in block diagram representation is built easily and simulation results are displayed quickly.

TWO AREA SYSTEM::

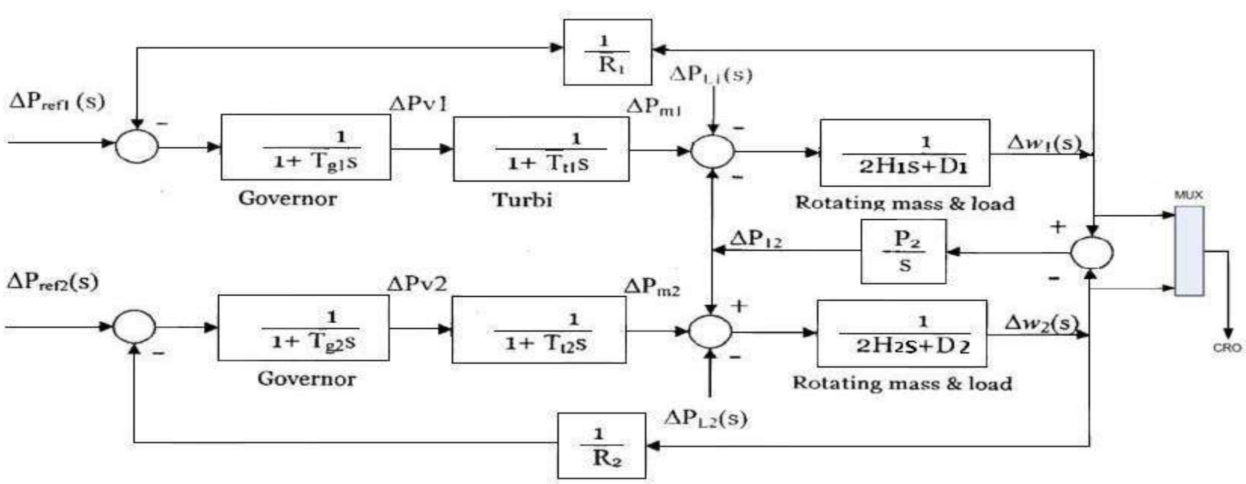


Fig : Two area system with only primary LFC Loop

Problem :

A two area system connected by a tie line has the same parameters on a 446 MVA common base. The units are operating in parallel at normal frequency at 50 Hz. The synchronizing power coefficient is computed from initial operating condition and isgiven to be Ps = 2.0 pu. A load change of 187.5 MW occurs in area 2.

a) Determine the new steady state frequency and the change in the lineflow.

b) Construct SIMULINK block diagram and obtain the frequency deviationresponse for the give condition

SIMULATION RESULT:

RESULT:

Exp. No. 8.

DATE:

I-V characteristics of a PV module

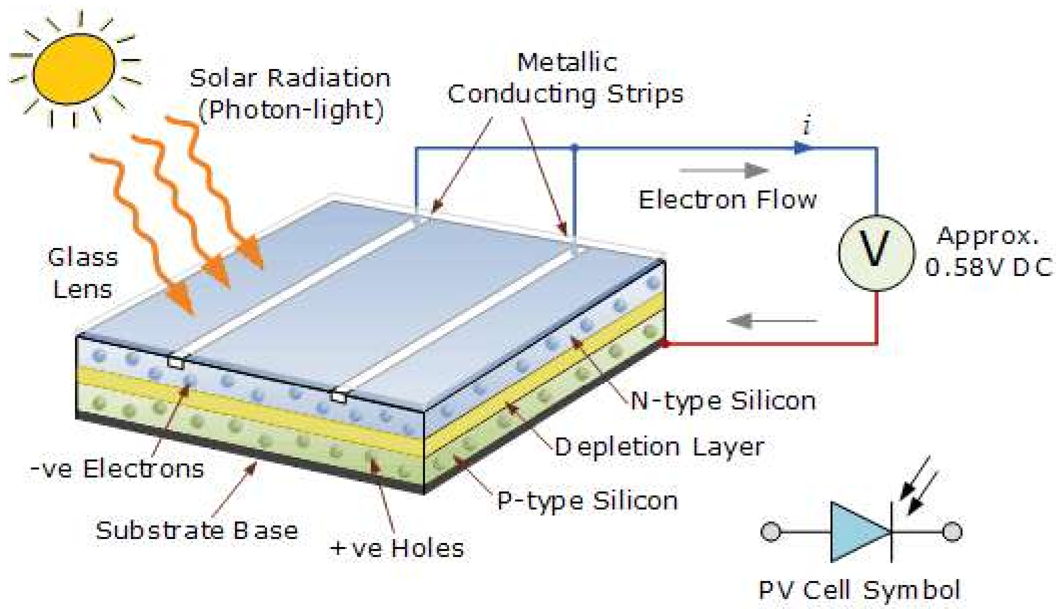
AIM:

To Plot the IV characteristics of a PV module and determine Maximum Power Point .

SOFTWARE REQUIRED : MATLAB 10

THEORY:

Solar cell is the basic unit of solar energy generation system where electrical energy is extracted directly from light energy without any intermediate process. The working of a solar cell solely depends upon its photovoltaic effect, hence a solar cell also known as photovoltaic cell. A solar cell is basically a semiconductor p-n junction device. It is formed by joining ptype (high concentration of hole or deficiency of electron) and n-type (high concentration of electron) semiconductor material. at the junction excess electrons from n-type try to diffuse to p-side and vice-versa. Movement of electrons to the p-side exposes positive ion cores in nside, while movement of holes to the n-side exposes negative ion cores in the p-side. This results in an electric field at the junction and forming the depletion region. When sunlight falls on the solar cell, photons with energy greater than band gap of the semiconductor are absorbed by the cell and generate electron-hole (e-h) pair. These e-h pairs migrate respectively to n- and p- side of the pn junction due to electrostatic force of the field across the junction. In this way a potential difference is established between two sides of the cell. Typically a solar or photovoltaic cell has negative front contact and positive back contact. A semiconductor p-n junction is in the middle of these two contacts like a battery. If these two sides are connected by an external circuit, current will start flowing from positive to negative terminal of the solar cell. This is basic working principle of a solar cell. For silicon, the band gap at room temperature is Eg = 1.1 eV and the diffusion potential is UD = 0.5 to 0.7 V. Construction of a Si solar cell is depicted in Fig.1.



Solar Cell I-V Characteristics Curve is the superposition of the I-V curves of the solar cell diode in absence (dark) and in presence of light. Illuminating a cell adds to the normal "dark" currents in the diode so that in the diode so that the diode law becomes:

$$I = I_0\left[\exp\left(\frac{qV}{nkT}\right) - 1\right] - I_L$$

where I_0 = "dark saturation current" or diode leakage current in absence of light q = electronic charge

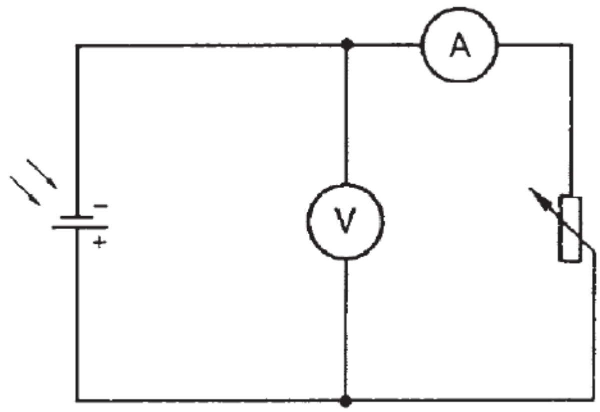
V = applied voltage across the terminals of the diode n

= ideality factor

k = Boltzmann's constant

T = temperature

I_L = light generated current.



C

A typical circuit for measuring I-V characteristics is shown in Fig.2. From this characteristics various parameters of the solar cell can be determined, such as: short-circ it current (I_{SC}), the open-circuit voltage (V_{OC}), the fill factor (FF) and the efficiency. The rating of a solar panel depends on these parameters.

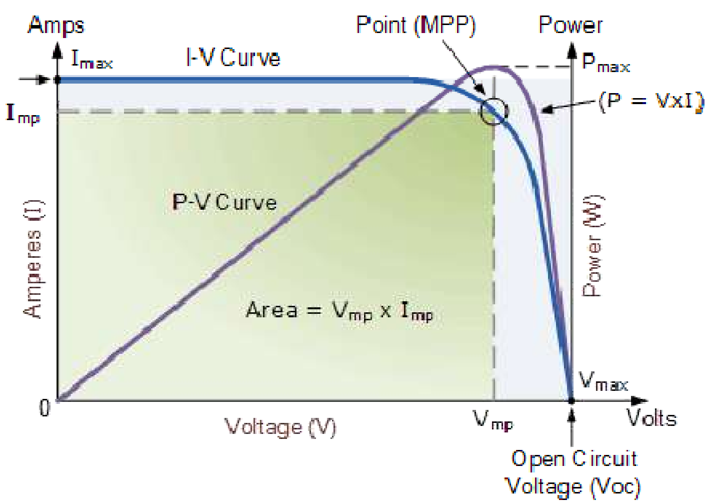
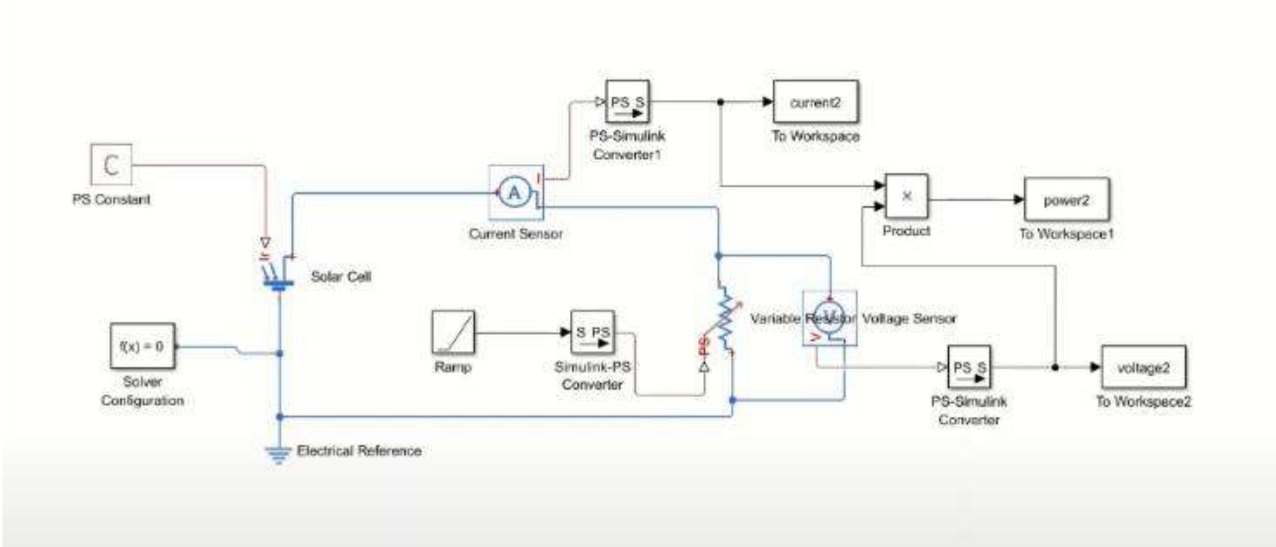


Fig. 3: A typical I-V curve and power curve of a solar cell

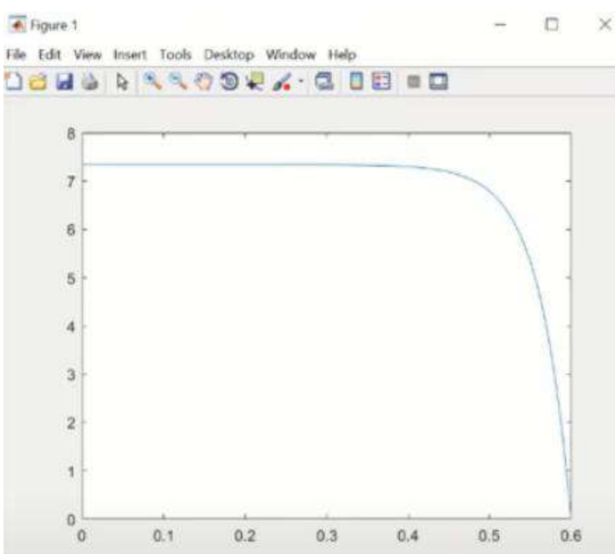
I-V curves of the solar cell Simulation

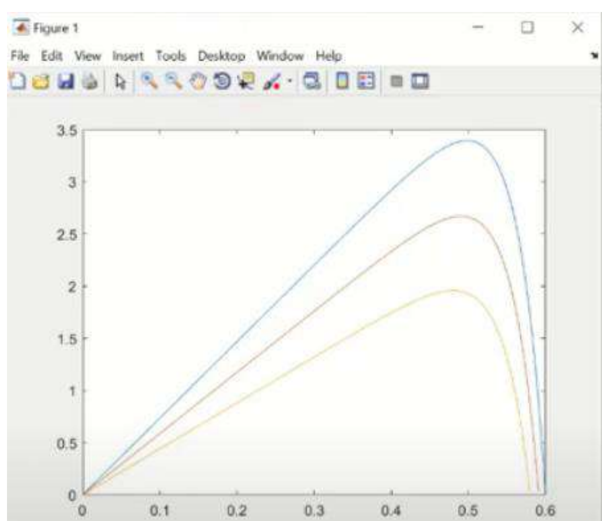


PROCEDURE:

1. Create MATLAB Simulink model file and save as PV CELL SIMULATION.
2. Using Simulink library simulate pv model as per diagram.
3. Run simulation and obtain the I-V and P-V curves.
4. Draw the I-V and P-V curves and obtain the MPPT.

SIMULATION RESULTS





RESULT:

Thus the IV characteristics of a PV module simulated and determined Maximum Power Point.

Exp. No. 9.
DATE:

RELAY TESTING - OVER CURRENT RELAY

AIM:

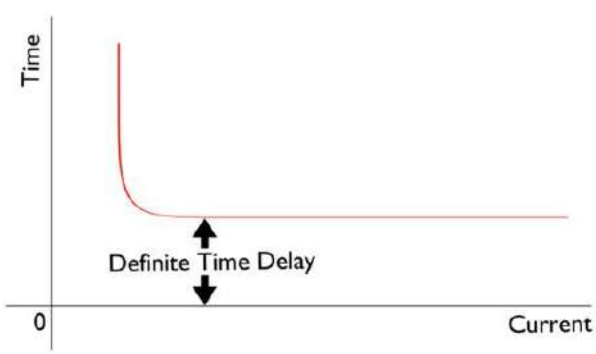
To study the Operation of a Non - Directional electromechanical type overcurrent (IDMT relay) and plot the inverse time current characteristics

APPARATUS REQUIRED :

S.No	Apparatus	Type	Quantity
1	IDMT Over current relay	Electro mechanical	1No
2	Timer	Digital	1No
3	Fault creation Panel	Digital	1No
4	Ammeter	30A MI	1No
5	Current Transformer-40/2A	Core type	1No

THEORY:

IDMT relay is inverse definite minimum time relay. It is one in which Time of operation is inversely proportional to magnitude of fault current near pickup value and becomes substantially constant slightly above the pickup value of the Relay. Fault current and measure relay operation time is used to conduct the experiment. Values recorded for various TSMs and PSMs. Characteristics studied with the help of a graph and correlated with theory.



The **current setting of relay** is expressed in percentage ratio of relay pick up current to the rated secondary current of CT.

$$Current\ setting\ =\ \frac{Pick\ up\ current}{Rated\ secondary\ current\ of\ CT}\times 100\%$$

Plug setting multiplier of relay is referred as ratio of fault current in the relay to its pick up current.

$$PSM\ =\ \frac{Fault\ current\ in\ relay\ coil}{Pick\ up\ current}$$

$$=\ \frac{Fault\ current\ in\ relay\ coil}{Rated\ CT\ secondary\ current\ \ \times\ Current\ setting}$$

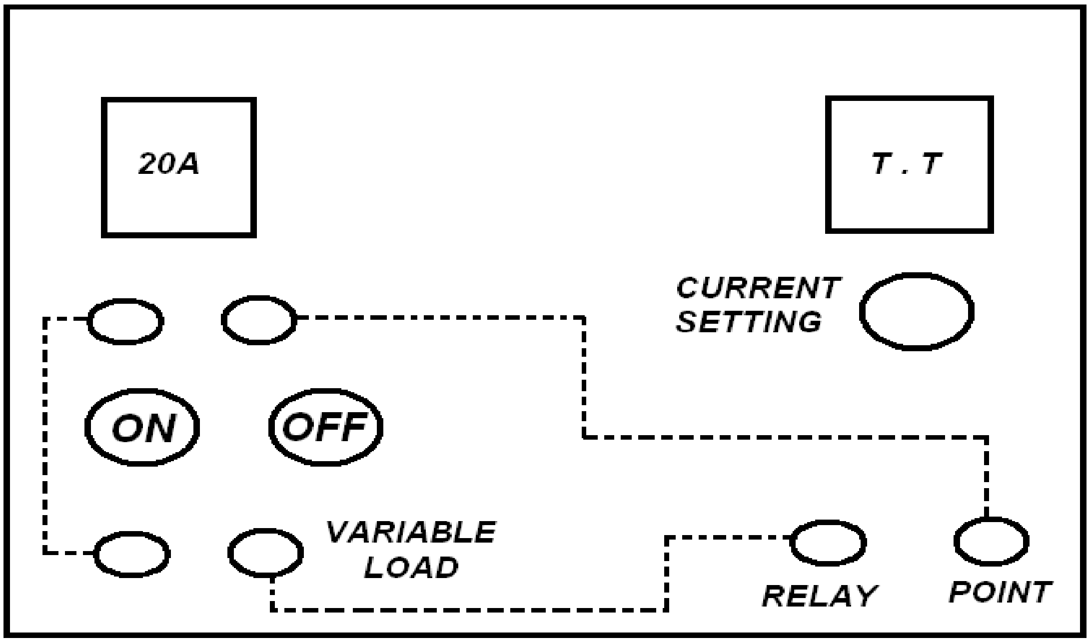
Precautions:-

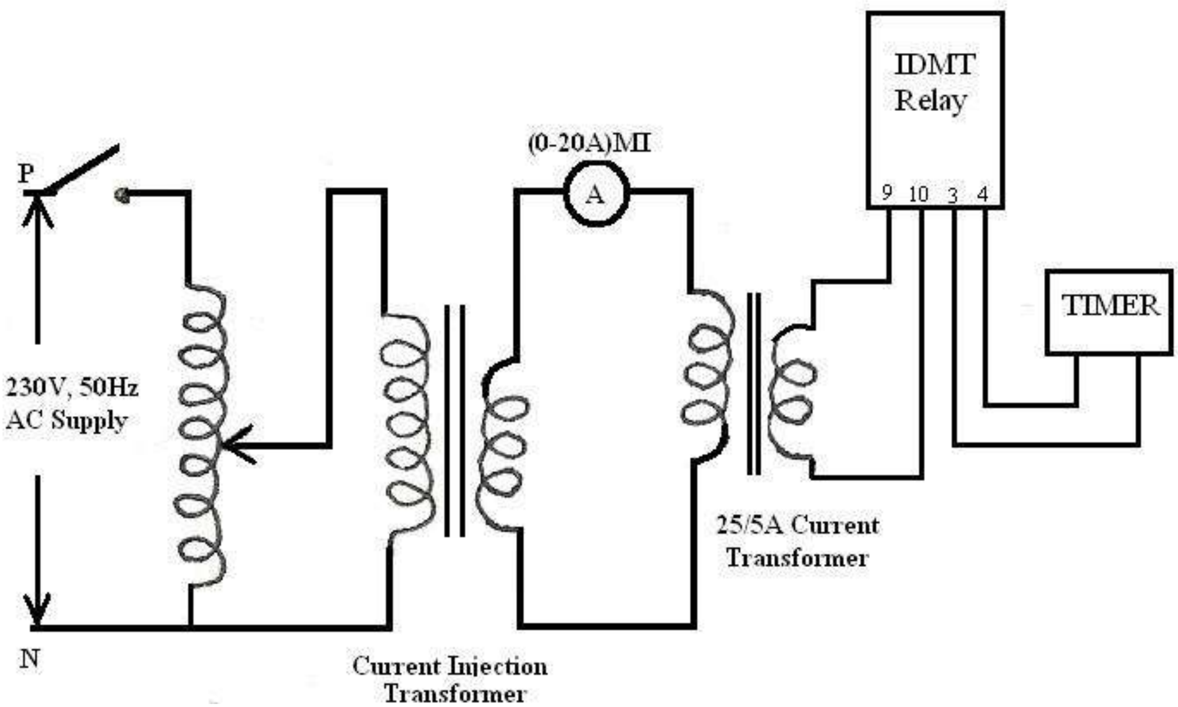
1. Keep the MCB is in off condition.
2. keep the autotransformer is in minimum position.
3. keep the power ON/OFF switch is in off position.

Procedure:-

2. Switch ON the MCB.
3. Initially rotor switch should be in OFF position.
4. Now set the described fault current by using the current source. For that switch ON the rotor switch and move the current till the described fault current is indicated in the ammeter.
5. Now move the rotor switch is OFF position and press the green button. Note downthe time in seconds after relay operated.
6. Repeat the same procedure for various T.S.M and P.S.M
7. Plot the graph between time take for relay to operate Vs P.S.M for various T.S.M.

CIRCUIT DIAGRAM





GRAPH

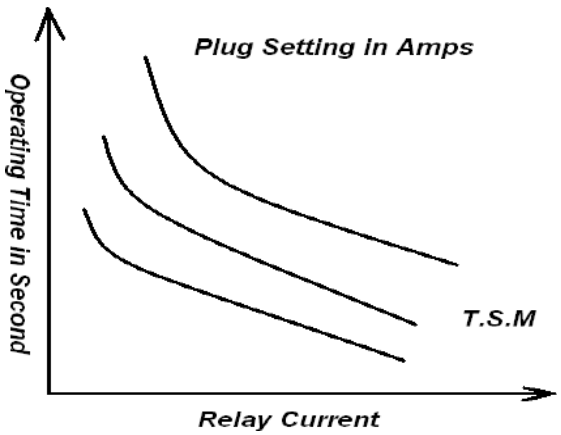


TABLE:

Sl.No	Applied Fault current	Calculated tripping time in ms	Measured tripping time in ms	TMS Time setting multiplier	PMS plug setting multiplier

TABLE:

Sl.No	Applied Fault current	Calculated tripping time in ms	Measured tripping time in ms	TMS Time setting multiplier	PMS plug setting multiplier

TABLE:

Sl.No	Applied Fault current	Calculated tripping time in ms	Measured tripping time in ms	TMS Time setting multiplier	PMS plug setting multiplier

RESULT

Thus the Operation of a Non - Directional electromechanical type overcurrent (IDMT relay) studied and plot the inverse time current characteristics.

Exp. No. 10.
DATE:

RELAY TESTING - OVER VOLTAGE RELAY

AIM:

To study the Operation of a microprocessor based overvoltage relay (IDMT relay) and plot it's inverse time current characteristics

APPARATUS REQUIRED:

S.No	Apparatus	Type	Quantity
1	IDMT Over voltage relay kit	Electro mechanical	1No
2	Batch card		

THEORY:

Over Voltage/Under Voltage Relay is an electronic microcontroller based single-phase voltage relay. It is suitable for over voltage/under voltage protection schemes in LV, MV and HV power distribution systems. It is also suitable for over voltage protection of AC circuits, capacitors, machines such as generators, synchronous motor and under voltage protection of AC circuits, Induction motors, automatic change over schemes etc.

The microcontroller-based design offers a wide range of Trip-Time characteristics, under voltage or over voltage mode and PT rating (110V, 240V, 415V), which can all be selected in the field at the time of commissioning. It accepts very wide auxiliary supply range.

Relay is designed for flush mounting. It is very compact in size, which results in saving of panel space. Its draw-out construction makes installation and maintenance very easy.

Precautions:-

1. Keep the MCB is in off condition.
2. keep the autotransformer is in minimum position.
3. keep the power ON/OFF switch is in off position.

Procedure

1. Set the pick-up value of the VOLTAGE marked ------V AC by inserting the plug in the groove.
2. Set the Time Multiplier Setting (TMS) initially at 1.0.
3. Connect front panel connector P1A to P1 By using connecting wires
4. Connect front panel connector P2A to P2 By using connecting wires
5. Connect Relay NC contact (1,2) to Trip circuit(1,2) (If not connected relay trip circuit will be open).
6. Switch ON the Power using Power ON/OFF Switch (IRS SWITCH)
7. Switch ON the MCB
8. Apply voltage ------ VAC Which should be GREATER THAN PLUG SETTING VALUE (voltage value is Indicated by front panel voltmeter) by Adjusting the Front panel Autotransformer
9. Now the set up is ready for applying Fault voltage of ----VAC
10. Press the START Button
11. If the Fault voltage is above the set voltage (In relay), then DISC in RELAY is start to rotate and timer is calculated in stop clock.
12. Once the RELAY is tripped and the STOP CLOCK is automatically stopped and indicate the relay trip time , note down this trip time in table

Calculation:

Fault voltage = Plug setting voltage X Set voltage

CIRCUIT DIAGRAM

GRAPH

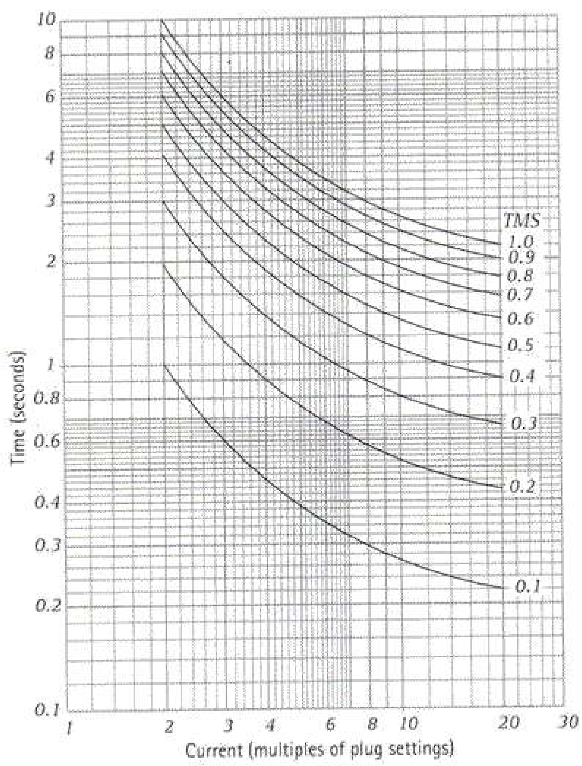


TABLE:

Sl.No	Applied Fault voltage	Calculated tripping time in ms	Measured tripping time in ms	TMS Time setting multiplier	Voltage setting

RESULT

Thus the Operation of a Non - Directional electromechanical type overcurrent (IDMT relay) studied and plot the inverse time current characteristics.

Exp. No. 11.

DATE: **TESTING OF CURREBT TTRANSFORMER AND POTENTIAL TRANSFORMER**

AIM:

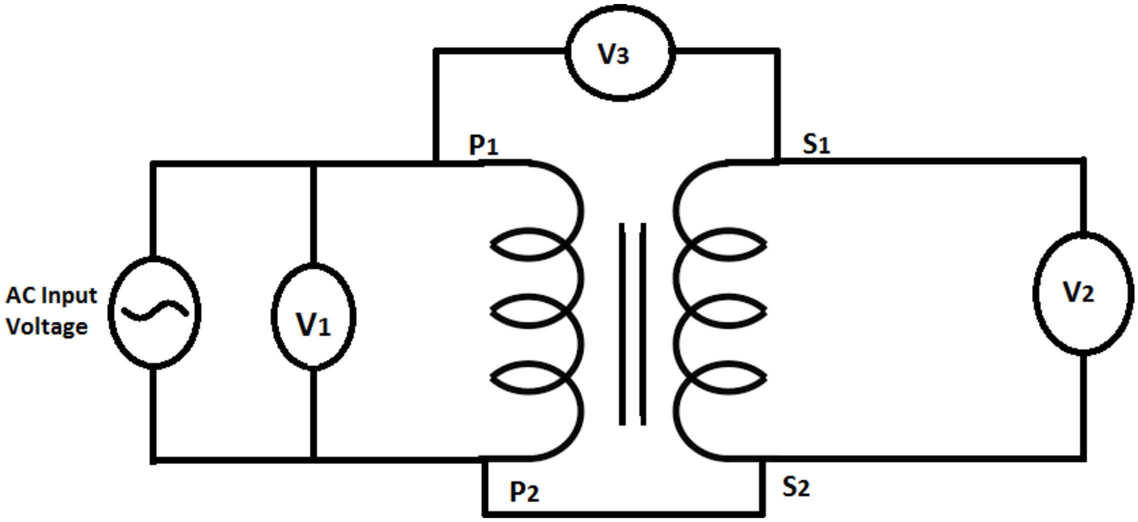
To test Polarity, Ratio and magnetisation characteristics of the given Current Transformer and Potential Transformer.

APPARATUS REQUIRED:

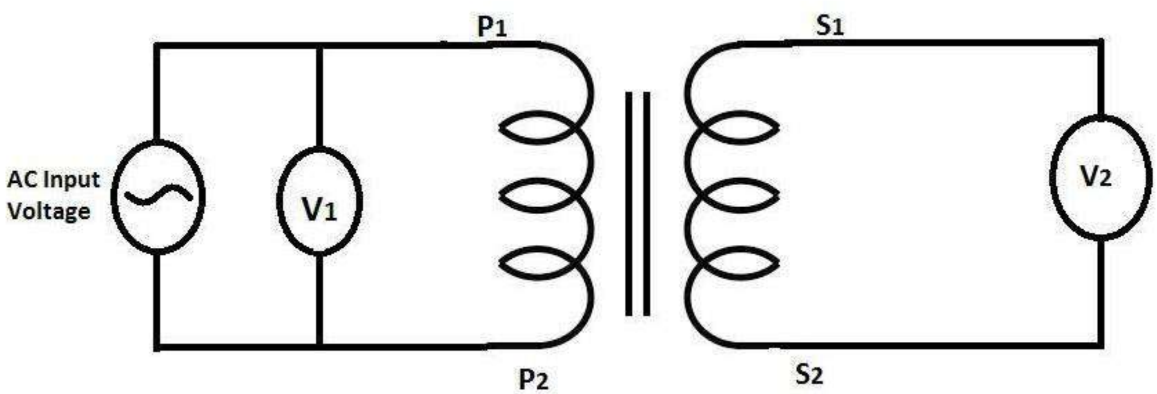
S.No	Apparatus	Type	Quantity
1	CT		
2	PT		
3			
4			
5			

Theory:

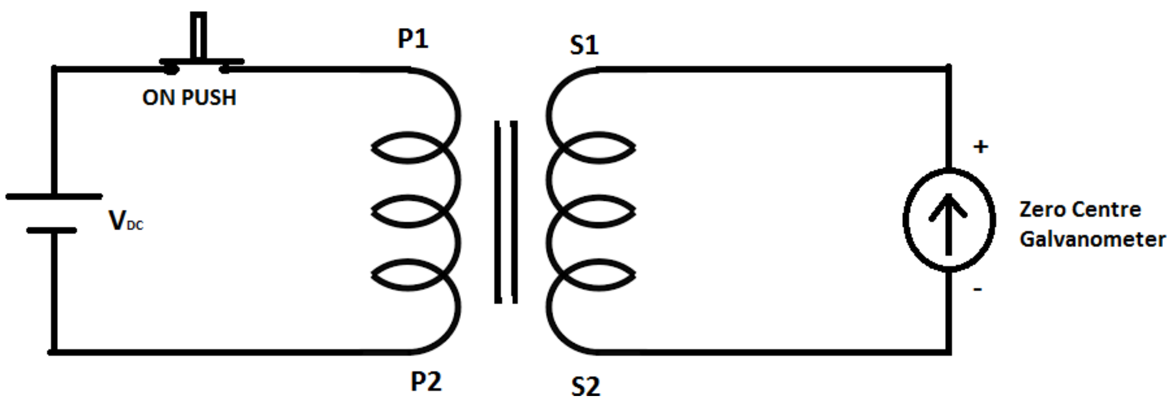
Circuit diagram for Polarity test of PT using AC supply:



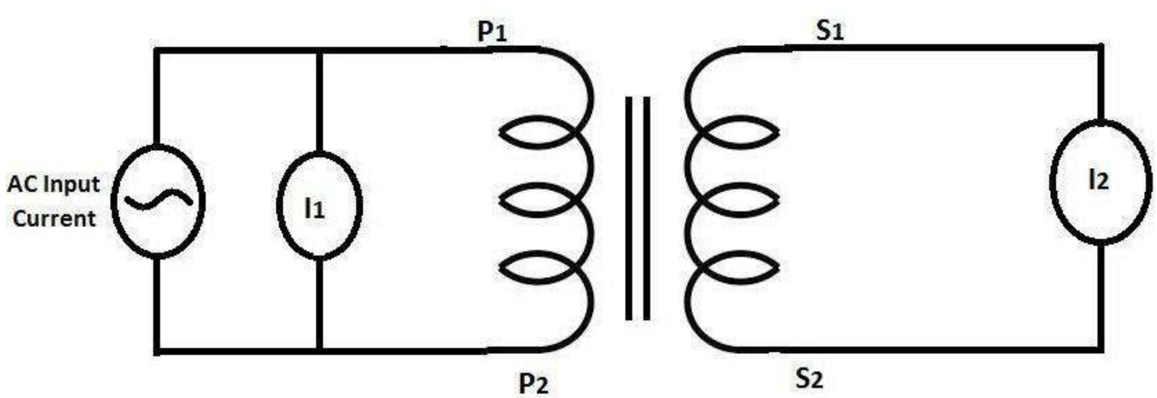
Circuit diagram of ratio test of PT using AC supply:



Circuit diagram for Polarity test of CT using DC supply:



Circuit diagram of ratio test of CT using AC supply:



Procedure:

Polarity test of PT using AC supply:

Connect the circuit as per circuit diagram and marked the each terminals of primary and secondary wingding input voltage at suitable value. Read the input voltage (V1) and output voltage (V2).

If the voltmeter connected between primary and secondary reads the

sumof voltages of (V1 + V2). Then P1 and S1 are opposite polarity.

If the voltmeter connected between primary and secondary reads the difference of voltages of(V1 – V2). Then P1 and S1 are same polarity.

Ratio test of PT:

Connect the circuit as per circuit diagram.

Connect the PT primary to the output of variable voltage source.

Increase the input voltage and take input and output voltage reading at least 10 point over its operating range.

Find out the transformation ratio. Also find error from the given ratio of the transformer.

Polarity test of CT using DC supply:

Connect the circuit as per circuit diagram and marked the each terminals of primary and secondary wingding.

Be sure the input voltage polarity to the input terminals and polarity of centre galvanometer connection in the output terminals.

Operate the push button for a fraction of time. Find the direction of deflection of the zero centregalvanometer.

If deflection is right hand side that means supply positive terminal and galvanometer positive terminal is same polarity. If deflection is left hand side that means supply positive terminal andgalvanometer positive terminal is opposite polarity.

Repeat the whole experiments after reversing the source.

Ratio test of CT:

Connect the circuit as per circuit diagram.

Connect the CT primary to the output of variable current source.

Increase the input current and take input and output current reading at least 10 point over itsoperating range.

Find out the transformation ratio. Also find error from the given ratio of the

transformer.Be sure that at any condition CT secondary will not open during

primary energies.

Observation And

Result:Polarity test of

PT:

Input voltage (V1)	Output voltage(V2)	Voltmeter between primary and secondary	Polarity according to marking

Ratio test of PT:

<table>
<tr><td rowspan="3">No of observation 01</td><td>Input voltage (V1)</td><td>Output voltage (V2)</td><td>Transformation Ratio (V1 / V2)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

Polarity test of CT:

Supply DC polarity to the primary terminal according to marking	Connected galvanometer to the secondary terminal marking	Direction of deflection	Polarity of terminals according to marking

Ratio test of CT:

No of observation	Input current (I1)	Output current (I2)	Transformation Ratio (I1/ I2)
01			
02			
03			

Result:

Exp. No. 11.
DATE: **MEASUREMENT OF EARTH RESISTANCE**

AIM:

To measure the earth resistance for the given plinth

APPARATUS REQUIRED:

S.No	Apparatus	Type	Quantity
1	Earth Tester (4 Terminal)		1
2	4 No's of Electrodes (Spike		1
3	4 No's of Insulated Wires		1
4	Hammer		1
5	Measuring tape		1

THEORY:

There are six basic test methods to measure earth resistance

1. Four Point Method (Wenner Method)
2. Three-terminal Method (Fall-of-potential Method / 68.1 % Method))
3. Two-point Method (Dead Earth Method)
4. Clamp-on test method
5. Slope Method
6. Star-Delta Method

Four Point Method (Wenner Method) Connections:

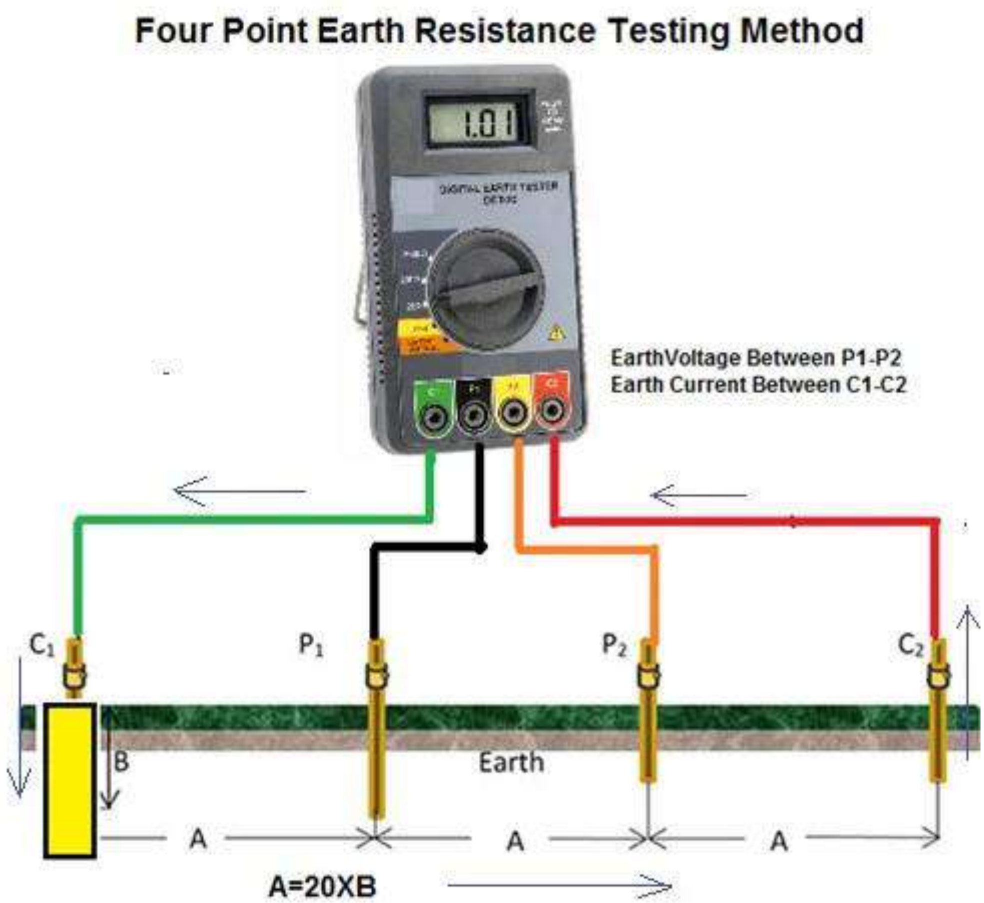
- First, isolate the grounding electrode under measurement by disconnecting it from the rest of the system.
- Earth tester set has four terminals, two current terminals marked C1 and C2 and two potential terminals marked P1 and P2.
- P1 = Green lead, C1 = Black lead, P2 = Yellow lead, C2 = Red lead
- In this method, **four small-sized electrodes** are driven into the soil at the **same depth and equal distance from one another** in a straight line.
- The distance between earth electrodes should be at least **20 times greater** than the electrode depth in ground.
- Example, if the depth of each earth electrode is 1 foot then the distance between electrodes is greater than 20 feet.

- The earth electrode under measurement is connected to **C1** Terminal of Earth Tester.
- Drive another potential Earth terminal **(P1)** at depth of 6 to 12 inches from some distance at **C1** Earth Electrode and connect to **P1** Terminal of Earth Tester by insulted wire.
- Drive another potential Earth terminal **(P2)** at depth of 6 to 12 inches from some distance at **P1** Earth Electrode and connect to **P2** Terminal of Earth Tester by insulted wire.
- Drive another Current Electrode **(C2)** at depth of 6 to 12 inches from some distance at **P2** Earth Electrode and connect to **C2** Terminal of Earth Tester by insulted wire.
- Connect the ground tester as shown in the picture**.**

Testing Procedure:

- Press START and read out the resistance value. This is the actual value of the ground Resistance of the electrode under test.
- Record the reading on the Field Sheet at the appropriate location. If the reading is not stable or displays an error indication, double check the connections. For some meters, the RANGE and TEST CURRENT settings may be changed until a combination that provides a stable reading without error indications is reached.
- The Earthing Tester has basically Constant Current generator which injects current into the earth between the two current terminals C1 (E) and C2 (H).
- The potential probes P1 & P2 detect the voltage ΔV (a function of the resistance) due to the current injected in the earth by the current terminals C1 & C2.
- The test set measures both the current and the voltage and internally calculates and then displays the resistance. $R=V/I$
- If this ground electrode is in parallel or series with other ground rods, the resistance value is the total value of all resistances.
- Ground resistance measurements are often corrupted by the existence of ground currents and their harmonics. To prevent this it is advisable to use Automatic Frequency Control (AFC) System. This automatically selects the testing frequency with the least amount of noise enabling you to get a clear reading.
- Repeat above steps by increasing spacing between each electrode at equal distance and measure earth resistance value.
- Average the all readings
- An effective way of decreasing the electrode resistance to ground is by pouring water around it. The addition of moisture is insignificant for the reading; it will only achieve a better electrical connection and will not influence the overall results. Also a longer probe or multiple probes (within a short distance) may help.

CIRCUIT DIAGRAM:



TABULAR COLUMN

S.No	Distance	Resistance

RESULT:

Exp. No. 13.

DATE:

TESTING OF TRANSFORMER OIL

AIM:

To measure the dielectric strength of given transformer oil.

APPARATUS REQUIRED:

S.No	Apparatus	Type	Quantity
1	Oil testing kit		1
2	Transformer oil		500ml
3	Sphere gap		1

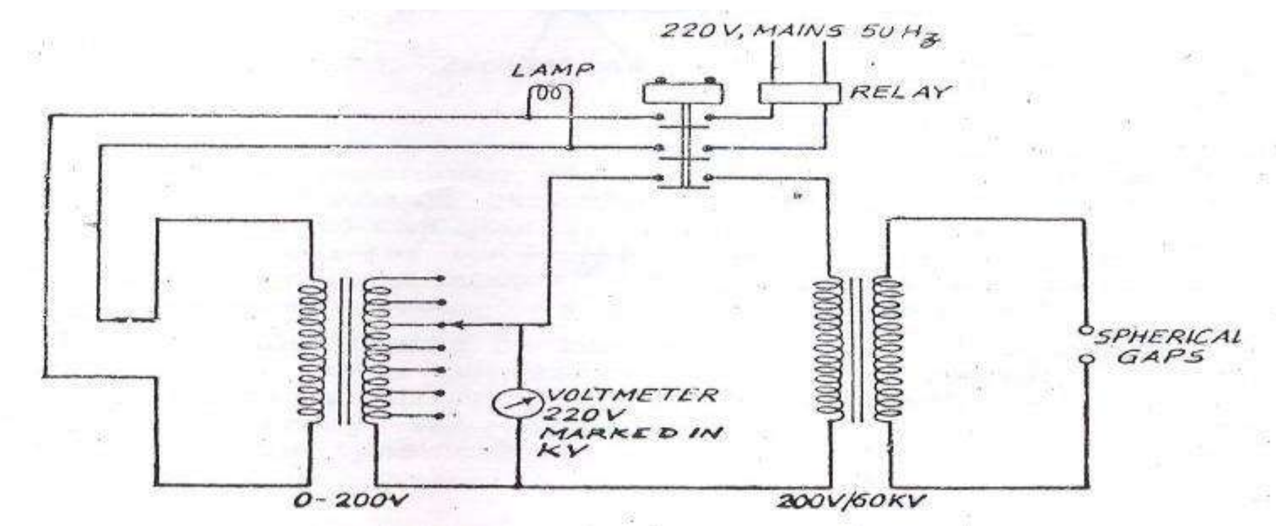
Theory:

When a sample of oil is subjected to dielectric stress in a gap between two spheres the materials of higher conductivity and higher spheres capacity are drawn into the intense field between the spheres and causes a distortion of the field resulting in local high density and disruption begins at these points. When testing transformer oil it is found often that one or more discharge occur across the gap at comparatively low voltages due to the presence of water particles but that the voltage can be raised to a very much higher value before complete rupture occurs. If particles of higher dielectric constant than the oil are drawn into the intense field, they will cause excessive local stress which may result in dissociation or ionization of oil and the gases of ionization may bridge the gap and causes complete rupture. In standard specifications for 'Insulating Oil' the method of applying the testing voltage (which must be alternating or approximately sine waveform of frequency between 25 and 100 Hz and with a peak factor of □2 +5% has been laid down. The test has to be carried out under standard conditions. The minimum dimensions of the test cell, diameter of the electrode and the distance between them are specified.

Procedure:

When testing oils the set is operated according to a particular method (in compliance with the regulations) i.e. with a fixed spark gap and variable testing voltage. The voltage should be increased gradually under continues observation of the measuring until the breakdown occurs. To test oils of high quality the distance between electrodes should be adjusted to 2 mm. The equipment permit 310 KV/cm to be measured. For testing oils of medium quality or inferior quality the spark gap should be adjusted to 4 mm by means of a distance gauge. The insulating material oil testing cup is equipped normally with two calotte-shaped electrodes of 36 mm dia, radius of each sphere is 25 mm. The oil testing cup is kept as small as possible to do with minimum quantity of oil. Suitable safety contacts are provided to put the set out of operation as soon as the top lid is opened in order to insert or remove the test cup, thus eliminating HT danger. The set is disconnected automatically as soon as the puncture occurs. No oil tests are possible as long as the lid of the rear of the cabinet is open.

CIRCUIT DIAGRAM:



Result:

Distance between electrodes = ____ Breakdown voltage = _____

Thus the dielectric strength of the given transformer oil was obtained.

EEL 202 Electrical Machines Lab I

INDEX

S.NO	NAME OF THE EXPERIMENT
1.	OPEN CIRCUIT CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR
2.	LOAD CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR
3.	BRAKE TEST ON DC SHUNT MOTOR
4.	LOAD TEST ON DC SERIES MOTOR
5	SWINBURNE’S TEST ON A DC SHUNT MACHINE
6	HOPKINSON’S TEST ON A PAIR OF DC MACHINES
7	OC & SC TESTS ON A SINGLE PHASE TRANSFORMER
8	LOAD TEST ON A SINGLE PHASE TRANSFORMER
9	SUMPNER’S TEST
10	SEPARATION OF CONSTANT LOSSES OF A SINGLE PHASE TRANSFORMER
11	PARALLEL OPERATION OF TWO DISSIMILAR SINGLE PHASE TRANSFORMER
12	RETARDATION TEST ON A PAIR OF DC MACHINE

Ex.No.1

OPEN CIRCUIT CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR

AIM:

To conduct no load test on the given self-excited DC shunt generator to obtain the open circuit characteristics and hence determine the following.

a) Predetermine the OCC at different speeds

b) Determine the critical field resistance

c) Obtain maximum voltage built up with given shunt field

d) Obtain critical speed for a given shunt field resistance

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-1)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	500 Ω, 1.5A	Wire Wound	2
4	SPST Switch	-	-	1
5	Tachometer	(0-1500)rpm	Digital	1

PRECAUTIONS:

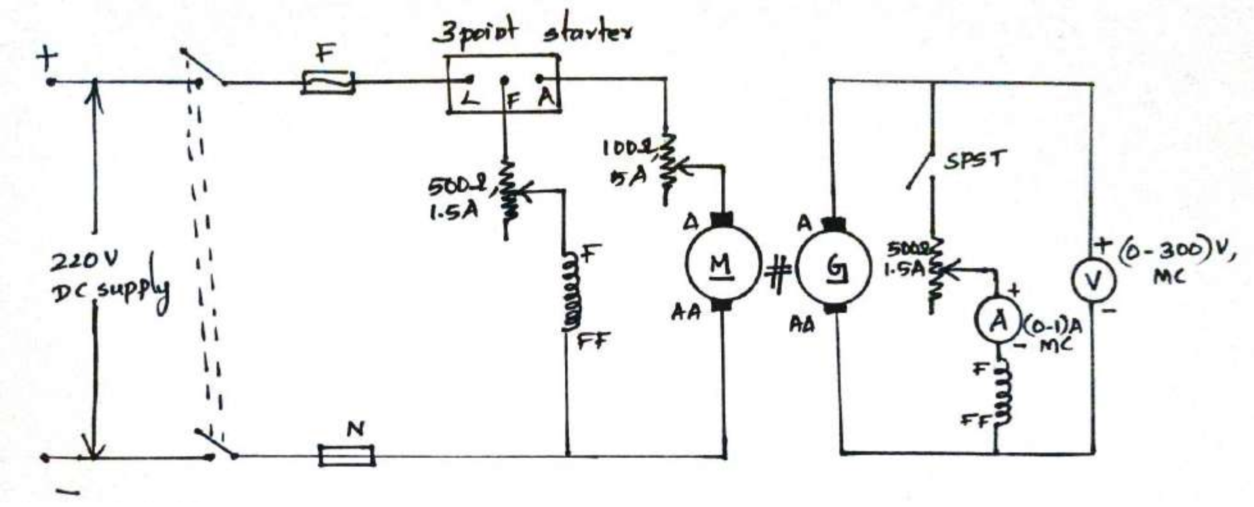
1. The field rheostat of motor should be kept in minimum resistance position at the time of starting and stopping the machine.
2. The field rheostat of generator should be kept in maximum resistance position at the time of starting and stopping the machine.
3. SPST switch is kept open during starting and stopping.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Keep the SPST switch in the generator field circuit open and set motor field rheostat to minimum and generator field rheostat to maximum position.
3. Switch on the supply and start the motor using the three phase starter.
4. By adjusting the field rheostat, the motor is brought to rated speed and note down the voltmeter and ammeter readings.

5. After closing the SPST switch, by varying the generator field rheostat, voltmeter and ammeter readings are taken.
6. Note down the generated voltage for zero field current. This voltage is known as residual voltage due to residual magnetism in the DC generator.
7. Close the SPST switch and vary the excitation of the generator in small steps by varying the generator field rheostat.
8. Record the field current and corresponding open circuit voltage. Rated speed should be maintained throughout the experiment.
9. Reading is taken up to 20-30% above the rated voltage in order to get saturation part of the characteristics.
10. Reduce the generator excitation and switch off the supply.
11. Connect the circuit the measure field resistance by varying the rheostat. Take various current and voltage reading.
12. The ratio of voltage drop to current gives the armature resistance. Mean value is taken which gives the field resistance of the machine.

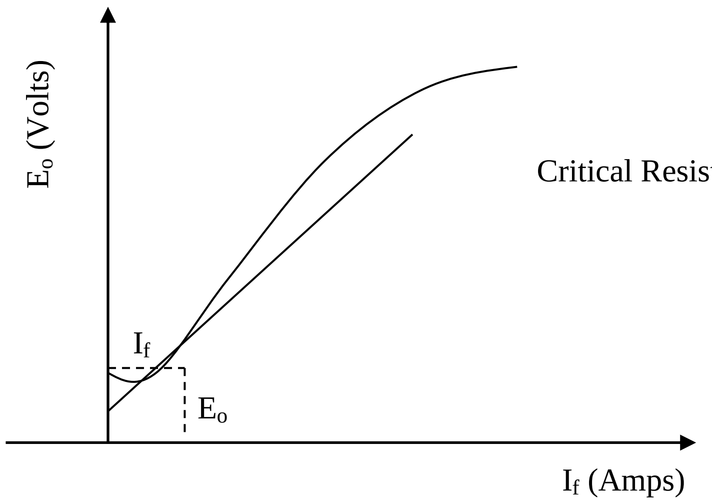
CIRCUIT DIAGRAM:



OBSERVATIONS:

S.No.	Field Current I_f (A)	Open Circuit voltage at rated speed E_o (V)	Open Circuit voltage at 75% of rated speed (V)	Open Circuit voltage at 50% of rated speed (V)

MODEL GRAPH:



Critical Resistance = E_o / I_f Ohms

Measurement of the armature winding resistance

S.No.	Current (A)	Voltage(V)

Mean Resistance:

RESULT:

Conducted no load test on given self-excited DC generator and plotted open circuit characteristics for different speed and also determined critical resistance.

Critical Speed =

Maximum built up voltage =

Critical resistance =

INFERENCE:

For self-excited DC machine there is a residual voltage even when current is zero.

Ex.No.2

LOAD CHARACTERISTICS OF SELF EXCITED DC SHUNT GENERATOR

AIM:

To conduct load test on a DC Shunt Generator and to determine the external & internal characteristics.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-2)A (0-10) A	MC MC	1 1
2	Voltmeter	(0-300)V	MC	1
3	Rheostats	230Ω, 2A	Wire Wound	2
4	Tachometer	(0-1500) rpm	Digital	1

THEORY:

Load test on dc shunt generator is conducted by connecting the generator to an external load and loading the generator in steps still full load is reached.

$Eg = V + Ia\ Ra$

The relationship between the generated emf Eg and armature current Ia gives the internal characteristics. The plot between terminal voltage V and the line voltage I_L gives the external characteristics. Always the plot of V and I_L lies below the plot of Eg and Ia due to Ia Ra drop. When dc shunt generator is loaded, its terminal voltage V drops with increase in load current. Such drop in voltage is undesirable. The drop in terminal voltage is due to;

a) Armature resistance drop
b) Reduction in main flux due to armature reaction.

The reduction in terminal voltage due to above two cases results in decreased filed current which causes flux and generated emf to decrease.

PRECAUTIONS:

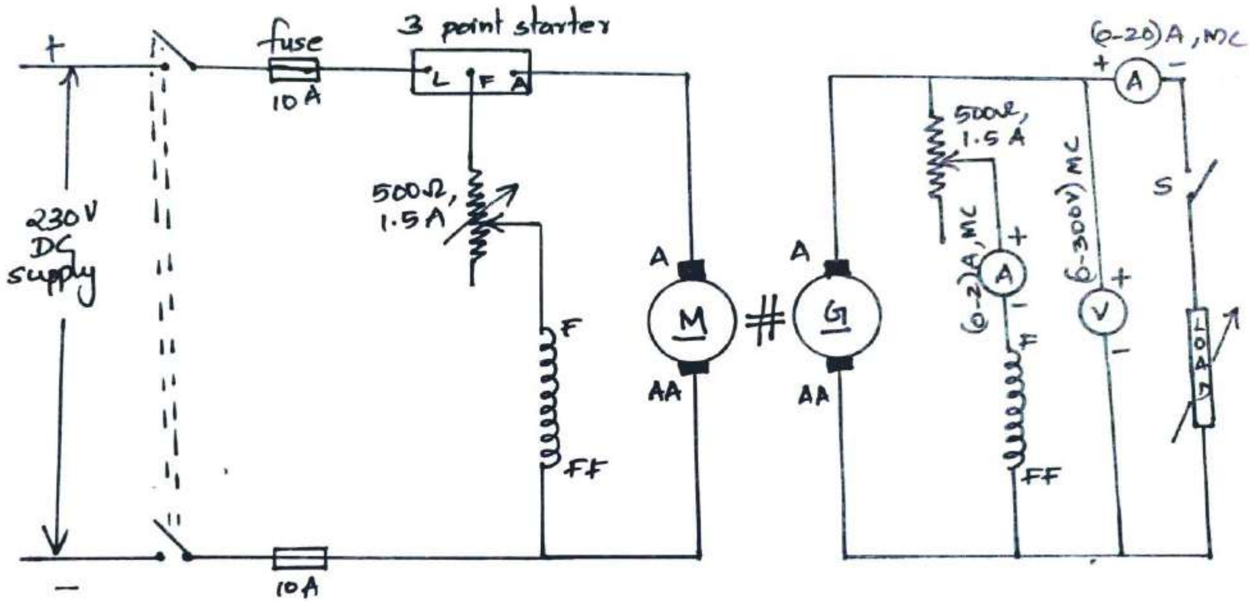
1. The field rheostat of motor should be at minimum position.
2. The field rheostat of generator should be at maximum position.
3. No load should be connected to generator at the time of starting and stopping.

PROCEDURE:

1. Connections are made as per the circuit diagram.

2. The motor field rheostat is kept at minimum position and generator field rheostat is kept at maximum position.
3. Starting resistance is gradually removed.
4. The field rheostat of motor is adjusted to make the motor run at rated speed. The generator coupled to thus is therefore made to rotate at rated speed.
5. Under no load condition, Ammeter and Voltmeter readings are noted, after bringing the voltage to rated voltage by adjusting the field rheostat of generator.
6. Load is varied gradually and for each load, voltmeter and ammeter readings are noted.
7. Then the generator is unloaded and the field rheostat of DC shunt generator is brought to maximum position and the field rheostat of DC shunt motor to minimum position, switch off the supply.

CIRCUIT DIAGRAM:



TABULAR COLUMN:

S.No.	Field Current I_f (Amps)	Load Current I_L (Amps)	Terminal Voltage (V) Volts	$I_a = I_L + I_f$ (Amps)	$E_g = V + I_a R_a$ (Volts)

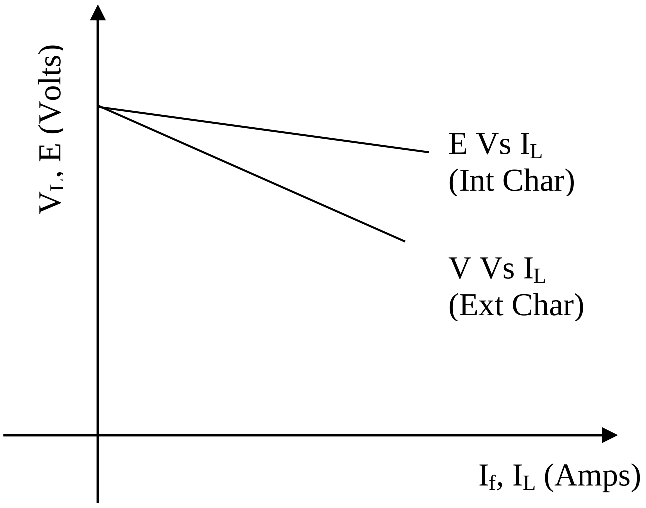
FORMULAE:

$E_g = V + I_a R_a$ (Volts)

$I_a = I_L + I_f$ (Amps)

E_g	:	Generated emf in Volts
V	:	Terminal Voltage in Volts
I_a	:	Armature Current in Amps
I_L	:	Line Current in Amps
I_f	:	Field Current in Amps
R_a	:	Armature Resistance in Ohms

MODEL GRAPH:



RESULT:

a) Determined the external and internal characteristics

b) Deduced the armature reaction curve.

INFERENCE:

Loading effect is obtained for the dc shunt generator. The plot of V v/s I_L lies below the plot of Eg v/s Ia due to armature resistance drop and armature reaction.

Ex.No.3

BRAKE TEST ON DC SHUNT MOTOR

AIM:

To conduct load test on DC shunt motor and to plot the following characteristics:

a) Performance characteristics

b) Electrical characteristics

c) Mechanical characteristics.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Rheostat	230Ω, 2A	Wire Wound	1
4	Tachometer	(0-1500) rpm	Digital	1

THEORY:

For the load test on DC shunt motor, a mechanical brake is connected with spring balance is used. The load characteristics of DC motor are broadly classified into:

a) Electrical characteristics
b) Mechanical characteristics

There are two basic electrical characteristics

a) Speed v/s armature current
b) Torque developed v/s armature current

Speed v/s torque characteristics is also known as mechanical characteristics.

PRECAUTIONS:

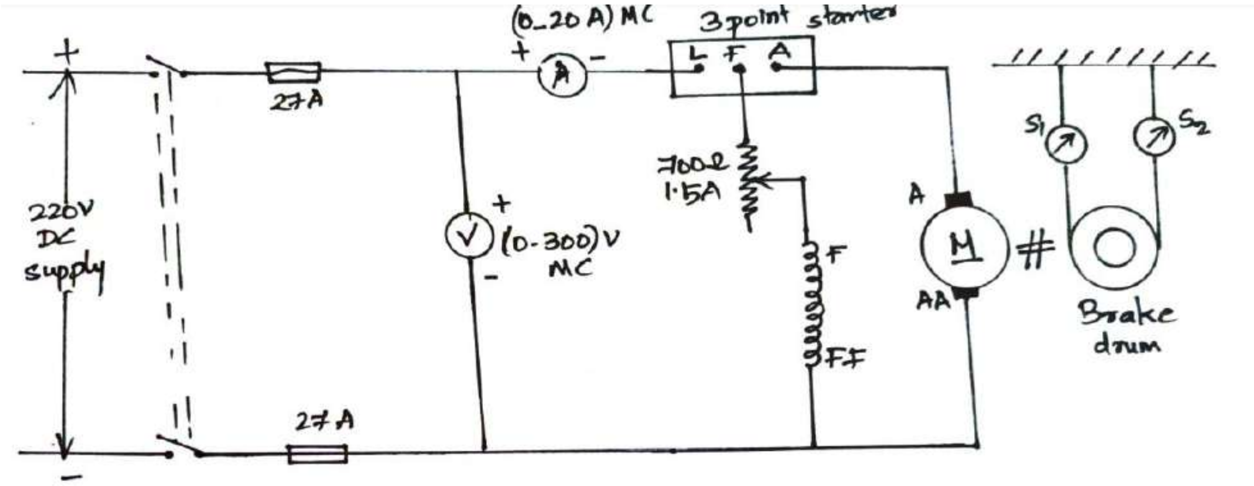
1. DC shunt motor should be started and stopped under no load condition.
2. Field rheostat should be kept in the minimum resistance position.
3. Brake drum should be cooled with water when it is on load.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Keep the field rheostat in minimum resistance position, starter resistance is gradually removed.
3. Switch on the supply and start the motor using 3 point starter.

4. The motor is brought to its rated speed by adjusting the field rheostat.
5. Ammeter, Voltmeter readings, speed and spring balance readings are noted under no load condition.
6. The load is then added to the motor gradually and for each load, voltmeter, ammeter, spring balance readings and speed of the motor are noted.
7. The motor is then brought to no load condition and field rheostat to minimum position, switch off the supply.

CIRCUIT DIAGRAM



TABULATION

S. No.	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		$(S_1 \sim S_2)$Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watts)	Input Power P_i (Watts)	Efficiency η%
			S_1(Kg)	S_2(Kg)						

FORMULAE:

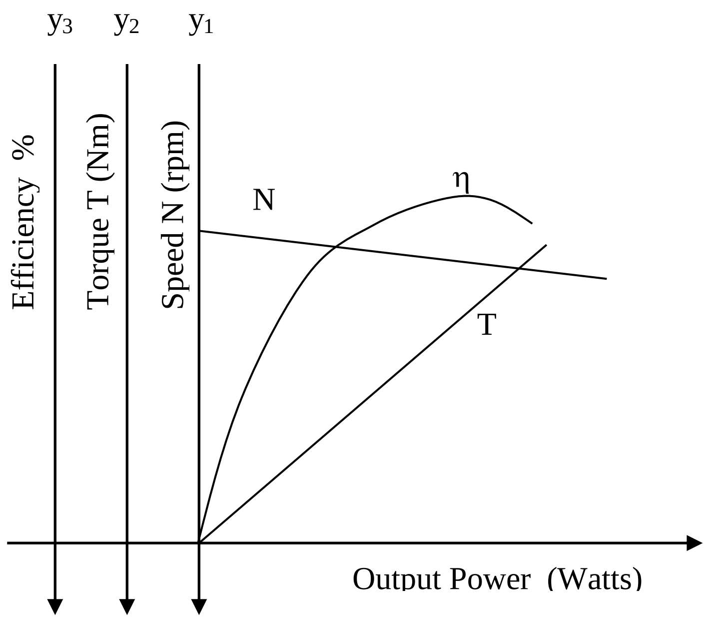
Torque T = ($S_1 \sim S_2$) x R x 9.81 Nm

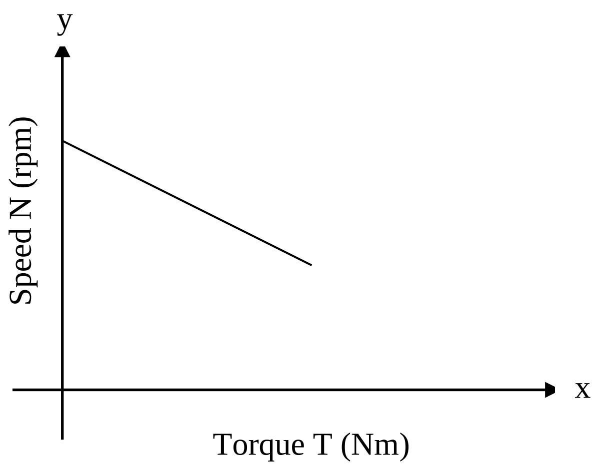
Input Power P_i = VI Watts

Output Power P_m = ($2\pi NT/60$) Watts

Efficiency η % = (Output Power / Input Power) x 100%

MODEL GRAPHS:





RESULT:

The load test on DC shunt motor is conducted and its performance characteristics are obtained.

Ex.No:4

LOAD TEST ON DC SERIES MOTOR

AIM:

To conduct Brake Test on a DC Series Motor and to plot the following characteristics

a) Performance characteristics

b) Electrical characteristics

c) Mechanical characteristics.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-20)A	MC	1
2	Voltmeter	(0-300)V	MC	1
3	Tachometer	(0-3000) rpm	Digital	1

THEORY:

The speed of a dc series motor is given by,

$N = \frac{V - Ia(Ra - Rsc)}{Ke * \phi}$

Where Ia is the armature current

Ra is the armature resistance

R_{se} is the series field

Φ is the flux per pole

N is the speed in rpm

The torque equation foe series motor is given as, T= k ϕ Ia

For series motor, the current in the field winding is same as the armature current. When this current is small, flux varies directly with the current.

ie, ϕ is proportional to Ia

ϕ = k Ia

However for high values of current Ia, flux does not increase in the same proportion as the current due to the saturation of magnetic circuit. Therefore the torque is proportional to Ia^2 for small values of Ia and as current. This gives a parabola is the initial region for current v/s torque. Speed of a series motor varies as the reciprocal of the square root of the torque. Therefore the speed curve will be a rectangular parabola. The efficiency of a small motor can be measured directly by the best placed on the water cooled pulley mounted on the shaft of the motors. Tension applied on the belt is measured by using spring balance.

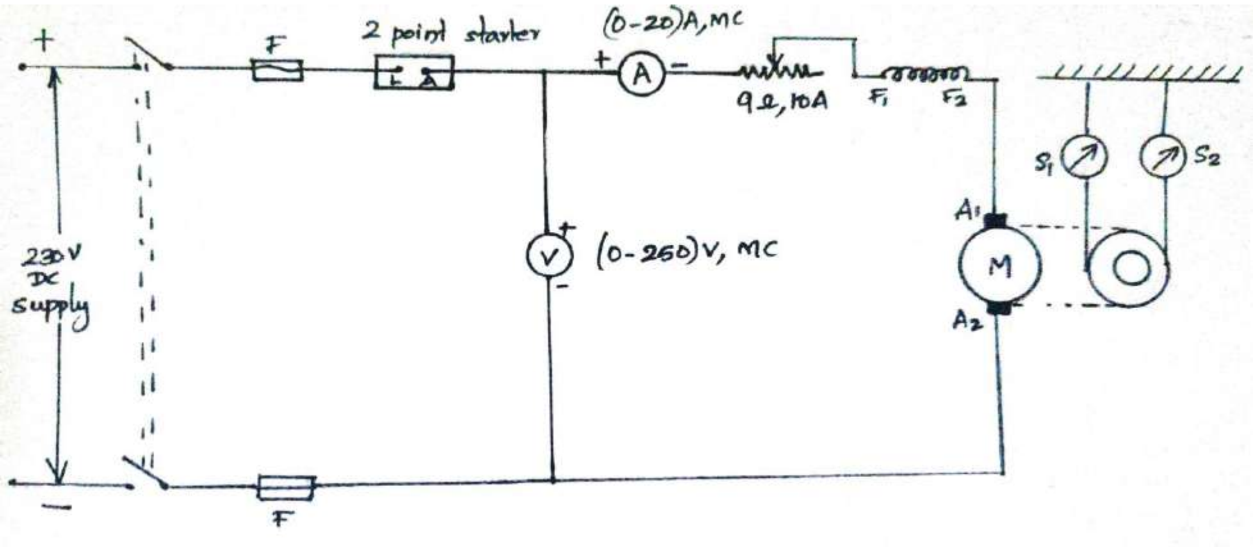
PRECAUTIONS:

1. The motor should be started and stopped with load.
2. Brake drum should be cooled with water when it is on load.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the load condition, DPST switch is closed and starter resistance is gradually removed and motor is started.
3. For various loads (up to 120% of the rated load current), Voltmeter, Ammeter readings, speed and spring balance readings are noted.
4. After bringing the load to initial position, DPST switch is opened.

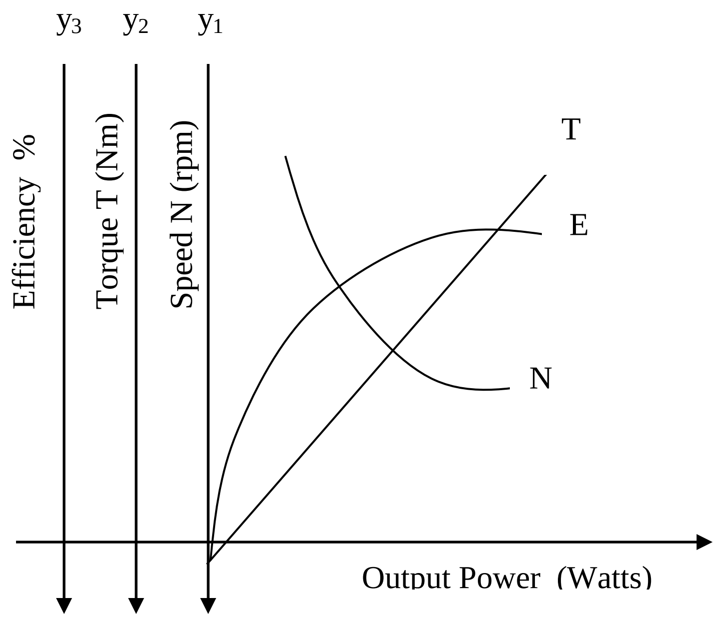
CIRCUIT DIAGRAM:



TABULAR COLUMN

S.No.	Voltage V (Volts)	Current I (Amps)	Spring Balance Reading		$(S_1 \sim S_2)$Kg	Speed N (rpm)	Torque T (Nm)	Output Power Pm (Watts)	Input Power P_i (Watts)	Efficiency η%
			S_1(Kg)	S_2(Kg)						

MODEL GRAPH:



FORMULAE:

Torque $T = (S_1 \sim S_2) \times R \times 9.81$ Nm

Input Power $P_i = VI$ Watts

Output Power $P_m = (2\pi NT / 60)$ Watts

Efficiency η % = (Output Power / Input Power) x 100%

RESULT:

Conducted brake test on given dc series motor and plotted the electrical, mechanical and performance characteristics.

Expt.5

Swinburne’s Test on a DC Shunt Machine

AIM:

To conduct Swinburne’s test on the given DC shunt motor and to determine the following:

a) To predetermine the efficiency when the machine operates as a motor and as a generator for various load conditions.
b) To plot the efficiency curves of the given DC machine.

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-5) A	MC	1
2	Ammeter	(0-2) A	MC	1
3	Voltmeter	(0-300) V	MC	1
4	Rheostats	230Ω, 2A	Wire Wound	1
5	Tachometer	(0-3000) rpm	Digital	1

THEORY:

The losses in a DC machine are iron losses, copper losses, mechanical losses. A shunt motor can be treated as a constant speed motor and a constant flux motor. The stray losses and shunt copper losses are assumed to be constant from no load to full load and are known as constant loss. Variable losses constant loss includes iron loss, mechanical loss and field loss. This method is applied to shunt machines the constant loss are determined by operating the machine. At no load and rated speed, rated voltage, variable losses are there by calculated from the known rating of the machine with these. It is possible to find the efficiency of machine operating as a generator as well as motor at any decided load conditions. The advantages of Swinburne's test are that the energy needed for the test is low as the test is conducted on no load condition. The machine is not actually loaded.

The energy consumed in equal to no load losses which include iron losses and shunt field copper loss, frictional losses and no load copper loss of the armature winding while performing the test, machine should be operated as a shunt motor.

PRECAUTIONS:

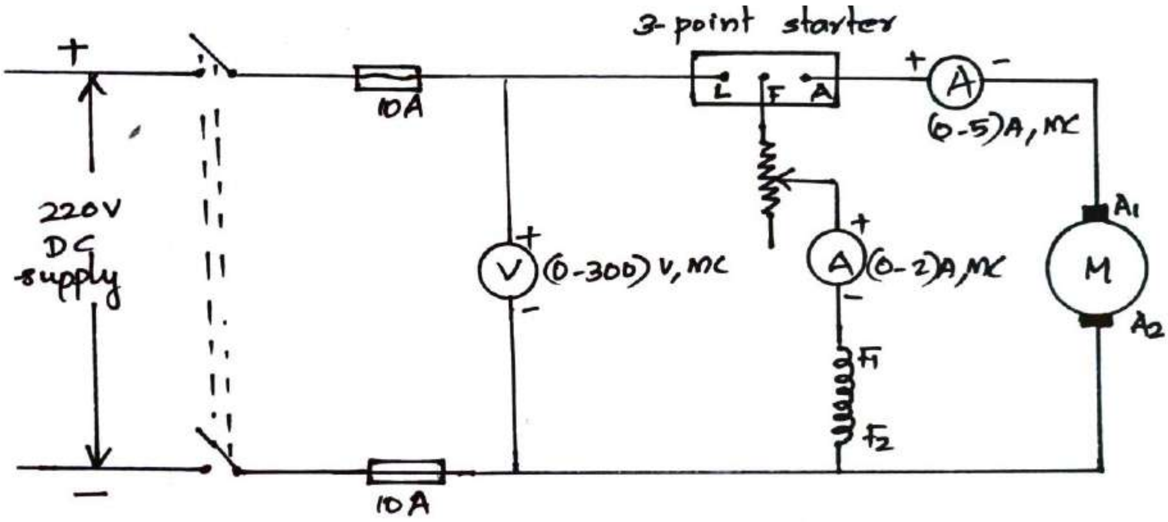
- The field rheostat should be in the minimum position at the time of starting and stopping the motor

- While starting field rheostat should be in maximum position and generator field should be in minimum position.
- Machine should be on no load.

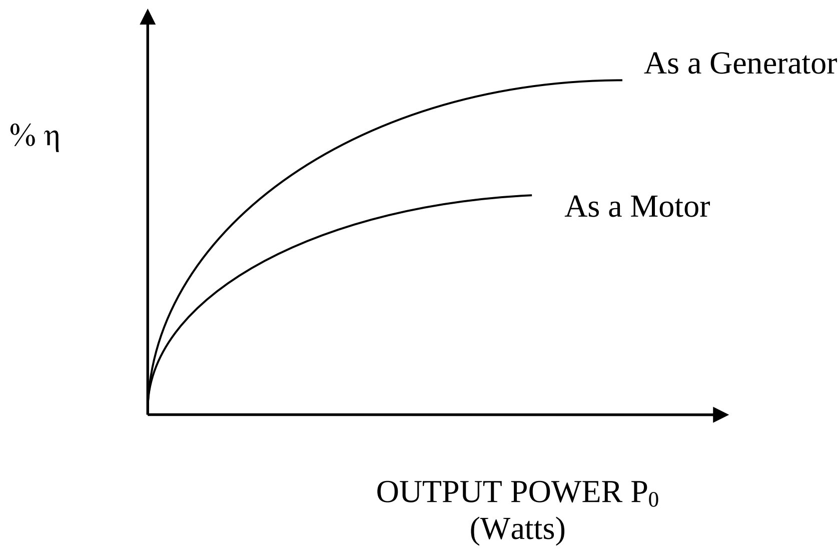
PROCEDURE

1. Connections are made as per the circuit diagram.
2. Keeping the starting rheostat in maximum position and field rheostat in minimum position, supply is switched on.
3. Starting rheostat is gradually reduced and by adjusting the field rheostat the motor is brought to rated speed.
4. The armature current, field current and voltage readings are noted.
5. The field rheostat is then brought to minimum position DPST switch is opened.

CIRCUIT DIAGRAM



MODEL GRAPH



AS MOTOR:

Load Current I_L = _____ Amps (Assume 15%, 25%, 50%, 75% of rated current)

Armature current Ia = $I_L – I_f$ Amps

Copper loss = $I_a^2 R_a$ watts

Total losses = Copper loss + Constant losses

Input Power = VI_L watts

Output Power = Input Power – Total losses

$$\text{Efficiency } \eta\% = \frac{\text{Output power}}{\text{Input Power}} \times 100\%$$

AS GENERATOR:

Load Current I_L = _____ Amps (Assume 15%, 25%, 50%, 75% of rated current)

Armature current Ia = $I_L + I_f$ Amps

Copper loss = $I_a^2 R_a$ watts

Total losses = Copper loss + Constant losses

Output Power = VI_L watts

Input Power = Input Power +Total losses

$$\text{Efficiency } \eta\% = \frac{\text{Output power}}{\text{Input Power}} \times 100\%$$

AS MOTOR:

S. No.	V (Volts)	I_L (Amps)	I_a (Amps)	Ia^2Ra (Watts)	Total Losses W (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%

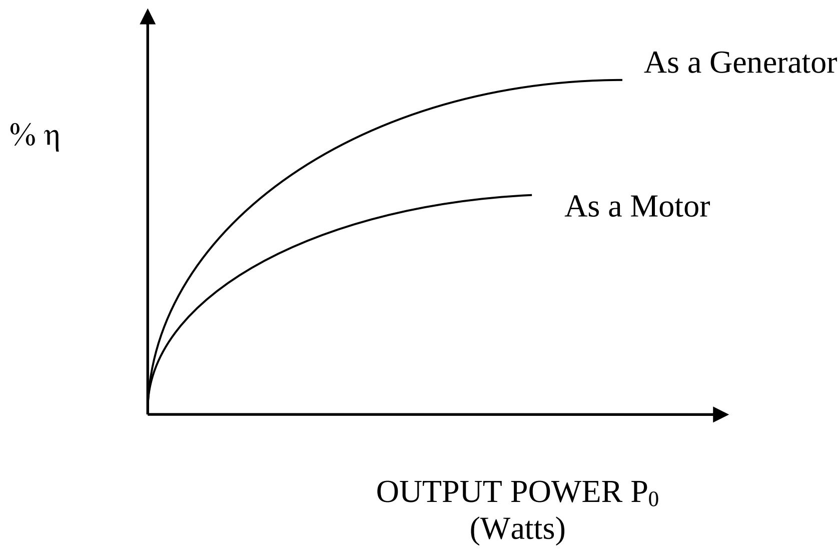
AS GENERATOR:

S. No.	V (Volts)	I_L (Amps)	I_a (Amps)	Ia^2Ra (Watts)	Total Losses W (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%

AS GENERATOR:

S. No.	V (Volts)	I_L (Amps)	I_a (Amps)	Ia^2Ra (Watts)	Total Losses (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%

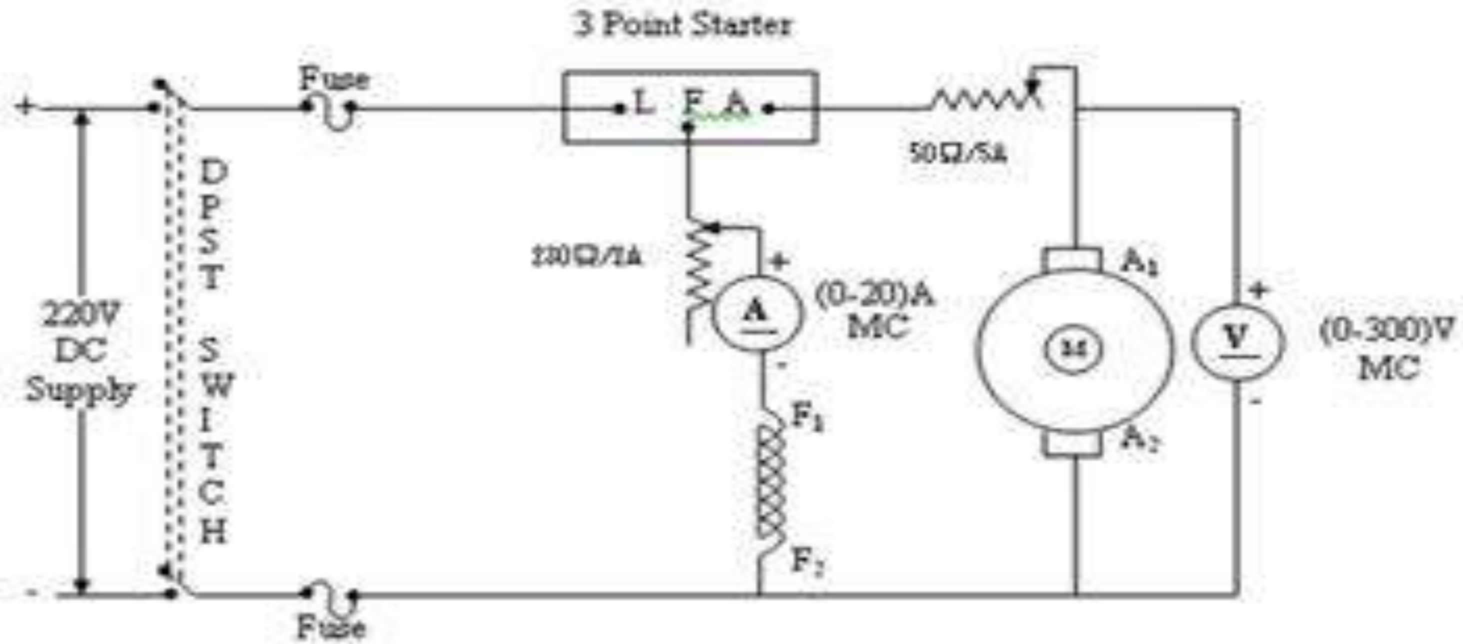
MODEL GRAPH



RESULT:

Thus the efficiency of the D.C machine is predetermined by using Swinburne's test.

CIRCUIT DIAGRAM:



FUSE RATING:

NAME PLATE DETAILS:

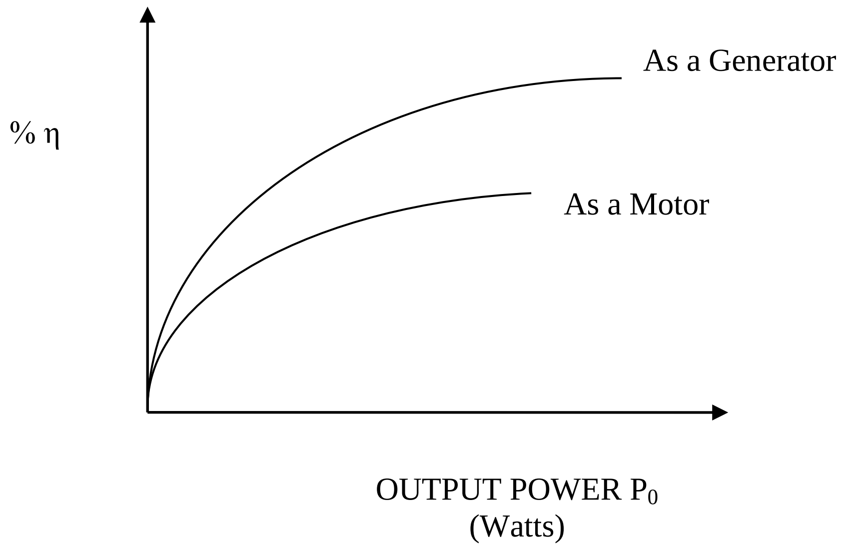
Rated Voltage :

Rated Current :

Rated Power :

Rated Speed :

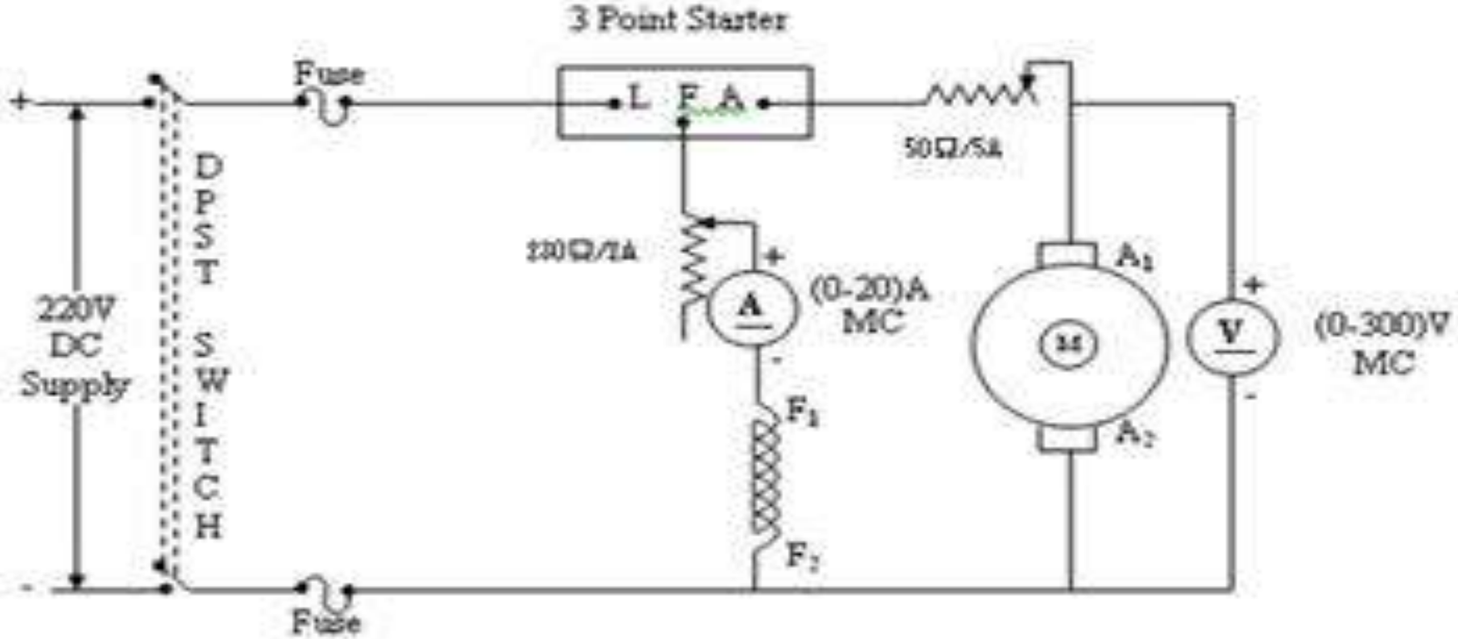
MODEL GRAPH:



RESULT:

Thus the efficiency of the D.C machine is predetermined by using Swinburne’s test.

CIRCUIT DIAGRAM:



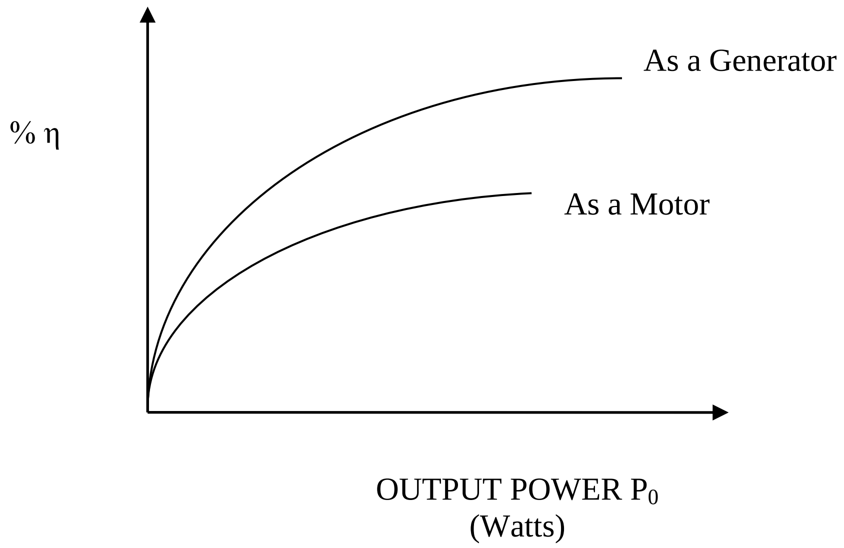
FUSE RATING:

NAME PLATE DETAILS:

Rated Voltage :
Rated Current :
Rated Power :
Rated Speed :

S. No.	V (Volts)	I_L (Amps)	I_a (Amps)	Ia^2Ra (Watts)	Total Losses W (Watts)	Output Power (Watts)	Input Power (Watts)	Efficiency η%

MODEL GRAPH:



RESULT:

Thus the efficiency of the D.C machine is predetermined by using Swinburne’s test.

Expt.6

Hopkinson's test on a pair of DC machines

AIM:

Determination of the efficiency of the given dc shunt machine working as a motor and generator under various load conditions. Determination of the efficiency of the given dc shunt machine working as a motor and generator under various load conditions.

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-5) A	MC	1
2	Ammeter	(0-2) A	MC	1
3	Voltmeter	(0-300) V	MC	1
3	Voltmeter	(0-300) V	MC	1
4	Rheostats	230Ω, 2A	Wire Wound	1
5	Tachometer	(0-3000) rpm	Digital	1

Theory:

The efficiency of a DC shunt motor and identical generator can be tested by Hopikson's test. In performing this test identical mechanically coupled are used. The generator output is used to supply the motoring machine and the mechanical output of motor is used to drive the generator. Here the test is called regenerative test. The power drawn from the supply is used for meeting the losses. Losses include armature copper, shunt field copper loss and stray losses. In this test, it is required to connect the generator to main supply to ensure two conditions. One is that the generating voltage should be equal to the Dc bus voltage and second condition is that the two voltage should be same polarity. Once the generator is paralleled with the mains it can be made to deliver any amount of load by increasing the field current.

Precautions:

- The DPST switch should be in open position.
- The field rheostat should be in the minimum position at the time of starting and stopping the motor

- While starting field rheostat should be in maximum position and generator field should be in minimum position.

Procedure:

1.Connect the circuit as per the circuit diagram.

2. Ensure that the motor field rheostat should be in minimum position and generator field rheostat should be in minimum output voltage position and also the SPST switch should be in open position at starting.

3. Give dc supply to the dc machine by closing the DPST switch and start the motor with the help of 3-point starter.

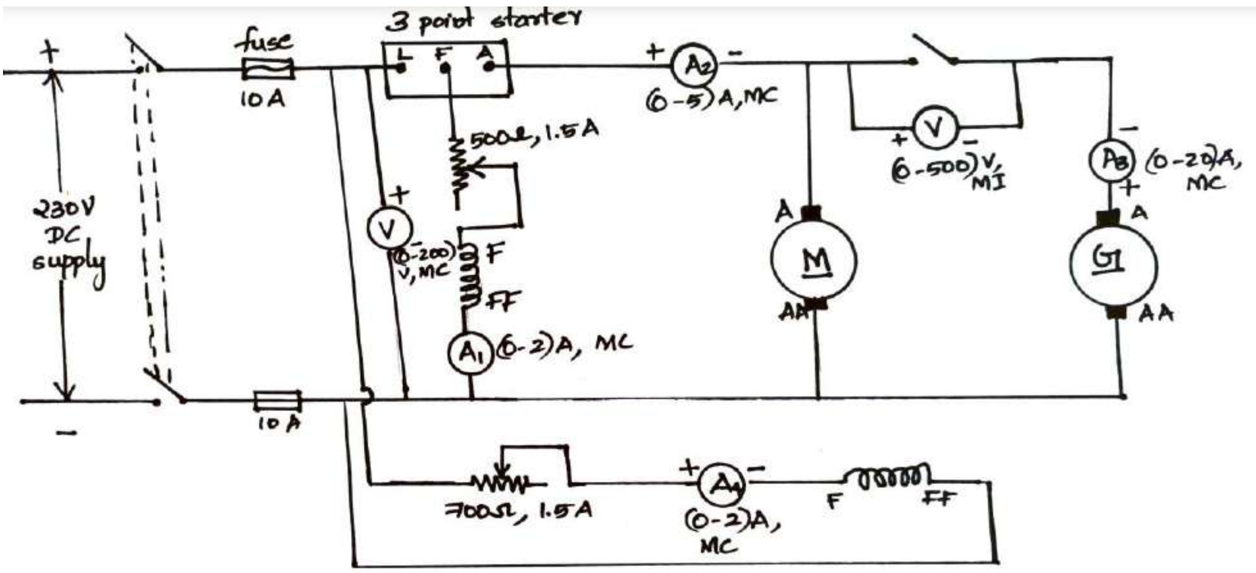
4. Adjust the motor field rheostat till the rated speed is obtained.

5. Adjust the generator field rheostat till the voltmeter across the SPST switch shows zero reading and then close the SPST switch.

6. By varying the generator field rheostat note down the readings of terminal voltage, generator field current, motor field current, output current of generator and total input current from the supply.

7. Repeat step 6, till the rated current of generator is obtained.

8. Reduce the current, set all rheostat in original position, switch off the dc supply by opening the DPST switch.



Tabular column1

Sl.No	Input Voltage V(volts)	Total input current I_1 (amps)	Generator field current I_4	Motor Field current I_2 (amps)	Generator Output current I_3	Input power Wi = V*I_1 (watts)	Armature cu losses of motor Wcu,m = (I_1 +I_3 –	Armature cu losses of generator Wcu,g	Motor field cu losses Wsh,m = V*I_2

			(amps)		**(amps)**		**$I_2)^2$ *Ra (watts)**	**= ($I_4 + I_3$ $)^2$ *Ra)**	**(watts)**

Generator field cu losses Wsh,g = V* I_4 (watts)	**Stray losses Ws = Wi – (Wcu,m + Wcu,g + Wsh,g + Wsh,m) (Watts)**	**Total losses of motor Wm = Wcu,m + Wsh,m + Ws/2 (Watts)**	**Total losses of generator Wg = Wcu,g + Wsh,g + Ws/2 (Watts)**	**% efficiency of Generator %ηg=[(VI_3)/((VI_3)+Wg)] *100**	**% efficiency of motor %ηm = $\frac{V(I_1 + I_3 - I_2) - Wm * 100}{V(I_1 + I_2 - I_4)}$**

Calculations:-

Input voltage V=___ volts

Total input current from the supply I_2 =____amps

Generator field current I_4 =____amps

Motor field current I_3 =____amps

Generator output current I_1 =____amps

Input power to the set Wi =V* I_2 watts

Armature copper losses of motor Wcu,m = (I_1 +I_2 - I_4) 2 *Ra watts

Armature copper losses of generator Wcu,g =(I_1 + I_3) 2 *Ra watts

Generator field copper losses Wsh,g = V* I_3 watts

Motor field copper losses Wsh,m = V* I_4 watts

Stray losses Ws = Wi - { Wcu,m + Wcu,g + Wsh,g + Wsh,m }Watts

Total losses of motor Wm = Wcu,m + Wsh,m + Ws/2 Watts

Total losses of generator Wg = Wcu,g + Wsh,g + Ws/2 Watts

Percentage efficiency of motor $\%\eta m = \frac{V(I_1 + I_2 - I_4) - Wm}{V(I_1 + I_2 - I_4)} * 100$

Percentage efficiency of generator $\%\eta g = \frac{(V I_1)}{((V I_1) + Wg))} * 100$

Result:

Hopkinson's test is conducted on a given DC shunt machines and efficiency is calculated for both motor and generator

Expt.7

OC & SC Tests on a Single Phase Transformer

AIM

a) To pre-determine the regulation and efficiency of the given single phase transformer at different loads and power factors
b) To obtain the equivalent circuit of the given transformer
c) To plot regulation vs power factor curves
d) To determine the power factors at which regulation is zero

APPARATUS REQUIRED:

S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-2)A (0-5) A	MI MI	1 1
2	Voltmeter	(0-150)V	MI	2
3	Wattmeter	(150V, 5A) (150V, 5A)	LPF UPF	1 1
4	Connecting Wires	2.5sq.mm	Copper	Few

THEORY:

A transformer works on the principle that energy can be transferred by magnetic induction from one set of coils to another set by means of a varying magnetic flux. The open circuit and short circuit test are performed for determining the parameter of the transformer like their efficiency, voltage regulation, circuit constant etc. These tests are performed without the actual loading and because of this reason the very less power is required for the test. The open circuit and the short circuit test gives a very accurate result as compared to the full load test.

The purpose of the open-circuit test is to determine the no-load current and losses of the transformer because of which their no-load parameters are determined. This test is performed on the primary winding of the transformer. The wattmeter, ammeter and the voltage are connected to their primary winding. The nominal rated voltage is supplied to their primary winding with the help of the ac source. The secondary winding of the transformer is kept open, and the voltmeter is connected to their terminal. This voltmeter measures the secondary induced voltage. As the secondary of the transformer is open, thus no-load current flows through the primary winding.The value of no-load current is very small as compared to the full rated current. The copper loss occurs only on the primary winding of the transformer because the secondary winding is open. The reading of the wattmeter only represents the core and iron losses. The core loss of the transformer is the same for all types of loads.

The short circuit test is performed on the secondary or high voltage winding of the transformer. The measuring instrument like wattmeter, voltmeter and ammeter are connected to the high voltage winding of the transformer. Their primary winding is short-circuited by the help of thick strip or ammeter which is connected to its terminal.The low voltage source is connected across the secondary winding because of which the full load current flows from both the secondary and the primary winding of the transformer. The full load current is measured by the ammeter connected across their secondary winding.The low voltage source is applied across the secondary winding, which is approximately 5 to 10% of the normal rated voltage. The flux is set up in the core of the transformer. The magnitude of the flux is small as compared to the normal flux.

The iron loss of the transformer depends on the flux. It is less occur in the short circuit test because of the low value of flux. The reading of the wattmeter only determines the copper loss occurred, in their windings. The voltmeter measures the voltage applied to their high voltage winding. The secondary current induces in the transformer because of the applied voltage.

PRECAUTIONS:

1. Auto Transformer should be in minimum voltage position at the time of staring.

PROCEDURE:

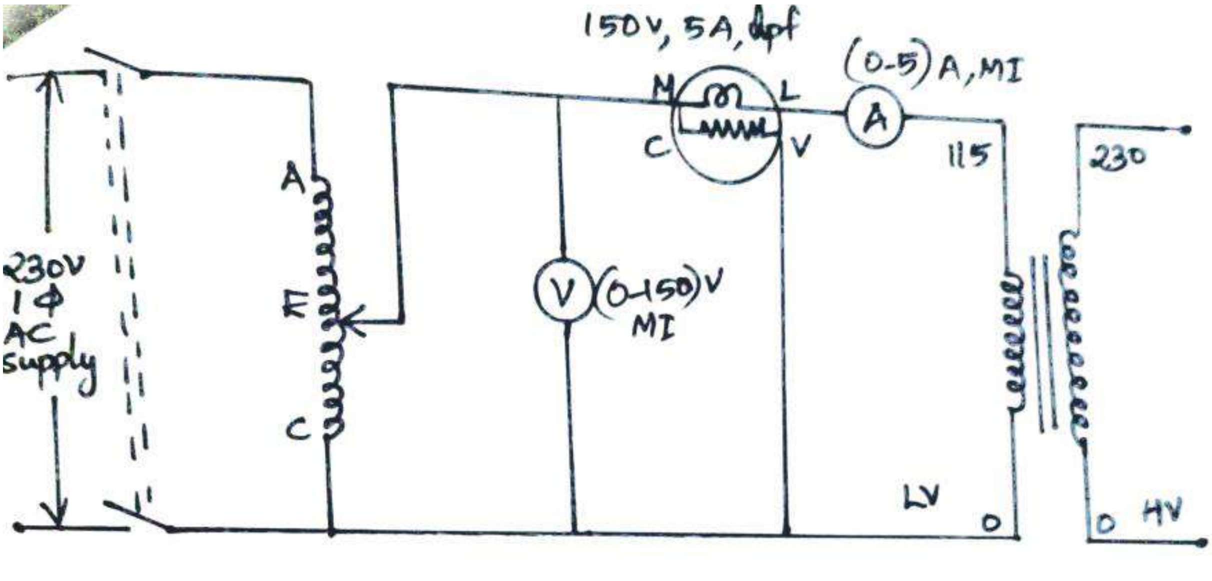
OPEN CIRCUIT TEST:

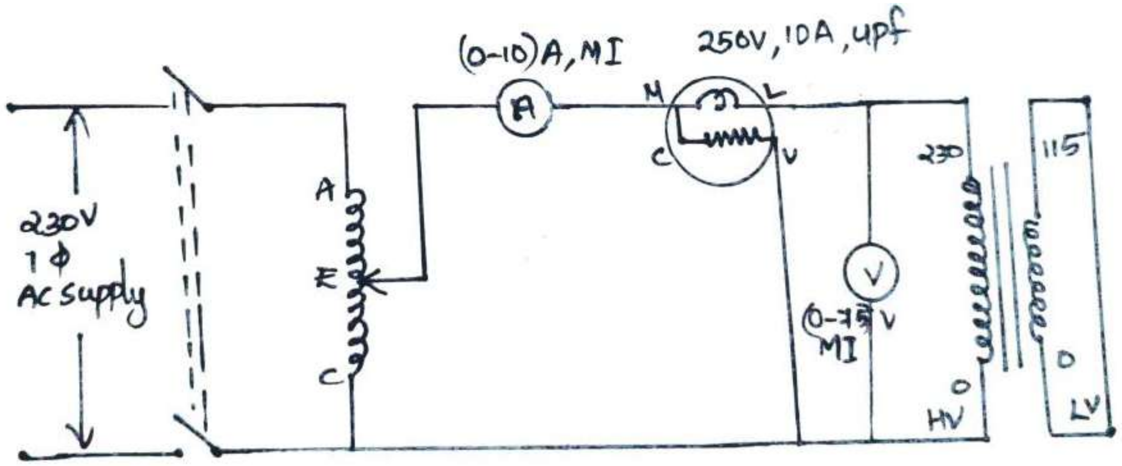
1. Connections are made as per the circuit diagram.
2. After checking the minimum position of Autotransformer, DPST switch is closed.
3. Auto transformer variac is adjusted get the rated primary voltage (LV side).
4. Voltmeter, Ammeter and Wattmeter readings on primary side are noted.
5. Auto transformer is again brought to minimum position and DPST switch is opened.

SHORT CIRCUIT TEST:

1. Connections are made as per the circuit diagram.
2. After checking the minimum position of Autotransformer, DPST switch is closed.
3. Auto transformer variac is adjusted get the rated primary current.
4. Voltmeter, Ammeter and Wattmeter readings on primary side are noted.
5. Auto transformer is again brought to minimum position and DPST switch is opened.

OC




(0-10)A, MI
250V, 10A, upf
M
L
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230V
1 ϕ
AC supply
A
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C
(0-75) V
MI
230
0
HV
115
0
LV

OPEN CIRCUIT TEST:

V_o (Volts)	I_o (Amps)	W_o (Watts)

SHORT CIRCUIT TEST:

V_{sc} (Volts)	I_{sc} (Amps)	W_{sc} (Watts)

Load(%)	Power factor	Core loss(W)	Cu loss(Wc) X^2Wsc	Output power(W)	Input power(W)	Efficiency(%)	Regulation Lag	Lead
¼								
½								
¾								
1								

FORMULAE:

Core loss: $W_o = V_o I_o \cos\phi_o$

$$\cos\phi_o = \frac{W_o}{V_o I_o} \qquad \phi_o = \cos^{-1}\frac{W_o}{V_o I_o}$$

$I_\omega = I_o \cos\phi_o$ (Amps) $I_\mu = I_o \sin\phi_o$ (Amps)

$$R_o = \frac{V_0}{I_\omega}\ \Omega \qquad X_o = \frac{V_0}{I_\mu}\ \Omega \qquad R_{o2} = \frac{W_{sc}}{I_{sc}^2}\ \Omega$$

$$Z_{o2} = \frac{V_{sc}}{I_{sc}}\ \Omega \qquad X_{o2} = (Z_o^2 - R_{o2}^2)^{1/2}$$

$$R_{o1} = \frac{R_{02}}{K^2}\ \Omega \qquad X_{o1} = \frac{X_{02}}{K^2}\ \Omega \qquad K = \frac{V_2}{V_1} = 2$$

Percentage Efficiency: for all loads and p.f.

$$\text{Efficiency } \eta\% = \frac{\text{Output Power}}{\text{Input Power}} = \frac{(X) \times \text{KVA rating} \times 1000 \times \cos\phi}{\text{Output power + losses}}$$

$$= \frac{(X) \times \text{KVA rating} \times 1000 \times \cos\phi}{(X) \times \text{KVA rating} \times 1000 \times \cos\phi + W_o + X^2 W_{sc}}$$

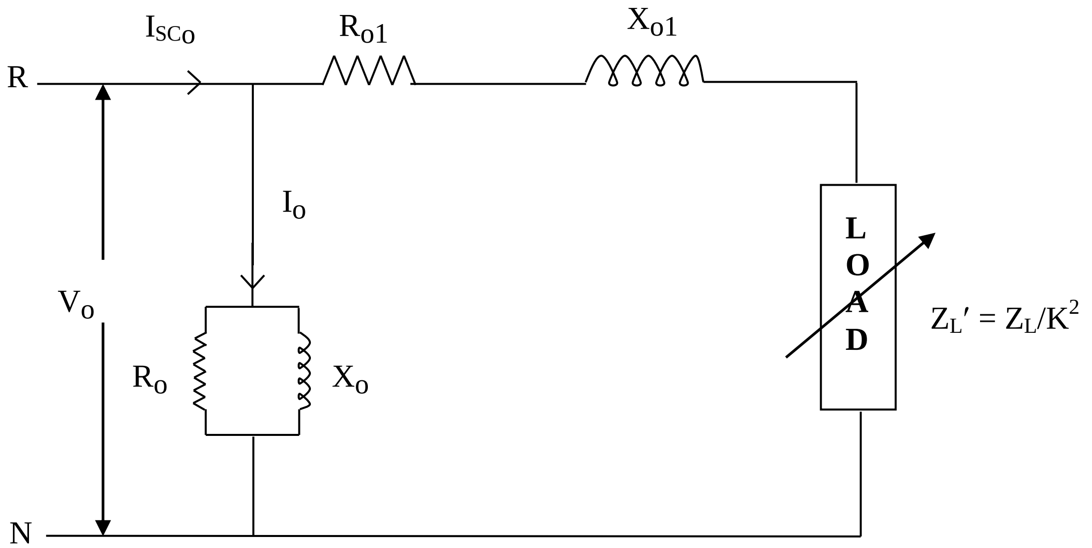
Percentage Regulation:

$$R\% = \frac{(X) \times I_{sc} (R_{o2}\cos\phi \pm X_{o2}\sin\phi) \times 100}{V_2}$$

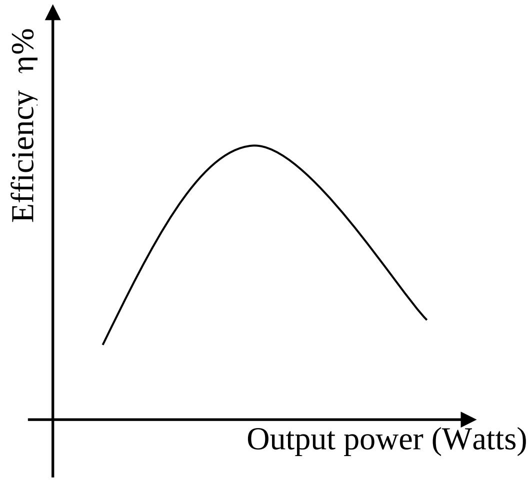
+ = lagging
- = leading

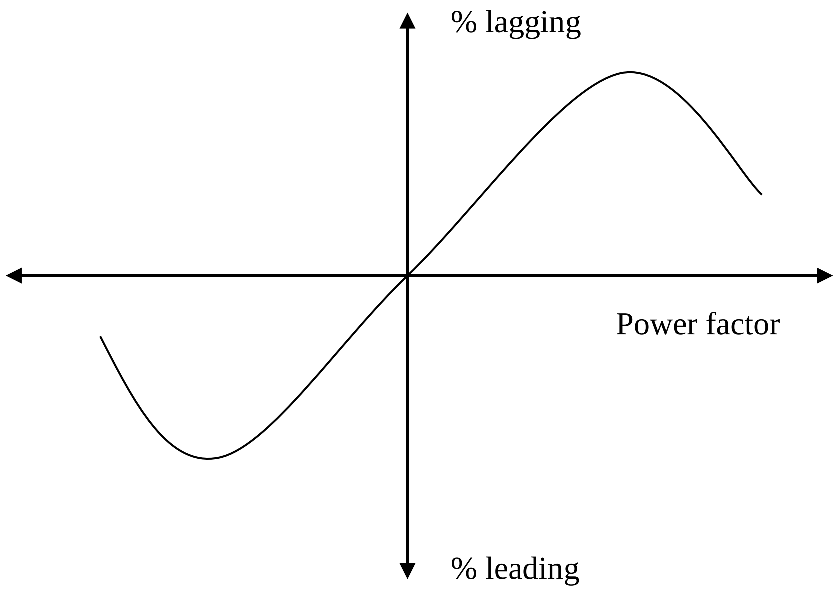
Where X is the load and it is 1 for full load, ½ for half load, ¾ load, ¼ load etc.. and the power factor is, upf, o.8 p.f lag and 0.8 p.f lead

EQUIVALENT CIRCUIT:



MODEL GRAPH:





RESULT:

Thus the efficiency and regulation of a transformer is predetermined by conducting open circuit test and short circuit test and the equivalent circuit is drawn.

EXPT:8

LOAD TEST ON A SINGLE PHASE TRANSFORMER

AIM:

a) To determine the efficiency of the given transformer at unity power factor at different loads

b) To determine the regulation of the given transformer at unity power factor at different loads

c) To plot the efficiency vs output and regulation vs output curves

APPARATUS REQUIRED:

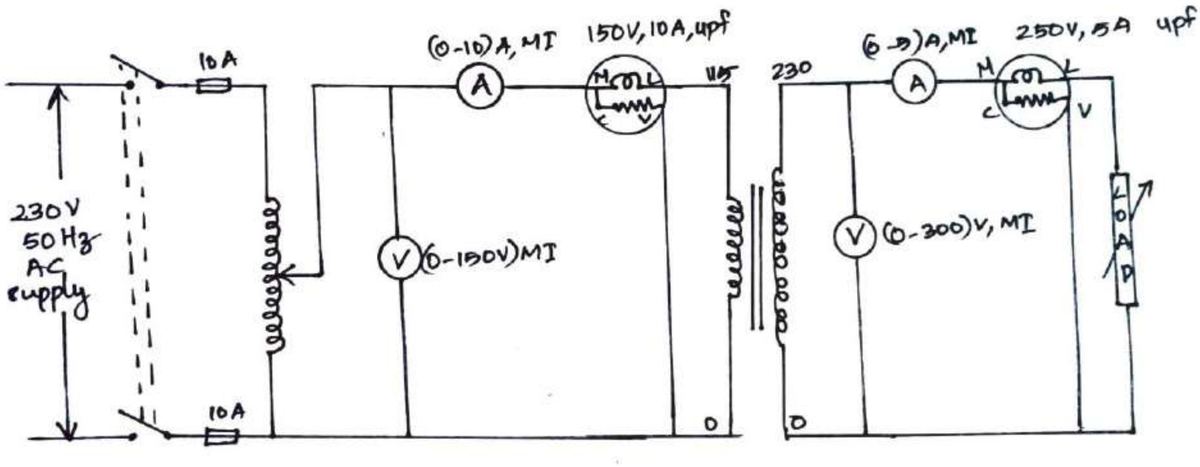
S.No.	Apparatus	Range	Type	Quantity
1	Ammeter	(0-10)A (0-5) A	MI MI	1 1
2	Voltmeter	(0-150)V (0-300) V	MI MI	1 1
3	Wattmeter	(300V, 5A) (150V, 5A)	Upf Upf	1 1
4	Auto Transformer	1ϕ, (0-260)V	-	1
5	Resistive Load	5KW, 230V	-	1
6	Connecting Wires	2.5sq.mm	Copper	Few

PRECAUTIONS:

1. Auto Transformer should be in minimum position.
2. The AC supply is given and removed from the transformer under no load condition.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. After checking the no load condition, minimum position of auto transformer and DPST switch is closed.
3. Ammeter, Voltmeter and Wattmeter readings on both primary side and secondary side are noted.
4. The load is increased and for each load, Voltmeter, Ammeter and Wattmeter readings on both primary and secondary sides are noted.
5. Again no load condition is obtained and DPST switch is opened.



FORMULAE:

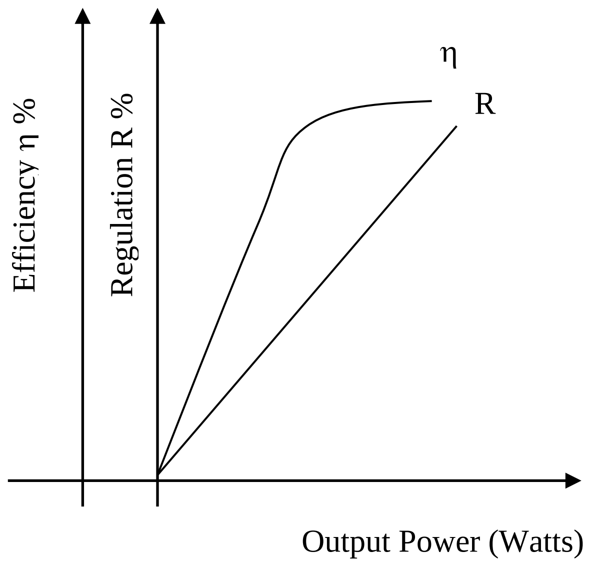
Output Power = W_2 x Multiplication factor

Input Power = W_1 x Multiplication factor

$$\text{Efficiency } \eta \% = \frac{\text{Output Power}}{\text{Input Power}} \times 100\%$$

$$\text{Regulation R } \% = \frac{V_{NL} - V_{FL} \text{ (Secondary)}}{V_{NL}} \times 100\%$$

MODEL GRAPHS:



TABULAR COLUMN

S. No.	Load	Primary			Secondary			Input Power W_1 x MF	Output Power W_2 x MF	Efficiency η %	% Regulation
		V_1 (Volts)	I_1 (Amps)	W_1 (Watts)	V_2 (Volts)	I_2 (Amps)	W_2 (Watts)				

RESULT:

Thus the load test on single phase transformer is conducted.

Ex.No. 09

SUMPNER'S TEST

AIM :

a) To predetermine efficiency at different loads and power factors

b) To predetermine regulation at different loads and power factors

c) To determine the equivalent circuit

APPARATUS REQUIRED:

S. No.	Name of the Apparatus	Range	Type	Quantity
1	Single phase Auto Transformer	(0-260) V,8A	-	2
2	Wattmeter	300 V, 5 A,LPF	Dynamometer	1
3	Ammeter	(0-5) A	MI	2
4	Voltmeter	(0-600) V (0-300) V	MI MI	1 1
5	Single phase transformer	115/230V,17.2A/8.6A (2KVA)	--	1
6	Connecting Wires	2.5sq.mm	Copper	As required

THEORY:

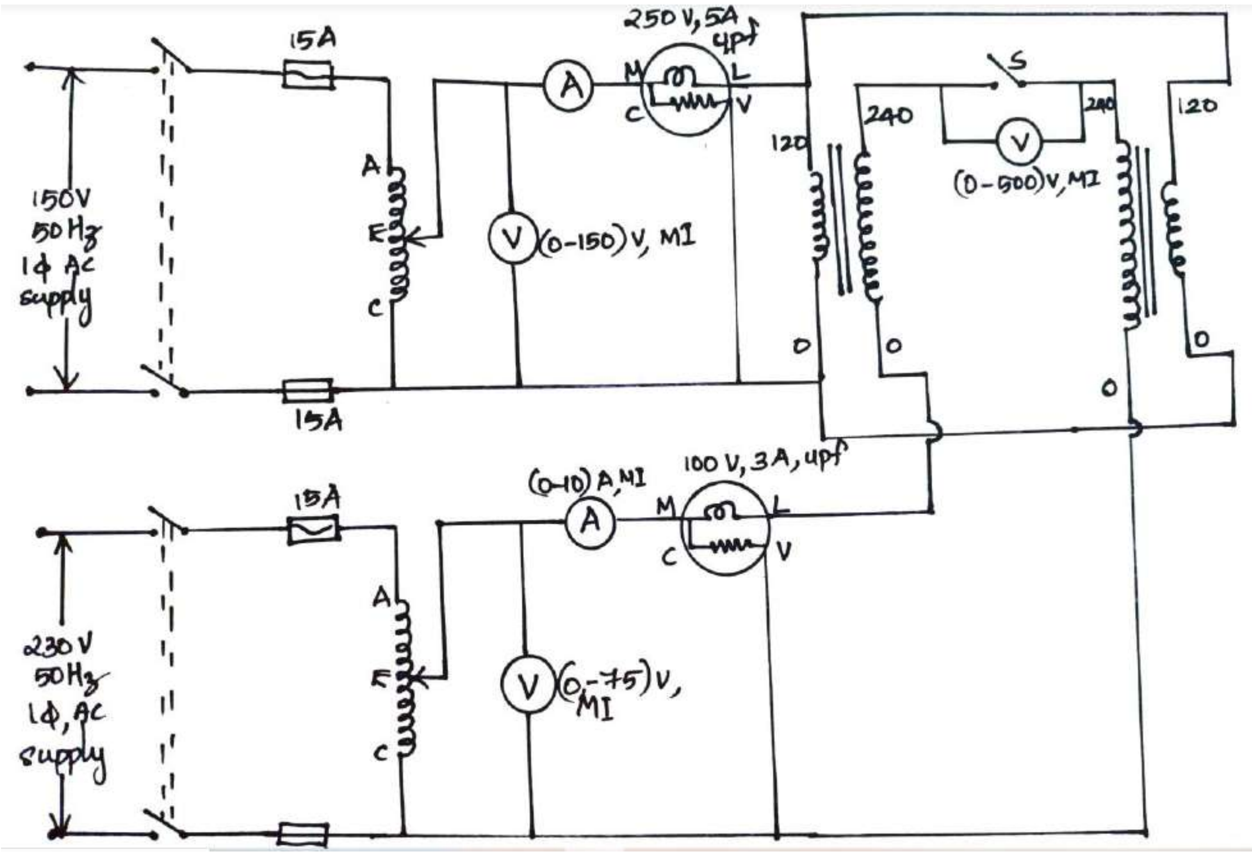
Sumpner's test or back to back test on transformer is another method for determining transformer efficiency, voltage regulation and heating under loaded conditions. Short circuit and open circuit tests on transformer can give us parameters of equivalent circuit of transformer, but they can not help us in finding the heating information. Unlike O.C. and S.C. tests, actual loading is simulated in Sumpner's test. Thus the Sumpner's test give more accurate results of regulation and efficiency than O.C. and S.C. tests. Sumpner's test or back to back test can be employed only when two identical transformers are available. Both transformers are connected to supply such that one transformer is loaded on another. Primaries of the two identical transformers are connected in parallel across a supply. Secondaries are connected in series such that emf's of them are opposite to each other. Another low voltage supply is connected in series with secondaries to get the readings.

PRECAUTIONS:

1. Auto Transformer whose variac should be in zero position, before switching on the ac supply.
2. Transformer should be operated under rated values.

PROCEDURE:

1. Connect the LV winding of transformer in parallel and HV side in phase opposition as in figure.
2. Rated voltage of 110V is adjusted to get in voltmeter by adjusting the variac of the Auto Transformer which would be in zero before switching on the supply at the primary side.
3. The readings of voltmeter, ammeter and wattmeter are noted on the primary side.
4. A voltmeter is connected across the secondary and with the secondary supply off i.e switch S is kept open. The voltmeter reading is noted.
5. If the reading of voltmeter reads higher voltage, the terminals of any one of secondary coil is interchanged in order that voltmeter reads zero.
6. The secondary is now switched on and SPST switch is closed with variac of auto transformer is zero.
7. After switching on the secondary the variac of transformer (Auto) is adjusted so that full load rated secondary current flows.
8. Then the readings of wattmeter, Ammeter and voltmeter are noted.
9. The Percentage Efficiency and percentage regulation are calculated and equivalent circuit is drawn.



FORMULAE:

Core loss of each transformer $W_o = \dfrac{W_1}{2}$ Watts

Full load copper loss of each transformer $W_c = \dfrac{W_2}{2}$ Watts.

$W_o = V_1 I_1 \cos \varphi_o$ $\varphi_o = \cos^{-1} \dfrac{W_o}{V_1 I_1}$ $I_1 = \dfrac{I_o}{2}$ A

$Iw = I_1 \cos\Phi o$ $I\mu = I_1 \cos\Phi$ $V2 = Vs/2 \times A$

$Ro = V_1 / Iw$ $Xo = V_1 / I\mu$ $R_{o2} = Wc / I2^2$ $Z_{o2} = V_2 / I_2$

$Xo_2 = \sqrt{Zo_2^2 - Ro_2^2}$

Copper loss at various loads $= I_2^2\, Ro_2$

PERCENTAGE REGULATION:

1. Upf : $I_2 / V\,(Ro_2 \cos\Phi o) \times 100$
2. Lagging pf : $I_2 / V\,(Ro_2 \cos\Phi o + Xo_2 \sin\Phi o) \times 100$

3. Leading pf : I_2 / V (Ro_2 CosΦo - Xo_2SinΦo) X 100

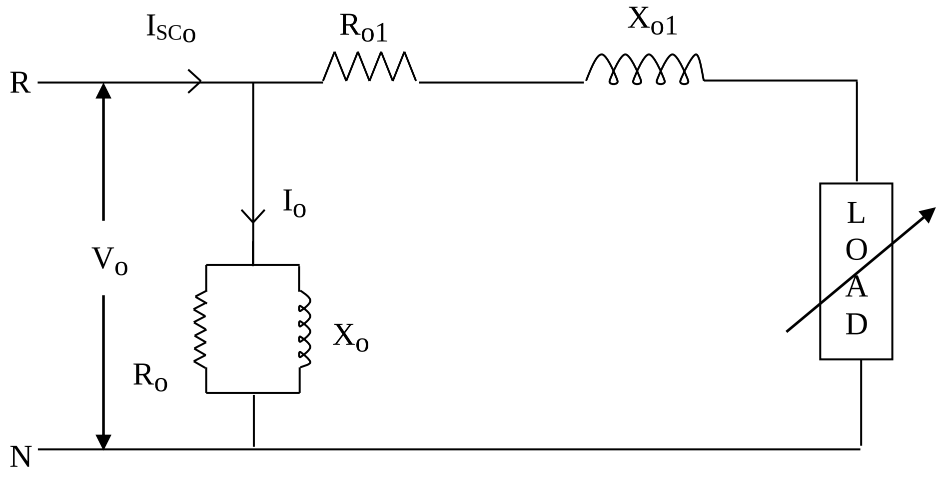
4. Output Power (1) Upf : 3Kw

(2) Pf : 3Kw CosΦo

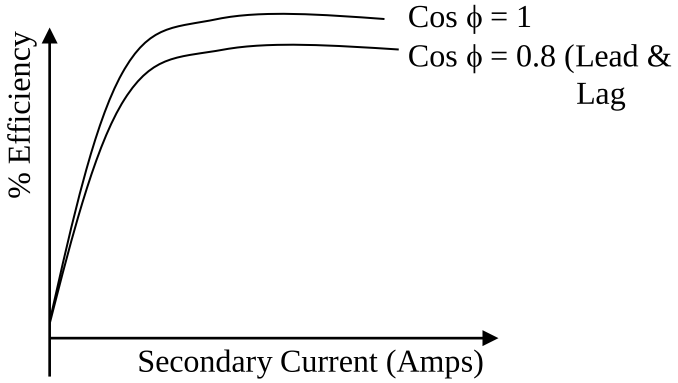
5. Input Power = Output Power + Core loss + Cu loss

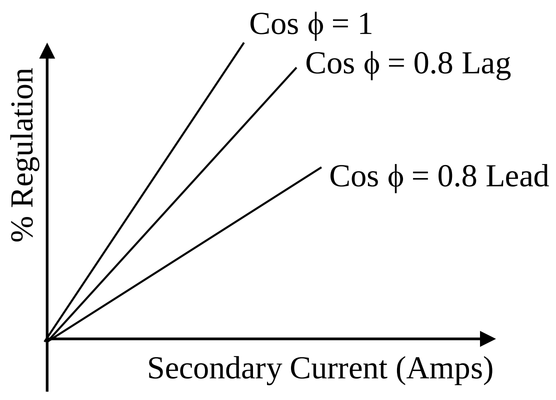
$$\text{6. Efficiency } \eta\% = \frac{\text{Output power}}{\text{Input Power}} \times 100\%$$

EQUIVALENT CIRCUIT:



MODEL GRAPHS:





RESULT:

Thus the efficiency and regulation of a given single phase Transformer is carried out by conducting back-to-back test and the equivalent circuit parameters are found out.

Ex.No. 10

SEPARATION OF CONSTANT LOSSES IN A SINGLE PHASE TRANSFORMER

AIM:

a) To separate the eddy current loss and hysteresis loss from the iron loss of single phase transformer, keeping V/f constant.
b) To plot losses vs frequency curves, by separating the hysteresis and eddy current losses at normal voltage and different frequencies

APPARATUS REQUIRED:

S. No.	Name of the Apparatus	Range	Type	Quantity
1	Rheostat	1250Ω , 0.8A	Wire Wound	2
2	Wattmeter	300 V, 5A	LPF	1
3	Ammeter	(0-2) A	MC	1
4	Voltmeter	(0-300) V	MI	1
5	Connecting Wires	2.5sq.mm	Copper	Few

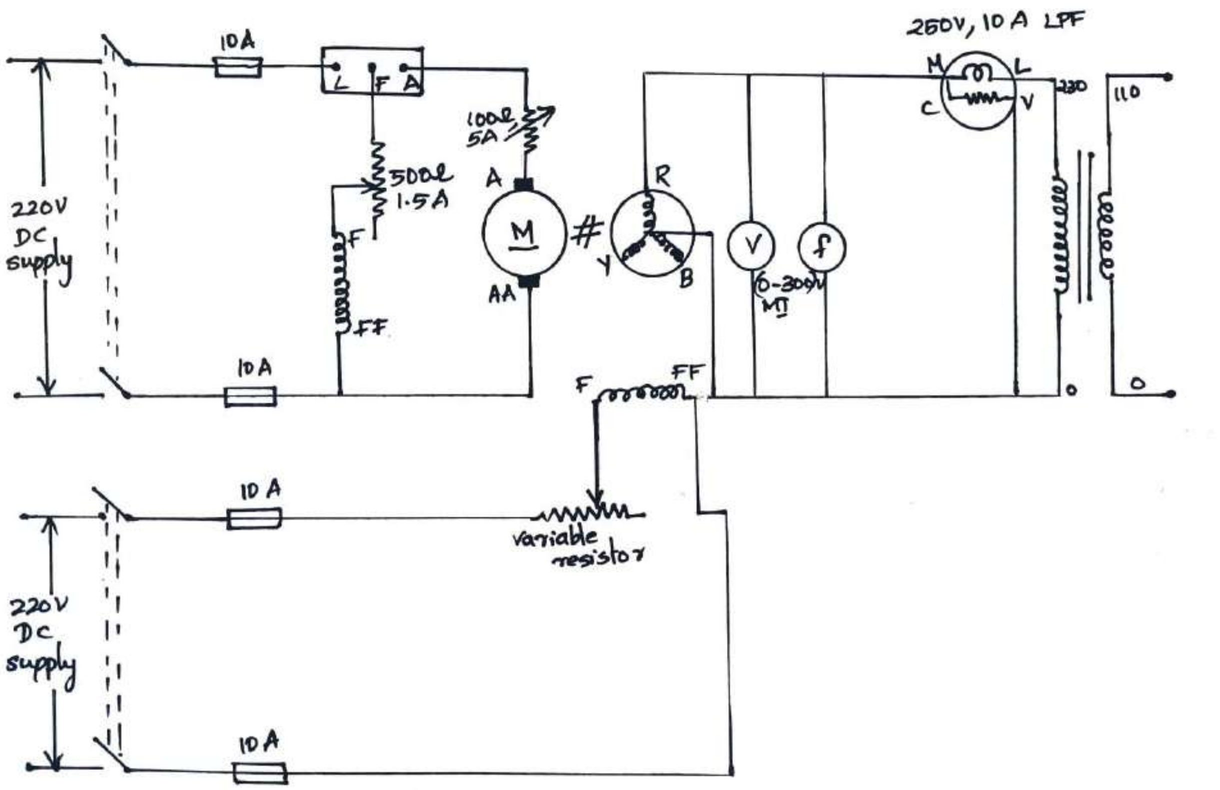
PRECAUTIONS:

1. The motor field rheostat should be kept at minimum resistance position.
2. The alternator field rheostat should be kept at maximum resistance position.

PROCEDURE:

1. Connections are given as per the circuit diagram.
2. Supply is given by closing the DPST switch.
3. The DC motor is started by using the 3 point starter and brought to rated speed by adjusting its field rheostat.
4. By varying the alternator filed rheostat gradually the rated primary voltage is applied to the transformer.
5. The frequency is varied by varying the motor field rheostat and the readings of frequency are noted and the speed is also measured by using the tachometer.
6. The above procedure is repeated for different frequencies and the readings are tabulated.

7. The motor is switched off by opening the DPST switch after bringing all the rheostats to the initial position.



TABULAR COLUMN:

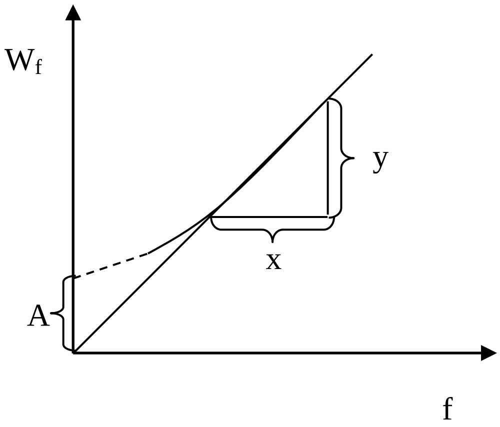
S.No.	Speed N (rpm)	Frequency f (Hz)	Voltage V (Volts)	Wattmeter reading Watts	Iron loss Wi (Watts)	W_i / f Joules

FORMULAE USED:

1. Frequency, f =(P*N_S) / 120 in Hz P = No.of Poles & Ns = Synchronous speed in rpm.
2. Hysteresis Loss W_h = A * f in Watts A = Constant (obtained from graph)
3. Eddy Current Loss W_e = B * f^2 in Watts B = Constant (slope of the tangent drawn to the curve)
4. Iron Loss W_i = W_h + W_e in Watts W_i / f = A + (B * f)

Here the Constant A is distance from the origin to the point where the line cuts the Y- axis in the graph between W_i / f and frequency f. The Constant B is $\Delta(W_i / f) / \Delta f$

MODEL GRAPH:



RESULT:

Thus separation of eddy current and hysteresis loss from the iron loss on a single-phase transformer is conducted.

EXPT NO: 11

Parallel Operation of two dissimilar Single Phase Transformers

Aim: a) To determine the load sharing of each transformer by their equivalent impedances.

b) To verify the load sharing by actual measurement.

APPARATUS:

S. No.	Name of the Apparatus	Range	Type	Quantity
1	Single phase Auto Transformer	(0-260) V,8A	-	2
2	Wattmeter	300 V, 5 A,LPF	Dynamometer	1
3	Ammeter	(0-5) A	MI	2
4	Voltmeter	(0-600) V (0-300) V	MI MI	1 1
5	Single phase load			
6	Single phase transformer	115/230V,17.2A/8.6A (2KVA)	--	2

THEORY:

Parallel operation of transformers is used for load sharing. The transformers are connected in parallel on both primary and secondary side. Following conditions to be satisfied during the parallel operation of transformers.

- Same polarities should be connected.
- The two transformers should have same voltage ratio.
- The percentage impedance should be same.
- There should be no circulating current.

PROCEDURE:

1. Connect the circuit as shown in the diagram.
2. Note down the readings of all wattmeters, ammeters and voltmeters for given load.
3. Repeat the above test for different values of load
4. Take at least three readings.

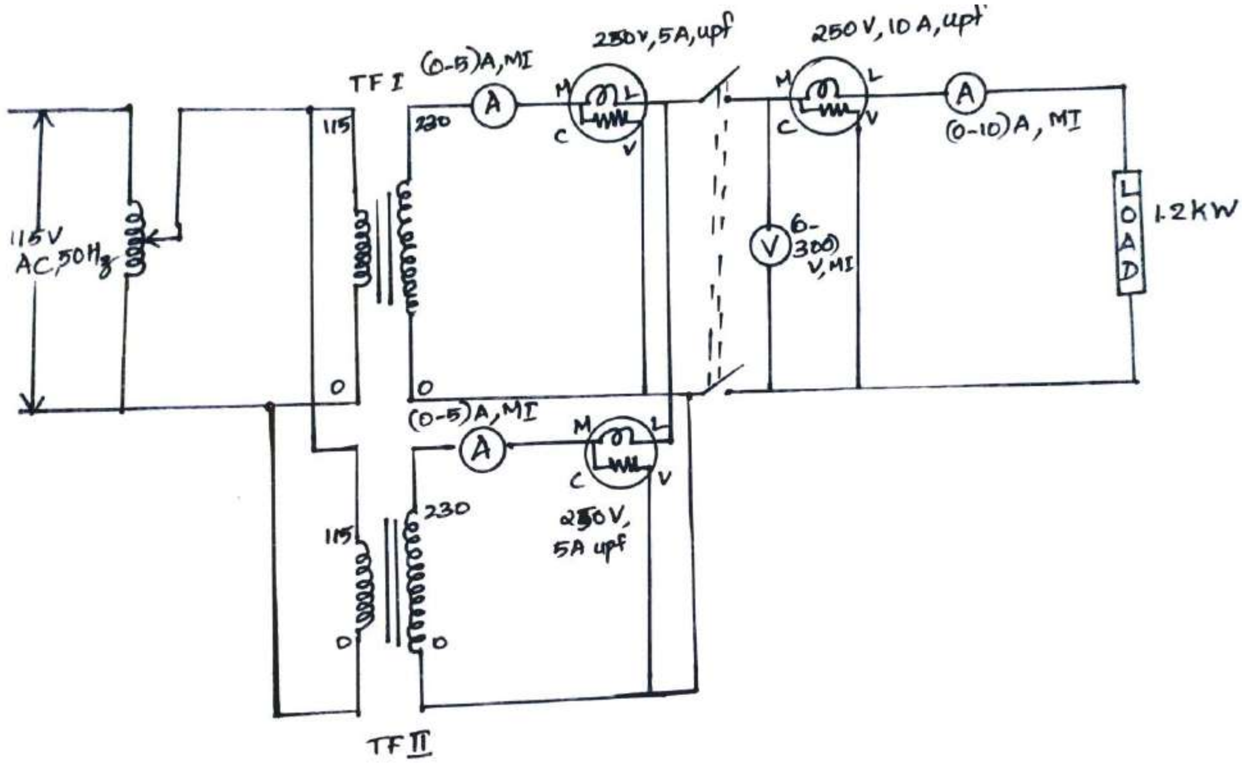
PRECAUTIONS:

1. Transformers should be connected in such a way that they have same polarity.
2. All connections should be neat and tight.
3. Connecting leads should be perfectly insulated.

OBSERVATION:

Sl No	I1 (AMPS)	W1(WATTS)	I2(AMPS)	W2(WATTS)	IL=I1+I2 (AMPS)	WL=W1+W2 (WATTS)
1						
2						
3						
4						
5						

CIRCUIT DIAGRAM:



RESULT:

Transformers connected in parallel shares equal load.

Expt No.12

RETARDATION TEST ON A PAIR OF DC MACHINE

Objectives:

a) Separation of hysteresis, eddy current, friction & windage losses.

b) Find the moment of inertia of the rotating system

Apparatus Required:

S. No.	Name of the Apparatus	Range	Type	Quantity
1	Rheostat	12Ω, 12A	Wire Wound	1
		500Ω, 1.5A	Wire Wound	1
		100Ω, 5A	Wire Wound	1
2	Thacho meter			1
3	Ammeter	(0-5) A	MC	1
4	Voltmeter	(0-300) V	MC	1

THEORY

The energy associated with a body is given by $(1/2)Jw^2$ where 'J' is the moment of inertia in the kgm^2 and 'w' is angular velocity in radian per second.

The corresponding power = time rate of change of energy
$d/dt\ ((1/2)Jw^2)) = Jw.dw/dt$

Now $w=2\pi N/60$
where 'N' is the speed in rpm

$Jw.dw/dt = J(2\pi N/60)^* (2\pi/60)^* dN/dt = 0.0109\ N.\ dN/dt$

This test is also known as the running down test. It is used for finding out the stray power losses of the shunt wound dc machine.

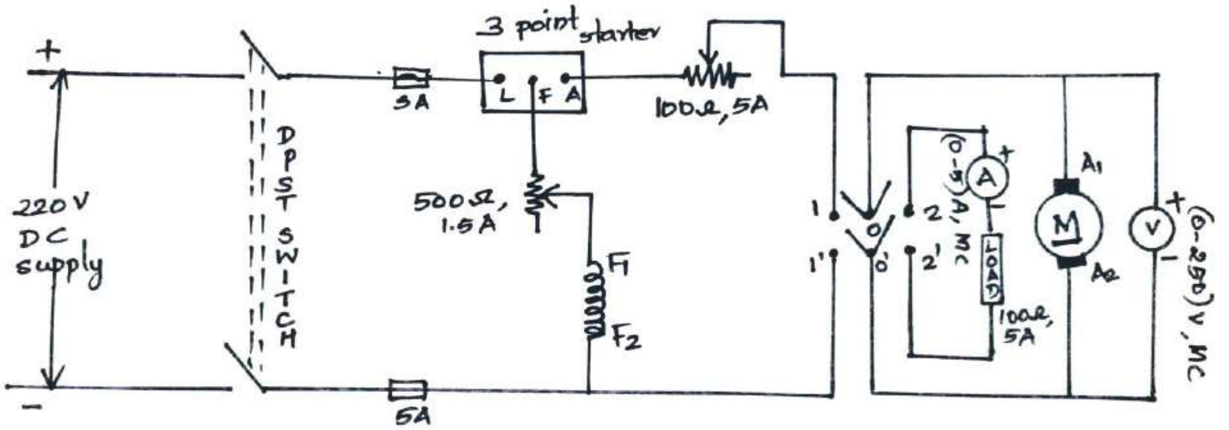
Case1:-
If the supply armature alone is cut off the machine retards due to mechanical loss&magnetic losses. The motor is started and the motor is allowed to slow down by DPST switch opening, thus cutting off the supply to the armature alone. As the field supply is retained the stored kinetic energy is utilized to meet both the mechanical losses (w_m) and iron losses (w_i)known as stray losses (w_s). The time to slow down, in this case, is denoted by t_1,

$w_s = w_m + w_i = 0.0109\ J\ Nr\ dN/dt_1$

Case2:-
With the DPST switch connected to the supply side, the motor is started on no-load and is &made to run at the rated speed at the rated voltage. Then after slightly increasing the speed above the rated speed, the DPST switch is opened. The motor speed starts to slow down the started kinetic energy which is used to meet the mechanical losses in the machine. The time to slow down in this case is denoted by 't_2'.
$w_m = 0.0109\ JNr\ dN/dt_2$

Case3:-
After the motor is started again, the DPST switch is changed from 1-1' to 2-2'. At this moment the motor is connected to an additional load and now the kinetic energy is used to supply the power to the load in addition to the rotational losses. The additional losses are denoted by w' the time taken to slow denoted loss is denoted by 't_s'

$w_0 + w' = 0.0109JNr\ dN/dt_s$



PROCEDURE:

1) Connections are made as shown in the circuit diagram.
2) Keep the motor field rheostat in minimum R position and armature 'R' in maximum position.
3) Keep the DPST switch in supply closed
4) Note down the zero error of various meters.

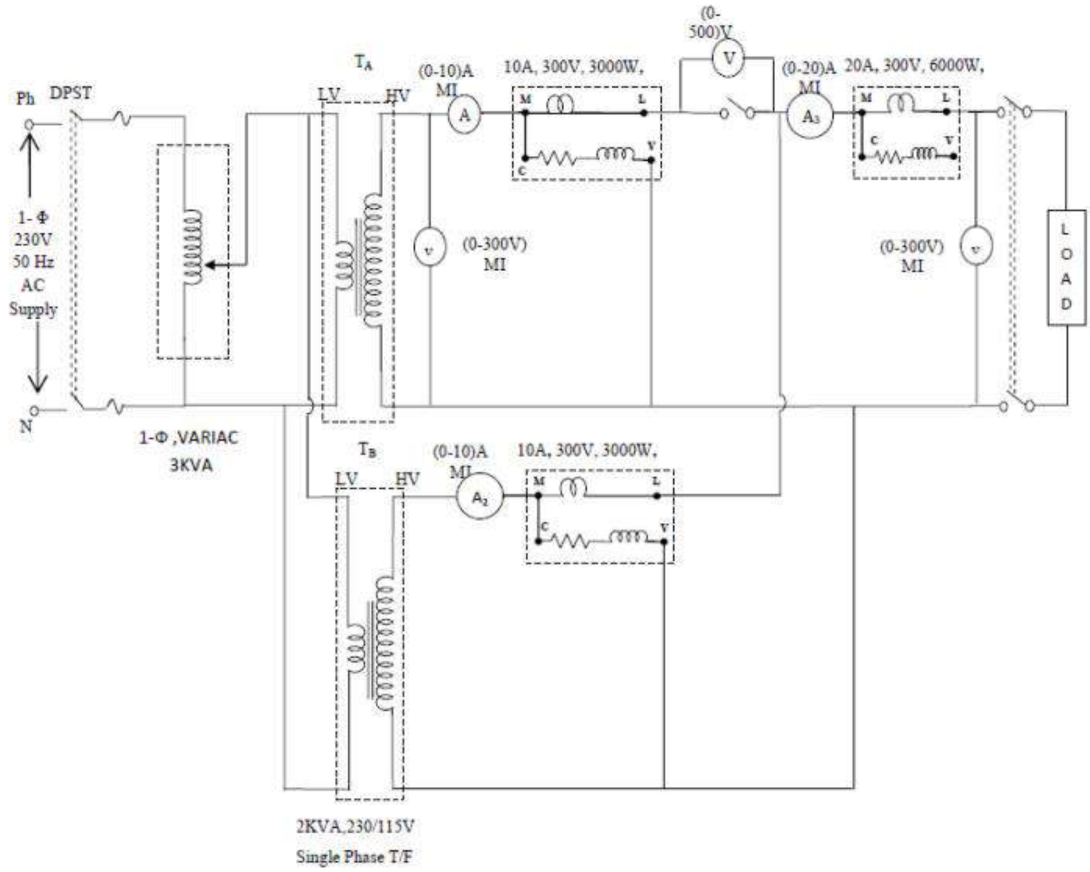
5) Switch ON the supply and start the motor using 3 point starter.
6) Using the field rheostat bring the speed of the motor to 15 to 20% of the rated speed.
7) Cut off the supply to the armature by putting the DPST switch in the open position.
8) When the motor speed reaches ay N1(above-rated speed) start the stopwatch & begin to note down the time taken in steps of 100rpm to 0 rpm.
9) The time required for slowing down from speed by'N1' to another speed should be noted repeatedly.N1+N2 are such that this average value is equal to the rated speed of the motor.
10) When the motor stops, switch off the supply so that the starter handle will return to the off position.
11) Close the DPST switch to the supply side.
12) Restart the motor & bring the speed of the motor a little above the rated value of N1.
13) Now cut off the supply to both field generator& armature by opening the switch DPDT4. Take the time required for the machine to slow down from 'N1' to 'N2'.
14) Again start the motor after closing the DPST switch to the supply side.
15) Once again bring the speed a little above the rated speed 'N1.
16) Now the DPST switch is changed over to the load side.
17) The motor slows down due to the magnetic losses, mechanical losses& losses taking place in rheostat. Time taken for speed drop from 'N1' to 'N2' is noted simultaneously note the V across the armature current through the loading 'R' corresponding to 'N1'&'N2'.
18) Open the DPPST switch & switch off the supply.

RESULT

Retardation test on DC machine is conducted & calculated the separation of eddy current hysteresis & windage losses, also the moment of inertia of the rotating system is calculated.

INFERENCE

Thus we observe that the moment of inertia of the rotating system is observed & also the separation of eddy current hysteresis and windage losses was done. Also, it is seen that the retardation time increases. When the armature supply is cut off the retardation time is least when the armature current is loaded.



Ph
DPST
1- Φ
230V
50 Hz
AC
Supply
N
1-Φ ,VARIAC
3KVA
T_A
LV
HV
(0-10)A
MI
A
10A, 300V, 3000W,
M
L
C
V
(0-300V)
MI
(0-
500)V
V
(0-20)A
MI
A_3
20A, 300V, 6000W,
(0-300V)
MI
LOAD
T_B
LV
HV
(0-10)A
MI
A_2
10A, 300V, 3000W,
2KVA,230/115V
Single Phase T/F

AHALIA SCHOOL OF ENGINEERING & TECHNOLOGY
(ISO 9001:2015 Certified Institution)
Approved by AICTE & Affilated to A. P. J. Abdul Kalam Technological University
Ahalia Health, Heritage & Knowledge Village, Palakkad - 678557. Ph: 04923-226666, www.ahalia.ac.in

DEPARTMENT OF
MECHANICAL ENGINEERING

LABORATORY MANUAL

MEL 331

MACHINE TOOLS LAB II

CONTENTS

General instructions to the students

- Do not touch anything with which you are not completely familiar. Carelessness may not only break the valuable equipment in the lab but may also cause serious injury to you and others in the lab.
- Follow instructions precisely as instructed by your supervisor.
- Do not start the experiment unless your setup is verified & approved by your supervisor.
- Do not leave the instruments unattended while in progress.
- Do not crowd around the equipment & run inside the laboratory.
- During experiments material may fail and disperse, maintain a safe distance from the experiment.
- If any part of the equipment fails while being used, report it immediately to your supervisor. Never try to fix the problem yourself because you could further damage the equipment and harm yourself and others in the lab.
- As far as possible highly finished surfaces should not be touched by hand because the natural acids on the skin are likely to corrode the surfaces and also the temperature of the body may upset the dimensions of precision instruments.
- Keep the work area clear of all materials except those needed for your work and cleanup after your work.

INDEX PAGE

Ex. No.	Name of the Experiment	Date		Marks Obtained	Signature
		Conduction	Submission		

INTRODUCTION OF METROLOGY

Introduction

Metrology is a science of measurements and the measurement is the language of science. It is divided depending upon the quantity like metrology of length, metrology of time etc., Also, it is divided depending upon the field of application as Industrial metrology, Medical metrology etc.,

Metrology is mainly concerned with

1. Establishing the units of measurements, reproducing these units in the form of standards and ensuring the uniformity of measurement.
2. Developing methods of measurement
3. Analyzing the accuracy of methods of measurement, reaching into the causes of measuring errors and eliminating these.
4. Design, manufacturing and testing of gauges of all kinds
5. measuring instruments and devices

Dynamic Metrology:
It is concerned with measuring small variations of continuous nature: Ex: Temp, pressure

Legal Metrology:
It is concerned with units of measurement, methods of measurement and the measuring instruments, in relation to the statutory technical and legal requirements. It is directed by National Organization is called National Service of Legal Metrology (NSLM). Its object is to maintain uniformity of measurement throughout the world.
Function of Legal Metrology are – to ensure conservation of national standards, to guarantee their accuracy by comparison with international standards, to impart proper accuracy to the secondary standards of the country by comparison with national standards and to carryout technical and scientific works.

Deterministic Metrology:
This is a new philosophy is which, part measurement is replaced by process measurement. In deterministic metrology, full advantage is taken of the deterministic nature of production machines and all of the manufacturing sub-systems are optimized to maintain deterministic performance within acceptable quality levels.

Passive Metrology:
Checking the components by using gauges is Passive metrology.

Active Metrology:
Checking the gauges with instruments is Active metrology.

Need of Inspection:
Inspection can be defined as the process of checking the materials, whether they satisfy design standards. The need of inspection can be summarized as:

- To ensure that the part confirms to the established standard
- To meet the interchange ability of manufacture
- To maintain customer relation by ensuring that no faulty product reaches the

customers

- Helps purchase of good quality raw materials, tools, equipment etc.,
- It gives necessary steps, so as to produce acceptable parts and reduce scrap

Physical Measurements:

It is defined as the act of deriving quantitative information about a physical object or action by comparison with a reference.

There are 3 important elements of measurement:

1. Measurand – physical quantity or property like length, angle etc., being measure
2. Comparison (or) Comparator – the means of comparing measured with some reference to render a judgment
3. Reference: The physical quantity or property to which quantitative comparisons made. Ex: Surface Table (Measurand), Scale or steel rule (Reference), Comparison by eye (Comparator).
4.

Measuring System:

A measuring system is made of five basic elements (SWIPE). These are

Standard	-	S
Work piece	-	W
Instrument	-	I
Person	-	P
Environment	-	E

Measuring Instruments:

These are measuring devices that transform the measured quantity or a related quantity into an indication or information. It can indicate either directly the value of the measured quantity or only indicated its equality to a known measure of the same quantity (equal arm balance, or null detecting galvanometer).

CHARACTERISTICS OF MEASURING INSTRUMENTS (DEFINITIONS):

Measuring Range:
It is the range of values of the measured quantity. The error does not exceed the maximum permissible error. It is limited by the maximum capacity (upper limit) and minimum capacity (minimum limit). It may or may not coincide with the range of scale indication.

Scale Interval:
It is the difference between two successive scale marks in units of the measured quantity. It is an important parameter that determines the ability of the instrument to give accurate indication of the value of the measured quantity.

Discrimination:
It is the ability of the measuring instrument to react to small changes of the measured quantity.

Hysteresis:
It is the difference between the indications of a measuring instrument when the same value of the measured quantity is reached by increasing or by decreasing that quantity. It is due to the presence of dry friction as well as to the properties of elastic elements. It results in the loading and unloading curves of the instrument being separated by a difference called the Hysteresis error. Hysteresis results in the pointer not returning completely to zero when the load is removed. Hysteresis in materials is due to presence of internal stresses. It reduced by proper heat treatment.

Response Time:
It is the time which elapses after a sudden change in the measured quantity until the instrument gives an indication differing from the true value by an amount less than a given permissible error. It is an exponential curve. It the inertia forces are not negligible; we get second order response. There are 3 possibilities. Those are Over damped system, under damped system and critically damped.

Bias:
It is the characteristics of a measure or a measuring instrument to give indications of the value of a measured quantity whose average differs from the true value of that quantity.

Inaccuracy:
It is the total error of a measure or measuring instrument under specified conditions of use and including bias and repeatability errors. This inaccuracy is called the "Uncertainty of measurement".

Accuracy Class:
Measuring instruments are classified into accuracy classes according to their metrological properties. There are two methods for classifying instruments into accuracy classes.

- Expressed by a class ordinal number that gives an idea but no direct indication of the accuracy. (Ex: block gauges 0, 1, 2, etc.)
- Expressed by a number stating the maximum permissible inaccuracy as % of the highest indication given by the instrument. (Ex: ±0.2 ie., 0.2 for 0 – 100)

Precision:
It is the repeatability of the measuring process. It refers to the group of measurements for the

same characteristics taken under identical conditions. If the instrument is not precise it will give different results for the same dimension when measure again and again.

Accuracy:

It is the agreement of the result of measurement with the true value of the measured quantity. For good accuracy avoid errors in manufacture and in measuring those errors during inspection. Highly accurate instrument possesses both great sensitivity and consistency. But the instrument which is sensitive and consistence need not necessarily be accurate. Higher the accuracy, higher will be the cost. According to the thumb rule, the instrument accuracy is more than component accuracy. In calibration, accuracy of master instrument is more than instrument accuracy (approximately by 10 times).

Error:

Error is the difference between true value and the measured value. It the error is less; accuracy will be more.

Repeatability:

It is the ability of the measuring instrument to give the same value every time the measurement of a given quantity is repeated, when the measurement are carried out - by the same observer, with the same instrument, under the same conditions, without any change in location, without change in method of measurement. And the measurements are carried out in short intervals.

Sensitivity:

Sensitivity refers to the ability of measuring device to detect small differences in quantity being measured. It is ratio of the scale spacing to the scale division value. It is also called amplification factor or gearing ratio. It may by constant (linear scale) or variable (non-linear scale) along the scale.

High sensitivity instruments may lead to drifts due to thermal or other effects and less repeatable or less precise.

Readability:

Readability refers to the ease with which the reading of a measuring instrument can read. It is the susceptibility of a measuring device to have its indications converted into meaningful number. Fine and widely spaced graduation lines improve the readability. By using magnifying devices, the readability improves.

Magnification:

Magnification means increasing the magnitude of output signal of measuring instrument many times to make it more readable. The magnification is possible on mechanical, pneumatic, optical, electrical principles or combination of these.

Reproducibility:

Reproducibility is the consistency of pattern of variation in measurement i.e., closeness of the agreement between the result of measurement of the same quantity, when by different observers, by different methods, using different instruments, under different conditions, locations, times etc.

Calibration:

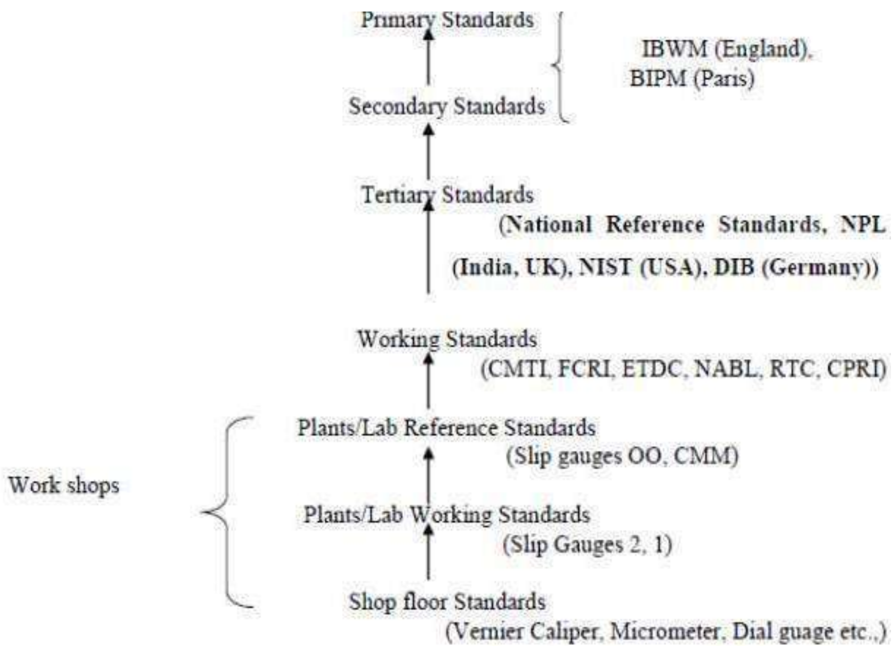
The calibration of any measuring system is very important to get meaningful results. It

measures the quantity in terms of standards unit. It is carried out by making adjustments such that readout device produces zero output for zero measured input. It should display an output equivalent to the known measured input near the full scale input value.
Accuracy of the instrument depends upon the calibration. Calibration depends upon the severity of use, environmental conditions and accuracy of measurement required etc.,

Traceability:
Concept of establishing a valid calibration of a measuring instrument of measurement standard by step by step comparing with better standards up to acceptable specified standards

Uncertainty:
Uncertainty is a parameter to quantify the reliability of mesurand. Uncertainty of measurement determines the measurement capability of a laboratory.

Standard:
A standard is defined as something that is setup and established by authority as rule for measurement of quantity, weight, extent, value or quality etc., any system of measurement must be related to known standard otherwise the measurement has no meaning. The role of standards is to support the system which makes uniform measurement throughout the world and helps to maintain interchangeability in mass production.



Measurement:
In industries, various quantities like length, width and other parameters are expressed in meaningful numbers by comparing them with standards. This result of quantitative comparison of unknown magnitude with the pre-determined standard is called measurement.

Gauging:
Gauging is the method of checking the dimensions of manufactured parts and it does not

indicate the actual value of the inspected dimension on the work and also used for determining as to whether the inspected parts are made within the specified limits.

SOURCES OF ERRORS:

Error is the difference between the actual value and the indicated value of the measured quantity. Errors may be classified in the following ways:

a) Static Errors – result from the physical nature of various components of the measuring system Ex: Internal imperfections, environmental effects, calibration effects, reading errors etc.,

b) Dynamic Errors – result by time variations in the measurand like inertia, clamping friction or other physical constraints in the measuring system.

I. Controllable or systematic or fixed errors:
   - Calibration errors
   - Ambient conditions
   - Stylus pressure
   - Random or accidental errors

II. Illegitimate Errors:
   - Blunders or mistakes
   - Computational errors
   - Chaotic errors

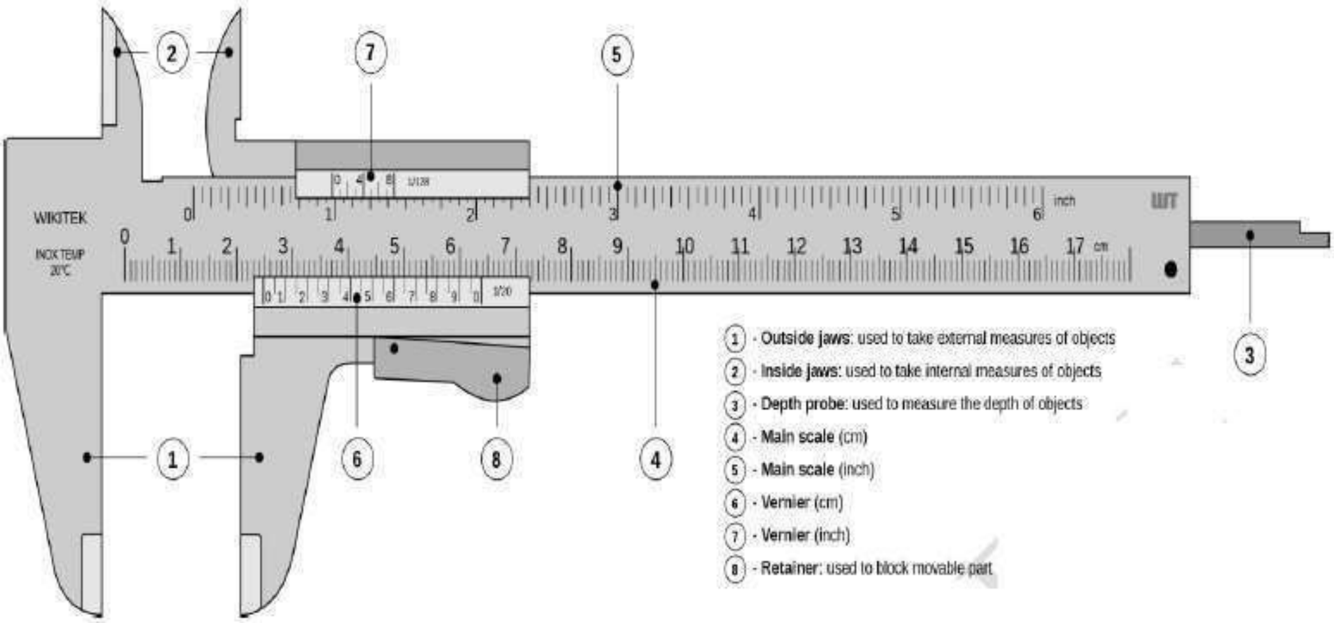


Figure 1 Vernier Caliper

Tabulation:

Sl. No.	Nominal Dimension (ND) mm	Main Scale Reading (MSR) in mm	Vernier Scale Coincidence (VSC)	Measured Dimension (MD) mm	Error =MD-ND mm
1					
2					
3					
4					
5					
Average Error					

Range = 0 to 150mm
Span = 150mm
Least Count = Value of one Main Scale division/ Total No. of divisions on Vernier Scale

= 1/50 = 0.02mm

Zero Error = Nil
Zero correction = Nil

MODEL CALCULATION

MD = MSR + (VSC x LC) + ZC MD =

EX.NO: **CALIBRATION OF VERNIER CALIPER**
DATE:

Aim:
To calibrate the given Vernier caliper using slip gauge as standard specimen.

Apparatus Required:

- Vernier Caliper
- Set of Slip gauges

Formula Used:

MD = MSR + (VSC x LC) + ZC

where,

MD	–	Measured Dimension	MSR	–	Main Scale Reading
VSC	–	Vernier Scale Coincidence	LC	–	Least Count
ZC	–	Zero Correction			

Procedure:

- Check the Vernier caliper for zero error.
- Select a standard slip gauge and place it between the fixed and movable jaws of the Vernier caliper.
- Note down the Main scale reading.
- Note down the Vernier scale Coincidence and find out the Measured Dimension.
- Repeat the above steps for different slip gauge combinations and tabulate the error.

Result:
Thus the given Vernier caliper is calibrated using standard slip gauges.

Mark	
Signature of the staff	

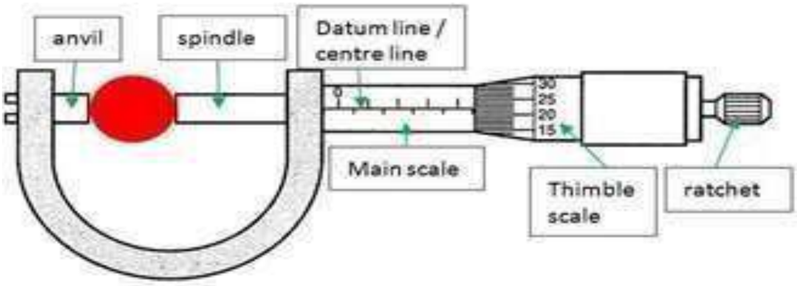


Figure 2 Micrometer

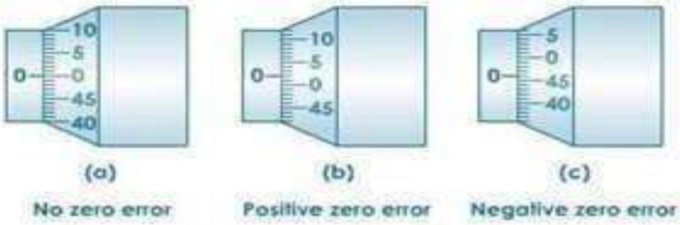


Figure 3 Types of error in Micrometer

Tabulation:

Sl. No.	Nominal Dimension (ND) mm	Main Scale Reading (MSR) in mm	Pitch Scale Coincidence (PSC)	Measured Dimension (MD) mm	Error =MD-ND mm
1					
2					
3					
4					
5					
Average Error					

Range = 0 to 25mm
Span = 25mm
Least Count = Value of one Main Scale division/ Total No. of divisions on Pitch Scale
= 0.5/50 = 0.01mm
Zero Error = 1 x 0.01 = 0.01mm
Zero correction = +0.01mm

MODEL CALCULATION
MD = MSR + (PSC x LC) + ZC
MD =

EX.NO: **CALIBRATION OF MICROMETER**
DATE:

Aim:
To calibrate a given micrometer using slip gauge as standard specimen

Apparatus Required:

- Micrometer
- Set of slip gauges

Formula Used:
MD = MSR + (PSC x LC) + ZC
where,

MD	–	Measured Dimension
MSR	–	Main Scale Reading
PSC	–	Pitch Scale Coincidence
LC	–	Least Count
ZC	–	Zero Correction

Procedure:

- Check the micrometer for the smooth running over its whole range.
- Clean the anvil and spindle carefully.
- Close the anvil and spindle and note the zero error
- Calculate the least count.
- Determine the progressive error, of the micrometer by choosing standard slip gauges for the whole range (0-25mm). Let the increment in the initial and final range be kept as small as possible.
- Determine the periodic error of the micrometer

Result:
Thus the given micrometer is calibrated.

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Signature of the staff	

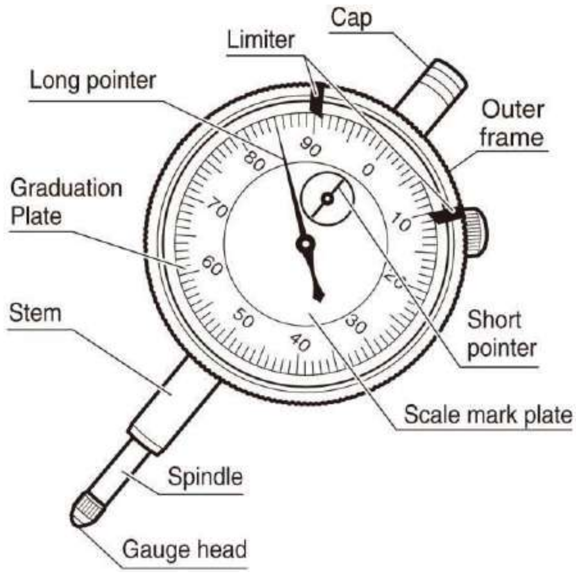

Figure 4 Dial Gauge

Tabulation:

Sl. No.	**Slip Gauge Reading (S) Mm**	**Observed Value (O) mm**	**Error = S – O mm**
1			
2			
3			
4			
5			
Average Error			

Range = 0 to 25mm
Span = 25mm
Least Count = 1/100
= 0.01mm
Zero Error = NIL
Zero Correction = NIL

EX.NO: **CALIBRATION OF DIAL GAUGE**
DATE:

Aim:
To calibrate the given dial gauge using slip gauge.

Apparatus Required:

- Dial gauge
- Slip gauge
- Magnetic Base

Procedure:

- Initially set the pointer of the dial gauge at zero reading.
- When the platform and tip of the plunger are in perfect touch with each other, lift the plunger and place a selected slip gauge.
- After placing the slip gauge between the plunger and platform, find the error.
- Likewise place selected slip gauges and tabulate the readings.

Result:
Thus the given dial gauge is calibrated.

Mark	
Signature of the staff	

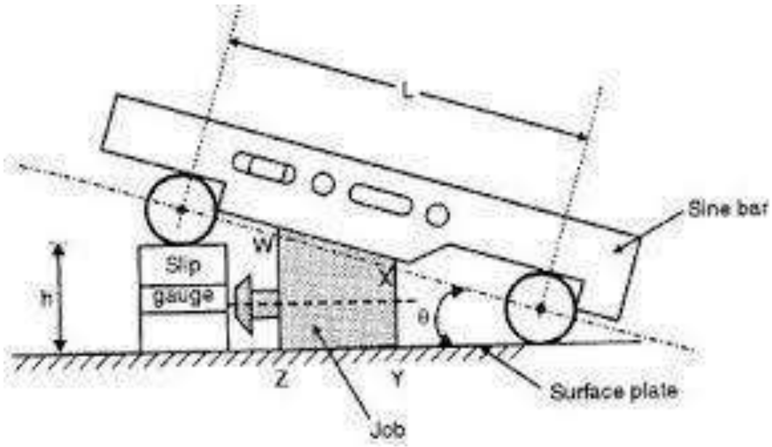

Figure 6 Sine bar

Tabulation:

Sl. No.	Specimen No.	Slip gauge reading		Taper angle of the plate
		Height of slip gauge (h) mm	Length of sine bar (l) mm	
1				
2				

EX.NO: **MEASUREMENT OF ANGLES USING SINE BAR**
DATE:

Aim:
To estimate the taper angle of the given work piece using a sine bar

Apparatus required:

- Sine bar
- Slip gauge
- Dial gauge with stand
- Surface plate

Formula Used:

$$\theta = \sin^{-1}(h/l)$$

Where,

h = height of slip gauge in m
l = centre to centre distance of the rollers of the sine bar in m.

Procedure:

- Clean the surface plate, sine bar and work piece thoroughly.
- Place the sine bar piece on the work piece placed on the surface plate.
- Add slip gauges at the bottom of any of the rollers in the sine bar to make the surface of the bottom of sine bar flat on the work piece.
- Note the height of the slip gauge.
- Calculate the angle of the work piece using the formula given above.

Result:
Thus the taper angle of the given work piece is measured using the sine bar.

Angle of the work piece 1 =

Angle of the work piece 2 =

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Signature of the staff	

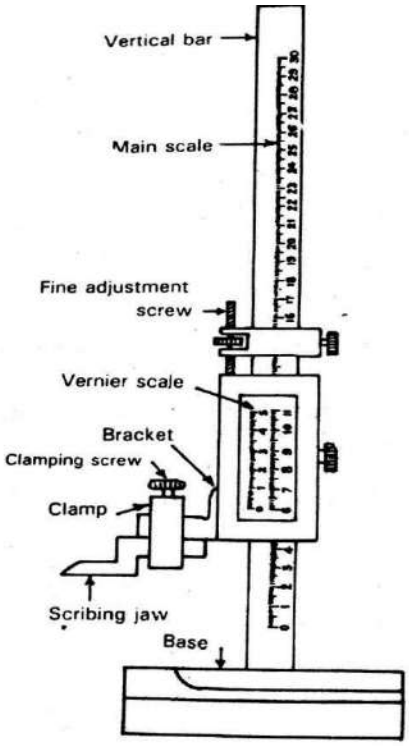


Figure 8 Vernier height gauge

Tabulation:

Specimen No.	Trial No.	Main Scale Reading mm	Vernier Scale Coincidence	Total Reading= MSR + (VSC x LC) mm	Average mm
1					
2					

Range = 0 - 300 mm
Span = 300 mm
Least Count = 1/50 = 0.02 mm
Zero Error = Nil

EX.NO: **MEASUREMENT OF DIMENSION OF SPECIMEN USING VERNIER HEIGHT GAUGE**
DATE:

Aim:

To measure the dimensions of a specimen using Vernier height gauge

Apparatus Required:

- Vernier Height Gauge
- Specimen
- Surface plate

Formula used:

MD = MSR + (VSC x LC) + ZC

where,

MD – Measured Dimension
MSR – Main Scale Reading
VSC – Vernier Scale Coincidence
LC – Least Count
ZC – Zero Correction

Procedure:

- Wipe the Vernier height gauge and specimen using a soft cloth.
- Check the Vernier height gauge for zero error.
- Loosen the locking screw and expand the measuring jaw to the approximate size of specimen.
- Place the specimen between the surface plate and the measuring jaw.
- Lock the locknut at the correct position.
- Note down the main scale and Vernier scale readings.
- Repeat the procedure for various positions of the specimen.
- Tabulate the measured readings.

Result:

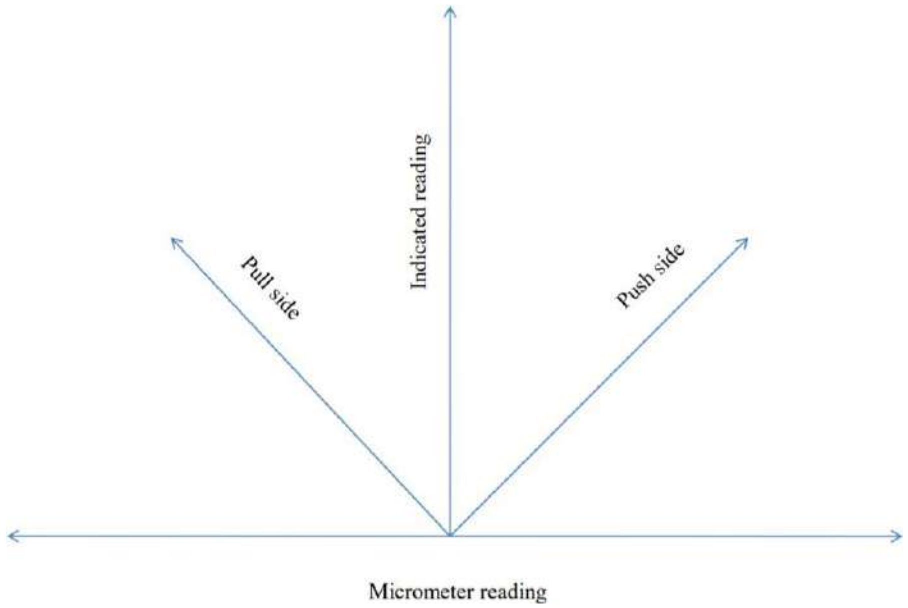
Thus the dimensions of a specimen are measured by using Vernier height gauge.
Height of specimen 1 = mm
Height of specimen 2 = mm

Mark	
Signature of the staff	

Tabulation:

Sl.No.	Push side readings		Pull side readings	
	Micrometer Reading(mm)	Indicated reading(mm)	Micrometer Reading(mm)	Indicated reading(mm)
1.				
2.				
3.				
4.				
5.				

Model Graph:
Micrometer reading Vs Indicated reading



EX.NO: **CALIBRATION OF LINEAR VARIABLE DIFFERENTIAL TRANSFORMER (LVDT)**
DATE:

Aim:
To calibrate the LVDT using micrometer / to study the characteristics of LVDT.

Apparatus required:
LVDT, Digital displacement indicator, Calibration jig (with micrometer).

Procedure:

- Plug power chord to AC mains 230 V, 50 Hz and switch on the instrument.
- Place the READ/CAL switch at READ position.
- Balance the amplifier with the help of zero knob so that display should read zero (00.00) without connecting the LVDT to instrument.
- Replace the READ/CAL switch at CAL position.
- Adjust the calibration point by rotating CAL knob so display should read 10.00 i.e., maximum calibration range.
- Again keep the READ/CAL switch at READ position and connect the LVDT cable to instrument.
- Make mechanical zero by rotating the micrometer. Display will read (00.00) this is null balancing.
- Give displacement with micrometer and observe the digital readings.
- Plot the graph of micrometer reading v/s digital reading

Result:
Thus the displacement is calibrated by using LVDT

Mark	
Signature of the staff	

Tabulation:

Sl.No.	Cicrle No:	Point-1	Point – 2	Point - 3
1.				
2.				
3.				

EX.NO: **DETERMINATION OF OUT OF ROUNDNESS**
DATE:

Aim:
To check the given cylindrical specimen for roundness and find the runout from the graphical representation.

Measuring Instruments:
V-Block, Dial Indicator, Dial indicator stand

Theory:
In any manufacturing industry, the accuracy and precision of the assembly made is well defined on geometrical tolerance and dimensionless tolerance of the various components involved in the assembly. Some of the geometric tolerances are

(i) Straightness
(ii) Roundness
(iii) Flatness
(iv) Squareness
(v) Parallelism

For cylindrical elements and shafts roundness and parallelism are most important. Hence the cylindrical element should be checked for roundness and parallelism.

<u>Roundness:</u>
An element is said to be round if all points on the surface are intersecting with perpendicular to a common axis and passing through a common center.

Procedure:
- The cylindrical mandrel was set on the V-block and free rotation was ensured.
- Dial gauge was fixed to the magnetic stand and was placed behind the specimen.
- At least 3 circles were marked along the length of specimen.
- At each circle, adjust the dial gauge to read to zero with initial the specimen is rotated once and change in the dial gauge reading was noted at 4-6 different points.
- The procedure is repeated at the 3 circles
- For all 3 readings of dial gauge, graphs were plotted and the run out was found. The maximum runout of the 3 circles will be the runout of the specimen.

Result:
The Runout of the specimen = mm.

Mark	
Signature of the staff	

EX.NO: **CYLINDRICAL GRINDING**
DATE:

Aim
To grind cylindrical surface of given material as per given dimension.

Materials Required
1. Cylindrical Grinding Machine
2. Grinding Wheel
3. Work piece
4. Steel Rule
5. Outside calliper
6. Cutting Tool

Procedure
- The given work piece is reduced to diameter 22.5 mm in lathe by turning and by facing the work piece. Length is reduced to 100mm.
- After preliminary lathe operation, work piece is held in the ends of the cylindrical grinder.
- Now the workpiece is fitted in chuck of the grinding machine.
- The grinding wheel is just touched with the workpiece and is taken as zero reference point.
- Coolant circulation is switched ON and grinding wheel is engaged with the workpiece.
- Both the workpiece and grinding wheel roll on contact with each other like two gears in mesh.
- Now, the wheel is moved slowly over the entire length of workpiece to get grinded finish.
- After feed is over, grinding wheel is moved further toward the axis of the workpiece and process is repeated until required dimension is achieved.
- Finally, dimensions are checked using Vernier caliper for 22 ± 0.1 mm.

Result
Thus the required dimension of cylindrical surface is obtained.

Mark	
Signature of the staff	

Tabulation:

Sl.No.	Tachometer reading (RPM)	Stroboscope reading (RPM)	% Error
1.			
2.			
3.			
4.			
5.			

$$\% \text{ Error} = \frac{\text{Tachometer reading} - \text{Stroboscope reading}}{\text{Tachometer reading}} \text{X } 100$$

EX.NO: **CALIBRATION OF STROBOSCOPE**
DATE:

Aim:
To calibrate the given stroboscope using tachometer and plot the following using graph.

1. Actual speed vs Indicated Speed
2. Actual speed vs % Error

Apparatus Required:
Stroboscope, Tachometer, AC Fan with speed control.

Theory:
A stroboscope is an instrument used to make a cyclically moving object appear to be moving slow or stationary. It consists of a rotating disk with slots or lamp which produces repetitive flashes of light. The principle is used for study of rotating, reciprocating, oscillating or vibratingobjects. Stroboscope is used to set ignition timing in IC engines and is called Timing light.

Procedure:

- Switch on the AC fan
- Use regulator to set the fan speed
- Press measure button at the side of the tachometer.
- Hold it for few seconds till it displays steady reading and note down the reading
- Turn on the stroboscope and tune it till the image of fan is visible
- Repeat the experiment for different speeds.
- Tabulate the reading and plot the required graph.

Result:
The given stroboscope is calibrated using tachometer and plotted the following graphs.

1. Actual speed vs Indicated Speed
2. Actual speed vs % Error

Mark	
Signature of the staff	

Sl.No.	Section	Reading	Error(max-min)
1.			
2.			
3.			
4.			
5.			

EX.NO: **FLATNESS MEASUREMENT USING DIAL INDICATOR**
DATE:

Aim
To determine the flatness of the surface.

Materials Required

1. Dial indicator
2. Work piece
3. Steel ruler
4. Pencil / Scriber

Theory

When measuring flatness, you **are checking for unevenness in the surface**, to see how precisely flat a surface is. The most protruding part and the most concaved part must be at a specific distance between two planes that are separated vertically.

Procedure

- The workpiece is initially parted in to different sections
- Dial indicator is moved from one end to other end of the section
- The maximum and minimum deviation is noted.
- The variation between maximum and minimum deviation is calculated using the below formula.
- Error value = Maximum deviation – Minimum deviation

Result:
The given workpiece is measured using dial indicator and error obtained is -----.

Mark	
Signature of the staff	

EX.NO: **REPEATABILITY & REPRODUCIBILITY**

DATE:

AIM

To evaluate the Repeatability and Reproducibility of measurements

MATERIALS REQUIRED

- Measuring Instrument

THEORY

Repeatability and reproducibility are ways of measuring precision, particularly in the fields of chemistry and engineering. In general, scientists perform the same experiment several times in order to confirm their findings. These findings may show variation. In the context of an experiment, Repeatability measures the variation in measurements taken by a single instrument or person under the same conditions, while reproducibility measures whether an entire study or experiment can be reproduced in its entirety.

What is repeatability?

Repeatability practices were introduced by scientists Bland and Altman. For repeatability to be established, the following conditions must be in place: the same location; the same measurement procedure; the same observer; the same measuring instrument, used under the same conditions; and repetition over a short period of time.

What's known as "the repeatability coefficient" is a measurement of precision, which denotes the absolute difference between a pair of repeated test results.

What is reproducibility?

Reproducibility, on the other hand, refers to the degree of agreement between the results of experiments conducted by different individuals, at different locations, with different instruments. Put simply, it measures our ability to replicate the findings of others. Through their extensive research,
controlled inter-laboratory test programs are able to determine reproducibility. The article **Precise Low Temperature Control Improves Reaction Reproducibility** discusses the challenges related to reproducibility in more detail.

Why are repeatability and reproducibility considered desirable?

In terms of repeatability and reproducibility, test/re-test reliability demonstrates that scientific findings and constructs are not expected to alter over time. For instance, if you used a certain method to measure the length of an adult's arm, and then repeated the process two years later using the same method, it's highly likely that your results would correlate. Yet if your results differed greatly, you would probably conclude that your findings were inaccurate, leading you on to further investigations. As such, repeatability and reliability imbue investigative findings with a degree of authority.

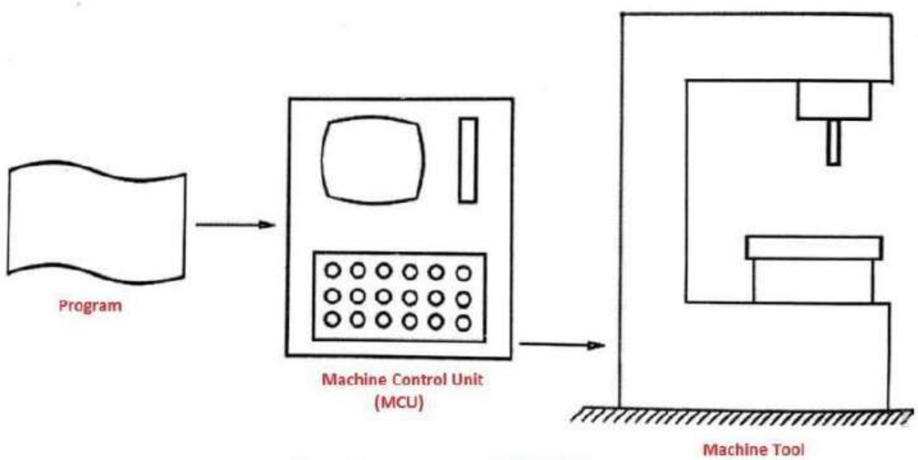
We can also use repeatability and reliability to measure difference and a lack of correlation. If, for instance, we are unable to repeat or reproduce our findings, we have to ask ourselves why, and to investigate further.

CNC

PART PROGRAMMING

Part program is a set of instructions which instruct the machine tool about the processing steps to be performed for the manufacture of a part. The shape and size of the finished component is totally dependent on how well the program has been prepared. CNC code consists of blocks, each of which contains an individual command for a movement or specific action. Just as with conventional machines, one movement is made before the next one. That's why CNC codes are listed sequentially in numbered blocks.

Machining involves an important aspect of relative movement between cutting tool and work piece. In machine tools this is accomplished by either moving the tool with respect to work piece or vice versa. In order to define relative motion of two objects, reference directions are required to be defined. A program defining motion of tool / work piece in this coordinate system is knownas a part program. The part program is a sequence of instructions, which describe the work, which has to be done on a part, in the form required by a computer. NC part programming comprises the collection of all data required to produce the part, the calculation of a tool path along which the machine operations will be performed and the arrangement of those given and calculated data in a standard format that can be read and processed by the MCU.



Basic Components of NC Machines

While making the part program for a component, the programmer first studies the drawing and decide upon the sequence of operations, the cutting tools, the path of cutter/tool, speeds and feeds at various points, other necessary information like starting and stopping of machine etc. The information is entered in a program sheet in a particular format acceptable by the machine tool-control unit combination.

Steps in part programming

The programmer has to do only following things:

A. Define the work part geometry.

B. Specifying the operation sequence.

a. Extraction of dimensional data from part drawings and data regarding surface quality requirements on the machined component.

b. Select the tool and determine the tool offset.

c. Set up the zero position for the work piece.

d. Select the speed and rotation of the spindle.

e. Set up the tool motions according to the profile required.

f. Return the cutting tool to the reference point after completion of work.

g. End the program by stopping the spindle and coolant.

Ways to program for numerical control

1) Manual part programming

2) Computer aided part programming.

3) Part programming using CAD/CAM

Manual Part Programming

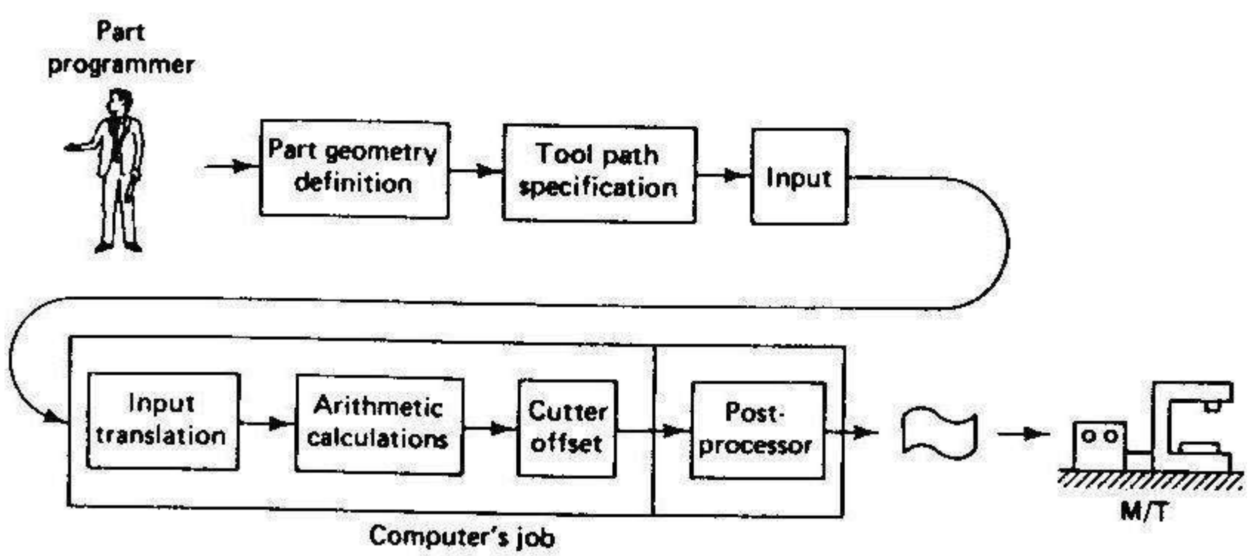
In manual programming, the machining instructions are prepared on a document called a part program manuscript in a standard format. Basically, the manuscripts is a listing of the relative cutting tool/ work piece positions which must be followed in order to machine the work piece. A punched tape is then prepared directly from the part programmer manuscript. After the program is typed, the punched tape is prepared on the flexo-writer. Complex shaped components require tedious calculations.

The part programming contains the list of coordinate values along the X, Y and Z directions of the entire tool path to finish the component. The program should also contain information, such as feed and speed. Each of the necessary instructions for a particular operation given in the part program is known as an NC word. A group of such NC words constitutes a complete NC instruction, known as block. The commonly used words are N, G, F, S, T, and M.

Computer Aided Part Programming

Manual part programming can be time consuming, tedious. and subject to errors for parts possessing complex geometries or requiring many machining operations. In these cases, and even for simpler jobs, it is advantageous to use computer-assisted part programming. In computer-assisted part programming, the machining instructions are written in English like statements that are subsequently translated by the computer into the low-level machine code that can be interpreted and executed by the machine tool controller. If the complex-shaped component requires calculations to produce the component are done by the programming software contained in the computer.

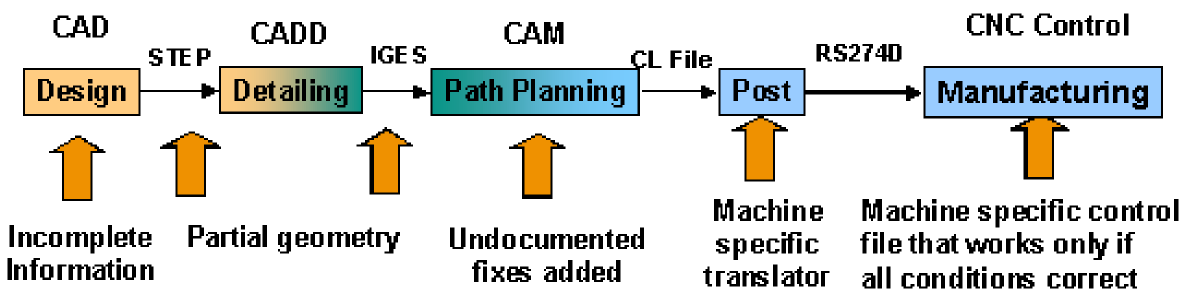
There are various programming languages developed in the recent past, such as APT, ADAPT, AUTOSPOT, COMPAT-II is used for writing a computer programme, which has English like statements. A translator known as compiler program is used to translate it in a form acceptable to MCU.



Steps in computer aided part programming

Part programming using CAD/CAM

With the development of the CAD/CAM system, interactive graphic system is integrated with the NC part programming. Built in tool motion commands can assist the part programmer to calculate the tool paths automatically. It greatly enhances the speed and accuracy in tool path generation.

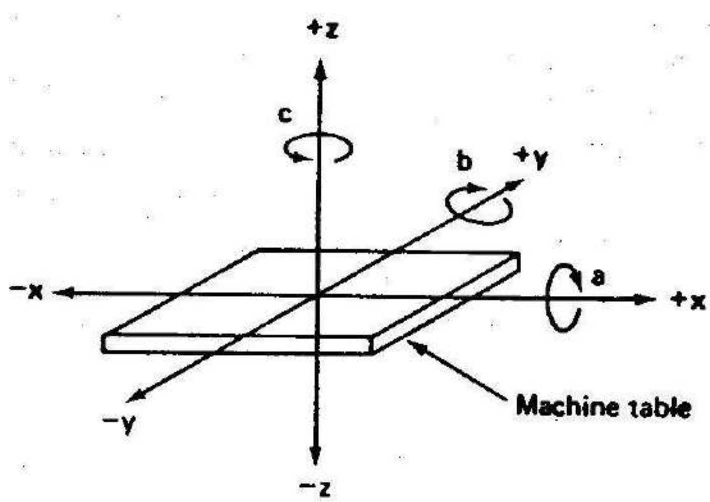


CAD/CAM Part Programming

NC COORDINATE SYSTEM

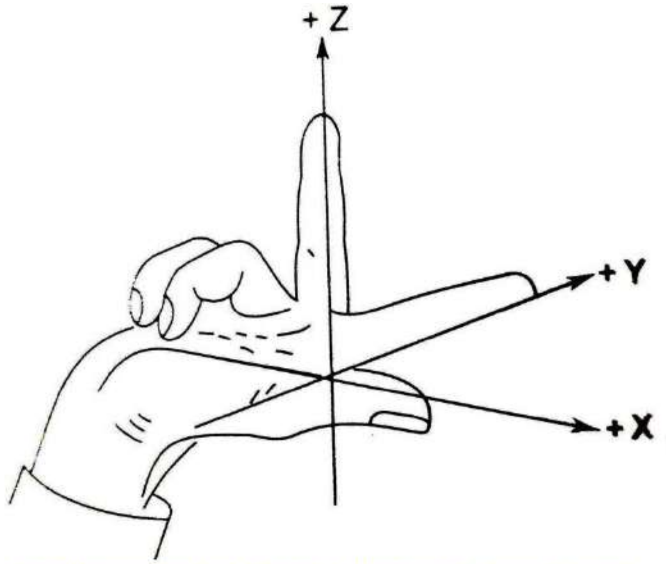
In order for the part programmer to plan the sequence of position and movements of the cutting tool relative to the work piece, it is necessary to establish a standard axis system by which relative position can be specified.

Two axes X and Y are defined in the plane of the table. The Z axis is defined in the plane perpendicular to the table and the movement in the z direction is controlled by the vertical motion of the spindle. The positive and negative directions of motion of the cutting tools are relative to the table along these axes. However, in addition to the three linear axes, these machines may possess the capacity to control one or more rotational axes. Three rotational axes are defined in NC: A, B, and C axes.

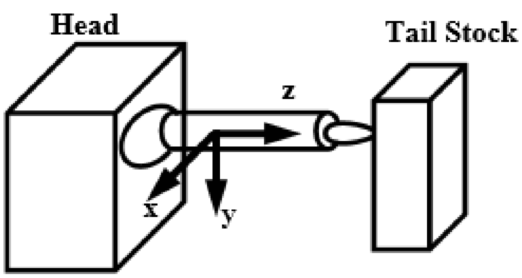


Machine tool coordinate system for NC

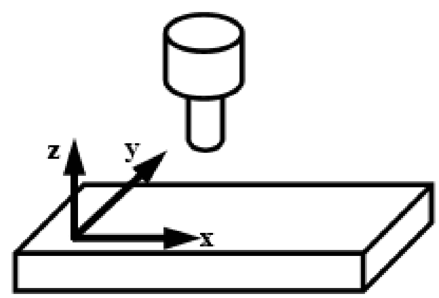
Machining of a work piece by an NC program in the NC lathe centres require a ‘coordinate system’ to be applied to the machine tool. The Z axis is always parallel to the main spindle of themachine. The x axis is at right angle to the Z axis and parallel to the work holding surface.



Axis Designation For Vertical Z Direction (Planer, Shaper and Milling Machine Axis)



Co-ordinate system for turning



Co-ordinate system for drilling and milling

Reference Points

A reference point is a fixed or selected arbitrary location on the machine, on the tool and on the part. A fixed reference point is a precise location along two or more axes, designed during manufacturing or setup. Three reference points are either set by manufacturer or user.

Machine Origin-Machine Zero Point

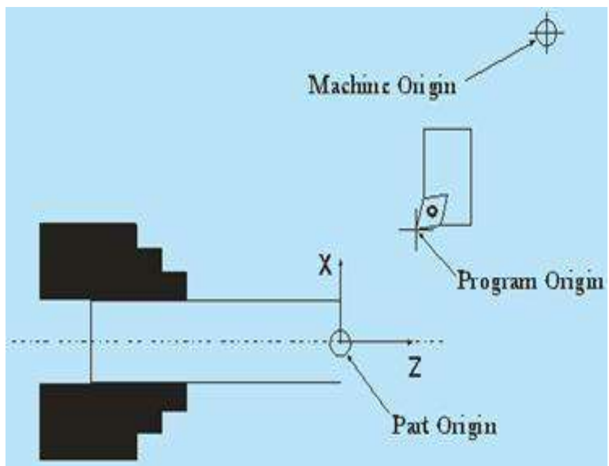
The machine origin is a fixed point set by the machine tool builder. Usually it cannot be changed. Any tool movement is measured from this point. The controller always remembers tool distance from the machine origin.

Program Origin

It is also called home position of the tool. Program origin is point from where the tool starts for its motion while executing a program and returns back at the end of the cycle. This can be any point within the workspace of the tool which is sufficiently away from the part. In case of CNC lathe it is a point where tool change is carried out.

Part Origin- Work piece zero point

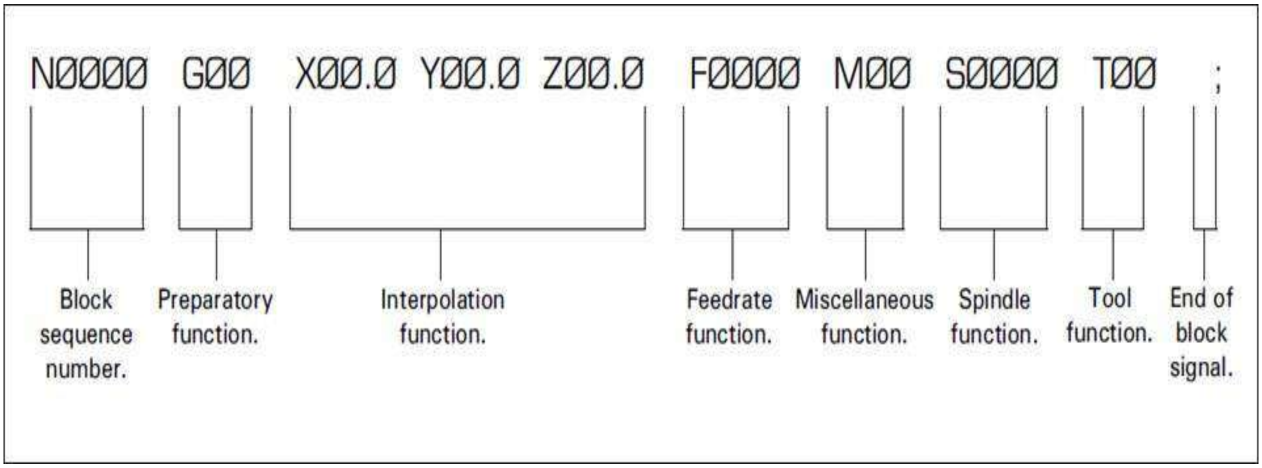
This point determines the work piece co- ordinate system in relation to the CNC system when setting up the machine. Usually part origin needs to be defined for each new setup.



Reference points on a lathe and milling machine

Tape Programming Format

The CNC machine uses a set of rules to enter, edit, receive and output data. These rules are known as CNC Syntax, Programming format, or tape format. The format specifies the order and arrangement of information entered. There are rules for the maximum and minimum numerical values and word lengths and can be entered, and the arrangement of the characters and word is important. The most common CNC format is the word address format and the other two formats are fixed sequential block address format and tab sequential format, which are obsolete. The instruction block consists of one or more words. A word consists of an address followed by numerals. For the address, one of the letters from A to Z is used.



Word Address Format

This type of tape format uses alphabets called address, identifying the function of numerical data followed. This format is used by most of the NC machines, also called variable block format.The MCU uses this alphabet for addressing a memory location in it.

A typical instruction block will be as below:

N20 G00 X1.200 Y.100 F325 S1000 T03 M09 <EOB>

or

N20 G00 X1.200 Y.100 F325 S1000 T03 M09;

Tab Sequential Format

Here the alphabets are replaced by a Tab code, which is inserted between two words. The MCU reads the first Tab and stores the data in the first location then the second word is recognized by reading the record Tab. A typical Tab sequential instruction block will be as below:

>20 >00 >1.200 >.100 >325 >1000 >03 >09

Fixed Block Format

In fixed block format no letter address of Tab code are used and none of words can be omitted. The main advantage of this format is that the whole instruction block can be read at the same instant, instead of reading character by character. This format can only be used for positioning work only. A typical fixed block instruction block will be as below:

20 00 1.200 .100 325 1000 03 09 <EOB>

1. **Sequence Number (N word)**

Sequence Numbers are words that begin with letter “N” followed by numbers. These are normally first word in every block of the program. These are used to identify and sequence each block of information so that it can be distinguished from the rest. Sequencenumber starts with any number and usually incremented in steps of 5 or 10s. Sequence numbers are very useful when it is necessary to edit or make revisions to the program.

2. **Preparatory functions (G word)**

In CNC the preparatory function prepares or initiates different actions to occur on the machine. It is a two-digit number (0 – 99) preceded by the word address letter “G”.

There are four main groups of G codes.

- To select a movement system (rapid movement or at a programmed feed rate)
- To select measurement system (metric or inch system)
- To program for compensation and differences in tool lengths and diameters
- To select a preset sequence of events known as canned cycles or fixed cycles.

3. **Dimensional information words (X, Y, Z)**

The desired work tool position is programmed using the address for the particular axis. The coordinate information may be expressed using X, Y, Z. To specify angular positions around the three coordinate axes used. Also the words I, J, K are used to specify the position of arc centre in case of circular interpolation. With dimensional words it is essential to enter a negative sign if required; if there is no sign the number is assumed tobe positive.

4. **Feed function (F word)**

Feed is the amount that the cutting tool advances into the work. It generally controls the amount and rate of material removal for a particular tool and depends on the type of work piece material to be machined. These are programmed in mm per minute or mm per revolution of the spindle. Appropriate G codes must be used to specify whether the feed isin mm per minute (G94) or mm per revolution (G95). To machine a part in 50mm/min thefeed will be specified as F50.

5. **Spindle speed function (S-word)**

Spindle speed measured in revolutions per minute (RPM), indicates the number of revolutions that the spindle makes in one minute. The letter address S indicates spindle speed and may be followed up to 5 digits. If the machine is required to run at 2000 rpm, then the speed will be specified as S2000.

6. **Tool selection function (T word)**

The T word is needed only for the machines which have programmable tool turret or automatic tool changer, which enables the tool loading and unloading in a very few seconds. Thus the ratio of cutting time to total machine time is considerably increased. Each tool pocket in a turret or automatic tool changer has a distinct tool number. The T word followed by two or three digits specifies which tool must be used for the operation.

For example, T12 means the tool number 12 (i.e. tool located in the position 12 of the magazine) is to be loaded in the spindle for the cutting operation.

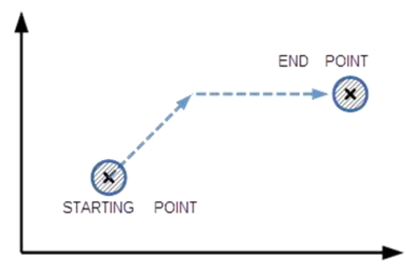
7. Miscellaneous function (M word)

Codes used for initiating machine tool functions like starting and stopping of the spindle, on/off control of coolant flow and optional stop. Some of the miscellaneous functions are modal (M03) and some are non-modal. The modal functions stay effective in successive blocks until replaced by another function code. In addition to these coded functions, spindle speeds, feeds and the required tool numbers to perform machining in a desired sequence are also given.

G- Code
description G00 –
Rapid traverse

The G00 code executes a non-cutting movement, at a rapid feed rate, to a specific co-ordinate position in the working area. G00 command is written in the following format *G00 X_ _ _ _Y_ _ _ _ Z_ _ _ _*

Here X, Y and Z denote the location of the ending position of the tool. The tool moves from starting point to the ending point in maximum possible speed. The path taken by the tool may not be linear, but it will be the quickest.



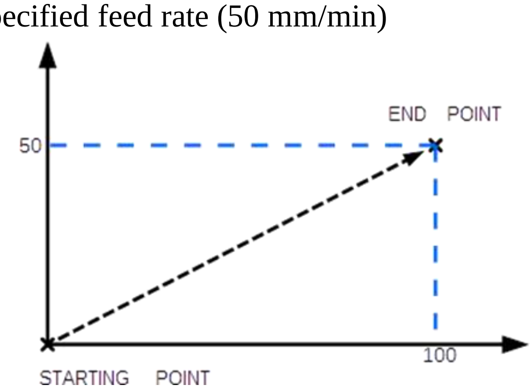
G01 Linear interpolation

The G01 code executes a cutting movement following a straight line, at a set feed rate.G01 command is written in the following format.

G01 X_ _ _ _Y_ _ _ _ Z_ _ _ _

If we give the command, *G01 X100 Y50 F50*

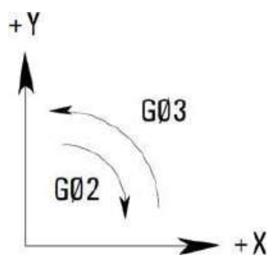
Then, the tool will move from starting point to end point performing cutting motion in astraight line between them at the specified feed rate (50 mm/min)

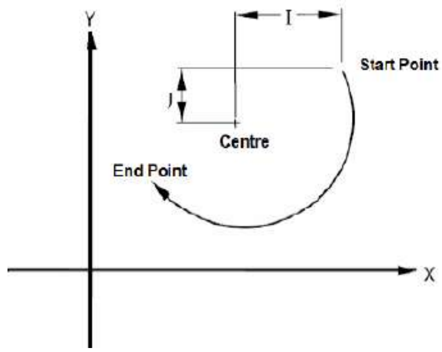


G02 AND G03 Circular interpolation

The G02 code executes a cutting movement following a clockwise circular path, at a set feed rate. The G03 code executes a cutting movement following a counter clockwise circular path, at a set feed rate.

"I" relate to the address X and is the incremental value from the start point of the arc in the X axis to the arc centre. J relates to the address Y and is the incremental value from the start point of the arc in the Y axis to the arc centre.





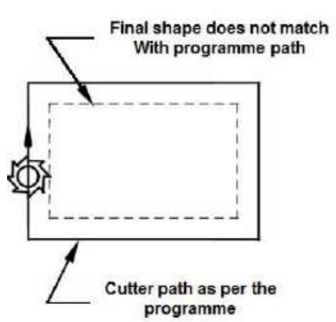
G20 AND G21 – Imperial/metric data input

The machine controller can be programmed in either Imperial (inch) unit input (G20) or Metric (millimeter) unit input (G21). The standard format for a CNC part program is to write the G20 or G21 code in the first block of the program.

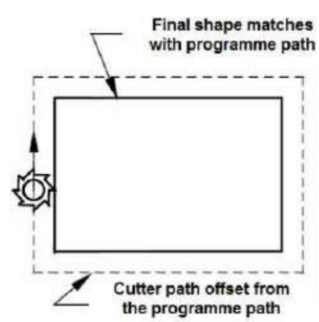
G20	Imperial	Inch
G21	Metric	Millimeter

G40 G41 G42 Cutter compensation

In NC machining, if the cutter axis is moving along the programmed path, the dimension of the work piece obtained will be incorrect since the diameter of the cutter has not be taken in to account. The use of cutter compensation allows the programmer to use the part geometry exactly as from the print for programmed coordinates. Without using compensation, the programmer must always know the cutter size and offset the programmed coordinates for the geometry by the amount of the radius of cutter. In this scenario, if a different size cutter is used the part will not be machined correctly.



Tool Path without Cutter Compensation

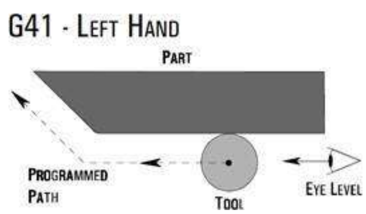


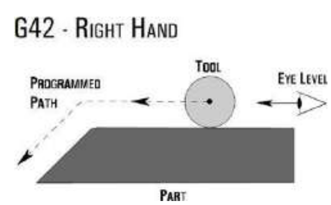
Tool Path with Cutter Compensation

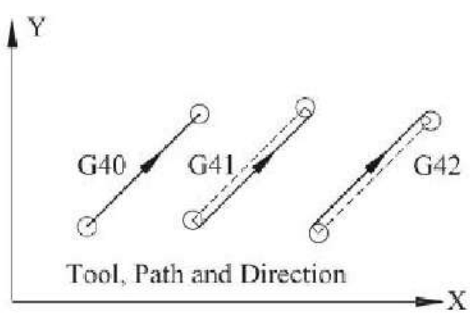
An added advantage for using cutter compensation is the ability to use any size cutter. Also it makes moving the cutter closer to the corner part where the tool offset is different due to radius of tool.

Compensation can be done in advance, by writing G codes that place the cutter closer to the part on diagonal and arc moves by including the G41 and/or G42 codes in the G code program. It allows the machine controller to produce very accurate arcs and tapers by compensating for the tool radius. An added advantage for using cutter compensation is the ability to use any size cutter as long as the offset amount is input accurately into the offset register. The use of cutter compensation allows the programmer to use the part geometry exactly as from the print for programmed coordinates.

G40	Cancel movement along programmed path
G41	Left hand movement on the left hand side of the programmed path
G42	Right hand movement on the right hand side of the programmed path







G40 = Cutter Compensation Cancel

G41 = Cutter Compensation Left

G42 = Cutter Compensation Right

Advantages of cutter compensation

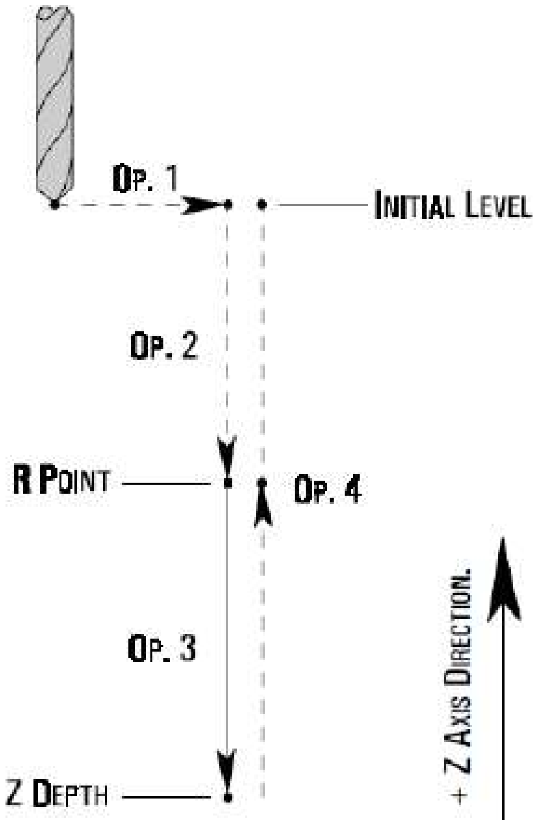
1. The mathematical computations for determining a tool path are greatly simplified.
2. Because the geometry and not the tool center are programmed, the same program can be used for a variety of different cutter diameters.
3. When using cutter compensation, you are then able to control and adjust for part dimensions using your cutter diameter/radius offsets register.
4. The same program path can be used for the roughing passes as well as finishing cuts by using different cutter offset numbers.

G80 G81 CANNED CYCLE – DRILLING

A **canned cycle** is a way of conveniently performing repetitive CNC machine operations. Canned cycles automate certain machining functions such as drilling, boring, threading, pocketing, etc. A canned cycle is used to simplify programming of a part. Once selected, a canned cycle is active until cancelled with the G80 code.

G80: canned cycle stop and G81 for canned drill.

*G98/G99 G81 X…… Y……. Z…….R F ..*_



When the G81 cycle is activated, in a single command, the following operations takes place

Sequence of moves:

- Op1 Rapid position to X, Y and Z (the Initial level)
- Op 2 Rapid traverse to R point level
- Op 3 Feed to Z depth
- Op 4 Rapid traverse to Initial Level (G98) or R point level(G99)

- G98 (default) will cause Z-axis to return to the initial starting point,
- G99 will return Z-axis to the R (reference) plane after a cycle has been executed and positions to a new location to execute another cycle.

M00 - Program Stop

When the machine controller reads the code M00 within a block, it halts the program. The [CYCLE START] key must be pressed to allow the program to continue.

M01 - Optional Stop

The M01 code performs the same function as the M00 code, except the machine controlleronly recognizes the signal to halt the program if the optional [STOP] input key is activated.

M02 - Program Reset

This code indicates the end of a program and performs a general reset function on the machine controller, ie, the CNC reverts to its initial state. The code also acts as an M05.

M03 - Spindle Forward (Clockwise).

The clockwise direction of the spindle is determined by viewing from the back of the machine headstock, along the Z axis towards the tailstock.

M04 - Spindle Reverse (Counter Clockwise)

An M04 code acts in the same way as an M03 code, only the spindle rotates in the opposite direction.

M05* - Spindle Stop.

The M05 code, to stop the spindle rotating, is activated at the end of the block in which it is programmed, ie , after any axis movement.

M06 - Automatic Tool Change

This code activates the machine turret and is followed by the code T______, instructing it to move to the stated tool number.

For example: M06 T0303;

This command change automatically from the current tool number to tool number 3.

M08 - Coolant On

This code switches the coolant pump on.

M09* - Coolant Off

This code switches the coolant pump off.

M98 - Sub Program Call

This code will cause the machine controller to jump across from the main program to reada different program in its memory (called a sub program).

M99 - Sub Program End and Return

On the last line of a sub program, the code M99 is entered. This reverts control back to themain program. If an M99 code is programmed at the end of a main program, a continuous loop will be established. If an M99 code is followed by a block number, P___, control will return to the program line with the same number as stated in P________________________.

G-Codes

G00 - Positioning at rapid speed; Mill and Lathe

G01 - Linear interpolation (machining a straight line); Mill and Lathe

G02 - Circular interpolation clockwise (machining arcs); Mill and Lathe

G03 - Circular interpolation, counter clockwise; Mill and Lathe

G04 - Mill and Lathe, Dwell

G09 - Mill and Lathe, Exact stop

G10 - Setting offsets in the program; Mill and Lathe

G12 - Circular pocket milling, clockwise; Mill

G13 - Circular pocket milling, counter clockwise; Mill

G17 - X-Y plane for arc machining; Mill and Lathe with live tooling

G18 - Z-X plane for arc machining; Mill and Lathe with live tooling

G19 - Z-Y plane for arc machining; Mill and Lathe with live tooling

G20 - Inch units; Mill and Lathe

G21 - Metric units; Mill and Lathe

G27 - Reference return check; Mill and Lathe

G28 - Automatic return through reference point; Mill and Lathe

G29 - Move to location through reference point;

G31 - Skip function; Mill and Lathe

G32 - Thread cutting; Lathe

G33 - Thread cutting; Mill

G40 - Cancel diameter offset; Mill. Cancel tool nose offset; Lathe

G41 - Cutter compensation left; Mill. Tool nose radius compensation left

G42 - Cutter compensation right; Mill. Tool nose radius compensation right

G43 - Tool length compensation; Mill

G44 - Tool length compensation cancel; Mill (sometimes G49)

G50 - Set coordinate system and maximum RPM; Lathe

G52 - Local coordinate system setting; Mill and Lathe

G53 - Machine coordinate system setting; Mill and Lathe

G54~G59 – Work piece coordinate system settings #1 t0 #6; Mill and Lathe

G61 - Exact stop check; Mill and Lathe

G65 - Custom macro call; Mill and Lathe

G70 - Finish cycle; Lathe

G71 - Rough turning cycle; Lathe

G72 - Rough facing cycle; Lathe

G73 - Irregular rough turning cycle; Lathe

G73 - Chip break drilling cycle; Mill

G74 - Left hand tapping; Mill

G74 - Face grooving or chip break drilling; Lathe

G75 - OD groove pecking; Lathe

G76 - Fine boring cycle; Mill

G76 - Threading cycle; Lathe

G80 - Cancel cycles; Mill and Lathe

G81 - Drill cycle; Mill and Lathe

G82 - Drill cycle with dwell; Mill

G83 - Peck drilling cycle; Mill

G84 - Tapping cycle; Mill and Lathe

G85 - Bore in, bore out; Mill and Lathe

G86 - Bore in, rapid out; Mill and Lathe

G87 - Back boring cycle; Mill

G90 - Absolute programming

G91 - Incremental programming

G92 - Reposition origin point; Mill

G92 - Thread cutting cycle; Lathe

G94 - Per minute feed; Mill

G95 - Per revolution feed; Mill

G96 - Constant surface speed control; Lathe

G97 - Constant surface speed cancel

G98 - Per minute feed; Lathe

G99 - Per revolution feed; Lathe

M Codes

M00 - Program stop;

M01 - Optional program stop;M02 -

Program end;

M03 - Spindle on clockwise;

M04 - Spindle on counter-clockwise;

M05 - Spindle off; M06 – Tool

change;M08 - Coolant on; **M09 -**

Coolant off;

M10 - Chuck or rotary table clamp; M11 - Chuck or

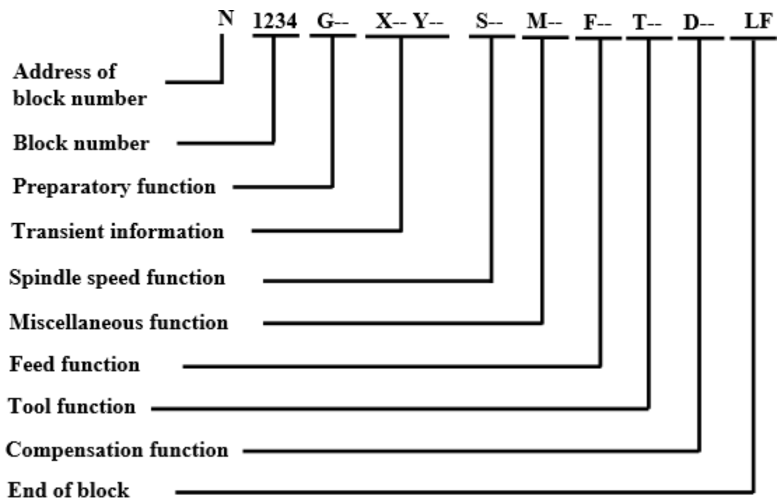
rotary table clamp off;M19 - Orient spindle;

M30 - Program end, return to start;M97 - Local

sub-routine call;

M98 - Sub-program call; M99 - End of

sub program;



Structure of a block in a part program

MEL 333

THERMAL ENGINEERING LAB 1

LAB MANUAL

Mr. Dheeraj P
Assistant Professor
Dept. of ME

Mr. Anil M
Assistant Professor
Dept. of ME

PROGRAM OUTCOMES (PO)	
1	**Engineering Knowledge:** Apply the knowledge of Mathematics, Science, Engineering fundamentals, and Mechanical Engineering to the solution of complex engineering problems.
2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and Engineering sciences.
3	**Design/development of solutions:** Design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4	**Conduct investigations of complex problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex Engineering activities with an understanding of the limitations.
6	**The Engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional Engineering practice.
7	**Environment and sustainability:** Understand the impact of the professional Engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable developments.
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice.
9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	**Communication:** Communicate effectively on complex Engineering activities with the Engineering Community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	**Project management and finance:** Demonstrate knowledge and understanding of the Engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multi-disciplinary environments.
12	**Life -long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life

PROGRAM SPECIFIC OUTCOMES	
1	To empower the students to apply practical skills, knowledge in major streams such as thermal, design, manufacturing and industrial engineering.
2	To enable the student to take-up career in industries or to pursue higher studies in mechanical and interdisciplinary programs with high regard for ethical values, environmental and social issues.

CODE	COURSE NAME:	CATEGORY	L	T	P	CREDIT
MEL333	THERMAL ENGINEERING LAB 1	PCC	0	0	3	2

Preamble: The course is intended to impart basic understanding on the working of internal combustion engines. This includes various performance tests on internal combustion engines as well as makes the students familiar with the evaluation of fuel properties such as viscosity, flash and fire points, calorific value etc. which are key to any performance test.

Prerequisite: Should have undergone a course on Thermal Engineering with emphasis on IC engines

Course Outcomes: After completion of the course the student will be able to

CO 1	**Measure thermo-physical properties of solid, liquid and gaseous fuels**
CO 2	**Identify various systems and subsystems of Diesel and petrol engines**
CO 3	**Analyse the performance characteristics of internal combustion engines**
CO 4	**Investigate the emission characteristics of exhaust gases from IC Engines**
CO 5	**Interpret the performance characteristics of air compressors / blowers**

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3		2	3			2		3	2		2
CO 2	3		2	3			2		3	2		2
CO 3	3		2	3			2		3	2		2
CO 4	3		2	3			2		3	2		2
CO 5	3		2	3			2		3	2		2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks
(d) Viva voce : 20 marks
(e) Record : 5 Marks

General instructions:

Practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

List of Exercises/Experiments: (Lab experiments may be given considering 12 sessions of 3 hours each. Minimum 12 experiments to be performed.)

1. Determination of flash and fire points of petroleum fuels and oils
2. Determination of viscosity of lubricating oils and fuels and its variation with temperature
3. Determination of calorific value of solid and liquid fuels- Bomb Calorimeter
4. Determination of calorific value of gaseous fuels –Gas Calorimeter
5. Familiarisation of various systems and subsystems of petrol engine / MPFI engine
6. Familiarisation of various systems and parts of Diesel engine / Turbocharged engine
7. Performance test on petrol engines / MPFI engine
8. Performance test on Diesel engines / Turbocharged engine
9. Heat Balance test on petrol/Diesel engines
10. Determination volumetric efficiency and Air-fuel ratio of IC engines
11. Cooling curve of IC engines
12. Valve timing diagram of IC engines
13. Economic speed test on IC engines
14. Retardation test on IC engines
15. Morse test on petrol engine
16. Experiment to find flame temperature of premixed flames at different equivalence ratios and temperature of diffusion flames at different fuel flow rates.
17. Analysis of automobile exhaust gas and flue gas using exhaust gas analyser.
18. .Performance test on reciprocating compressor
19. Performance test on rotary compressor/blower

Reference Books

1. J.B.Heywood, I.C engine fundamentals, McGraw-Hill, 2017
2. V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2017
3. Stephen R Turns, An Introduction to Combustion: Concepts and Applications, McGraw-Hill, 2017

Study No.: Date:

SYSTEMS OF COMPRESSION IGNITION ENGINE

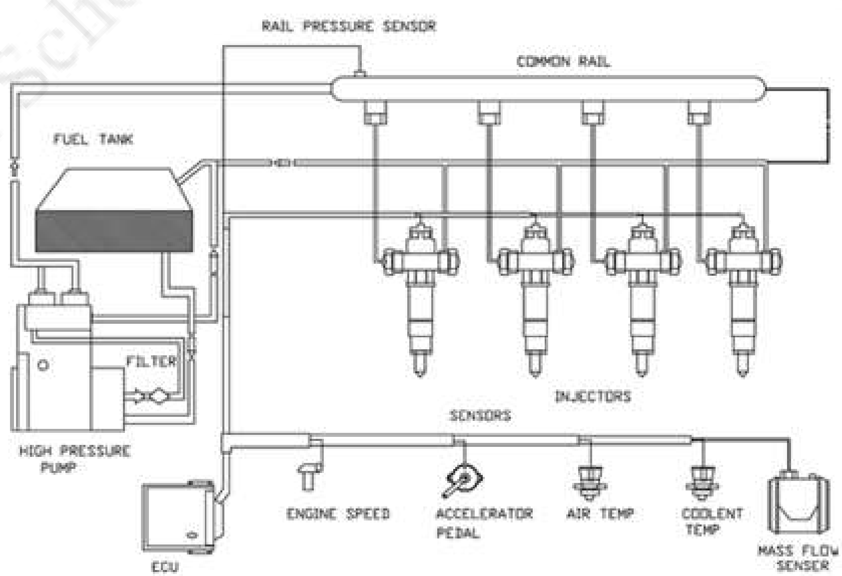
I. FUEL SUPPLY SYSTEM

Fuel supply system of diesel engine consists of the following components

i. Fuel tank
ii. Fuel lift pump or fuel feed pump
iii. Fuel filter
iv. Fuel injection pump
v. High pressure pipe
vi. Over flow valve
vii. Fuel injector

Fuel is drawn from fuel tank by fuel feed pump and forced to injection pump through fuel filter. The injection pump supplies high pressure fuel to injection nozzles through delivery valves and high pressure pipes. Fuel is injected into the combustion chamber through injection nozzles. The fuel that leaks out from the injection nozzles passes out through leakage pipe and returns to the fuel tank through the over flow pipe.

Over flow valve installed at the top of the filter keeps the feed pressure under specified limit. If the feed pressure exceeds the specified limit, the over flow valve opens and then the excess fuel returns to fuel tank through over flow pipe.



i. **Fuel tank**

It is a storage tank for diesel. A wire gauge strainer is provided under the cap to prevent foreign particles entering the tank

ii. **Fuel lift pump**

It transfers fuel from fuel tank to inlet gallery of fuel injection pump

iii. **Preliminary filter (sediment bowl assembly)**

This filter is mostly fitted on fuel lift pump. It prevents foreign materials from reaching inside the fuel line. It consists of a glass cap with a gasket.

iv. **Fuel filter**

Mostly two stage filters are used in diesel engines

a. Primary filter b. Secondary filter

Primary filter removes coarse materials, water and dust. Secondary filter removes fine dust particles.

v. **Fuel injection pump**

It is a high pressure pump which supplies fuel to the injectors according to the firing order of the engine. It is used to create pressure varying from 120 kg/cm^2 to 300 kg/cm^2. It supplies the required quantity of fuel to each cylinder at appropriate time.

vi. **Air venting of fuel system**

When air has entered the fuel lines or suction chamber of the injection pump, venting should be done properly. Air is removed by the priming pump through the bleeding holes of the injection pump.

vii. **Fuel injector**

It is the component which delivers finely atomized fuel under high pressure to combustion chamber of the engine. Modern tractor engines use fuel injectors which have multiple holes. Main parts of injectors are nozzle body, and needle valve. The needle valve is pressed against a conical seat in the nozzle body by a spring. The injection pressure is adjusted by adjusting a screw. In operation, fuel from injection pump enters the nozzle body through high pressure pipe. When fuel pressure becomes so high that it exceeds the set spring pressure, the needle valve lifts off its seat. The fuel is forced out of the nozzle spray holes into the combustion chamber.

II. LUBRICATION SYSTEM

IC engine is made of moving parts. Duo to continuous movement of two metallic surfaces over each other, there is wearing of moving parts, generation of heat and loss of power in engine. Lubrication of moving parts is essential to prevent all these harmful effects. Lubrication systems of both SI and CI engines are same.

III. IGNITION SYSTEM

Fuel mixture of CI engine must be ignited in the engine cylinder at proper time for useful work. Arrangement of different components for providing ignition at proper time in the engine cylinder is called Ignition system

Types of ignition systems used in CI engines are

i. Ignition by heat of compression or compression ignition
ii. Ignition by hot tube or hot bulb

IV. COOLING SYSTEM

Fuel is burnt inside the cylinder of an internal combustion engine to produce power. The temperature produced on the power stroke of an engine can be as high as 1600 ºC and this is greater than melting point of engine parts.. The best operating temperature of IC engines lie between 140 F and 200 ºF and hence cooling of an IC engine is highly essential. . It is estimated that about 40% of total heat produced is passed to atmosphere via exhaust, 30% is removed by cooling and about 30% is used to produce power.

Purpose of cooling

- ✓ To maintain optimum temperature of engine for efficient operation under all conditions.
- ✓ To dissipate surplus heat for protection of engine components like cylinder, cylinder head, piston, piston rings, and valves
- ✓ To maintain the lubricating property of oil inside engine

Methods of cooling

A. Air cooled system
B. Water cooled system

A. AIR COOLING SYSTEM

Air cooled engines are those engines in which heat is conducted from the working components of the engine to the atmosphere directly.

Principle of air cooling- The cylinder of an air cooled engine has fins to increase the area of contact of air for speedy cooling. The cylinder is normally enclosed in a sheet metal casing called cowling. The fly wheel has blades projecting from its face, so that it acts like a fan drawing air through a hole in the cowling and directed it around the finned cylinder. For maintenance of air cooled system, passage of air is kept clean by removing grasses etc. by a stiff brush of compressed air

Advantages of air cooled engine

- ✓ It is simple in design and construction
- ✓ Water jackets, radiators, water pump, thermostat, pipes, hoses are not required

- ✓ It is more compact
- ✓ Lighter in weight

Disadvantages

- ✓ There is uneven cooling of engine parts
- ✓ Engine temperature is generally high during working period

B. WATER COOLING SYSTEM

Engines using water as cooling medium are called water cooled engines. Water is circulated round the cylinders to absorb heat from the cylinder walls. The heated water is conducted through a radiator to remove the heat and cool the water.

Methods of water cooling

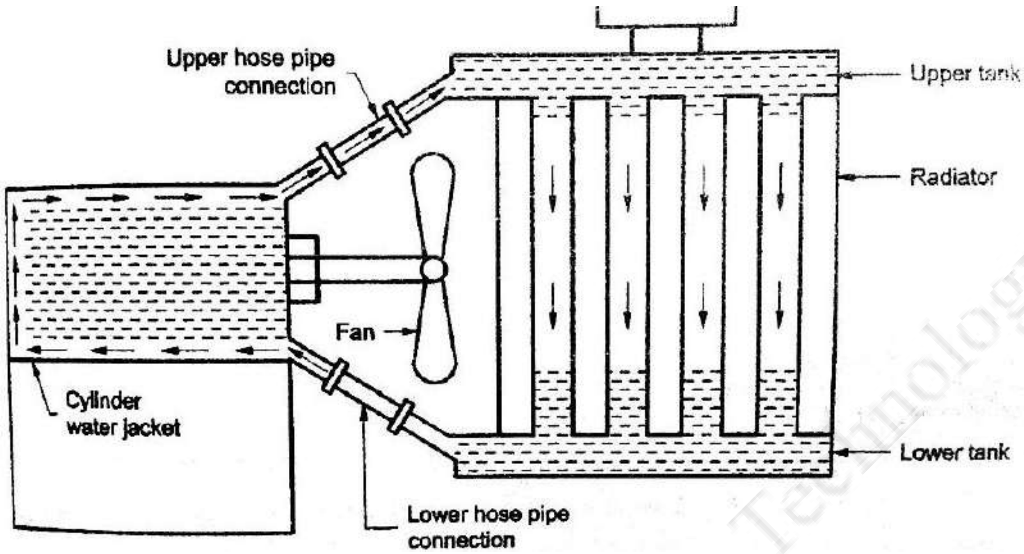
i. Open jacket or hopper method
ii. Thermo siphon method
iii. Forced circulation method

i. Open jacket method

There is a hopper or jacket containing water which surrounds the engine cylinder. So long as the hopper contains water the engine continues to operate satisfactorily. As soon as the water starts boiling it is replaced by cold water. The hopper is large enough to run for several hours without refilling. A drain plug is provided in a low accessible position for draining water as and when required.

ii. Thermo siphon method

It consists of a radiator, water jacket, fan, temperature gauge and hose connections. The system is based on the principle that heated water which surrounds the cylinder becomes lighter and it rises upwards in liquid column. Hot water goes to the radiator where it passes through tubes surrounded by air. Circulation of water takes place due to the reason that water jacket and radiator are connected at both sides i.e. at top and bottom. A fan is driven with the help of a V belt to suck air through tubes of the radiator unit, cooling radiator water. The disadvantage of the system is that circulation of water is greatly reduced by accumulation of scale or foreign matter in the passage and consequently causing over heating of the engine.



iii. Forced Circulation system

In this method, a water pump is used to force water from radiator to the water jacket of the engine. After circulating the entire run of water jacket, water comes back to the radiator where it loses its heat by the process of radiation. To maintain the correct engine temperature, a thermostat valve is placed at the outer end of cylinder head. Cooling liquid is by-passed through the water jacket of th3e engine until the engine attains the desired temperature. The thermostat valve opens and the by-pass is closed, allowing the water to go to the radiator. The system consists of the following components

1. Water pump	2. Radiator
3. Fan	4. Fan-belt
5. Water jacket	6. Thermostat valve
7. Temperature gauge	8. Hose pipe

Water pump

It is a centrifugal pump. It draws the cooled water from bottom of the radiator and delivers it to the water jackets surrounding the engine..

Thermostat valve

It is a control valve used in cooling system to control the flow of water when activated by a temperature signal**.**

Fan

The fan is mounted on the water pump shaft. It is driven by the same belt that drives the pump and dynamo. The purpose of radiator is to provide strong draft of air through the radiator to improve engine cooling

Water jacket - Water jackets are passages cored out around the engine cylinder as well as around the valve opening

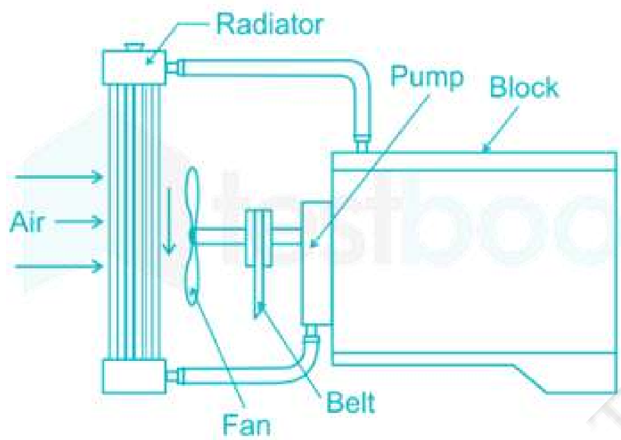


Fig: Forced Circulation cooling system- Water cooled engine

V. GOVERNOR

Governor is mechanical device, designed to control the speed of the engine with in specified limit, used on tractor or stationary engine for

1. Maintaining a nearly constant speed of engine under different load conditions
2. Protecting the engine and attached equipments against high speeds, when the load is removed or reduced

Types of governors

1. Centrifugal governor
2. Pneumatic governor
3. Hydraulic governor

Governor regulation

The governor is fitted on an engine for maintaining a constant speed, even then some variation in speed is observed at full load and no load conditions. In normal working, a variation of about 100 rev/min is observed between full load and no load conditions for a good governor. Hence it is possible to regulate the governor to maintain a higher or lower speed by changing the tension of the spring. The extent of regulation done is expressed in terms of percentage called percentage regulation. This is also called speed drop. It is the variation in the engine speed between full load and no load condition. It is usually expressed as percentage of rated speed. This is given by

$$R = \frac{N_1 - N_2}{(N_1 + N_{2)}/2} X \ 100$$

Where,

R – % regulation,

N_1 – Speed at no load, rpm

N_2 – Speed at full load, rpm

Problem- Find the percentage regulation in a governor if speed at no load is 1600 rev/min and at full load is 1500 rev/min

Governor hunting

Governor hunting is the erratic variation of the speed of the governor when it over compensates for speed changes. When the governor produces a periodic effect on the engine speed like too fast and then too slow, then too fast and so on it is a sign of governor hunting. In such cases it is observed that when the engine speeds up quickly, the governor suddenly responds, the speed drops quickly, the governor again responds and this process is repeated. The reason for governor hunting may be due to incorrect adjustment of fuel pump or carburetor, improper adjustment of the idling screw and excessive friction. Hunting may be due to governor being too stiff or due to some obstruction in free movement of governor components.

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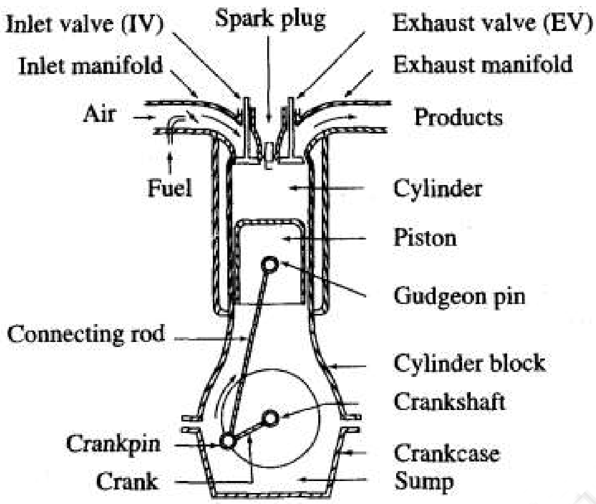
1. ENGINE COMPONENTS

A cross section of a single cylinder engine with overhead valves is shown in Fig. The major components of the engine and their functions are briefly described below.



i. Cylinder block

The cylinder block is the main supporting structure for the various components. The cylinder of a multi cylinder engine is cast as a single unit, called cylinder block. The cylinder head is mounted on the cylinder block. The cylinder head and cylinder block are provided with water jackets in the case of water cooling or with cooling fins in the case of air cooling.

ii. Cylinder

As the name implies it is a cylindrical vessel or space in which the piston makes a reciprocating motion. The varying volume created in the cylinder during the operation of the engine is filled with the working fluid and subjected to different thermo dynamic processes. The cylinder is supported in the cylinder block.

iii. Piston

It is a cylindrical component fitted into the cylinder forming the moving boundary of the combustion system. It fits perfectly (snugly) into the cylinder providing a gas-tight space with the piston rings and the lubricant. It forms the first link in transmitting the gas forces to the output shaft.

iv. Combustion chamber

The space enclosed in the upper part of the cylinder, by the cylinder head and the piston top during the combustion process, is called the combustion chamber. The combustion of fuel and the consequent release of thermal energy results in the building up of pressure in this part of the cylinder.

v. Inlet manifold

The pipe which connects the intake system to the inlet valve of the engine and through which air or air-fuel mixture is drawn into the cylinder is called the inlet manifold.

vi. Exhaust manifold

The pipe which connects the exhaust system to the exhaust valve of the engine and through which the products of combustion escape into the atmosphere is called the exhaust manifold.

vii. Inlet and Exhaust valves

Valves are commonly mushroom shaped pop-pet type. They are provided either on the cylinder head or on the side of the cylinder for regulating the charge coming into the cylinder (inlet valve) and for discharging the products of combustion (exhaust valve) from the cylinder.

viii. Spark Plug

It is a component to initiate the combustion process in Spark- Ignition (SI) engines and is usually located on the cylinder head.

ix. Connecting Rod

It interconnects the piston and the crankshaft and transmits the gas forces from the piston to the crankshaft. The two ends of the connecting rod are called as small end and the big end (Fig.1.3). Small end is connected to the piston by gudgeon pin and the big end is connected to the crankshaft by crankpin.

x. Crankshaft

It converts the reciprocating motion of the piston into useful rotary motion of the output shaft. In the crankshaft of a single cylinder engine there are a pair of crank arms and balance weights. The balance weights are provided for static and dynamic balancing of the rotating system. The crankshaft is enclosed in a crankcase.

xi. Piston rings

Piston rings, fitted into the slots around the piston, provide a tight seal between the piston and the cylinder wall thus preventing leakage of combustion gases.

xii. Camshaft

The camshaft (not shown in the figure) and its associated parts control the opening and closing of the two valves. The associated parts are push rods, rocker arms, valve springs and tappets. This shaft also provides the drive to the ignition system. The camshaft is driven by the crankshaft through timing gears.

xiii. Gudgeon pin

It links the small end of the connecting rod and the piston.

xiv. Cams

These are made as integral parts of the camshaft and are so de-signed to open the valves at the correct timing and to keep them open for the necessary duration.

xv. Flywheel

The net torque imparted to the crankshaft during one complete cycle of operation of the engine fluctuates causing a change in the angular velocity of the shaft. In order to achieve a uniform torque an inertia mass in the form of a wheel is attached to the output shaft and this wheel is called the flywheel.

xvi. Carburetor

Carburetor is used in petrol engine for proper mixing of air and petrol.

xvii. Fuel pump

Fuel pump is used in diesel engine for increasing pressure and controlling the quantity of fuel supplied to the injector.

xviii. Fuel injector

Fuel injector is used to inject diesel fuel in the form of fine atomized spray under pressure at the end of compression stroke.

2. FUEL & CALORIFIC VALUE

Different systems available for efficient functioning of an engine are as follows

- **Fuel**

Fuel is a substance consumed by the engine to produce power. The common fuel for Internal Combustion engines are

i. Petrol

ii. Power kerosene

iii. High speed diesel etc.

- **Calorific value of fuel**

The heat liberated by combustion of a fuel is known as calorific value or heat value of the fuel. It is expressed in kcal/kg of the fuel

Sl. No	Name of fuel	Calorific value, kJ/kg
1	Coal	15,000 - 27,000
2	Coke	28,000 - 31,000
3	Diesel	45,350
4	Hydrogen	141,790
5	Petrol	48,000

3. SYSTEMS OF SPARK IGNITION ENGINE

I. FUEL SUPPLY SYSTEM

a. Carburetor system

The fuel supply system of spark ignition engine consists of

i. Fuel tank

ii. Sediment bowl

iii. Fuel lift pump

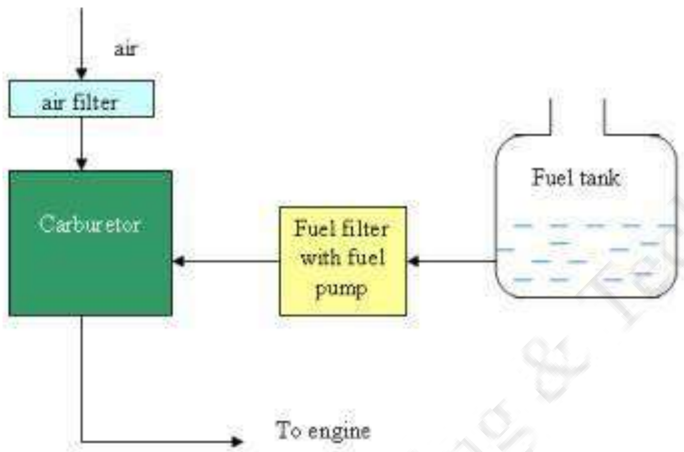
iv. Carburetor

v. Fuel pipes

In some spark ignition engines the fuel tank is placed above the level of the carburetor. The fuel flows from fuel tank to the carburetor under the action of gravity.

There are one or two filters between fuel tank and carburetor. A transparent sediment bowl is also provided to hold the dust and dirt of the fuel. If the tank is below the level of carburetor, a lift pump is provided in between the tank and the carburetor for forcing fuel from tank to the carburetor of the engine.

The fuel comes from fuel tank to sediment bowl and then to the lift pump. From there the fuel goes to the carburetor through suitable pipes. From carburetor the fuel goes to the engine cylinder through inlet manifold of the engine.



❖ **Carburetor**

The process of preparing air-fuel mixture away from the engine cylinder is called carburetion and the device in which this process takes is called carburetor.

- **Functions of carburetor**

✓ To mix the air and fuel thoroughly

✓ To atomize the fuel

✓ To regulate the air- fuel ratio at different speeds and loads on the engine.

✓ to supply correct amount of mixture at different speeds and loads

b. Multi point and single point fuel injection systems

Fuel injection is a system for admitting fuel into an internal combustion engine. It has become the primary fuel delivery system used in automotive engines, having replaced carburetors during the 1980s and 1990s. A variety of injection systems have existed since the earliest usage of the internal combustion engine. The primary difference between carburetors and fuel injection is that fuel injection atomizes the fuel by forcibly pumping it through a small nozzle under high pressure, while a carburetor relies on suction created by intake air accelerated through a Venturi-tube to draw the fuel into the airstream.

Modern fuel injection systems are designed specifically for the type of fuel being used. Some systems are designed for multiple grades of fuel (using sensors to adapt the tuning for the fuel currently used). Most fuel injection systems are for gasoline or diesel applications. Different methods of fuel injection in a 4 stroke and 2 stroke engines are as shown in fig. (a), (b) & (c). In the manifold injection and port injection arrangements, the injector is moved farther from the combustion chamber. This provides a longer period for mixing and warming the charge.

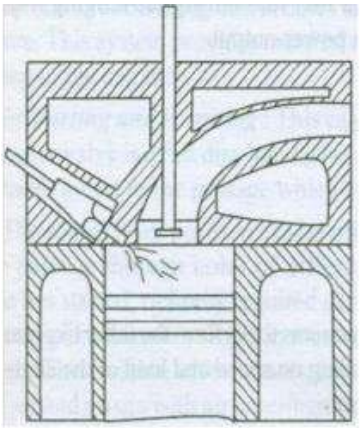


Fig. (a) Direct injection system

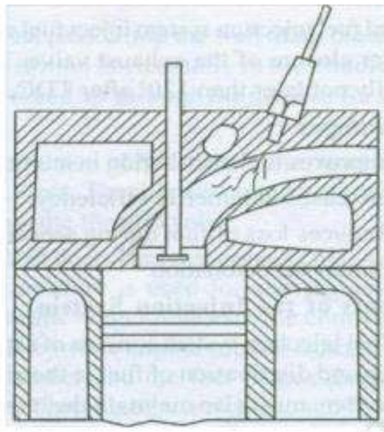


Fig. (b) Port injection system

The manifold injection system may be of two types. Single point and multipoint injection. In the first type one or two injectors are mounted inside the throttle body assembly. Fuel is sprayed at one point or location at the center inlet of the engine intake manifold. Hence this method is also called throttle body injection. The later type has one injector for each engine cylinder and fuel is sprayed in more than one location. Port injection employs individual injectors delivering locally to each port.

In SI engine continuous injection, or timed injection system is used. The later type consists of a fuel supply pump to supply fuel at low pressure (2 bar). A fuel metering or injection pump and nozzle are present. The nozzle injects the fuel in the manifold or cylinder head port. In some design, the fuel is injected directly into the combustion chamber.

Timed fuel injection system injects fuel usually during the first half of the suction stroke. Injection begins after closure of the exhaust valve. This eliminates fuel loss during scavenging. Injection ends usually not later than 120^0 after TDC, for maximum power output.

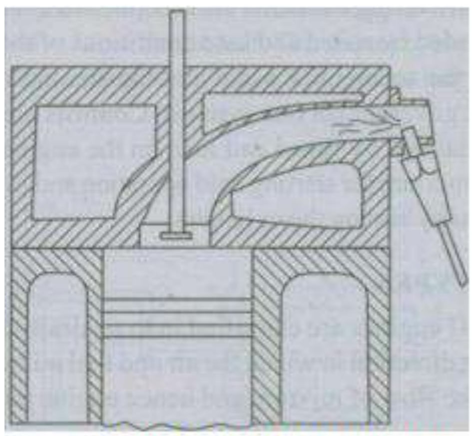


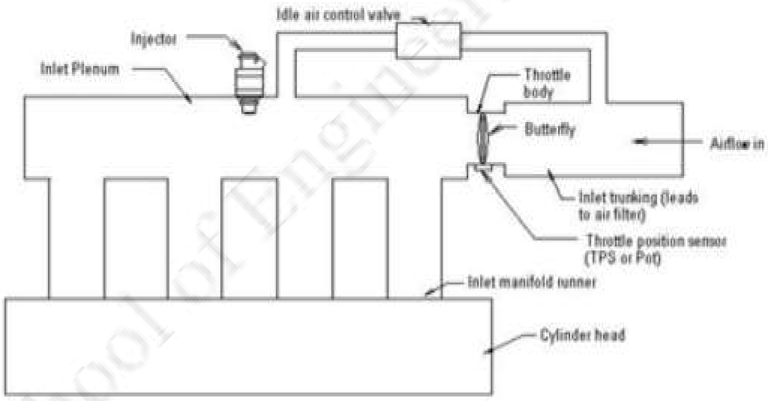
Fig. (c) Throttle body injection

❖ **Components of the Injection System:**

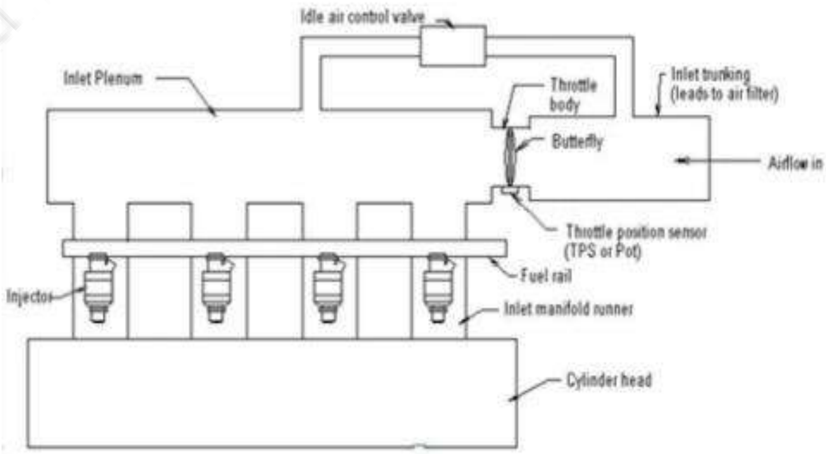
The fuel injection system consists of a number of components to perform the tasks like metering, atomization and distribution of fuel in the air mass. Depending on speed and load of the engine, the injection system must also maintain the required air fuel ratio. Pumping elements includes necessary piping, filter etc., and are used to move the fuel from fuel tank to the cylinders. Metering elements checks (measures) the correct quantity of fuel and delivers it at the rate demanded by speed and load conditions of the engine. The metering units are controlled by a linkage to the accelerator pedal and the amount of fuel supplied by the pump is controlled by a centrifugal governor (in one system). Controls are provided to adjust the mixture strength (A/F ratio) as demanded by speed and load on the engine. Different controls are used to increase the richness of the mixture for starting cold operation and high speeds. Distributing elements divide the metered fuel equally among the cylinders.

- **Single-point or throttle body injection (TBI)**

The earliest and simplest type of fuel injection, single-point simply replaces the carburetor with one or two fuel-injector nozzles in the throttle body, which is the throat of the engine's air intake manifold. For some automakers, single-point injection was a stepping stone to the more complex multi-point system. Though not as precise as the systems that have followed, TBI meters fuel better than a carburetor and is less expensive and easier to service.



- **Port or multi-point fuel injection (MPFI):**



Multi-point fuel injection devotes a separate injector nozzle to each cylinder, right outside its intake port, which is why the system is sometimes called port injection. Shooting the fuel vapor this close to the intake port almost ensures that it will be drawn completely into the cylinder. The main advantage is that MPFI meters fuel more precisely than do TBI designs, better achieving the desired air/fuel ratio and improving all related aspects

Also, it virtually eliminates the possibility that fuel will condense or collect in the intake manifold. With TBI and carburetors, the intake manifold must be designed to conduct the engine's heat, a measure to vaporize liquid fuel. This is unnecessary on engines equipped with MPFI, so the intake manifold can be formed from lighter-weight material, even plastic. Incremental fuel economy improvements result. Also, where conventional metal intake manifolds must be located atop the engine to conduct heat, those used in MPFI can be placed more creatively, granting engineers design flexibility

II. LUBRICATION SYSTEM

IC engine is made of moving parts. Duo to continuous movement of two metallic surfaces over each other, there is wearing of moving parts, generation of heat and loss of power in engine. Lubrication of moving parts is essential to prevent all these harmful effects.

❖ **Purpose of lubrication**

- ✓ Reducing frictional effect
- ✓ Cooling effect
- ✓ Sealing effect
- ✓ Cleaning effect Types of lubricants

Lubricants are obtained from animal fat, vegetables and minerals. Vegetable lubricants are obtained from seeds, fruits and plants. Cotton seed oil, olive oil, linseed oil, caster oil are used as lubricants. Mineral lubricants are most popular for engines and machines. It is obtained from crude petroleum found in nature.. Petroleum lubricants are less expensive and suitable for internal combustion engines

❖ **Engine lubrication system**

The lubricating system of an engine is an arrangement of mechanisms which maintains the supply of lubricating oil to the rubbing surfaces of an engine at correct pressure and temperature.
The parts which require lubrication are

i. Cylinder walls and piston
ii. Piston pin
iii. crankshaft and connecting rod bearings
iv. Camshaft bearings
v. Valve operating mechanism
vi. Cooling fan
vii. Water pump and

viii. Ignition mechanism

❖ **Types of lubricating systems**

various lubrication system used for IC engines are,

(a) Mist lubrication system

(b) Wet sump lubrication system

(c) Dry sump lubrication system

(a) Mist lubrication system:

- Used where crankcase lubrication is not suitable
- Generally adopted in two stroke petrol engine line scooter and motor cycle. It is the simplest form of lubricating system.
- It is the simplest form of lubricating system. It does not consist of any separate part like oil pump for the purpose of lubrication.
- In this system the lubricating oil is mixed into the fuel (petrol) while filling in the petrol tank of the vehicle in a specified ratio (ratio of fuel and lubricating oil is from 12:1 to 50:10 as per manufacturers specifications or recommendations.
- When the fuel goes into the crank chamber during the engine operation, the oil particles go deep into the bearing surfaces due to gravity and lubricate then. The piston rings, cylinder walls, piston pin etc. are lubricated in the same way.
- If the engine is allowed to remain unused for a considerable time, the lubricating oil separates oil from petrol & leads to clogging (blocking) of passages in the carburettor, results in the engine starting trouble. This is the main disadvantage of this system.
- It causes heavy exhaust smoke due to burning of lubricating oil partially or fully
- Increase deposits on piston crown and exhaust ports which affect engine efficiency
- Corrosion of bearing surfaces due to acids formation
- thorough mixing can fetch effective lubrication
- Engine suffers insufficient lubrication during closed throttle i.e. vehicle moving down the hill.

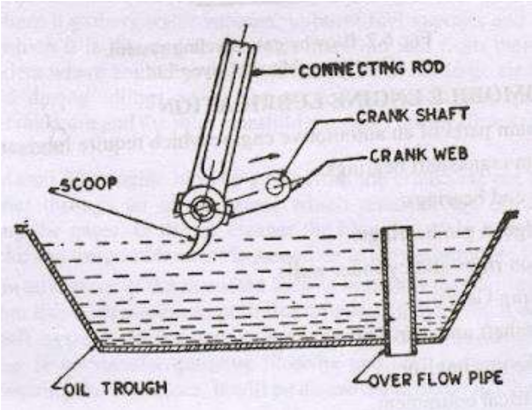
(b) Wet sump lubrication system:

Bottom of the crankcase contains oil pan or sump from which the lubricating oil is pumped to various engine components by a pump. After lubrication, oil flows back to the sump by gravity. Three types of wet sump lubrication system,
(i) Splash system
(ii) Splash and pressure system
(iii) Pressure feed system

(i) Splash system:

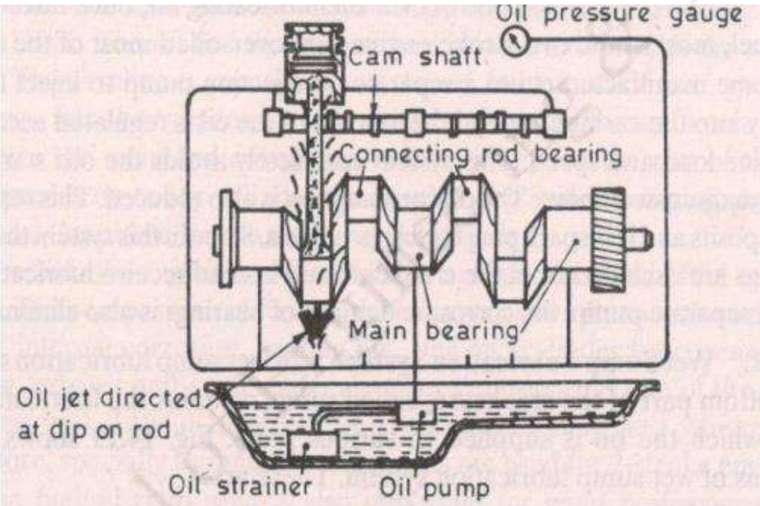
-In this system of lubrication the lubricating oil is stored in an oil sump. A scoop or dipper is made in the lower part of the connecting rod. When the engine runs, the dipper dips in the oil once in every revolution of the crank shaft, the oil is splashed on the cylinder wall. Due to this action engine walls, piston ring, crank shaft bearings are lubricated.

-It is used for light duty engine

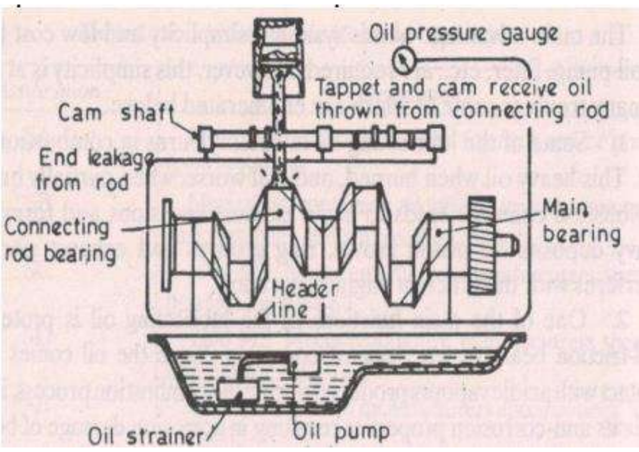


(ii) Splash and pressure system:

Lubricating oil is supplied under pressure to main, camshaft bearings and pipes which direct a stream of oil against the dippers on the big end of connecting rod bearing cup and thus crankpin bearings are lubricated by the splash or spray of oil thrown up by the dipper.



(iii) Pressure feed system:



In this system of lubrication, the engine parts are lubricated under pressure feed. The lubricating oil is stored in a separate tank (in case of dry sump system) or in the sump (in case of wet sump system), from where an oil pump (gear pump) delivers the oil to the main oil gallery at a pressure of 2-4 kg/cm2 through an oil filter. The oil from the main gallery goes to main bearing, from where some of it falls back to the sump after lubricating the main bearing and some is splashed to lubricate the cylinder walls and remaining goes through a hole to the crank pin.

From the crank pin the lubricating oil goes to the piston pin through a hole in the connecting rod, where it lubricates the piston rings. For lubricating cam shaft and gears the oil is led through a separate oil line from the oil gallery. The oil pressure gauge used in the system indicates the oil pressure in the system. Oil filter & strainer in the system clear off the oil from dust, metal particles and other harmful particles

III. IGNITION SYSTEM

Fuel mixture of IC engine must be ignited in the engine cylinder at proper time for useful work. Arrangement of different components for providing ignition at proper time in the engine cylinder is called Ignition system

Types of ignition systems

i. Ignition by electric spark or spark ignition
ii. Ignition by heat of compression or compression ignition
iii. Ignition by hot tube or hot bulb
iv. Ignition by open fire

Only the first two are important methods for modern engines

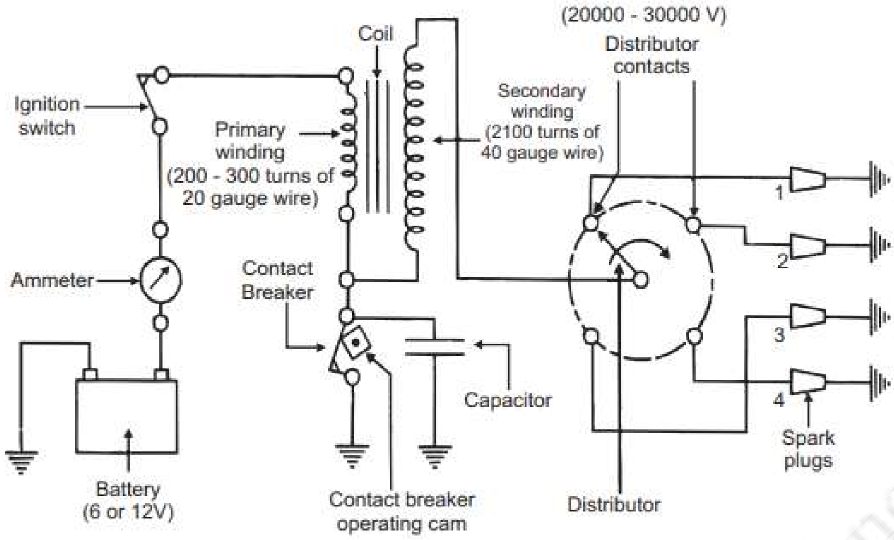
A. SPARK IGNITION

The purpose of spark ignition is to deliver a perfectly timed surge of electricity across an open gap in each cylinder at the exact moment so that the charge may start burning with maximum efficiency

Two types of spark ignition are i. Battery ignition   ii. magneto ignition

i. Battery IGNITION SYSTEM

Figure shows line diagram of battery ignition system for a 4-cylinder petrol engine. It mainly consists of a 6 or 12 volt battery, ammeter, ignition switch, auto-transformer (step up transformer), contact breaker, capacitor, distributor rotor, distributor contact points, spark plugs, etc. Note that the Figure shows the ignition system for 4-cylinder petrol engine, here there are 4-spark plugs and contact breaker cam has 4-corners. (If it is for 6-cylinder engine it will have 6-spark plugs and contact breaker cam will be a perfect hexagon). The ignition system is divided into 2-circuits.



Primary Circuit : It consists of 6 or 12 V battery, ammeter, ignition switch, primary winding it has 200-300 turns of 20 SWG (Sharps Wire Gauge) gauge wire, contact breaker, capacitor.

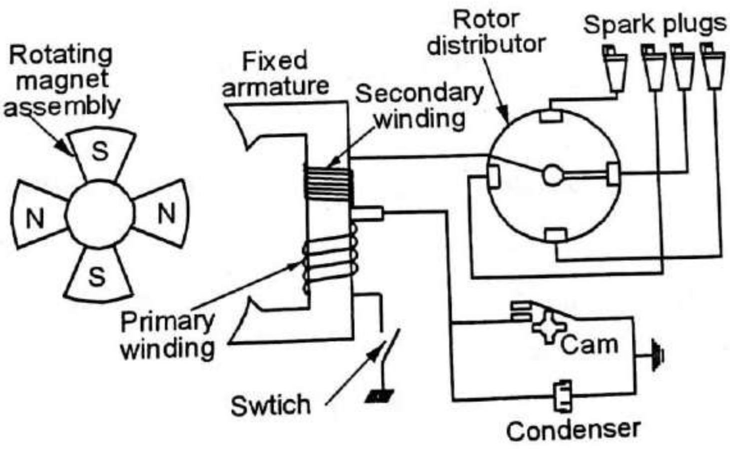
Secondary Circuit : It consists of secondary winding. Secondary Ignition Systems winding consists of about 21000 turns of 40 (S WG) gauge wire. Bottom end of which is connected to bottom end of primary and top end of secondary winding is connected to centre of distributor rotor. Distributor rotors rotate and make contacts with contact points and are connected to spark plugs which are fitted in cylinder heads (engine earth).

Working: When the ignition switch is closed and engine in cranked, as soon as the contact breaker closes, a low voltage current will flow through the primary winding. It is also to be noted that the contact beaker cam opens and closes the circuit 4-times (for 4 cylinders) in one revolution. When the contact breaker opens the contact, the magnetic field begins to collapse. Because of this collapsing magnetic field, current will be induced in the secondary winding. And because of more turns (@ 21000 turns) of secondary, voltage goes unto 28000-30000 volts.

This high voltage current is brought to centre of the distributor rotor. Distributor rotor rotates and supplies this high voltage current to proper stark plug depending upon the engine firing order. When the high voltage current jumps the spark plug gap, it produces the spark and the charge is ignited-combustion starts-products of combustion expand and produce power.

ii. MAGNETO IGNITION SYSTEM

In magneto ignition system a magneto is used to generate electric current for producing spark. A high tension magneto generates a very high voltage needed for spark plug



Main components of magneto ignition system

a) Frame b) Permanent magnet

c) Armature d) Soft iron field

e) rotor f) Primary and secondary winding

g) Breaker points h) Condenser

The armature consists of an iron core on which there are two sets of windings Primary & Secondary

The armature is driven by the engine. As the armature rotates, primary windings cut the lines of force of magnetic field and an induced current flows in the primary circuit. As the primary current reaches its maximum value in each direction, the primary circuit is suddenly opened by a contact breaker and the current collapses. This action induces a very high voltage in the secondary winding which causes a momentary spark to jump at the spark plug gap. A distributor is provided which carries current to the spark plug through high tension wires. The condenser is used to eliminate the arching at the breaker points and intensifying the current in the secondary circuit. For multi cylinder engines, a distributor and a rotor are required to distribute the current to different spark plugs.

IV. COOLING SYSTEM

Cooling is done with either air or liquid to remove the waste heat from an engine. For small or special purpose engines, cooling using air from the atmosphere makes for a lightweight and relatively simple system. Watercraft can use water directly from the surrounding environment to cool their engines. For water-cooled engines on aircraft and surface vehicles, waste heat is transferred from a closed loop of water pumped through the engine to the surrounding atmosphere by a radiator.

Water has a higher heat capacity than air, and can thus move heat more quickly away from the engine, but a radiator and pumping system add weight, complexity, and cost. Higher-power engines generate more waste heat, but can move more weight, meaning they are generally water-cooled.

V. GOVERNOR

Governor is mechanical device, designed to control the speed of the engine with in specified limit., used on tractor or stationary engine for

1. Maintaining a nearly constant speed of engine under different load conditions
2. Protecting the engine and attached equipments against high speeds, when the load is removed or reduced

Exp. No: **Date:**

DETERMINATION OF FLASH AND FIRE POINT

AIM:

Determination of flash and fire point of a combustible liquid by Cleveland's open cup apparatus.

APPARARTUS REQUIRED:

Cleveland open cup apparatus, Thermometers.

THEORY:

The Flash Point of oil may be defined as the minimum temperature to which it must be heated to give off sufficient vapour to ignite momentarily or less than 5 seconds when a flame of standard dimensions (Approx. 4 mm) is brought near the surface of the sample for a prescribed rate in an apparatus of specified dimensions. This is detected by the appearance of momentary flash upon the application of small flame over the surface of oil.

The Fire Point of oil may be defined as the minimum temperature to which it must be heated to give off sufficient vapour to ignite for more than 5 seconds when a flame of standard dimensions (Approx. 4 mm) is brought near the surface of the sample for a prescribed rate in an apparatus of specified dimensions.

Every flammable liquid has a vapour pressure, which is a function of the liquid's temperature. As the temperature increase, the vapour pressure increases, as the vapour pressure increases, the concentration of evaporated flammable liquid in the air increases. Hence, temperature determines the concentration of its vapour in the air to sustain combustion. The flash point of a flammable liquid is the lowest temperature at which there can be enough flammable vapour to ignite, when an ignition source is applied. Oil containing minute quantities of volatile organic substances is liable to flash below the true flash point of the oil. Although a small flash may be observed in such cases, it should not be confused with the true flash point, since its intensity does not increase with increase in temperature, as occurred when the true flash point is reached.

PROCEDURE:

1. Note down the name and serial number of oil sample.
2. The cup is filled with the given sample of oil up to the standard filling mark in the cup. A thermometer is held in the oil such that it does not touch the metallic parts.

3. When the sample of oil is kept stirred and heated it gives out a vapor. A test flame using a glowing splinter is applied at a short distance over the surface of the oil, while watching for a flickering sound and a flash.
4. The minimum temperature at which the momentary flash is obtained is called the flash point. The flash point is noted from the thermometer.
5. Heating is continued further. As done earlier a test flame is applied but watching for the continuous burning of the vapours.
6. The lowest temperature at which the ignited vapor continuously burns is called the fire point the fire point is noted from the thermometer.
7. Repeat the procedure for a different sample.

S. NO.	NAME OF THE OIL SAMPLE	TEMPERATURE	INFERENCE (NO FLASH OR FLASH OBSERVED)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			

RESULT:

1. The flash point of the given ………....………...... oil is found to be ………......^{0}C
2. The fire point of the given ………....………......oil is found to be ………......^{0}C
3. The flash point of the given ………....………...... oil is found to be ………......^{0}C
4. The fire point of the given ………....………......oil is found to be ………......^{0}C

Exp. No: **Date:**

VISCOSITY MEASUREMENT OF LUBRICATING OIL USING REDWOOD VISCOMETER

AIM:

To determine the kinematic viscosity and absolute viscosity of the given lubricating oil at different temperatures using Redwood Viscometer

APPARATUS REQUIRED:

- Redwood Viscometer
- Thermometer
- Stop watch
- flask
- Given Sample of oil

THEORY:

Viscosity is the property of fluid. It is defined as “The internal resistance offered by the fluid to the movement of one layer of fluid over an adjacent layer”. It is due to the Cohesion between the molecules of the fluid. The fluid which obey the Newton law of Viscosity are called as Newtonian fluid. The dynamic viscosity of fluid is defined as the shear required to produce unit rate of angular deformation.

Formulae Used:

Kinematic Viscosity $\nu = At - \frac{B}{t}$ centistokes (1 centistokes = 10^{-6} m^2/s)

Density of oil at particular temperature $\rho_t = \rho_r - 0.00065\ (T - T_r)$ g/cm^3

(1 g/cm^3 = 1000 kg/m^3)

Dynamic or Absolute Viscosity $\mu = \rho_t \; X \; \nu$ N s/m^2

(1 N s/m^2 = 10 poise)

Where,

A (Constant) = 0.26

B (Constant) = 171.5

t= Time taken to fill flask in Sec

ρ_r = Density of oil at room temperature in gm / cm^3

T = Temperature at which the density is required

Tr = Room Temperature

PROCEDURE:

1. Clean the cylindrical oil cup and ensure the orifice tube is free from dirt.
2. Close the orifice with ball valve.
3. Place the flask below the opening of the Orifice.
4. Fill the oil in the cylindrical oil cup up to the mark in the cup.
5. Fill the water in the water bath.
6. Insert the thermometers in their respective places to measure the oil and water bath temperatures.
7. Heat the oil by heating the water bath, Stir the water bath and maintain the uniform temperature.
8. At particular temperature lift the ball valve and collect the oil in the 50 ml flask and note the time taken in seconds for the collecting 50 ml of oil. A stop watch is used to measure the time taken . This time is called Redwood seconds.
9. Increase the temperature and repeat the above step and note down the Redwood seconds for different temperatures.

GRAPH:

The following graph has to be drawn

1. Temperature vs Redwood seconds
2. Temperature vs Kinematic Viscosity
3. Temperature vs Dynamic Viscosity

RESULT:

The kinematic and dynamic viscosity of given oil at different temperatures were determined.

INFERENCE:

OBSERVATION AND TABULATION

1. Room temperature Tr = ……. °C
2. Density of oil at room temperature = …….. gm/cm^3

Sl. No .	Tempera ture of oil °C	Time taken to fill 50ml flask in 'Sec'	Kinematic Viscosity		Density in gm/cm^3	Dynamic (or) Absolute viscosity ' Centi Poise'	
			Centistokes	m^2/s		poise	N s/m^2
1							
2							
3							
4							

Exp. No: **Date:**

PERFORMANCE TEST ON 4 STROKE SINGLE CYLINDER DIESEL ENGINE

AIM:

To determine the performance of the single cylinder diesel IC engine

APPARATUS REQUIRED:

4- Stroke single cylinder Diesel engine with a rope break dynamometer, Stop watch, Tachometer

THEORY:

Single cylinder stationary, constant speed diesel engines are generally quality governed. As such the air supplied to the engine is not throttled as in the case of S.I. engines. To meet the power requirements of the shaft, the quantity of fuel injected into the cylinder is varied by the rack in the fuel pump. The rack is usually controlled by a governor or by a hand. The air flow rate of single cylinder engine operating at constant speed does not vary appreciably with the output of the engine. Since the fuel flow rate varies more or less linearly with output, the fuel air ratio increases with output. Performance tests can be conducted either at constant speed (or) at constant throttle. The constant speed method yields the F.P. of the engine.

PROCEDURE:

1. Check the fuel level in the fuel tank and open the fuel knob.
2. Check lubrication oil level in the crankcase
3. Ensure cooling water supply to engine before starting the engine.
4. Ensure cooling water supply to brake drum before loading the engine.
5. Engine should be started on no load condition.
6. Load should be added or removed gradually by adjusting the speed of the engine to its rated value by screwing in or out of the governor nut.
7. Engine should be stopped only at no load condition
8. During starting the engine, the handle used on the crank shaft to start the engine, should be removed immediately once the engine is started
9. Decompression lever should not be used to stop the engine.
10. Do not over load the engine beyond ten percent more than the full load cpa
11. Allow the fuel to flow to to the engine directly from the tank.
12. Open the cooling water valves and ensure water flows through the engine.
13. Start the engine and allow running on no load condition for few minutes.
14. Load engine by adding weights upon the hanger.
15. Allow the cooling water in the brake drum and adjust it to avoid spilling.
16. Allow the engine to run at this load for few minutes.

17. Note the following readings
    a. Engine speed.
    b. Weight on the hanger.
    c. Spring balance
    d. Manometer
    e. Time for 10 cc of fuel consumption
18. Repeat the above procedure at different loads.
19. Stop the engine after removing load on the engine

OBSERVATIONS:

Manometer reading h_1 = ……….. cm of water

Manometer reading h_2 = ……….. cm of water

Make	:
Bore	:
Stroke	:
Rated Speed	:
Max. B. P	:
Compression Ratio	:
Orifice Diameter	:
Fuel	:
Density of Diesel	:
Calorific Value of Diesel	:
Brake drum diameter	:
Rope diameter	:
Equivalent diameter	:

S.NO	Load on the brake drum			Speed, Rpm	Time for 10 cc of fuel , Sec	T.F.C, Kg/hr	S.F.C, Kg/Kw-hr	B.P, KW	H.I, KW	I.P, K.W	I.M.E.P ,KPa	B.M.E.P, KPa	Efficiencies			
	W_1 Kg	W_2 Kg	W kg										$\eta_{B\ th}$	$\eta_{I\ th}$	η_m	η_{Vol}
1																
2																
3																
4																
5																

CALCULATIONS:

Maximum Load Calculation:

$$Rated\ Power, P = \frac{2\pi N W_{max} R_e g}{60 \times 1000}$$

$$W_{max} = \frac{Rated\ Power \times 60 \times 1000}{2\pi N R_e g}$$

Where,

$N = Rated\ speed\ in\ rpm$

$W_{max} = Maximum\ load\ in\ kg$

$R_e = Effective\ brake\ drum\ radius\ (R + d)$

$R = Drum\ Radius$

$d = Diameter\ of\ rope$

$g = acceleration\ due\ to\ gravity = 9.81\ m/s^2$

1 Engine output (Brake Power) [B.P] $= \frac{2\Pi NT}{60 \times 1000}$ ...... KW

Where,

N = Rated speed ..... Rpm,

W_0 = Weight of hanger = 1.0 kg

W_1 = Weight on hanger .... kg

W_2 = spring balance reading ....kg

R_e = Effective brake drum radius = (R + d) ... m

Where R is Brake drum radius

d is Rope diameter

W = Net Load = $[(W_1\text{-}W_2) + W_0] \times 9.81$ .... N

T = $(W * R_e)$...........N-m

2 Indicated Power

Time for 10cc of fuel consumption, t = ……. Sec,

Mass of fuel consumption per min, $m_f = \frac{10}{t} \times \frac{\text{Density of diesel}}{1000X1000} \times 60$ ..kg/ min.

$\frac{10}{t} \times \frac{1}{10^6} \times$ Density of diesel $\times 60$ ..kg/ min.

Total Fuel consumption, TFC = … $m_f \times 60$….kg / hr.

Specific fuel consumption, SFC = $\frac{T.F.C}{B.P}$ ……..Kg / Kw-hr

Heat Input, HI = $\frac{TFC \times CV}{60 \times 60}$ …….KW

Where CV is calorific value of Diesel = 45,350 KJ / kg

Indicated Power, I.P = B.P + F.P

Where F. P = Frictional Power from William's line diagram (TFC Vs B.P)

3. Brake thermal efficiency, $\eta_{B\ th} = \frac{B.P}{HI} \times 100$

4 Indicated thermal efficiency, $\eta_{I\ th} = \frac{I.P}{HI} \times 100$

5 Mechanical efficiency, $\eta_m = \frac{B.P}{I.P} \times 100$

6 I.M.E.P = $\frac{I.P \times 60}{L \times A \times n \times K}$ .....KPa

7 B.M.E.P. = $\frac{B.P \times 60}{L \times A \times n \times K}$ ....KPa

Where L = Stroke of length ......'m'
A = Cross section area of piston in 'm^2'
n = Number of working strokes = $\frac{N}{2}$ (for 4 stroke engine)
K = Number of cylinders =1

8 Volumetric Efficiency, η_{Vol} = $\frac{V_s}{V_t} \times 100$

i) <u>Actual Air intake:</u>

Manometer reading h_1 = ...cm of water

Manometer reading h_2 = ...cm of water

Difference in water level, h_w = $\frac{h_1 - h_2}{100}$ ....m of water

Equivalent air column, h_a = $h_w \times \frac{Density\ of\ water}{Density\ of\ air}$ = $h_w \times \frac{1000}{1.16}$ ....m. of air

Orifice diameter, d = 0.03 m

Area of orifice, a = $\frac{\pi \times (0.03)^2}{4}$ ....m^2

Actual Volume of air intake, V_a =60 × C_d × a × $\sqrt{2gh_a}$ ....m^3 / min.

Where C_d = 0.62

Mass of air intake, $m_a = \rho_a \times V_a$ ……kg / min

Density of air $\rho_a = 1.16$ Kg/m^3

ii) Theoretical Air intake:

Diameter of piston, D = 0.102 m

Stroke length, L = 0.116 m

Engine speed, N = ……….rpm

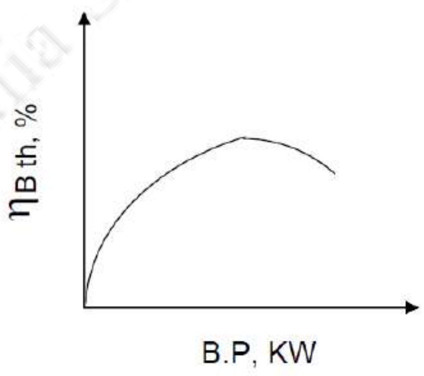
Theoretical volume of air intake, $V_t = \left(\frac{\pi}{4}\right) \times D^2 \times L \times \frac{N}{2}$ …..m^3 / min

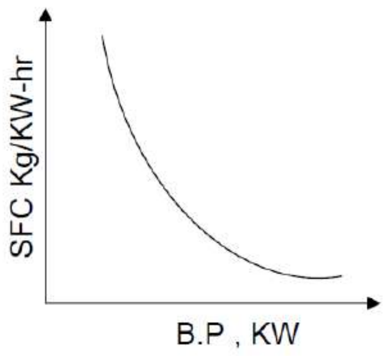
Volumetric efficiency, $\eta_{Vol} = \frac{V_a \times 100}{V_t}$

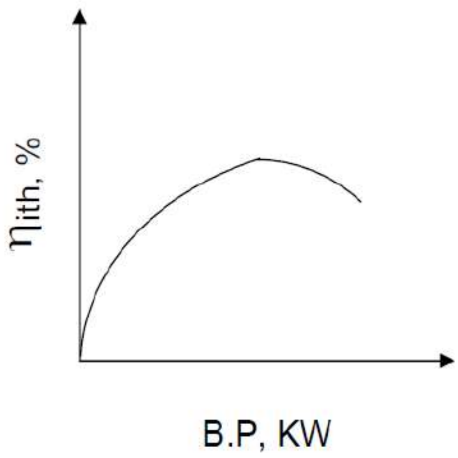
9 Air- Fuel Ratio = $\frac{Mass\ of\ actual\ air\ intake\ per\ minute\ (kg/min)}{Mass\ of\ fuel\ intake\ per\ minute\ (kg/min)} = \frac{m_a}{m_f}$

RESULT:

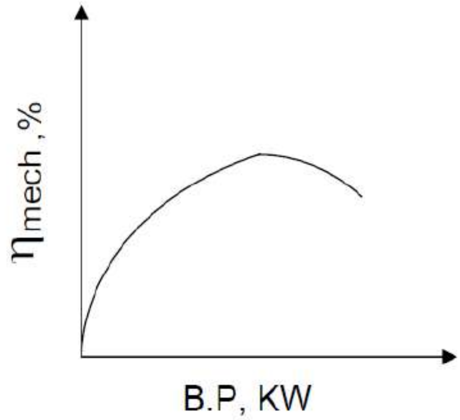
MODEL GRAPHS:



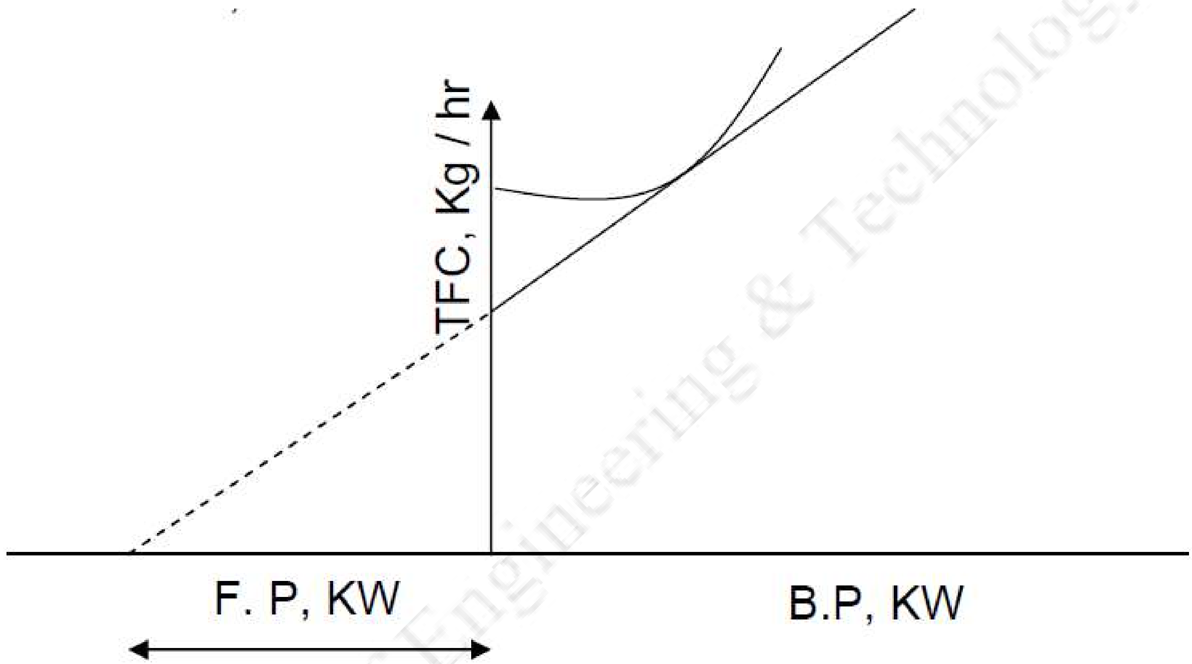




η_{ith}, %
B.P, KW



η_{mech} ,%
B.P, KW



TFC, Kg / hr
F. P, KW
B.P, KW

Exp. No: **Date:**

PERFORMANCE TEST ON TWO STAGE RECIPROCATING AIR COMPRESSOR

AIM:

To conduct performance test on reciprocating air compressor, to determine volumetric efficiency and Isothermal efficiency

APPARATUS REQUIRED:

Two - stage air compressor, Stop watch, Tachometer

THEORY:

The air compressor is a two stage, reciprocating type. The air is sucked from atmosphere and compressed in the first cylinder. The compressed air then passes through an inlet cooler into the second stage cylinder, the compressed air then goes to reservoir through safety valve. This valve operates an electrical switch that shuts off the motor when pressure exceeds the set limit.

The test consists of an air chamber containing an orifice plate and a u-tube manometer, the compressor and an induction motor.

PROCEDURE:

1. Open the discharge valve of the compressor and drain off air completely and close the valve.
2. Start the compressor, by starting the compressor motor& observe the pressure developing slowly
3. At the particular test pressure, the outlet valve is opened slowly and adjusted so that the pressure in the tank maintained constant.
4. At the particular test pressure, note the following reading:
    a. Manometer,
    b. Speed of the compressor,
    c. Pressure,
    d. Time taken for 10 revolutions of energy meter.
5. Adjust the discharge valve so that pressure changes again.
6. Repeat the above procedure for different pressures.
7. Switch off the power supply and stop the compressor

OBSERVATION:

S.No.	Pressure (kgf/cm^2)	Energy meter reading for 'n' Number of revolutions	Difference in manometer reading, h_w cm	Speed N rpm	Actual Volume V_a m^3/sec	Theoretical Volume, V_t m^3/sec	η_{vol}

S.No.	Gauge Pressure (kgf/cm^2)	Motor input= $\frac{3600 \times n}{k \times t}$ Kw	Motor output= $motorinput \times 0.8$	Compressor input= $motorinput \times 0.8 \times 0.95$	Compressor output= $P_a \times V_a \times ln C$	η_{iso}

CALCULATIONS:

Make :

Dia. of low-pressure piston :

Dia. of High-Pressure Piston :

Stroke :

Operating Pressure :

Speed :

Diameter of orifice :

Power :

1. <u>Actual Air intake:</u>

Manometer reading h_1 = …………..cm of water

Manometer reading h_2 = …………..cm of water

Difference in water level, $h_w = \frac{h_1 - h_2}{100}$ m of water

Equivalent air column, $h_a = \frac{h_w \times Density\ of\ water}{Density\ of\ Air} = \frac{h_w \times 1000}{1.16}$ ….m. of air

Where

h_w = m. of water column

h_a =m. of air column

ρ_w =Density of water in kg/m^3 (1000 kg/m^3)

ρ_a =Density of air in kg/m^3 (1.16 kg/m^3)

2. The actual volume of air compressed, $V_a = C_d \times a \times \sqrt{2gh_a}$ …..m3 / Sec

Where

C_d=co efficient of discharge for the orifice =0.62

Orifice diameter = 0.02 m

Area of orifice, $a = \frac{\pi \times (0.02)^2}{4}$ = …..m^2

h_a=equivalent air column in 'm'

3. Theoretical volume of air compressed, $V_t = \frac{\left(\frac{\pi}{4}\right) \times D^2 \times L \times N}{60}$ …..m^3 / Sec

Diameter of piston, D = 0.07 m

Stroke length, L = 0.09 m

Speed of the compressor, N = ……..rpm

4. Volumetric efficiency = $\frac{V_a}{V_t} \times 100$

5. Compressor input = Motor input $\times 0.8 \times 0.95$ .....KW

Where

Energy meter constant, K= 200 Rev/Kwh

Time for 'n' number of rev. = t sec

Motor input = $\frac{3600 \times n}{K \times t}$ .... KW

Efficiency of motor = 80%

Output of motor = Motor input $\times 0.8$

Belt transmission efficiency = 95 %(assumed)

Compressor input = Motor input $\times 0.8 \times 0.95$ .....KW

6. Compressor output = $P_a \times V_a \times \ln C$ ....Kw

Compression ratio, C = $\frac{Gauge\ pressure + Atm.\ pressure}{Atm.\ pressure}$

$= \frac{\text{Gauge pressure} + 1.0325}{1.0325}$

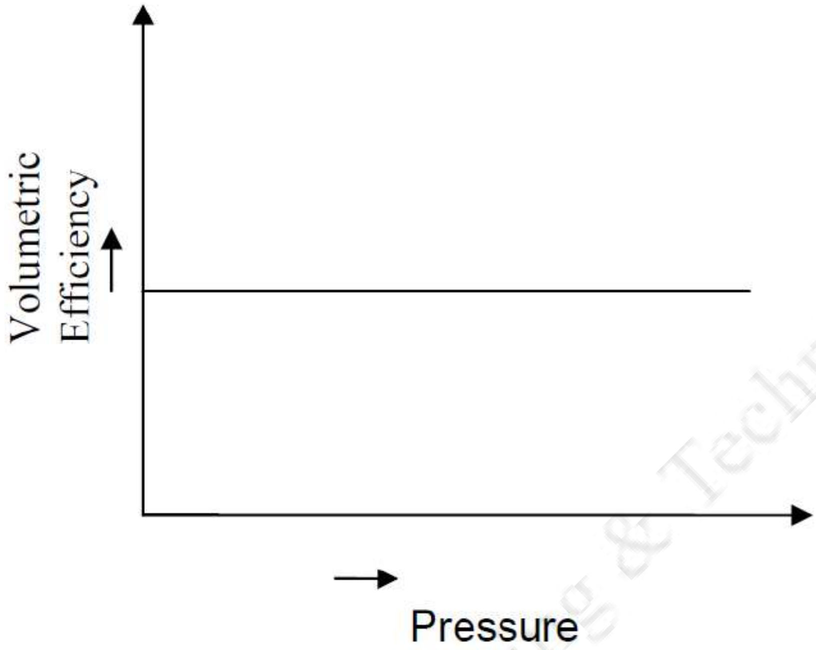
Note: Gauge pressure in Kgf/cm^2

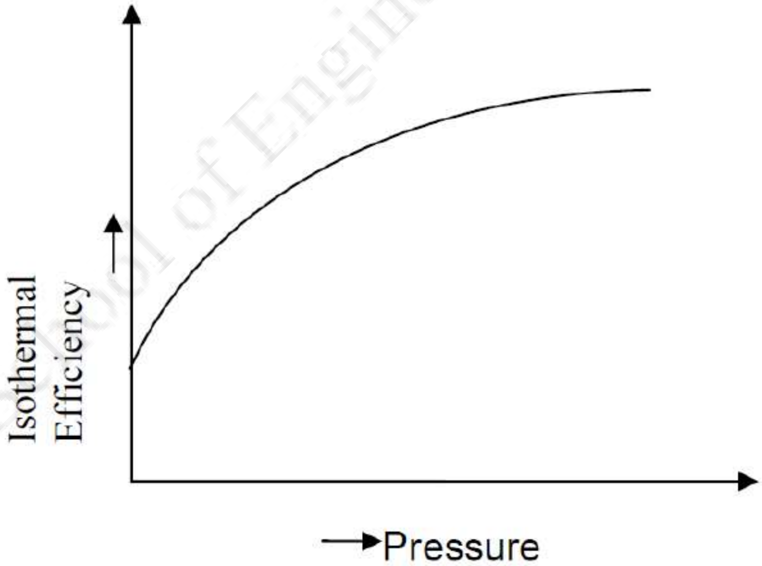
P_a= Atmospheric pressure = 101.325 KPa

V_a= Actual volume of air compressed m^3/sec

7. Isothermal efficiency $= \dfrac{Compressor\ output}{Compressor\ input} \times 100$

MODEL GRAPHS:





RESULT:

Exp. No: **Date:**

RETARDATION TEST ON SINGLE CYLINDER DIESEL ENGINE

AIM:

To determine the frictional horse power of the engine by conducting retardation test and plot the graph of rated speed vs retardation time

APPARATUS REQUIRED:

4- Stroke single cylinder Diesel engine, Stopwatch, Tachometer

THEORY:

The engine is loaded with the help of brake drum dynamometer. Retardation test is conducted to find out the power loss due to friction in an IC engine. The time to retard the engine from an initial to final speed is noted at no load as well as on loaded condition. The torque on the engine at no load and at specific loads within the maximum load is calculated. The torque on engine at no load will be solely due to friction which can be calculated and the power loss due to friction is calculated.

PROCEDURE:

1. Calculate the maximum load that can be applied on the engine
2. Take all the precaution before starting the engine
3. Engine is started at no load condition and is made to run at a rated speed
4. The fuel is then cut-off using the fuel cut-off lever and note the time taken for the speed to drop to a lower speed using a stopwatch
5. The fuel cut-off lever is disengaged and the engine is brought back to the rated speed
6. The experiment is conducted for 5 to 6 different range of engine speed and the respective time is noted
7. The above steps are repeated by adding weight equal to the half of the maximum load and 5 to 6 readings are noted again for this weight
8. Plot the graph and calculate the frictional power

OBSERVATIONS:

Make	:
Bore Diameter	:
Stroke Length	:
Rated Speed, N	:
Max. B. P	:
Fuel	:
Brake drum diameter	:
Rope diameter	:

Equivalent diameter :

OBSERVATIONS:

Sl. No.	Speed Range (rpm)	Time in Seconds		Frictional Torque, T_F (N/m)	Frictional Power, F.P. (W)
		No Load	Half load (__kg)		

CALCULATIONS:

$$B.P._{max} = \frac{2\pi N W_{max} R_e g}{60 \times 1000}$$

$$W_{max} = \frac{B.P._{max} \times 60 \times 1000}{2\pi N R_e g}$$

Where, $N = Rated\ speed\ in\ rpm$

$W_{max} = Maximum\ load\ in\ kg$

$R_e = Effective\ brake\ drum\ radius\ (R + d)$

$R = Drum\ Radius$

$d = Diameter\ of\ rope$

$g = acceleration\ due\ to\ gravity = 9.81\ m/s^2$

$$\text{Torque on half load, } T_L = \frac{W_{max}}{2} R_e$$

$$\text{Brake Power on half load, } B.P._L = \frac{2\pi N T_L}{60}$$

$$\text{Frictional Torque, } T_F = T_L \frac{t_3}{t_2 - t_3}$$

$$\text{Frictional Power, } F.P. = \frac{2\pi N T_F}{60}$$

$t_2 = Retardation\ time\ at\ no\ load$

$t_3 = Retardation\ time\ at\ half\ load$

$$\text{Indicated Power, } I.P = B.P + F.P$$

$$\text{Mechanical Efficiency, } \eta_{mech} = \frac{B.P}{I.P} \times 100\ \%$$

RESULT:

Graph between Retardation time and engine speed is drawn.

Frictional Power of the engine = ----------------------------

Mechanical Efficiency =

INFERENCE:

Exp. No: **Date:**

VALVE TIMING DIAGRAM OF DIESEL ENGINE

The experiment is conducted to determine the actual valve timing for a 4-stroke diesel engine and hence
draw the diagram.

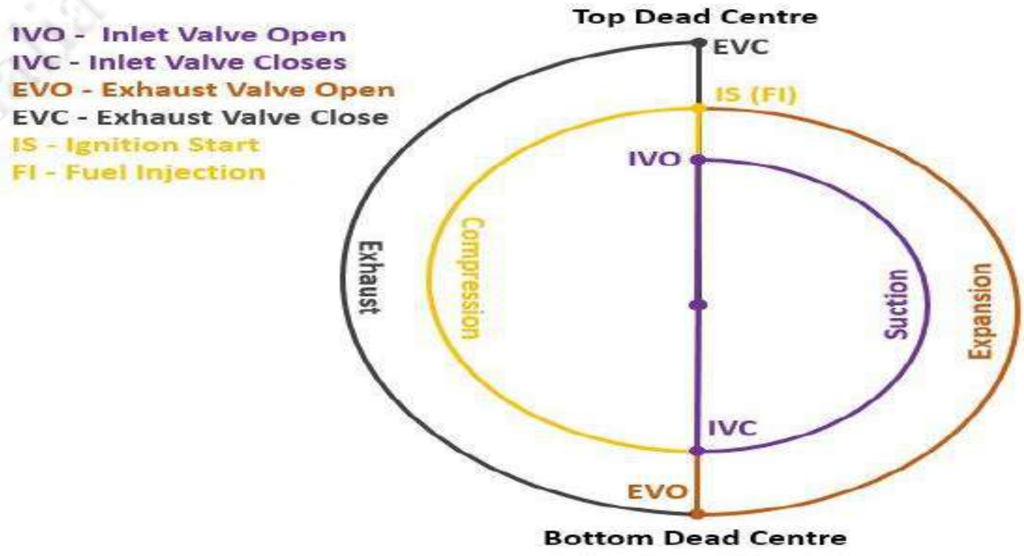
APPARATUS REQUIRED:

4- Stroke single cylinder Diesel engine cut section, measuring tape, Chalk

THEORY:

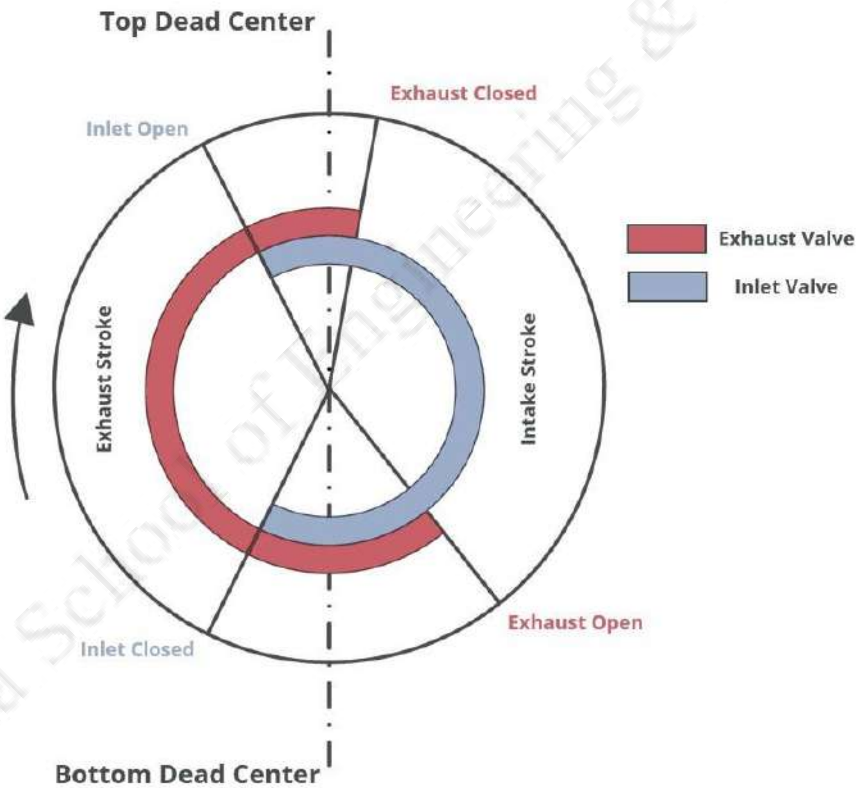
The valve timing diagram gives an idea about how various operations are taking place in an engine cycle. The four stroke diesel engines have inlet valve to supply air inside the cylinder during suction stroke and an exhaust valve to transfer exhaust gas after combustion to the atmosphere. The fuel is injected directly inside the cylinder with the help of a fuel injector. The sequence of events such as opening and closing of valves which are performed by cam follower rocker arm mechanism in relation to the movements of the piston as it moves from TDC to BDC and vice versa. As the cycle of operation is completed in four strokes, one power stroke is obtained for every two revolutions of the crankshaft.

The suction compression, power and exhaust processes are expected to complete in the respective individual strokes. In an ideal engine, the inlet valve opens at TDC and closes at BDC. The exhaust valve opens at BDC and closes at TDC. The fuel is injected into the cylinder when the piston is at TDC and at the end of compression stroke.



Actual Valve Timing Diagram

But in actual practise it will differ. Valves do not open or close exactly at the two dead centres in order to transfer the intake charge and the exhaust gas effectively. In an actual engine, the inlet valve begins to open 5° to 20° before the piston reaches the TDC during the end of exhaust stroke. This is necessary to ensure that the valve will be fully open when the piston reaches the TDC. If the inlet valve is allowed to close at BDC, the cylinder would receive less amount of air than its capacity and the pressure at the end of suction will be below the atmospheric pressure. To avoid this inlet valve is kept open for 25° to 40° after BDC. Complete clearing of the burned gases from the cylinder is necessary to take in more air into the cylinder. To achieve this exhaust valve is opens at 35° to 45° before BDC and closes at 10° to 20° after the TDC.



It is clear from the diagram, for certain period both inlet valve and exhaust valve remain in open condition. The cranks angles for which the both valves are open are called as overlapping period. This overlapping is more for diesel engine than petrol engine.

PROCEDURE:

1. Keep the decompression lever in vertical position.
2. Bring the TDC mark to the pointer level closed.

3. Rotate the flywheel till the inlet valves moves down i.e., opened.
4. Draw a line on the flywheel in front of the pointer and take the reading.
5. Continue to rotate the flywheel till the inlet valve goes down and comes to horizontal position and take reading.
6. Continue to rotate the flywheel till the outlet valve opens, take the reading.
7. Continue to rotate the flywheel till the exhaust valve gets closed and take the reading.
8. Draw the diagram

OBSERVATIONS:

SL. NO.	VALVE POSITION	DISTANCE FROM THE NEAREST DEAD CENTRE IN CM	ANGLE IN DEGREES
1	Inlet Valve Open		
2	Inlet Valve Closed		
3	Exhaust Valve Open		
4	Exhaust Valve Close		

CALCULATIONS:

1. $\text{Diameter of the flywheel, D} = \frac{\text{Circumference of the flywheel}}{\pi}$
2. $\text{Angle }'\theta'\text{in degrees} = \frac{S \times 360}{D \times \pi}$

Where, S = Arc length, mm

RESULT:

INFERENCE:

Ex.No: **Date:**

HEAT BALANCE TEST ON 4-STROKE SINGLE CYLINDER DIESEL ENGINE

AIM:

To do heat balance test on 4-stroke, single cylinder diesel engine under various loads.

APPARATUS REQUIRED:

1. 4-Stroke, single cylinder Diesel engine with a rope break dynamometer.
2. Stopwatch.

SPECIFICATIONS:

ENGINE	:	FOUR STROKE SINGLE CYLINDER
MAKE	:	KIRLOSKAR
BP	:	3.7 kW
RPM	:	1500 rpm
FUEL	:	Diesel
BORE	:	87.5 mm
STROKE LENGTH	:	110 mm
STARTING	:	CRANKING
WORKING CYCLE	:	FOUR STROKE
METHOD OF COOLING	:	WATER COOLED
METHOD OF IGNITION	:	COMPRESSION IGNITION

THEORY:

Single cylinder stationary, constant speed diesel engines are generally quality governed. As such the air supplied to the engine is not throttled as in the case of S.I. engines. To meet the power requirements of the shaft, the quantity of fuel injected into the cylinder is varied by the rack in the fuel pump. The rack is usually controlled by a governor or by a hand. The air flow rate of single cylinder engine operating at constant speed does not vary appreciably with the output of the engine. Since the fuel flow rate varies more or less linearly with output, the fuel air ratio increases with output. Performance tests can be conducted either at constant speed (or) at constant throttle. The constant speed method yields the F.P. of the engine.

PROCEDURE:

1. Fill up the diesel into the fuel tank mounted on the panel frame.

2. Connect the instrumentation power input plug to a 230V, single phase power source. Now the digital meters indicators display the respective readings.
3. Connect the water line to the engine jacket and brake drum.
4. Check the lubricating oil in the oil sump.
5. Open the fuel valve and ensure no air trapped in the fuel line.
6. Start the engine and allow it to stabilize rated speed.
7. Now load the engine in steps to full load & 10% over load and allow the engine to stabilize at each load.
8. Note the following readings
    a. Engine speed.
    b. Weight on the hanger.
    c. Spring balance
    d. Manometer
    e. Time for 10 cc of fuel consumption
    f. Temperatures
9. Repeat the above procedure at different loads.
10. Turn off the fuel knob provided on the panel after the test.

RESULT

INFERENCE

OBSERVATIONS & TABULAR COLUMN

T1 = Air Inlet Temperature

T2 = Water Inlet Temperature

T3 = Water Outlet Temperature

T4 = Air Exhaust Temperature

Sl. No	Load on the brake drum (W kg)			Manometer reading				Time for collecting Y ml of water (sec)		Time for X cc of fuel (sec)	T1 (^0C)	T2 (^0C)	T3 (^0C)	T4 (^0C)	B.P kW
	Load on hanger W1 kg	Spring balance reading W2 kg	Actual Load W= W1-W2 kg	h1	h2	h= h1-h2	h_a								
1	Half Load														
2															

SAMPLE CALCULATIONS:

A. Heat input =($m_f \times$ CV) kJ/min

Where

$$mass\ of\ fuel, m_f = \frac{X}{t \times 10^6} \times Density\ of\ fuel \times 60\ kg/min$$

Where,

$X = amount\ of\ fuel\ consumed\ in\ cc$

$t = Time\ for\ consuming\ X\ cc\ of\ fuel$

CV = Calorific Value of Fuel

B. Heat equivalent to BP

$$Brake\ power\ BP = \frac{2\pi NT}{1000}\ kJ/min$$

Where,

$N = Rated\ speed\ in\ rpm$

$T = Torque\ on\ engine = (W + W_0)R_e g$

$W_0 = weight\ of\ hanger = 1\ kg$

$W = Load\ on\ the\ \ brake\ drum$

$R_e = Effective\ brake\ drum\ radius\ (R + d)$

$R = Drum\ Radius =$ mm

$d = Diameter\ of\ rope =$ mm

$g = acceleration\ due\ to\ gravity = 9.81\ m/s^2$

C. Heat carried away by engine cooling water = m_w x c_{pw} x (T_3 – T_2) kJ/min

Where m_w = mass of cooling water

$$m_w = \frac{\text{Amount of water collected in ml (Y)} \times \text{ Density of water in kg}/m^3}{\text{Time for collecting Y ml of water in sec}}$$

c_{pw} = Specific Heat of water at constant pressure at outlet temperature

T2 = Water Inlet Temperature

T3 = Water Outlet Temperature

D. Heat carried away by exhaust gases = m_g x c_{pg} x (T_4 – T_1) kJ/min

Where m_g = m_a + m_f

m_a = mass of air = $density\ of\ air\ \times c_d \times A \times \sqrt{2gh_a} \times 60\ kg/min$

Density of air = 1.16 kg/m^3

C_d = Coefficient of discharge of orifice = 0.6

A= Area of orifice = $\frac{\pi d^2}{4}$

d= diameter of orifice = 15 mm

h_a = height of air column = $\frac{h_1 - h_2}{100} \times \frac{Density\ of\ water}{Density\ of\ air}$

h_1 = Left limb reading of manometer in cm

h_2 = Right limb reading of manometer in cm

C_{pg} = Specific heat of hot gas kJ/kg K

T1 = Air Inlet Temperature

T4 = Air Exhaust Temperature

E. Unaccounted heat = A – (B+C+D) kJ/min.

HEAT BALANCE SHEET ON MINUTE BASIS:

Heat Supplied	**kJ/min**	**%**	**Heat distributed**	**kJ/min**	**%**
Heat supplied by the fuel		100	1. Heat equivalent to B.P 2. Heat carried by engine Cooling water 3. Heat Carried by exhaust gases 4. Unaccounted losses (radiation, friction, etc.,)		
		100	Total		100

Ex.No: **Date:**

DETERMINATION VOLUMETRIC EFFICIENCY AND AIR-FUEL RATIO OF CI ENGINE

AIM:

To determine the volumetric efficiency and air-fuel ratio of a 4-stroke, single cylinder diesel engine under various loads and to draw the following graphs

1. BP vs AFR
2. BP vs Mass flow rate of air
3. BP vs Mass flow rate of fuel consumed
4. BP vs Volumetric Efficiency

APPARATUS REQUIRED:

1. 4-Stroke, single cylinder Diesel engine with a rope break dynamometer.
2. Stopwatch.

SPECIFICATIONS:

ENGINE	:	FOUR STROKE SINGLE YLINDER
MAKE	:	KIRLOSKAR
BP	:	3.7 kW
RPM	:	1500 rpm
FUEL	:	Diesel
BORE	:	87.5 mm
STROKE LENGTH	:	110 mm
STARTING	:	CRANKING
WORKING CYCLE	:	FOUR STROKE
METHOD OF COOLING	:	WATER COOLED
METHOD OF IGNITION	:	COMPRESSION IGNITION

THEORY:

Volumetric efficiency describes its ability to put air into its cylinders; the greater the efficiency percentage, the more completely the engine fills available cylinder volume. For engines of the same displacement, those with better volumetric efficiency develop more power and torque.

The air–fuel ratio (AFR) is a significant indicator and very important measure for engine performance and exhaust emissions pollution reasons. The AFR called or known as stoichiometric mixture when the provided air is exactly enough to completely burn all of the fuel. Air–fuel ratio with lower numbers than stoichiometric are considered rich air–fuel mixture, which are less efficient, generate more power and mixture burn cooler. Air–fuel ratio numbers higher than stoichiometric mixture are considered lean air–fuel mixtures, which are more efficient but cause damages to the engine and generate higher levels of nitrogen oxides (NOx) emission.

PROCEDURE:

1. Check the fuel level in the fuel tank and open the fuel knob.
2. Check lubrication oil level in the crankcase
3. Ensure cooling water supply to engine before starting the engine.
4. Ensure cooling water supply to brake drum before loading the engine.
5. Engine should be started on no load condition.
6. Engine should be stopped only at no load condition
7. During starting the engine, the handle used on the crank shaft to start the engine, should be removed immediately once the engine is started.
8. Decompression lever should not be used to stop the engine.
9. Do not over load the engine beyond ten percent more than the full load capacity.
10. Allow the fuel to flow to to the engine directly from the tank.
11. Open the cooling water valves and ensure water flows through the engine.

12. Start the engine and allow running on no load condition for few minutes.
13. Load engine by adding weights upon the hanger.
14. Allow the cooling water in the brake drum and adjust it to avoid spilling.
15. Allow the engine to run at this load for few minutes.
16. Note the following readings
    a. Engine speed.
    b. Weight on the hanger.
    c. Spring balance
    d. Manometer
    e. Time for 10 cc of fuel consumption
17. Repeat the above procedure at different loads.
18. Stop the engine after removing load on the engine

RESULT:

INFERENCE:

OBSERVATIONS & TABULAR COLUMN:

N = Engine speed =

Sl. No	Load on the brake drum (W kg)			Manometer reading				Time for consuming X cc of fuel (sec)	Mass of Fuel m_f kg/min	Mass of air m_a kg/min	Actual Volume flow rate Va m^3/min	Theoretical volume Flow Rate Vt m^3/min	Brake power BP kW	Air-Fuel Ratio	Volumetric Efficiency η_v %
	Load on hanger W1 kg	Spring balance reading W2 kg	Actual Load W= W1-W2 kg	h1	h2	h_W= h1-h2	h_a								
1															
2															

SAMPLE CALCULATIONS:

1. Maximum load calculation:

$$Rated\ Power, P = \frac{2\pi N W_{max} R_e g}{60 \times 1000}\ kW$$

$$W_{max} = \frac{Rated\ Power \times 60 \times 1000}{2\pi N R_e g}$$

Where,

$N = Rated\ speed\ in\ rpm$

$W_{max} = Maximum\ load\ in\ kg$

$R_e = Effective\ brake\ drum\ radius\ (R + d)$

$R = Drum\ Radius =$ mm

$d = Diameter\ of\ rope =$ mm

$g = acceleration\ due\ to\ gravity = 9.81\ m/s^2$

2. Brake power

$$Brake\ power\ BP = \frac{2\pi NT}{60 \times 1000}\ kW$$

Where,

$N = Rated\ speed\ in\ rpm$

$T = Torque\ on\ engine = (W + W_0) R_e g$

$W_0 = weight\ of\ hanger = 1\ kg$

$W = Load\ on\ the\ brake\ drum$

$R_e = Effective\ brake\ drum\ radius\ (R + d)$

$R = Drum\ Radius =$ mm

$d = Diameter\ of\ rope =$ mm

$g = acceleration\ due\ to\ gravity = 9.81\ m/s^2$

3. Mas of fuel consumed

$$m_f = \frac{X}{t \times 10^6} \times Density\ of\ fuel \times 60\ kg/min$$

Where,

$X = amount\ of\ fuel\ consumed\ in\ cc$

$t = Time\ for\ consuming\ X\ cc\ of\ fuel$

4. **Actual volume flow rate V_a**

Manometer reading h_1 = ...cm of water

Manometer reading h_2 = ...cm of water

Difference in water level, $h_w = \frac{h_1 - h_2}{100}$ ....m of water

Equivalent air column, $h_a = h_w \times \frac{Density\ of\ water}{Density\ of\ air} = h_w \times \frac{1000}{1.16}$ ....m. of air

Orifice diameter, d

Area of orifice, $a = \frac{\pi \times d^2}{4}$........$m^2$

Actual Volume of air intake, $V_a = 60 \times C_d \times a \times \sqrt{2gh_a}$ ....m^3 / min.

Where $C_d = 0.6$

5. **Theoretical Volume flow rate V_{th}**

Theoretical volume of air intake, $V_t = \left(\frac{\pi}{4}\right) \times D^2 \times L \times \frac{N}{2}$ .....m^3 / min

D = Diameter of piston

L = Stroke length

N = Engine speed

6. **Volumetric Efficiency η_{vol}**

Volumetric efficiency, $\eta_{Vol} = \frac{Va \times 100}{Vt}$

7. **Mass of air**

Mass of air intake, $m_a = \rho_a \times V_a$ ......kg / min

Density of air $\rho_a = 1.16$ Kg/m^3

8. Air-Fuel Ratio (AFR)

$$\text{Air- Fuel Ratio} = \frac{Mass\ of\ actual\ air\ intake\ per\ minute\ (kg/min)}{Mass\ of\ fuel\ intake\ per\ minute\ (kg/min)} = \frac{m_a}{m_f}$$

Ex.No: **Date:**

COOLING CURVE TEST ON 4-STROKE SINGLE CYLINDER DIESEL ENGINE

AIM:

To study the influence of cooling water temperature on efficiencies of engine and plot the following graphs

1. Cooling Water Temperature vs BP
2. Cooling Water Temperature vs BSFC
3. Cooling Water Temperature vs η_{BTH}

APPARATUS REQUIRED:

1. 4-Stroke, single cylinder Diesel engine with a rope break dynamometer.
2. Stopwatch.

SPECIFICATIONS:

ENGINE	:	FOUR STROKE SINGLE YLINDER
MAKE	:	KIRLOSKAR
BP	:	3.7 kW
RPM	:	1500 rpm
FUEL	:	Diesel
BORE	:	87.5 mm
STROKE LENGTH	:	110 mm
STARTING	:	CRANKING
WORKING CYCLE	:	FOUR STROKE
METHOD OF COOLING	:	WATER COOLED
METHOD OF IGNITION	:	COMPRESSION IGNITION

THEORY:

Single cylinder stationary, constant speed diesel engines are generally quality governed. As such the air supplied to the engine is not throttled as in the case of S.I. engines. To meet the power requirements of the shaft, the quantity of fuel injected into the cylinder is varied by the rack in the fuel pump. The rack is usually controlled by a governor or by a hand. The air flow rate of single cylinder engine operating at constant speed does not vary appreciably with the output of the engine. Since the fuel flow rate varies more or less linearly with output, the fuel air ratio increases with output.

Performance tests can be conducted either at constant speed (or) at constant throttle. The constant speed method yields the F.P. of the engine.

PROCEDURE:

1. Fill up the diesel into the fuel tank mounted on the panel frame.
2. Connect the instrumentation power input plug to a 230V, single phase power source. Now the digital meters indicators display the respective readings.
3. Connect the water line to the engine jacket and brake drum.
4. Check the lubricating oil in the oil sump.
5. Open the fuel valve and ensure no air trapped in the fuel line.
6. Start the engine and allow it to stabilize rated speed.
7. Now load the engine to full load and allow the engine to stabilize at that load.
8. Note the following readings
    a. Engine speed.
    b. Weight on the hanger.
    c. Spring balance
    d. Time for consuming X cc of fuel consumption
    e. Time for collecting Y ml of water
    f. Outlet water temperature
9. Repeat the above procedure at different mass flow rate of cooling water by closing the cooling water valve in steps.
10. Turn off the fuel knob provided on the panel after the test.

RESULT

INFERENCE

OBSERVATIONS & TABULAR COLUMN

T3 = Water Outlet Temperature

Sl. No	Load on the brake drum (W kg)			Time for consuming X cc of fuel (sec)	Time for collecting Y ml of water (sec)	Mass flow rate of water kg/sec	T3 (^{0}C)	B.P kW	TFC Kg/sec	HI kW	BSFC Kg/kW-hr	η BTH %
	Load on hanger W1 kg	Spring balance reading W2 kg	Actual Load W= W1-W2 kg									
1												
2												
3												
4												

SAMPLE CALCULATIONS:

1. Maximum load calculation:

$$Rated\ Power, P = \frac{2\pi N W_{max} R_e g}{60 \times 1000}\ kW$$

$$W_{max} = \frac{Rated\ Power \times 60 \times 1000}{2\pi N R_e g}$$

Where,

$N = Rated\ speed\ in\ rpm$

$W_{max} = Maximum\ load\ in\ kg$

$R_e = Effective\ brake\ drum\ radius\ (R + d)$

$R = Drum\ Radius =$ mm

$d = Diameter\ of\ rope =$ mm

$g = acceleration\ due\ to\ gravity = 9.81\ m/s^2$

2. Brake power (BP)

$$Brake\ power\ BP = \frac{2\pi NT}{60 \times 1000}\ kW$$

Where,

$N = Rated\ speed\ in\ rpm$

$T = Torque\ on\ engine = (W + W_0)R_e g$

$W_0 = weight\ of\ hanger = 1\ kg$

$W = Load\ on\ the\ \ brake\ drum$

$R_e = Effective\ brake\ drum\ radius\ (R + d)$

$R = Drum\ Radius =$ mm

$d = Diameter\ of\ rope =$ mm

$g = acceleration\ due\ to\ gravity = 9.81\ m/s^2$

3. Total Fuel Consumption (TFC)

$$TFC\ (m_f) = \frac{X}{t \times 10^6} \times\ Density\ of\ fuel \quad kg/sec$$

Where,

$X = amount\ of\ fuel\ consumed\ in\ cc$

$t = Time\ for\ consuming\ X\ cc\ of\ fuel$

4. Heat input (HI)

HI = TFC × CV kW

CV = Calorific Value of Fuel in kJ/kg

5. Brake Specific Fuel Consumption (BSFC)

$$BSFC = \frac{TFC\ X\ 3600}{BP}\ \text{kg/kW-hr}$$

6. Brake Thermal Efficicency (η BTH)

$$\eta_{\text{BTH}} = \frac{BP}{HI}\ X\ 100$$

ELECTRICAL ENGINEERING PRACTICE

INTRODUCTION:

Electric power is supplied for commercial and residential use in three phases with a neutral. Some of the low power consumption residential connections will have only a single phase with a neutral. The single-phase AC supply is 230V but a three-phase supply is 440V.

SAFETY MEASURES

1. Use approved tools, equipment's and protective devices.

2. Do not work under poor light or when you are tired.

3. Do not work in damp areas or in wet shoes or clothes.

4. Keep tools and equipment's clean and in good working condition.

5. Read all instructions carefully before using the appliances.

6. To prevent electrical hazards, DO NOT immerse appliances in water or other liquids.

7. Always unplug an appliance before cleaning, or whenever it is not in use. Ensure that you pull by the plug and not the cord.

8. DO NOT operate any appliance with a damaged cord or plug.

9. Always use an appliance on a dry, level surface.

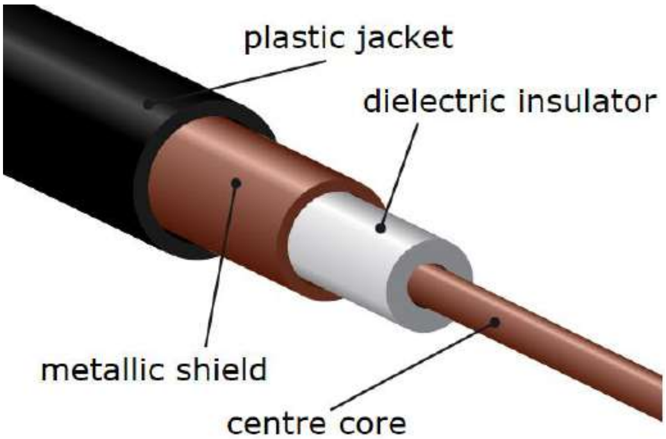
10. Keep appliances away from heated surfaces and open flames.

11. Check the electric power supply from the switch position

Expt: 1 Study of different types of cables, switches, fuses, MCB, ELCB and MCCB

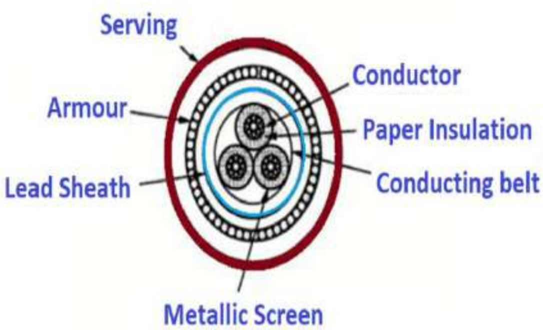
High Voltage cable (HV cable)

A high-voltage cable (HV cable) is a cable used for electric power transmission at high voltage. A cable includes a conductor and insulation. Cables are considered to be fully insulated. This means that they have a fully rated insulation system that will consist of insulation, semi-con layers, and a metallic shield. This is in contrast to an overhead line, which may include insulation but not fully rated for operating voltage (EG: tree wire). High-voltage cables of differing types have a variety of applications in instruments, ignition systems, and alternating current (AC) and direct current (DC) power transmission.



Three Core Cable

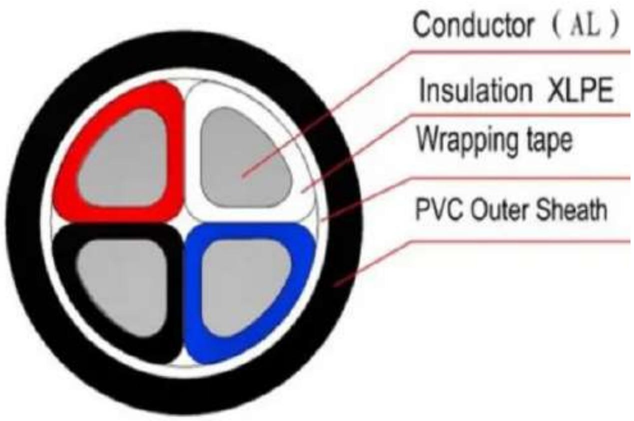
These cables are used generally for a perfect balanced 3 phase system. When the currents on the 3 live wires of a 3 phase system are equal and exact 120º phase angle, then the system is said to be balanced. The 3 phase loads are identical in all respects with no need of a neutral conductor.



Four Core Cable

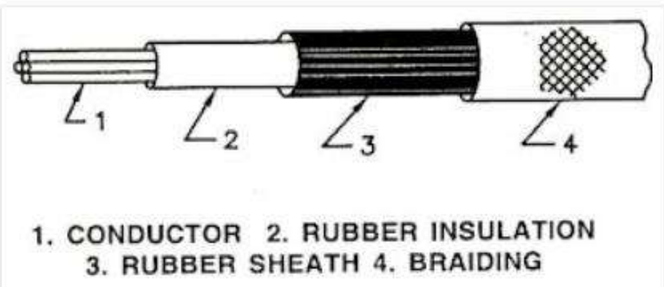
When there is severe out-of-balance conditions, the amount of fault current will raise to a very high level. Generally in the case of linear loads, the neutral only carries the current due to imbalance between the phases.

The non-linear loads such as switch-mode power supplies, computers, office equipment, lamp ballasts and transformers on low loads produce third order harmonic currents which are in the phase of all the supply phases. These currents do not cancel at the star point of a three-phase system as do normal frequency currents, but add up, so that the neutral carries very heavy third harmonic currents.



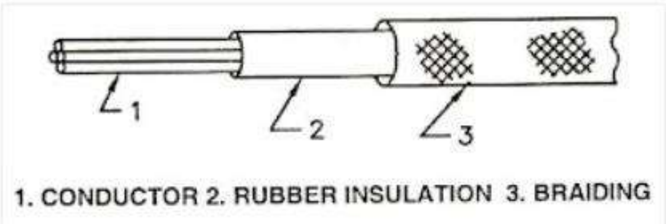
C.T.S (Cab Type Sheathed) or T.R.S Wires (Tough Rubber Sheathed)

These C.T.S or T.R.S wires consists of vulcanized rubber insulated conductor. This insulation layer is covered by a layer made of tough rubber (or) tough rubber sheathed covering is provided over this insulation layer. This covering will be very hard and protects the wire from moisture and provides mechanical strength to the wire. These wires are available in single core, twin core, triple core etc. These are available in 1/18, 3/20, 7/20, 7/16 etc sizes. These wires are used for batten wiring. As these wires have tough rubber covering no additional protection or strength is required.



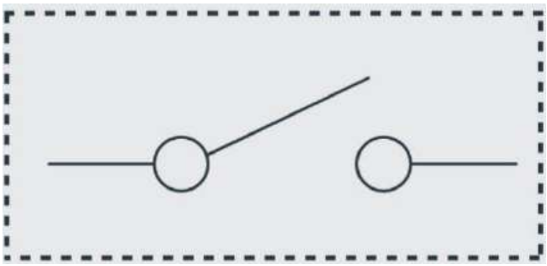
V.I.R Wires (Vulcanized Indian Rubber)

These consists of a copper conductor covered with a insulation layer of Vulcanized Indian Rubber (VIR). A cotton tape covering is provided over this insulation layer to protect the wire from moisture and to provide mechanical strength to the wire. The thickness of the Vulcanized Indian Rubber depends on the voltage. These type of wires are used in 250V CTS wiring, casing or capping or cleat wiring and conduit wiring. VIR wires are available in sizes like 1/18, 3/20, 7/20, 7/16 and 19/16. Here a 3/20 wire means numerator 3 denotes the number of conductors used and the denominator 20 denotes the gauge of each conductor. Based on this gauge number count the diameter of any conductor can be determined.



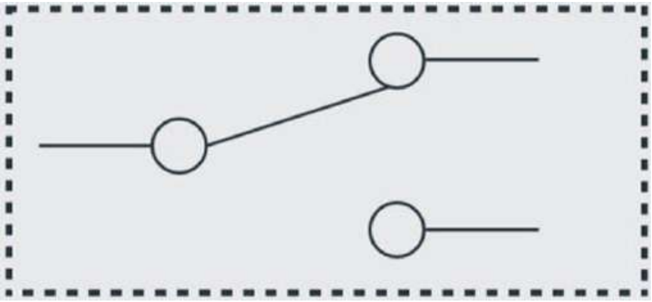
Single Pole Single Throw Switch (SPST)

This is the basic ON and OFF switch consisting of one input contact and one output contact. It switches a single circuit and it can either make (ON) or break (OFF) the load. The contacts of SPST can be either normally open or normally closed configurations. This switch has three terminals: one is input contact and remaining two are output contacts.



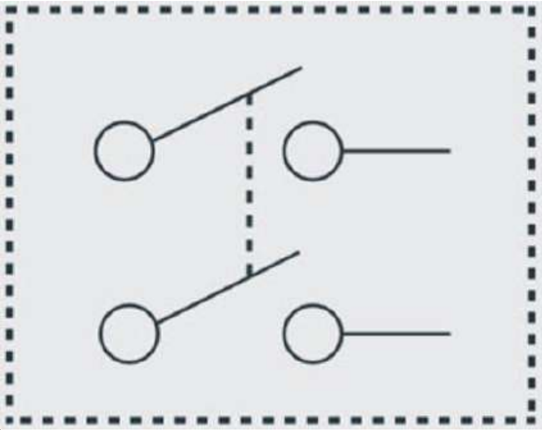
Single Pole Double Throw Switch (SPDT)

It consists of two ON positions and one OFF position. In most of the circuits, these switches are used as changeover to connect the input between two choices of outputs. The contact which is connected to the input by default is referred as normally closed contact and contact which will be connected during ON operation is a normally open contact.



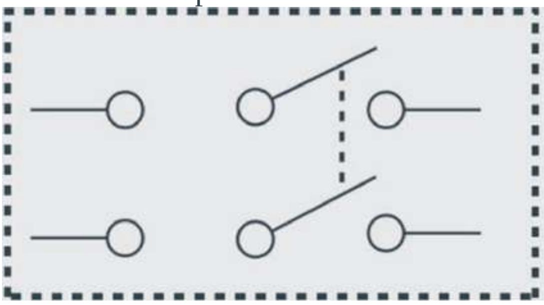
Double Pole Single Throw Switch (DPST)

This switch consists of four terminals: two input contacts and two output contacts. It behaves like a two separate SPST configurations, operating at the same time. It has only one ON position, but it can actuate the two contacts simultaneously, such that each input contact will be connected to its corresponding output contact. In OFF position both switches are at open state. This type of switches is used for controlling two different circuits at a time. Also, the contacts of this switch may be either normally open or normally closed configurations.



Double Pole Double Throw Switch (DPDT)

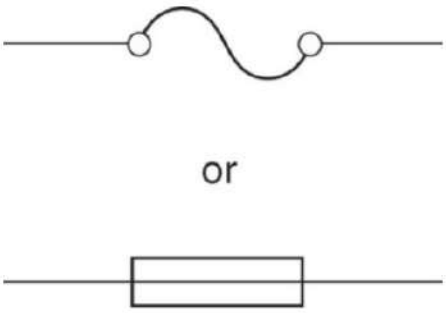
This is a dual ON/OFF switch consisting of two ON positions. It has six terminals, two are input contacts and remaining four are the output contacts.It behaves like a two separate SPDT configuration, operating at the same time. Two input contacts are connected to the one set of output contacts in one position and in another position, input contacts are connected to the other set of output contacts.



Fuse and Fuse Carriers

A fuse is an electrical safety device that operates to provide overcurrent protection of an electrical circuit. Its essential component is a metal wire or strip that melts when too much current flows through it, thereby stopping or interrupting the current. It is a sacrificial device; once a fuse has operated it is an open circuit, and must be replaced or rewired, depending on its type.

Fuses have been used as essential safety devices from the early days of electrical engineering. Today there are thousands of different fuse designs which have specific current and voltage ratings, breaking capacity, and response times, depending on the application. The time and current operating characteristics of fuses are chosen to provide adequate protection without needless interruption. Wiring regulations usually define a maximum fuse current rating for particular circuits. Short circuits, overloading, mismatched loads, or device failure are the prime or some of the reasons for fuse operation. When a damaged live wire makes contact with a metal case that is connected to ground, a short circuit will form and the fuse will melt.



Cartridge fuse

Cartridge fuse is a fast type of safety device that is used to protect cables, power lines, and equipment against overloads and short circuits in electrical systems. The main function of a cartridge fuse is to protect systems and human life. Cartridge fuse is made of ceramic, porcelain, or glass.

Kit Kat Fuse

It is a semi-enclosed fuse, which is also considered a rewireable fuse. This fuse is mainly designed for domestic wiring and small scale usage. There are two parts in kit kat fuse – fuse wire and fuse base. The range is available from 16A to 500A with standard handle and lugs variants. Kit Kat Fuse requires little to almost no maintenance throughout its serving life.

MCB

An electric current requires two wires to complete the circuit : From source via the in wire to the load and from there via the out wire back to the electrical source. The current in these two wires should always be identical. When an electrical leak to earth occures, these two currents are no longer identical. In the MCB both currents are run through 2 small coils, mounted in such way that the magnetic fields produced are annihilating each other. A small mechanical switch mounted near these coils trips however when the fields are no longer identical, and therefore result in an electromagnetical field.(earth leak protection) The system is further wired in such a way that by abnormal high currents the switch also trips (short circuit protection). Note that MCB's have a max. Current above which tripping occures. An MCB, therefore, has two forms of over current protection build into its mechanism. To protect against overload currents, it has a thermal device (bimetallic strip) which will trip the mechanism once it reaches a set temperature. To protect against shortcircuit currents, it has an electromagnetic device (electromagnet) which will trip the mechanism when the flux density reaches a set point power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter.

MCCB

MCCB stands for Molded Case Circuit Breaker. It is another type of electrical protection device which is used when load current exceeds the limit of a miniature circuit breaker. The MCCB provides protection against overload, short circuit faults and is also used for switching the circuits. It can be used for higher current rating and fault level even in domestic applications. The wide current ratings and high breaking capacity in MCCB find their use in industrial applications. MCCB can be used for protection of capacitor bank, generator protection and main electric feeder distribution. It offers adequate protection whenever an application requires discrimination, adjustable overload setting or earth fault protection.

Earth Leakage Circuit Breaker or ELCB

An Earth-leakage circuit breaker (ELCB) is a safety device used in electrical installations (both residential and commercial) with high Earth impedance to prevent electric shocks. It detects small stray voltages on the metal enclosures of electrical equipment, and interrupts the circuit if a dangerous voltage is detected. ELCBs help detect current leaks and insulation failures in the electrical circuits that would cause electrical shocks to anyone coming into contact with the circuit.

Earth Leakage Circuit Breaker

Name	**Ratings**	**Uses**
MCB	0-63 A	Light, Fan
ELCB	0-2500 A	Earth leakage Sensing/ Protection from shock
MCCB	0-1000 A	Main Power controlling

Expt.2 HOUSE SERVICE CONNECTION

Aim: To prepare residential wiring of power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter.

Apparatus Required:

1.One way Switch

2.Energy Meter

3.ELCB

4.Lamp

5.Wires

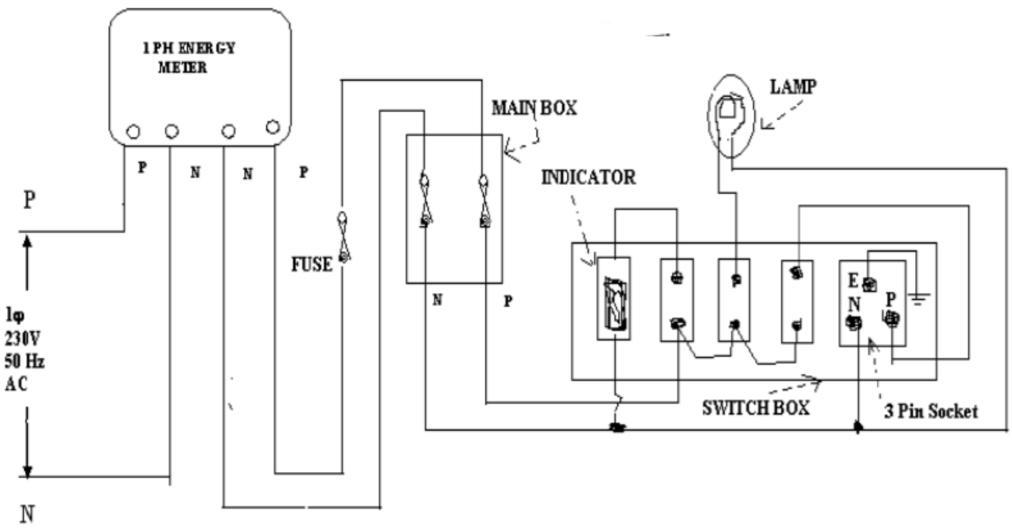
Procedure:

1. Connections are given as per the circuit diagram.

2. When the Switch is closed, the Lamp will glow and the metering is running.

3. The corresponding readings are noted from energy meter by observing number of cycles of the disc for a particular time period.

Circuit Diagram



House Service Connection

Result: The residential wiring is implemented and tested for its operation.

Expt.3 ONE LAMP CONTROLLED BY ONE SWITCH

AIM:- To wire up a circuit in conduit system one lamp controlled by one switch

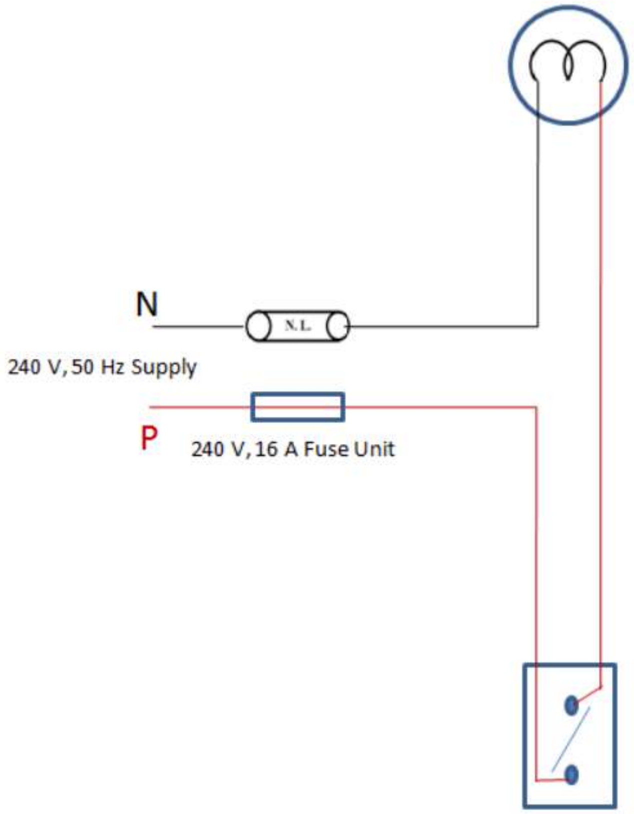
TOOLS AND INSTRUMENTS REQUIRED

1. Steel rule 300mm
2. Combination Plier 200mm
3. Electricians Knife
4. Screw driver 200mm, 10mm tip
5. Ball peen hammer 220gm
6. Gimlet 25mm
7. Neon tester 0-500V
8. Wire stripper
9. Firmer chisel 5/8”

PROCEDURE:-

1. Draw the lay out and connection diagram.
2. Collect the required wiring materials.
3. Connect the required materials on the work board as per connection diagram.
4. Check the circuit for continuity.
5. Given the supply to the circuit after checking.
6. Completed the work neatly and correctly.

Circuit Diagram



RESULT:- Wired up a circuit in conduit system one lamp controlled by one switch

Expt.4 STAIR CASE WIRING

Aim: To wire for a stair case arrangement using a two-way switch.

Tool Required: 1. Screw driver

2. Hammer

3. Pliers

4.Line tester

Components Required: 1. Two-way switches

2. Bulb holders

3. Bulbs

4. Joint clips

5. Wires

6. Screws

7. Ceiling rose

8. Switch board

Theory:

A two switch is installed near the first step of the stairs. The other two way switch is installed at the upper part where the stair ends. The light point is provided between first and last stair at an adequate location and height if the lower switch switches on the light. The switch at the top or vice versa can switch it off. Two number of two way switches are used for the purpose. The supply is given to the switch at the short circuited terminals. The connection to the light point is taken from the similar short circuited terminal of the second switch; other two independent terminals of each circuit are connected through cable.

Procedure:

1. Mark switch and bulb location points and draw lines for wiring on the wooden Board.

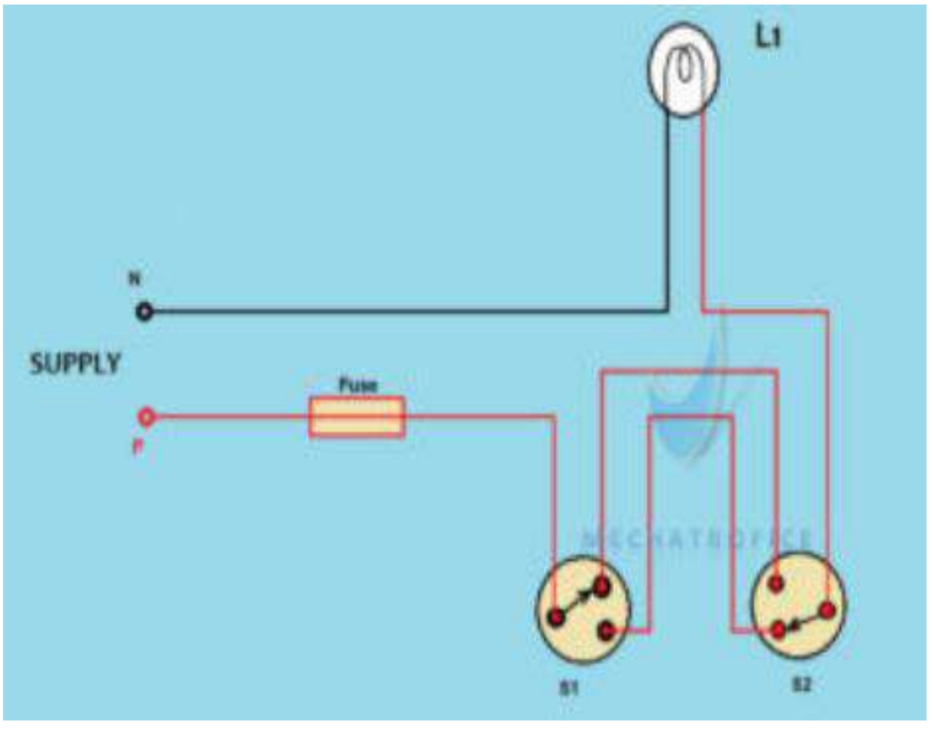
2. Place wires along the lines and fix them with the help of clips.

3. Fix the two-way switches and bulb holder in the marked position on the wooden Board.

4. Complete the wiring as per the wiring diagram.

5. Test the working of the bulbs by giving electric supply to the circuit.

Circuit Diagram



Stair case wiring

SWITCH POSITION		LAMP CONDITION
SWITCH- 1	SWITCH- 2	
OFF	OFF	OFF
ON	OFF	ON
OFF	ON	ON
ON	ON	OFF

Result: The staircase wiring is completed and tested.

Expt.5 FLUORESCENT LAMP WIRING

Aim: To prepare wiring for a fluorescent tube light with switch control.

Tools Required: 1. Screw driver

2. Hammer
3. Pliers
4. Line tester

Components Required: 1. Switch

2. Tube light with fitting
3. Joint clips
4. Wires
5. Screws
6. Switch board

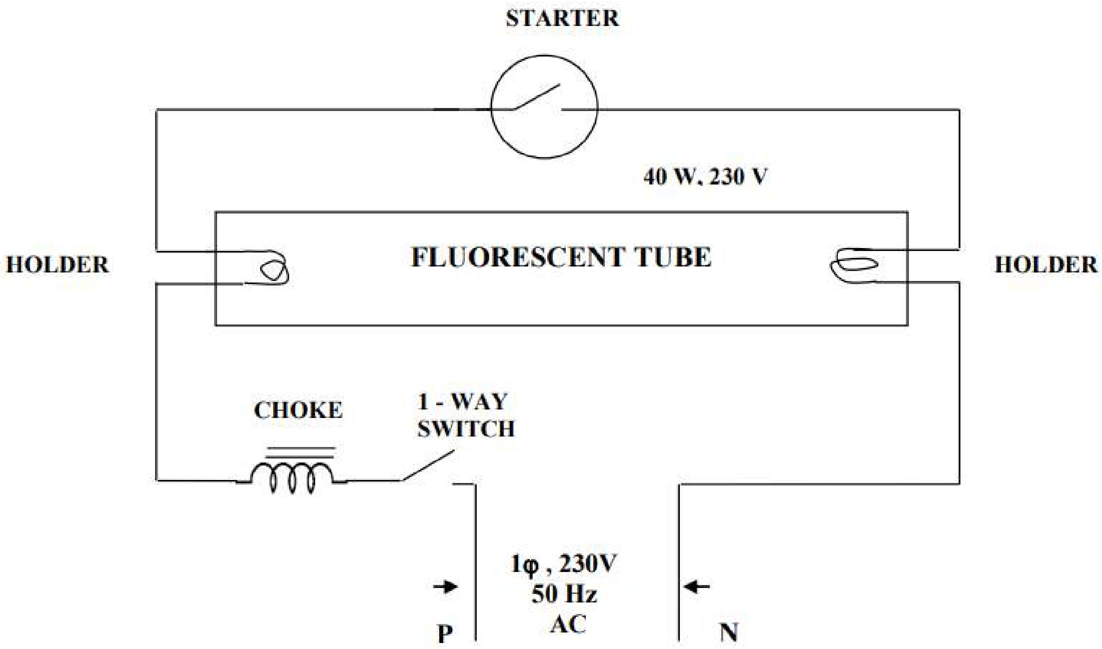
Working of the Fluorescent Tube Light:

The fluorescent lamp circuit consists of a choke, a starter, a fluorescent tube and a frame. The length of the commonly used fluorescent tube is 100 cm; its power rating is 40 W and 230V. The tube is filled with argon and a drop of mercury. When the supply is switched on, the current heats the filaments and initiates emission of electrons. After one or two seconds, the starter circuit opens and makes the choke to induce a momentary high voltage surge across the two filaments. Ionization takes place through argon and produces bright light.

Procedure:

1. Mark the switch and tube light location points and draw lines for wiring on the wooden board.
2. Place wires along the lines and fix them with the help of clips.
3. Fix the switch and tube light fitting in the marked positions.
4. Complete the wiring as per the wiring diagram.
5. Test the working of the tube light by giving electric supply to the Circuit.

CIRCUIT DIAGRAM



TUBE LIGHT

Result: The wiring for the tube light is completed and tested.

Expt .6 Study of Earthing

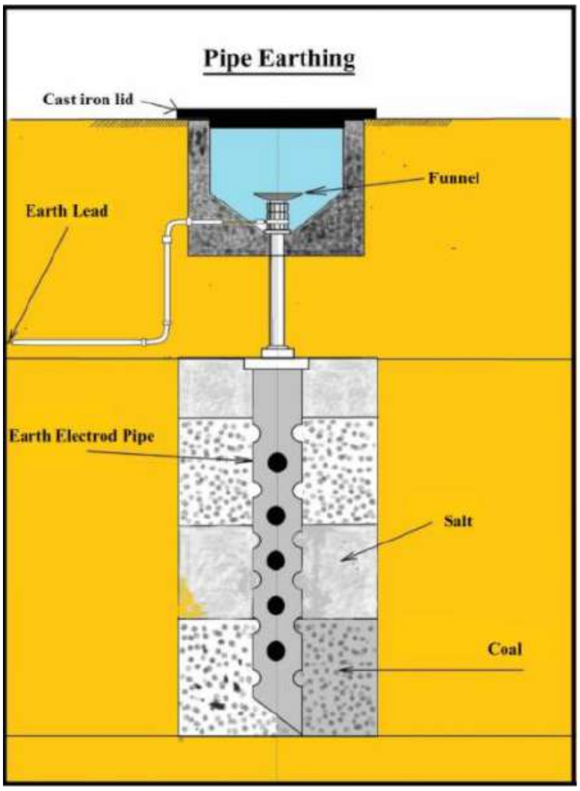
The process of transferring the immediate discharge of the electrical energy directly to the earth by the help of the low resistance wire is known as the electrical earthing. The electrical earthing is done by connecting the non-current carrying part of the equipment or neutral of supply system to the ground.

Mostly, the galvanised iron is used for the earthing. The earthing provides the simple path to the leakage current**.** The short circuit current of the equipment passes to the earth which has zero potential. Thus, protects the system and equipment from damage.

There are several common methods employed for earthing of appliances and each of them is used type and number of appliances according to the site of the building, the type and number of appliances to be earthed, the budget and other factors. Here are few of them.

1.Pipe Earthing

A galvanized steel and a perforated pipe of approved length and diameter is placed vertically in a wet soil in this kind of system of earthing. It is the most common system of earthing. The size of pipe to use depends on the magnitude of current and the type of soil. The dimension of the pipe is usually 40mm (1.5in) in diameter and 2.75m (9ft) in length for ordinary soil or greater for dry and rocky soil. The moisture of the soil will determine the length of the pipe to be buried but usually it should be 4.75m



2.Plate Earthing

In this type of earthing, a plate made up of galvanized copper or iron is buried vertically at a depth of not less than 3m from ground level. The earth plate is inserted into auxiliary layers of coke and salt for a minimum thickness of 15 cm. The earth wire (GI or copper wire) is tightly bolted to an earth plate with the help of nut or bolt. The copper plate and copper wire are usually not employed for grounding purposes because of their higher cost.