Lab Manual

for

MECHANICAL ENGINEERING LABORATORY

(ME F215/ MF F215)

Edited By

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PILANI – 333 031 (RAJASTHAN)

2013

Preface

The manual is derived from the EDD notes of TA C222 Measurement Techniques-II. Apart from some experiments which are the same as prescribed in the above notes, there are few additional experiments which are beneficial for the Mechanical and Manufacturing Engineering students. The efforts are made to include theoretical concepts behind each experiment in the preparation of this manual. We feel that this would equip the student with sufficient knowledge to conduct the experiments. We would like to hear any suggestions or constructive feedback for further development of the manual.

We wish to express our sincere thanks to Prof. K. S. Sangwan, HOD Mechanical and Manufacturing Engineering Department and Prof. M. S Dasgupta for their guidance and encouragement in preparation of this manual. We would like to thanks our higher degree students Mr. Sidharth Khare, Mr. Subhash Bhosle, Ms Vasudha Batra, Mr. Aswan, Abdul Razak and Mr. K. Lakshminarayana for helping us in preparation of this laboratory manual. We also thank Mr. Harish Soni, Mr. Jangvir and Mr. R. Yadav for helping in conducting and validating the experiments.

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EXPERIMENTS

SOLID MECHANICS/MATERIALS TESTING CYCLE

ME-1

MEASUREMENT OF MODULUS OF ELASTICITY

OBJECTIVE:-

To measure tensile strain by Ewing's extensometer during tension test on an M.S specimen and to determine the value of modulus of elasticity.

APPARATUS:-

50 Ton 'Amsler' Hydraulic testing Machine, Ewing's extensometer, 0.8 inch diameter M.S. test specimen, marking gauge and micrometer screw gauge.

THEORY:-

If a bar of steel is pulled at its ends, with the application of force, it is elongated. Various m/c and structure components are subjected to tensile loading in numerous application. For safe design of these components, there ultimate tensile strength and ductility is to be determined before actual use. Tensile test can be conducted on UTM. A material when subjected to a tensile load resists the applied load by developing internal resisting force. These resistances come due to atomic bonding between atoms of the material. The resisting force for unit normal cross-section area is known as stress.

The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength. The end of elastic limit is indicated by the yield point (load). This can be seen during experiment as explained later in procedure with increase in loading beyond elastic limit original cross-section area goes on decreasing and finally reduces to its minimum value when the specimen breaks.

TEST SET-UP

The tensile test is conducted on UTM. It is hydraulically operates a pump, oil in oil sump, load dial indicator and central buttons. The left has upper, middle and lower cross heads i.e; specimen grips (or jaws). Idle cross head can be moved up and down for adjustment. The pipes connecting the lift and right parts are oil pipes through which the pumped oil under pressure flows on left parts to more the cross-heads.

PROCEDURE:

1. Fix the M.S. specimen in the marking gauge, symmetrically with respect to its length. Mark the gauge length of 8 inches correct to 0.01 inch.
2. Using a micrometer screw gauge, determine the diameter of the M.S. specimen at five different locations within the gauge length. Determine the average of these reading to find the area of cross-section.
3. Firmly grip the upper end of the specimen in the movable cross-head of the testing machine. Grip the lower end of the specimen in the bottom cross-head, after adjusting the required height.
4. Determine the least count of the extensometer and attach it firmly to the specimen.
5. Run the hydraulic testing machine at the slowest for applying load to the specimen, make simultaneous record of the observations of load and extension, without stopping the machine.
6. Load is applied until the specimen fails.

OBSERVATION :-

Gauge length of specimen l = ------mm.

Least count of extensometer= 0.0002 inch

Diameter of specimen d = 0.8 inches =

Area of cross section of specimen =

OBSERVATION TABLE

S No.	Load on specimen (T)	Stress (T/in^2)	Extensometer reading (division)	Strain X 10^{-5}

RESULT:-

The Young’s modulus of the given specimen = -------GPa

PRECAUTIONS:-

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the compression plates.
3. Take reading carefully.
4. After failed specimen stop to m/c.

ME-2

MEASUREMENT OF MODULUS OF ELASTICITY

OBJECTIVE:-

To measure bending strain by dial-gauge indicator during bending test on Aluminium specimen and determine the value of modulus of elasticity.

APPARATUS :-

Strain Indicator (με), Aluminium Specimen, Weights Nos.6(each 5 Kg), Vernier Caliper, Dial Gauge

THEORY :-

Bending test is perform on beam by using the three point loading system The loading is held in the middle. At a particular load the deflection at the center of the beam is determined by using a dial gauge.

In engineering mechanics, bending (also known as flexure) characterizes the behavior of a slender structural element subjected to an external load applied perpendicular to an axis of the element. When the length is considerably larger than the width and the thickness, the element is called a beam.

Simple beam bending is often analyzed with the Euler-Bernoulli beam equation. The classic formula for determining the bending stress in a member is:

$$\sigma = \frac{My}{I_{xx}}$$

Where:

σ is the bending stress

M the moment about the neutral axis

y the perpendicular distance to the neutral axis

Ixx the area moment of inertia about the neutral axis x

PROCEDURE :

1. Measure the length, width and thickness of test piece, by vernier caliper.
2. Place the bending fixture on the lower cross head of the testing m/c.
3. Place the test piece on the rollers of the bending fixture.

4. By loading the dial gauge in a stand, make its spindle knob the test piece.
5. Start the m/c and note down the load and dial gauge readings.
6. Plot the graph between load and deflection.

OBSERVATION :-

Least count of dial-gauge indicator = 0.1 mm

Length of beam (L) =

Width of beam (b) = ------

Thickness of beam (t) = ------

OBSERVATION TABLE:-

Sl no.	Load on specimen (Kg)	Stress (Kg/cm^2)	Dial gauge indicator reading	Strain X 10^{-5}

CALCULATION :-

$$\sigma = \frac{My}{I_{xx}}$$

$$I_{xx} = \frac{bh^3}{12}$$

$$y = \frac{t}{2}$$

$$E = \frac{11l^3}{568I}\left(\frac{w}{\delta}\right)$$

RESULT :- The Young's modulus of the given specimen = -------GPa

ME-3

COMPRESSION TEST

OBJECTIVE:-

To Perform compression test on UTM.

APPARATUS :-

A UTM or A compression testing m/c, cylindrical or cube shaped specimen of cast iron, Alumunium or mild steel, vernier caliper, liner scale, dial gauge (or compressometer).

THEORY :-

Several m/c and structure components such as columns and struts are subjected to compressive load in applications. These components are made of high compressive strength materials. Not all the materials are strong in compression. Several materials, which are good in tension, are poor in compression. Contrary to this, many materials poor in tension but very strong in compression. Cast iron is one such example. That is why determine of ultimate compressive strength is essential before using a material. This strength is determined by conduct of a compression test.

Compression test is just opposite in nature to tensile test. Nature of deformation and fracture is quite different from that in tensile test. Compressive load tends to squeeze the specimen. Brittle materials are generally weak in tension but strong in compression. Hence this test is normally performed on cast iron, cement concrete etc. But ductile materials like aluminium and mild steel which are strong in tension, are also tested in compression.

TEST SET-UP, SPECIFICATION OF M/C AND SPECIMEN DETAILS :

A compression test can be performed on UTM by keeping the test-piece on base block and moving down the central grip to apply load. It can also be performed on a compression testing machine. A compression testing machine has two compression plates/heads. The upper head moveable while the lower head is stationary. One of the two heads is equipped with a hemispherical bearing to obtain. Uniform distribution of load over the test-piece ends. A load gauge is fitted for recording the applied load.

SPECIMEN :-

In cylindrical specimen, it is essential to keep $h/d \leq 2$ to avoid lateral instability due to

bucking action. Specimen size = $h \leq 2d$.

PROCEDURE :-

1. Dimension of test piece is measured at three different places along its height/length to determine the average cross-section area.
2. Ends of the specimen should be plane . for that the ends are tested on a bearing plate.
3. The specimen is placed centrally between the two compression plates, such that the centre of moving head is vertically above the centre of specimen .
4. Load is applied on the specimen by moving the movable head.
5. The load and corresponding contraction are measured at different intervals.
6. Load is applied until the specimen fails.

OBSERVATION :-

Initial length or height of specimen h = ------mm.

Initial diameter of specimen do = ------------mm.

Applied load (P) in Newton =

Recorded change in length (mm)=

CALCULATION :-

Original cross-section area Ao = -----

Final cross-section area Af = --------

Stress = -------

Strain = -------

Draw stress-strain (ζ-ε) curve in compression,

Determine Young's modulus in compression

RESULT :-

The Young's modulus of the given specimen = -------GPa

PRECAUTIONS :-

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the compression plates.
3. Take reading carefully.
4. After failed specimen stop to m/c.

ME-4

BRINELL HARDNESS TEST

OBJECTIVE:

To measure the hardness of the given samples and to correlate them with the Ultimate Tensile Strength (UTS) of the materials using Brinell Hardness Testing Machine.

ACCESSORIES:

Power operated Brinell Hardness Testing Machine, Brinell microscope and Steel ball indenters of 10 mm & 5 mm Ball and specimens (MS, Brass, Aluminium, CI, Broken HSS bits).

THEORY:

Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear identification of strength. In all hardness testes, a define force is mechanically applied on the test piece for about 15 seconds. The indentor, which transmits the load to the test piece, varies in size and shape for different tests. Common indenters are made of hardened steel or diamond. In Brinell hardness testing, steel balls are used as indentor. Diameter of the indentor and the applied force depend upon the thickness of the test specimen, because for accurate results, depth of indentation should be less than 1/8th of the thickness of the test pieces. According to the thickness of the test piece increase, the diameter of the indentor and force are changed.

The following formula is used to calculate the BHN for a given specimen :

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

where, D= Diameter of the ball

P= Load applied

d= Diameter of the indentation

PROCEDURE:

1. Insert ball of dia ‘D’ in ball holder of the m/c.

2. .Make the specimen surface clean by removing dust, dirt, oil and grease etc.
3. Make contact between the specimen surface and the ball by rotating the jack adjusting wheel.
4. Push the required button for loading.
5. Pull the load release level and wait for minimum 15 second. The load will automatically apply gradually.
6. Remove the specimen from support table and locate the indentation so made.
7. View the indentation through microscope and measure the diameter ‘d’ by micrometer fitted on microscope.
8. Repeat the entire operation, 3-times.

OBSERVATIONS:

Materials given =

Diameter of Indenter (D) =

Type of Indenter =

Load applied (P) = Kg

S.No	Material	Diameter of the indentation (d) mm

CALCULATION :-

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

RESULT:-

PRECAUTION:-

1. At least two preliminary tests should be performed before beginning any measuring, in order to acclimatize the indenter, raising/lowering screw, and specimen platform.
2. Ensure that contact surfaces such as the indenter attachment face, between the specimen and specimen platform, and between the specimen platform and raising/lowering screw are continually maintained in a clean state.
3. Wipe all contact surfaces thoroughly with a clean cloth before performing tests.
4. The specimen measurement location must be spaced at least 4d (where d is the indentation diameter) from the center of indentations already present.

ME-5

ROCKWELL HARDNESS TEST

OBJECTIVE:

To measure the hardness of the given samples and to correlate them with the Ultimate Tensile Strength (UTS) of the materials using Rockwell Hardness Testing Machine.

ACCESSORIES:

Direct Reading Rockwell Hardness Testing Machine, Diamond cone and Steel ball indenters and specimens (MS, Brass, Aluminium, CI, Broken HSS bits).

THEORY:

The Rockwell test for hardness consists of the application of a hard indenter of known Diamond under a known load for the specified time period, to the surface of specimen under test and the Rockwell Hardness of material by measuring the depth of penetration of standard indenters under standard loading conditions, and gives a visible indication of degree of hardness according to establishes scales. The dial indicator eliminates the requirement of a microscope for measuring the indentation.

The following table gives the standard loads and scales used:

Scale Symbol	Indenter	Minor Load (Kg)	Major Load (Kg)
A	Diamond Cone	10	50
B	Steel Ball	10	90
C	Diamond Cone	10	140

PROCEDURE:

1. The specimen is placed on the table and the table is raised by rotating the hand wheel clockwise until contact is made with the indenter.
2. Continue rotating the hand wheel until the small indicator on the dial indicates “Set” and the main indicator is approximately vertical i.e. rotate the dial itself until the SET (i.e. C.0 and B.30) position coincides with the main indicator.
3. In the preliminary setting operation as the minor load of 10 kg is applied automatically, the major load P is applied by pushing back lever on the right hand side of the machine to its full extent.
4. As soon as the reading of the depth indicator becomes steady the major load is removed by gently raising the hand lever and the hardness degree may then be read from scale B or scales C as the case may be.
5. The initial load may be removed by rotating the hand wheel anti clockwise and lower the elevating screw to facilitate the removal of the specimen without damaging the indenter.

OBSERVATIONS:

Materials given =

Diameter of Indenter = mm

Type of Indenter =

Load applied (P) = Kg

Reading of scale B or C =

Rockwell Hardness =

Sl. No	**Material**	**e (=100-E)**

RESULT:-

PRECAUTION :-

1. At least two preliminary tests should be performed before beginning any measuring, in order to acclimatize the indenter, raising/lowering screw, and specimen platform.
2. Ensure that contact surfaces such as the indenter attachment face, between the specimen and specimen platform, and between the specimen platform and raising/lowering screw are continually maintained in a clean state.
3. Wipe all contact surfaces thoroughly with a clean cloth before performing tests.
4. The specimen measurement location must be spaced at least 4d (where d is the indentation diameter) from the center of indentations already present.

ME-6

VICKER’S HARDNESS TEST

OBJECTIVE:

To measure the hardness of the given materials using Vicker’s Hardness Testing Machine.

ACCESSORIES:

Vicker’s Hardness Testing Machine, Diamond pyramid indenter and specimens (MS, Brass, Aluminum, CI, Broken HSS bits).

THEORY:

The Vickers hardness test uses a square base diamond pyramid as the indenter. The included angle between the opposite faces of the pyramid is l36° as shown in fig 1. The Vickers hardness tester operates on the same basic principle as the Brinell tester, the numbers being expressed in the terms of load and area of the impression. As a result of the indenter’s shape, the impression on the surface of the specimen will be a square. The length of the diagonal of the square is measured through a microscope fitted with an ocular micro meter that contains movable knife edges. The Vickers hardness values are calculated by the formula:

$$HV = \frac{2F \sin\left(\frac{\alpha}{2}\right)}{d^2} = \frac{1.8544\ F}{d^2}$$

where F is the applied load in kg, α is the included angle between opposite faces of indenter and d is average length of the diagonal in mm as shown in fig 2.

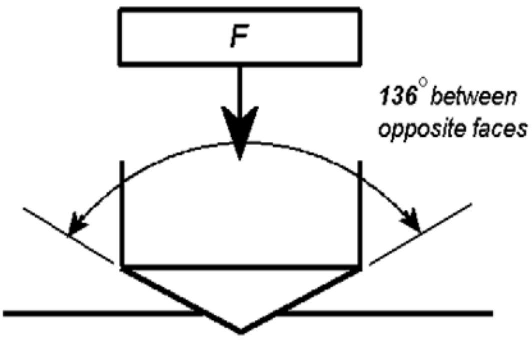


Fig. 1

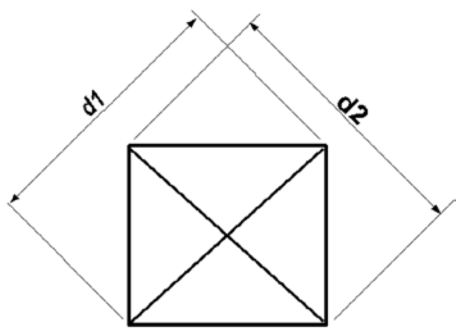


Fig. 2

The Vickers hardness should be reported like 800 HV/10, which means a Vickers hardness of 800, was obtained using a 10 kgf test force. The advantages of the Vickers hardness test are that extremely accurate readings can be taken, and just one type of indenter is used for all types of metals and surface treatments. The Vickers method is capable of testing the softest and hardest of materials, under varying loads.

PROCEDURE:

1. The hardness tester is to connect with the power supply by the main switch. The light projector flashes up.
2. The corresponding push button is to be pushed for the desired loading. If a loading was previously applied which differs fundamentally from the desired one or the method of testing is changed, it might become necessary to set the loading velocity new. This can be achieved by regulating the knurl nut altering the passage drilling inside of the piston of the oil brake. If the loading wants to be applied slowly on the specimen, the knurl nut must be screwed to the right. By a left turn of the knurl nut a faster application of the loading is achieved.
3. The hand wheel is turned to the right and the specimen, resting on the table is moved upwards so long until the surface shows distinctly on the focussing screen. After this the clamping sleeve is clamped by hand against the specimen in that way that at repeated driving against the specimen a moderate pre-loading of this is achieved. For bulky or jutting specimen a powerful pre-loading must be chosen.
4. By pushing the button the optic disconnects automatically while the indenter connects. The adjusted loading, which is intended to act on the specimen, must be applied in about 15 seconds.
5. After completion of testing time the hand lever must be pressed down. The specimen is released of the test load, the hardness impression is projected on the focussing screen.
6. The evaluation of the impressions takes place by means of an inserted projecting device, measuring two diagonals vertically up on each others. The mean value serves to calculate the hardness number by using the above mentioned formula.

OBSERVATIONS:

Materials given =

Type of indenter =

Load on specimen = Kgf

Sl. No	Length of diagonal d1 (mm)	Length of diagonal d2 (mm)	Avg. length of diagonal d= (d1+d2)/2

RESULTS :

Vicker's Hardness Number =

Ultimate Tensile Strength of the specimen =

PRECAUTION :

1. When doing the hardness tests the minimum distance between indentations and the distance from the indentation to the edge of the specimen must be taken into account to avoid interaction between the work-hardened regions and effects of the edge.

Wipe all contact surfaces thoroughly with a clean cloth before performing tests.

ME-7

IZOD IMPACT TEST

OBJECTIVE:-

To study the Impact Testing m/c and Perform Izod impact test.

APPARATUS :-

Impact testing m/c, Izod test specimens of mild steel, Aluminium, copper, Vernier calliper, specimen setting fixture.

THEORY :-

In manufacturing locomotive wheels, coins, connecting rods etc. the components are subjected to impact (shock) loads. These loads are applied suddenly. The stress induced in these components are many times more than the stress produced by gradual loading. Therefore, impact tests are performed to asses shock absorbing capacity of materials subjected to suddenly applied loads. These capabilities are expressed as (i) Rupture energy (ii) Modulus of rupture and (iii) Notch impact strength.

Two types of notch impact tests are commonly-

1. Charpy test
2. Izod test

In Izod test, the specimen is placed as 'cantilever beam'. The specimens have V-shaped notch of 45°. U-shaped notch is also common. The notch is located on tension side of specimen during impact loading.

Depth of notch is generally taken as t/5 to t/3 where 't' is thickness of the specimen.

SPECIFICATION OF M/C AND SPECIMEN DETAILS :

Maximum impact Energy of Pendulum=170 Joules

Angle of hammer before striking = 90^o

Angle of striking edge = 75^o

Specimen size=

Type of Notch= V-notch

Angle of notch=45°

Depth of notch =

PROCEDURE:-

1. Select Izod test on control panel using test key.
2. Now, raise the pendulum manually and latch it. Please ensure that a proper striker (which is used for Izod test)is attached firmly on bottom of hammer.
3. Press start key on control panel.
4. Clamp the Specimen for Izod test firmly in support using help of clamping screw and setting gauge.
5. Please ensure that notch on the specimen should face the pendulum striker.
6. Operate the lever to release the hammer and hammer will strike the specimen.
7. Wait till the pendulum reverses its swing and carefully retard the swinging pendulum by operating pendulum brake.
8. Note down the impact energy. And remove the broken specimen.

OBSERVATION :-

S.no.	Specimen Material	Impact Energy Absorbed (Joules)	Notch Impact strength(J/cm2)

CALCULATION :-

• Notch impact strength = Impact Energy Absorbed /Area of cross-section of specimen below notch

RESULT :-

The impact strength of given specimen = -------Joule/cm^2

PRECAUTIONS :-

1. Do not stand in front of swinging hammer or releasing hammer.
2. The specimen should be prepared in proper dimensions.
3. Place the specimen proper position
4. Before proceeding to actual test, it is to be confirmed that strikers and supports are correctly selected.
5. Notch impact strength depends largely on the shape of specimen and notch. The values determined with other specimens, therefore may not be compared with each other.

ME-8

TORSION TEST

OBJECTIVE:-

To find the angle of twist and to obtain some of the mechanical properties of the given material by conducting torsion test.

INTRODUCTION:-

Torsion occurs when any shaft is subjected to a torque. This is true whether the shaft is rotating (such as drive shafts on engines, motors and turbines) or stationary (such as with a bolt or screw). The torque makes the shaft twist and one end rotates relative to the other inducing shear stress on any cross section. Failure might occur due to shear alone or because the shear is accompanied by stretching or bending.

THEORY:-

A shaft fixed at one end and twisted at the other end due to the action of torque T. The radius of shaft is R and the length is L.

Imagine a horizontal radial line drawn on the end face. When the end is twisted, the line rotates through an angle Θ.

G is one of the elastic constants of the material. The equation is only true so long as the material remains elastic.

$$\frac{T}{J} = \frac{G\Theta}{l}$$

Where

T = torque applied

J = polar moment of inertia of the shaft

G = rigidity modulus of the material

Θ = relative angle of twist in radians

L = gauge length (length of the shaft over which the relative angle of twist is measured)

Note the relationship between the modulus of elasticity, E, and G the modulus of rigidity within the linear elastic range of the material is described by Hooke’s law, which relates E, G, and

Poisson's ration, ν. The knowledge of any two can be used to find the third using the relationship

$E = 2G * (1 + \nu)$

It is easy to recognize that the torsional test measures shear stress vs. shear strain to find the shear modulus where as in a tensile test, axial stress and axial strain are used to determine Young's modulus.

PROCEDURE:-

1. Measure the overall length and the diameter at about three places and take the average value of the test specimen.
2. Draw a line down the length of the test section of the specimen with a chalk; this serves as a visual aid to the degree of twist being put on the specimen during loading.
3. Select the driving dogs to suit the size of the specimen and clamp it in the machine by means of a sliding spindle.
4. Choose the appropriate range by capacity change lever.
5. Set the maximum load pointer to zero.
6. Set the protector to zero for convenience and clamp it by means knurled screw.
7. Carry out straining by rotating the hand wheel in either direction.
8. Load the machine in suitable increments, taking note of the torque and the corresponding angle of twist.
9. Plot a graph between torque and angle of twist and calculate the value of G.

OBSERVATION:-

Length of the member, l =

Diameter of the member, d =

Polar moment of inertia, $J = \frac{\pi d^4}{32} =$

Sl. No	Load in ft. lbs	No. of Divns. In right hand chuck. $\Theta 1$	No. of Divns. In left hand chuck. $\Theta 2$	Actual $\theta = \Theta 1 - \Theta 2$

RESULT:-

From torque-twist graph,

Modulus of rigidity of the material =

FLUID MECHANICS CYCLE

CH – 1

CALIBRATION OF AIR AND LIQUID ROTAMETER

OBJECTIVE:

To study the effect of different floats on the flow rates.

ACCESSORIES:

Stopwatch, metre scale, 10 ml graduated pipette, Air and Liquid rotameters

THEORY:

The measurement of fluid flow is important in applications ranging from measurement of blood flow rates in a human artery to the measurement of the flow of liquid in oxygen in a rocket. In some cases extreme precision is called for in flow measurement while in other instances only crude measurements are necessary. Flow rate measurement devices frequently require accurate pressure and temperature instruments in order to calculate the output of the instrument. The overall accuracy of the instrument is governed primarily by the accuracy of some pressure or temperature measurement.

The rotameter is a very commonly used flow measurement device. The flow enters the bottom of a tapered vertical tube and causes the float or bob to move upwards. The bob will rise to a point such that the drag forces are balanced by the weight and buoyancy forces. The drag forces are forces which act on a solid object in the direction of the relative flow velocity. The position of the bob is then taken as an indication of the flow rate. The elevation (height) of the bob is dependent on the annular area between it and the tapered glass tube. By equating all the forces we get mean velocity between bob and tube, u_m.

$$u_m = \left[\frac{1}{C_d}\frac{2g\,V_b}{A_b}\left(\frac{\rho_b}{\rho_f} - 1\right)\right]$$

$$Q = A\,u_m$$

$$= A\left[\frac{1}{C_d}\frac{2g\,Vb}{A_b}\left(\frac{\rho_b}{\rho_f} - 1\right)\right]$$

where Q – volumetric flow rate, m^3/s

C_d – Drag coefficient.

A_b – maximum cross sectional area of the float, m^2.

g – Acceleration due to gravity, m/s^2.

ρ_b, ρ_f – densities of bob and fluid respectively, kg/m^3.

V_b – total volume of the bob, m^3.

A – Annular area, m^2.

PROCEDURE:

AIR ROTAMETER

1. Open the supply valve partly and allow the air to flow through the rotameter.
2. Observe the position of the float.
3. Measure the displacement of the water level with respect to the fixed time ‘t’ seconds.
4. Calculate the volumetric flow rate
5. Repeat the experiment by adjusting the supply valve for increased flow.
6. Repeat the experiment for different rotameters having different floats.

LIQUID ROTAMETER

PART A

1. Known volume of water is passed into the rotameter tube and the corresponding height of the water column is measured.
2. Plot the volume v/s height of the rotameter reading.
3. At any particular graduation find volume / height (V/ h).
4. Measure the maximum cross sectional area of the float (A).
5. Obtain annular area = (V/ h) – A.

PART B

1. On the equipment open the supply valve partially and allow the fluid to flow through the rotameters.
2. Observe the position of the float.
3. Collect the discharge in a measuring jar for a fixed time to calculate the rate of flow.
4. Repeat the experiment by adjusting the supply valve for increased flow for entire range of rotameter.
5. Calculate the values of C_d for different flow rates.
6. Plot the rotameter reading v/s volumetric flow rate graph.

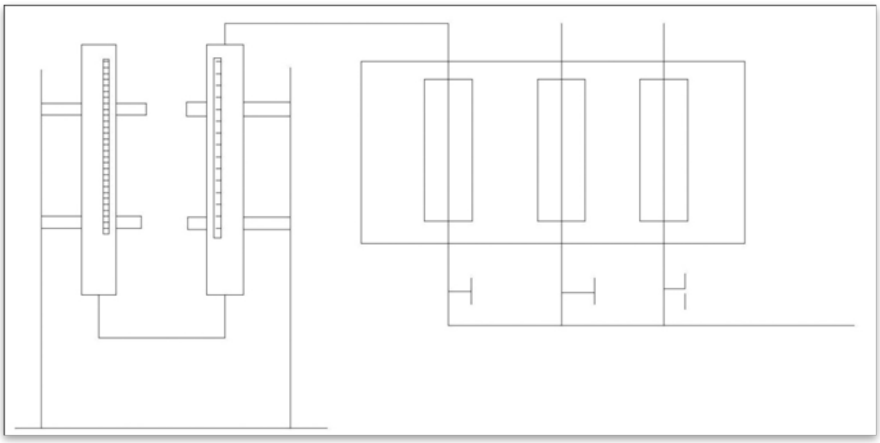


Fig 1 Air Rotameter Apparatus

OBSERVATION:

Diameter of the measuring tube = ________________ m

Area of the measuring tube (A) = ________________ m^2

	Sl. No.	Rotameter graduation reading	Measuring tube				Time of water collection (t), s	Q = V/t, m^3/s
			Initial reading, m	Final reading, m	Difference (Δh), m	Volume (V) = A * Δh		
Float 1	1.							
	2.							
	3.							
	4.							
Float 2	1.							
	2.							
	3.							
	4.							
Float 3	1.							
	2.							
	3.							
	4.							

Part A

Sl. No.	Volume of water added, ml (10^{-3} m^3)	Total volume of water (V), m^3	Rotameter graduated reading	Height of water column (h), m
1.				
2.				
3.				
4.				
5.				

Calculations from the plot of V v/s h.

Sl. No.	Rotameter graduation reading	V/ h, m^2	Cross sectional area of float, m^2	Annular Area, m^2
1.				
2.				
3.				
4.				
5.				

Part B

Volume of float, V_b = _______________ m^3

Density of float, ρ_b = _______________ kg/ m^3

Density of fluid ρ_f = _______________ kg/ m^3

Sl. No.	Rotameter Reading	Volume of water collected, m^3	Time of water collection, s	Volumetric flow rate (Q), m^3/s	Drag coefficient (C_d)
1.					
2.					
3.					
4.					
5.					

CALCULATION AND DISCUSSION:

RESULT:

PRECAUTIONS:

1. Operate the valve slowly.
2. Operate one valve at a time i.e. one air rotameter at a time.
3. Note the rotameter reading corresponding to the upper portion of the float, in the air rotameter.

CH – 2

STUDY OF VISCOSITY COEFFICIENT

OBJECTIVE:

The experiment is to determine the viscosity coefficient of a liquid by means of an Oswald's viscometer, which is a simple viscometer based on Poiseuille's law.

ACCESSORIES:

Oswald viscometer, 10 ml graduated pipette, tall beaker, 0-100º C thermometer, stopwatch, stirring motor with arm, Bunsen burner or heater and stand.

THEORY:

The methods frequently used for the determination of the viscosity coefficient (dynamic viscosity) of liquids are those based on the rate of flow of the liquid having coefficient of viscosity η (Ns/m^2) through a capillary tube of length L (m) of uniform radius r (m) under a pressure difference of ΔP (Newton/ m^2) is given by the expression for a particular temperature.

$$V = \frac{\pi P r^4 t}{8 l \eta}, (m^3)$$

This relationship is valid only if the flow is not turbulent and is slow enough for the kinetic energy to be negligible.

The essential measurement is the timing of the passage through the capillary of a fixed volume of liquid under a fixed mean hydrostatic head of the liquid. If the density of the liquid is ρ (kg/m^3), for a given viscometer having K as constant of viscometer can be written as:

$$\eta \propto t \rho$$

$$\eta = K t \rho$$

$$\eta = \eta_s \frac{t \rho}{t_s \rho_s}$$

where η and η_s are the viscosity coefficients of the liquid and water respectively. ρ and ρ_s are the densities of liquid and water, respectively, t and t_s are the time taken for liquid and water to flow between the markings of the viscometer. Knowing the value of viscosity of one liquid, one can calculate the viscosity of other liquid. The constant of viscometer can be found for each viscometer from its known dimension or by calibration with a liquid whose viscosity coefficient is known. Viscosity coefficient and density of water can also be obtained from Perry's Chemical Engineers handbook.

PROCEDURE:

1. Thoroughly clean the viscometer with warm chromic acid, rinse well several times with distilled water and drain well. Introduce into the viscometer, by means of the pipette, a known volume of distilled water sufficient for in one meniscus to be in the lower part of bulb while the other meniscus to be in the upper bulb.
2. Clamp the viscometer vertically in the large beaker filled with water almost to its brim so that mark 'a' is below the surface.
3. Keep the temperature of the bath as close as to 25ºC as possible by occasional heating with the heater; stir the thermostat continuously. Allow 15 min for thermal equilibrium to be attained. Suck the water into limb 'b' and note the time taken for the passage of meniscus between the marks A and B. Repeat the experiment twice.
4. Drain the water from the viscometer, rinse twice and dry by blowing air through the instrument. Introduce the same volume of the given liquid as was used for the first measurement with water. Allow sufficient time for thermal equilibrium and determine the time required for flow through the capillary tube at 25º C as before.
5. Repeat the experiment on the given liquid at approximately 5º C interval up to and including 60º C.
6. Plot the viscosity coefficient v/s temperature curve.

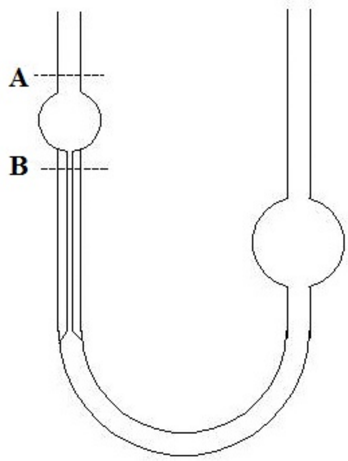


Fig 1 Oswald's Viscometer

TABLE:

Case A: For water

ρ_s = ________________ kg/ m^3

η_s = ________________ Ns/ m^2

Case B: For unknown liquid

ρ = ________________ kg/ m^3

Sl. No.	Temp, ºC	Time (t_s), s	Sl. No.	Temp, ºC	Time (t), s
1.			1.		
2.			2.		
3.			3.		

CALCULATION AND DISCUSSION:

RESULT:

PRECAUTION:

1. Handle the viscometer with care, it is a fragile instrument. A slight torque can snap the viscometer.
2. Make sure that the viscometer is vertical.
3. Filter the liquid before use to prevent solid from clogging the capillary.
4. Raise the level of liquid by forcing air out of the capillary end. If the level is raised by aspiration at the capillary end, liquid often gets into rubber tubing contaminating the system.

CH -3

STUDY OF REYNOLD'S APPARATUS

OBJECTIVE:

The objective of this laboratory experiment is to demonstrate the differences between laminar, turbulent, and transitional fluid flow, and the Reynolds's numbers at which each occurs.

ACCESSORIES:

Reynolds apparatus, water source, dye, measuring cylinder, stop watch, thermometer.

THEORY:

Professor Osborne Reynolds (1842-1912) experiment is used to investigate the characteristic of the flow of the liquid in the pipe which is also used to determine the Reynolds Number for each state of the flow. The design of the apparatus allowed studying the characteristic of the flow of the fluid in the pipe, the behavior of the flow and also to calculate the range for the laminar and turbulent flow where the calculation is used to prove the Reynolds number is dimensionless by using the Reynolds Number formula.

Laminar and turbulent flow-

Professor Osborne Reynolds first realized that there was a critical velocity at which the law relating loss of pressure energy and velocity in pipe flow changed. He first demonstrated this with his famous Color Band (on the die-line) experiment. This consisted of injecting a line jet of dye into the flow of water visible through a transparent pipe. At low velocities the dye-line was unbroken, but as the velocity of the flow through the pipe was increased, the dye-line broke up and eddies were seen to form. From this and further experiments, he came to the conclusion that there are two distinct types of flow:

1. Streamline or Laminar Flow (Latin lamina = layer of thin sheet)- The fluid moves in layers without irregular fluctuation in velocity. Laminar flow occurs at low Reynolds Numbers. (The flow of oil in bearing is Laminar).

2. Turbulent flow- This results in the fluid particles moving in irregular patterns carrying an exchange of momentum from one portion of the fluid to another .

Reynolds investigated these two different types of motion and concluded that the parameters which were involved in the flow characteristics were

D_H is the diameter of the pipe; its characteristic travelled length, L, (m).

Q is the volumetric flow rate (m^3/s).

A is the pipe *cross-sectional* area (m^2).

V is the mean velocity of the object relative to the fluid (m/s).

μ is the dynamic viscosity of the fluid (Pa·s or N·s/m² or kg/(m · s).

ρ is the density of the fluid (kg/m^3).

He arrived at a dimensionless constant (Reynolds number)-

$$\mathrm{Re} = \frac{\rho \mathrm{v} D_H}{\mu} = \frac{\mathrm{v} D_H}{\nu}$$

PROCEDURE:

1. Fill the tank with water and the dye-chamber with dye.
2. Note the water temperature.
3. Start the water flow and maintain a small flow rate, enough to fill the whole pipe cross-section.
4. Once the flow stabilizes, start the dye injection. The injection rate should be just enough to give a clear visible streak of dye.
5. Observe the pattern of the dye streak. The dye should flow in a straight line.
6. Increase the water in small and equal increments and observe the die streak.
7. Repeat step (6) until some undulations commences in the streak. Note the corresponding volumetric flow rate of water, which is the critical Reynolds number. Appearance of the undulations signifies of the intermediate or transition flow.
8. Keep increasing the flow rate of the liquid further until one point there is found a complete dispersion of the dye (indicated by the liquid getting colored through the cross-section) just as it comes out of the injection needle . This point shows the conversion to a fully turbulent regime.
9. Note the corresponding volumetric flow rate.

OBSERVATION:

Temperature of the liquid = °C

Pipe diameter = m

Volumetric flow rate corresponding to fully transition flow = m^3/s

Volumetric flow rate corresponding to fully turbulent flow = m^3/s

Liquid density at the observed temperature = Kg/m^3

Liquid viscosity at the observed temperature = Kg/m s

CALCULATION:

- **Volumetric flow rate:-**

  Q =v/s (m³/s)

  Where:-

  Q = volumetric flow rate

  v= volume (m³)

  s= time (s)

- **Velocity:-**

  V=Q/A (m/s)

- **For flow in pipe or tube, the Reynolds number is:-**

$$\mathrm{Re} = \frac{\rho \mathbf{v} D_H}{\mu} = \frac{\mathbf{v} D_H}{\nu}$$

`

RESULTS:

PRECAUTIONS:

1. Close the die valve before closing the water flow.
2. Open the valves gradually for measurement.

CH-4

STUDY OF DYNAMIC BEHAVIOUR OF A THERMOMETER

OBJECTIVE:

To study the dynamic behavior of a thermometer.

THEORY:

Mercury in glass thermometer:-

The liquid in glass thermometer is one of the most common temperature measuring devices. Both liquid and glass on heating and their differential expansion is used to indicate the temperature. The lower temperature limit is- 37.8 °C for mercury. The higher temperature range is 340°C but this range may be extended to 560°C by filling the space above mercury with CO_2 or N_2 at high pressure thereby increasing its boiling point and range. Though the liquid in glass thermometer has certain laboratory applications yet it is not much used industrially because of its fragility, and because of the inevitable proximity of the display to the measuring point.

The Dynamic response of a measuring instrument is the change in the output y caused by a change in the input x. Both x and y are functions of time t.A temperature measuring device when put into different environment does not immediately indicate the temperature of the changed environment. It takes some time to indicate the actual temperature. The lag between actual and measured value depends on the order of the system. The mercury thermometer behaves as the *first order system*.

The response of it is given by:

$$\mathbf{Y(t) = AK(1-e^{-t/\tau})}$$

Where:-

Y (t) = (Temperature indicated at time 't')-(Temperature indicated at time t=0).

A = (Temperature of the new environment)-(Temperature indicated by the thermometer before it is put in the new environment).

t = time in second.

τ = time constant of the thermometer in second.

A first order linear instrument has an output which is given by a non-homogeneous first order linear differential equation

τ.dy(t)/dt + y(t) = K.x(t),

where τ(*tau)* is a constant, called the **time constant** of the instrument. In these instruments there is a time delay in their response to changes of input. The time constant *tau* is a measure of the time delay.

Thermometers for measuring temperature are first-order instruments. The time constant of a measurement of temperature is determined by the thermal capacity of the thermometer and the thermal contact between the thermometer and the body whose temperature is being measured.

The response of a first order instrument to the unit step function for $t > 0$ is the solution of

τ.dy(t)/dt + y(t) = K

with the initial condition y(0) = 0. The solution is

y(t) = AK[1 - exp(-t/τ)].

After a long time y(t) approaches the value K. If τ is small the response of the instrument is fast. If τ is large the response of the instrument is slow.

ACCESSORIES:

Mercury thermometer, electric heater, beaker, water source.

PROCEDURE:

- **Case (a):-**
    1. Measure the room temperature.
    2. Boil water in a beaker and measure its temperature.
    3. Put the thermometer in the boiling water and immediately start the stopwatch and record time vs. temperature data.
    4. Repeat step (3).
- **Case (b):-**
    1. Boil water in a beaker and measure its temperature.
    2. Measure the room temperature.
    3. Remove the thermometer from the beaker and hang it outside.
    4. Immediately start and stop watch and record time vs. temperature data.
    5. Repeat step (3).

OBSERVATION:

A = temperature in step (2)- temperature in step(1)   [for both cases]

- **Case (a):-**

  Room temperature =

  Temperature of boiling water =

  Amplitude (A) =

- **Case (b):-**

  Room temperature =

  Temperature of boiling water =

  Amplitude (A) =

OBSERVATION TABLE:

- **Case (a):-**

S.No.	Time(sec.)	Temperature(°C)	Y(t)	ln(1-Y)/A
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

- **Case (b):-**

S.No.	Time(sec.)	Temperature(°C)	Y(t)	ln(1-Y)/A
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

CALCULATION:

For this experiment take K = 1.

1. The slope of straight line between ln(1-Y/A) vs. t is –(1/ τ).
2. Plot (Y/A) vs. t find the time at which Y/A is 0.632. This time is the time constant 'τ' of the thermometer.

RESULTS:

The time constant:

- Case (a):-
- Case (a):-

PRECAUTIONS:

1. Do not lift the beaker off the heater.
2. Dip the thermometer in the water for measuring the temperature.
3. Start measuring only when the water starts boiling.

CH-5

VERIFICATION OF BERNOULLI'S THEOREM

OBJECTIVE:

To verify Bernoulli's Equation

THEORY:

Bernoulli's equation is obtained by integrating the Euler's Equation of Motion:

$$\int dp/\rho + \int gdz + \int vdv = \text{const}$$

The Bernoulli theorem is an approximate relation between pressure, velocity, and elevation, and is valid in regions of steady, incompressible flow where net frictional forces are negligible. The equation is obtained when the Euler's equation is integrated along the streamline for a constant density (incompressible) fluid. The constant of integration (called the Bernoulli's constant) varies from one streamline to another but remains constant along a streamline in steady, frictionless, incompressible flow. Despite its simplicity, it has been proven to be a very powerful tool for fluid mechanics. Bernoulli's equation states that " the sum of the kinetic energy (velocity head), the pressure energy (static head) and Potential energy (elevation head) per unit weight of the fluid at any point remains constant" provided the flow is steady, irrotational, and frictionless and the fluid used is incompressible. This is however, on the assumption that energy is neither added to nor taken away by some external agency. The key approximation in the derivation of Bernoulli's equation is that viscous effects are negligibly small compared to inertial, gravitational, and pressure effects. We can write the theorem as

Pressure head ($p/\rho g$)+ Velocity head ($v^2/2g$)+ Elevation (Z) = a constant

Where

P = the pressure (N/m2)

ρ = density of the fluid (kg/m3)

V = velocity of flow (m/s)

g = acceleration due to gravity (m/s2)

Z = elevation from datum line (m)

$\gamma=\rho g$ (specific weight)

Assumptions for Bernoulli’s equation:

i) Fluid is ideal i.e. no viscosity ii) flow is steady

iii) Fluid is incompressible iv) Flow is irrotational

The Bernoulli’s equation forms the basis for solving a wide variety of fluid flow problems such as jets issuing from an orifice, jet trajectory; flow under a gate and over a weir, flow metering by obstruction meters, flow around submerged objects, flows associated with pumps and turbines etc.

EXPERIMENTAL SET-UP:

The equipment is designed as a self-sufficient unit it has a sump tank, measuring tank and a pump for water circulation as shown in figure1. The apparatus consists of a supply tank, which is connected to flow channel. The channel gradually contracts for a length and then gradually enlarges for the remaining length. That channel is like venture with a no. Of piezometric points at which piezometric tubes are attached to give piezometric heads at different elevation of water level in tank.

PROCEDURE:

1. Note down the cross sectional area of duct at all piezometric points.
2. Open the supply valve and adjust the flow such that water level in the inlet tank remains stable.
3. Measure the piezometric head for each piezometric point.
4. Collect the discharge in a collecting tank for a known time and compute flow rate (Q).
5. Repeat the steps (2 to 4) for various discharges.
6. Plot and observe the variation of total energy (y-axis)across the piezometric points (x-axis).

Table 1. Measurement of Discharge(Q)

Area of measuring tank(A_c): Length____________(m) x Breadth____________(m)

Trials used for discharge variation	Rise of water level(h) in collecting tank(m)	Time of collection t(sec)	Volume V(m^3)=(Acxh)	Discharge Q (m^3/sec)=V/t
1.				
2.				
3.				
4.				

Figure

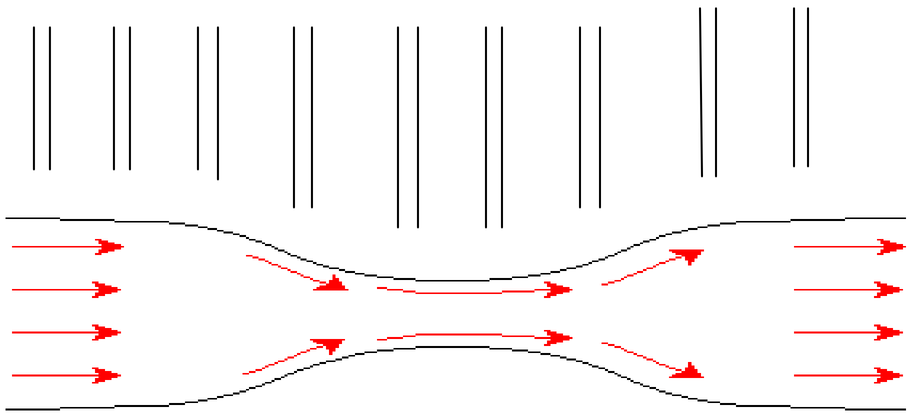


Table 2. Computational of Total Head(m) for each variation of discharge

Discharge (Q) for trial 1:

Piezomic Tube number	1	2	3	4	5	6	7	8	9
Cross sectional area A (m^2)									
Piezometric head (p/γ +z) (m)									
Velocity (m/sec)=Q/A									
Velocity head v^2 /2g (m)									
Total head (m)									

Discharge (Q) for Trial 2:

Piezomic Tube number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Cross sectional area A (m^2)									
Piezometric head (p/γ +z) (m)									
Velocity (m/sec)=Q/A									
Velocity head v^2 /2g (m)									
Total head (m)									

Discharge (Q) for trial 3:

Piezomic Tube number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Cross sectional area A (m^2)									
Piezometric head (p/γ +z) (m)									
Velocity (m/sec)=Q/A									
Velocity head v^2 /2g (m)									
Total head (m)									

Discharge (Q) for Trial 4:

Piezomic Tube number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Cross sectional area A (m^2)									
Piezometric head (p/γ +z) (m)									
Velocity (m/sec)=Q/A									
Velocity head v^2 /2g (m)									
Total head (m)									

RESULTS:

Draw graphs for each trial.

PRECAUTIONS

1. Take heads for trial in between top head and bottom head.
2. Take accurate readings from piezometric tubes.
3. Drain out water after each trial from measuring tank while calculating h.

CH-6

CALIBERATION OF ORIFICE AND ELBOWMETER

OBJECTIVE:

To calibrate Orificemeter and elbowmeter.

THEORY:

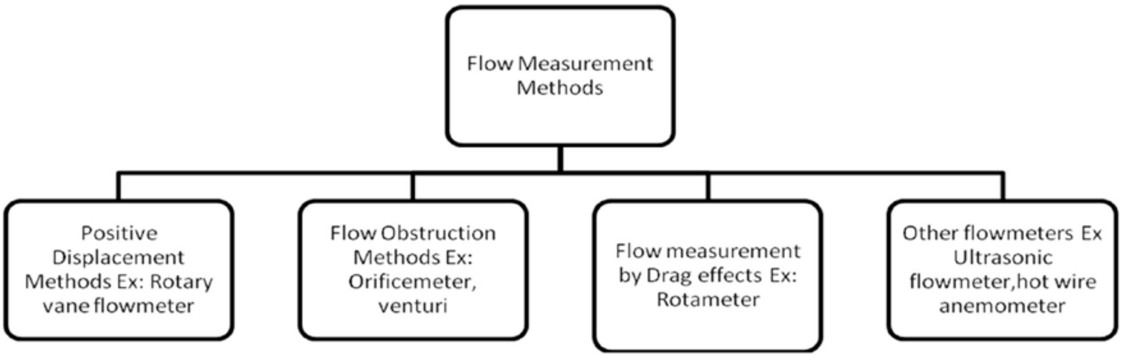
Flow Q is the volume flowing through a mathematically precise determined cross-section over a certain time unit.

Q = Volume/time

Q = velocity • Area

Volume V is the flow volume within a certain time interval.

V = Q • t



ORIFICEMETER: An orifice plate is a restriction with an opening smaller than the pipe diameter which is inserted in the pipe; the typical orifice plate has a concentric, sharp edged opening, as shown in Figure 1. Because of the smaller area the fluid velocity increases, causing a corresponding decrease in pressure. The flow rate can be calculated from the measured pressure drop across the orifice plate, P_1-P_3. The orifice plate is the most commonly used flow sensor, but it creates a rather large non-recoverable pressure due to the turbulence around the plate, leading to high energy consumption.

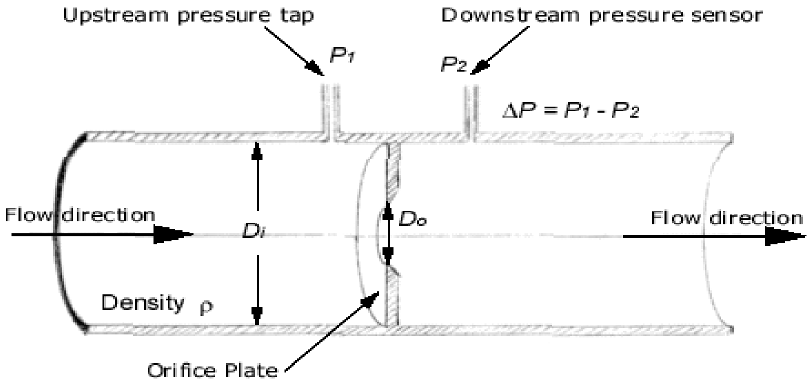


Figure 1

***Elbow meter*:** A differential pressure exists when a flowing fluid changes direction due to a pipe turn or elbow, as shown in Figure 2 below. The pressure difference results from the centrifugal force. Since pipe elbows exist in plants, the cost for these meters is very low. However, the accuracy is very poor; there are only applied when reproducibility is sufficient and other flow measurements would be very costly.

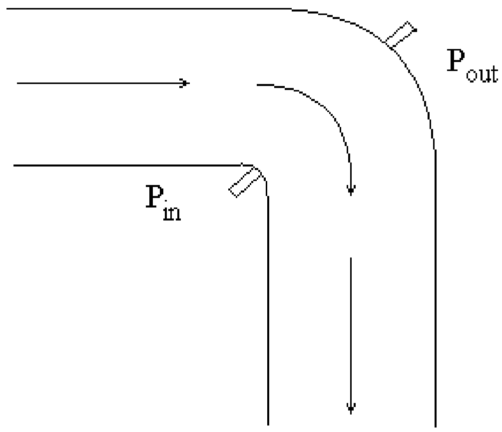


Figure 2 (Elbow flow meter)

PROCEDURE:

1. Start the air flow through the pipe by switching on the blower.
2. At steady state (unchanging liquid height in the manometers), note the height difference in the liquid-levels in each of the manometers attached to the orifice meter and elbow meter.
3. Using a stop-watch and anemometer, determine the flow velocity.
4. Record the temperature of the process fluid(air).
5. Repeat steps 1-4 for different airflow rates by changing the variac-position.
6. Plot discharge coefficient versus the Reynolds number, Dv/γ (D-pipe diameter, v-flow velocity, γ- kinematic viscosity of process fluid)

$\Delta P = P_0 - P_i$

P_0 = Pressure at outer radius of elbow

P_i = Pressure at inner radius of elbow

OBSERVATIONS:

1. Temperature of air (flowing through pipe)= ________________
2. Diameter of orifice = 2.54 cm
3. Diameter of pipe = 5.08 cm
4. Angle of inclination of the inclined tube
5. of manometer with the elbow meter = ________________

Table

S.No.	Velocity measurement				Height difference in manometer	
	Time	Anemometer reading		Flow velocity (m/s)	Elbow meter (cm)	Orifice meter (cm)
		Ft	m			

CALCULATIONS:

1. $Q = vA_p = \pi/4\, D^2 v$

   v- flow velocity

   1. D- pipe dia

2. $A_0 = \pi/4\, D_0^2$

   A_0- Orifice cross-sectional area

   1. D_0- Orifice diameter :

3. $$C = \frac{Q}{A\sqrt{\frac{\rho_m hg}{\rho_f}}}$$

4. $Re = Dv / \gamma$

5. $\gamma = \mu_f / \rho_f$

μ_f and ρ_f should be found at the temperature of process fluid, ρ_m should be determined at the ambient temperature.

For the elbow meter , take $h = h_m \sin\alpha$

α: Angle with the horizontal of the inclined downstream tube of the inclined manometer.

h_m : Difference in the liquid level in the two limbs.

RESULTS:

S.No.	Reynold number	Discharge coefficient	
		Orifice meter	Elbow meter

RESULTS:

PRECAUTIONS:

1. Keep the other valves closed while taking reading through one pipe.
2. The initial error in the manometer should be subtracted from the final reading.
3. The parallax error should be avoided.
4. Maintain a constant discharge for each reading.

ELECTRICAL AND ELECTRONICS ENGINEERING CYCLE

EEE –1

STUDY OF LOGIC GATES AND COMBINATIONS

OBJECTIVE:

To study the basic logic gates: AND, OR, NOT, NAND, NOR and EX-OR and combinational circuits.

ACCESSORIES:

Digital IC power supply, bread board, 7408, 7432, 7404, 7400, 7402, 7486 IC's, LEDs and 1kΩ resistance and connecting wires etc.

THEORY:

Transistors, when operated at their bias limits, may be in one of two different states: either cut-off (no controlled current) or saturation (maximum controlled current). If a transistor circuit is designed to maximize the probability of falling into either one of these states (and not operating in the linear, or active, mode), it can serve as a physical representation of a binary bit. A voltage signal measured at the output of such a circuit may also serve as a representation of a single bit, a low voltage representing a binary "0" and a (relatively) high voltage representing a binary "1".

A logic gate is a special type of amplifier circuit designed to accept and generate voltage signals corresponding to binary 1's and 0's. As such, gates are not intended to be used for amplifying analog signals (voltage signals between 0 and full voltage). Used together, multiple gates may be applied to the task of binary number storage (memory circuits) or manipulation (computing circuits), each gate's output representing one bit of a multi-bit binary number.

PROCEDURE:

1. Each IC has four gates with an exception of 7404which is having six gates.
2. For all gates, output terminal is to be connected to the LED through the 1kΩ resistance. If LED glows, output will be treated as 1; if LED does not glow, output will be treated as 0.
3. For '1' input a voltage of +5V is to be applied and for '0' input a voltage of 0 level means to be grounded and should not be left open.
4. Connect –ve terminal of the IC power supply to pin no.7 and +ve terminal of IC power supply to pin no.14 of the IC.

EXPERIMENT: Let A and B be the inputs to gates and Y be the corresponding output in each of the following runs

OBSERVATIONS:

RUN 1:

(a) AND GATE

Y = A AND B

= A.B

INPUT		**OUTPUT**
A	**B**	**Y**
0	**0**	
0	**1**	
1	**0**	
1	**1**	

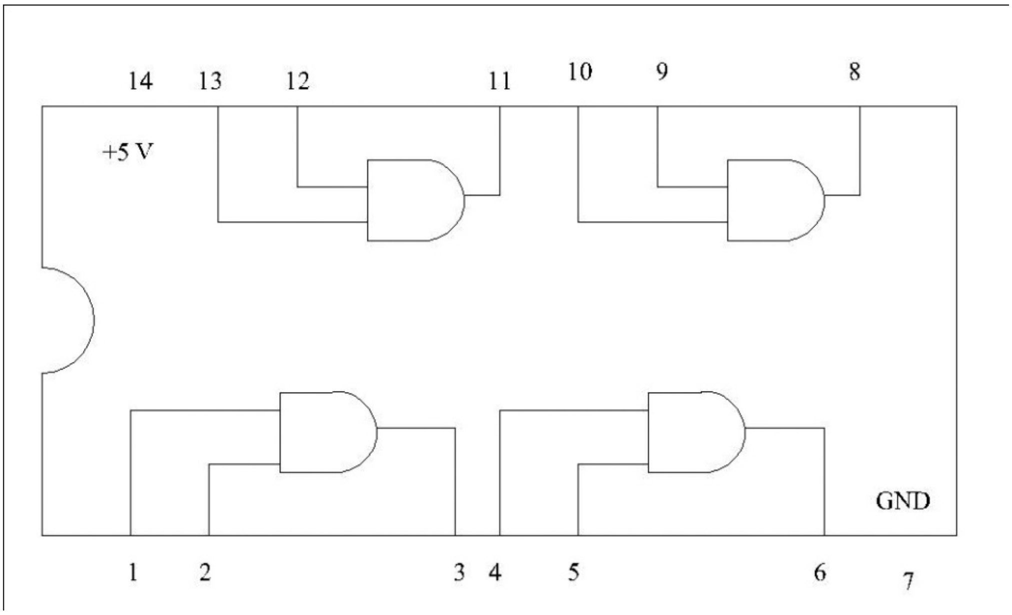


Fig 1 AND GATE IC 7408

(b) OR GATE

Y = A OR B

= A + B

INPUT		OUTPUT
A	**B**	**Y**
0	**0**	
0	**1**	
1	**0**	
1	**1**	

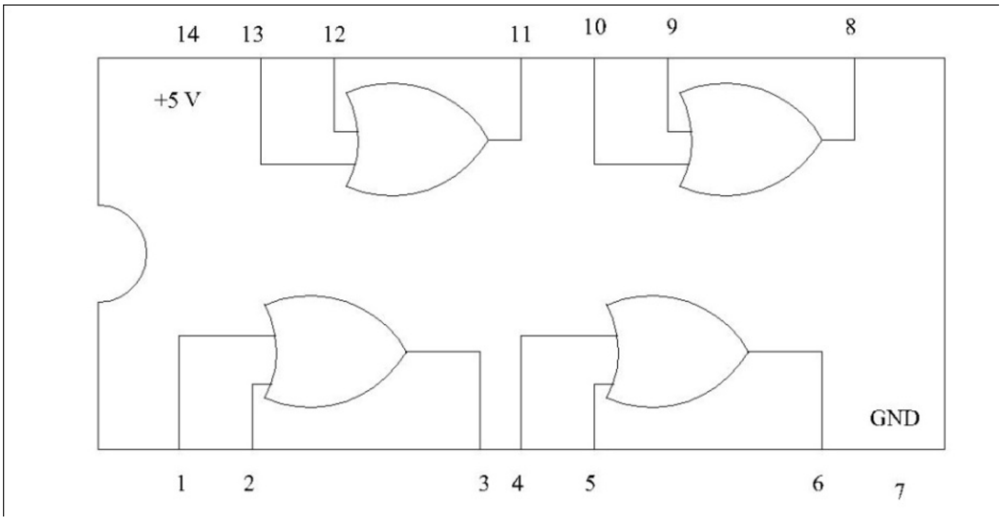


Fig 2 OR GATE IC 7432

(c) NOT GATE

Y = $\bar{A}$

INPUT	OUTPUT
A	**Y**
0	
1	

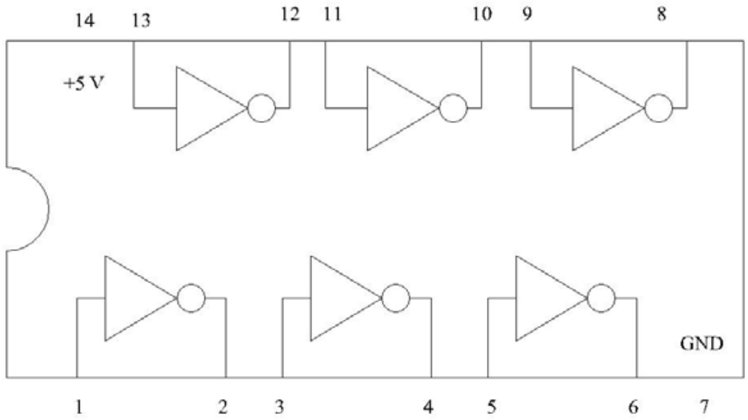


Fig 3 NOT GATE IC 7404

(d) NAND GATE

Y = A NOT AND B

= A NAND B

= $\overline{(A \cdot B)}$

INPUT		OUTPUT
A	**B**	**Y**
0	**0**	
0	**1**	
1	**0**	
1	**1**	

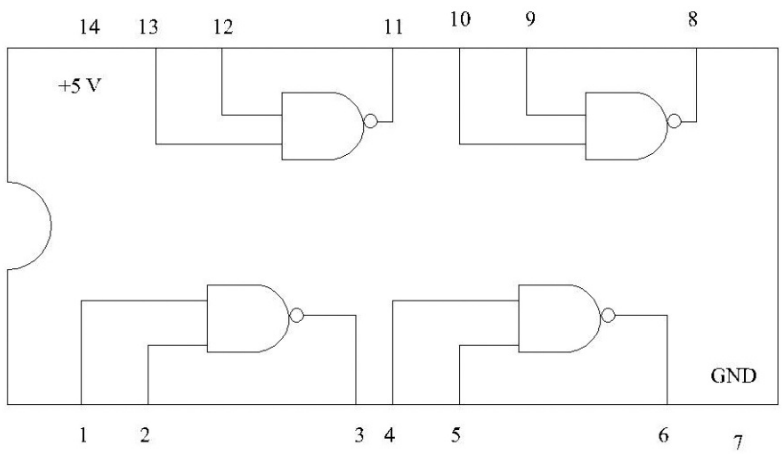


Fig 4 NAND GATE IC 7400

(e) NOR GATE

Y = A NOT OR B

= A NOR B

= $\overline{(A + B)}$

INPUT		OUTPUT
A	**B**	**Y**
0	**0**	
0	**1**	
1	**0**	
1	**1**	

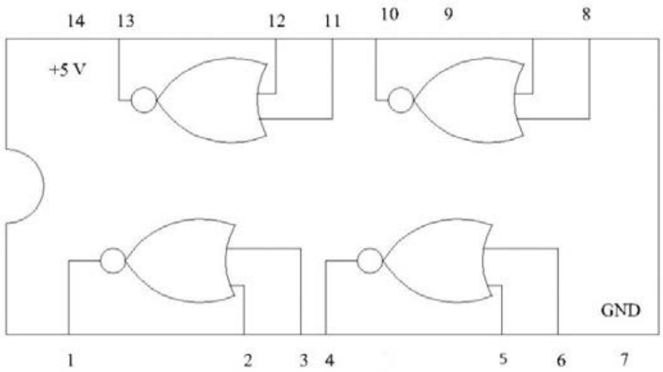


Fig 5 NOR GATE IC 7402

(f) EX-OR GATE

Y = A EX-OR B

= A $\oplus$ B

INPUT		OUTPUT
A	**B**	**Y**
0	**0**	
0	**1**	
1	**0**	
1	**1**	

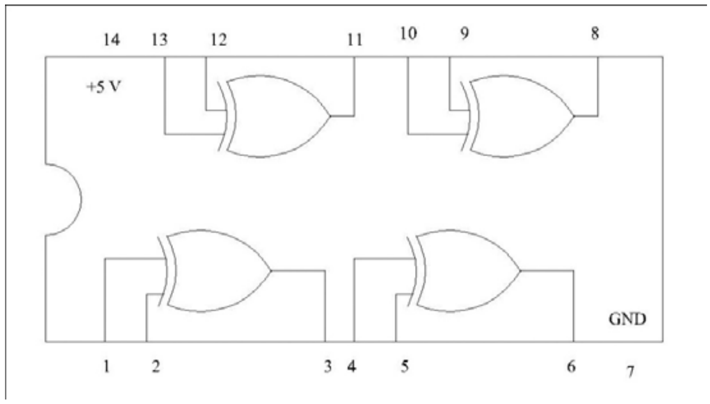
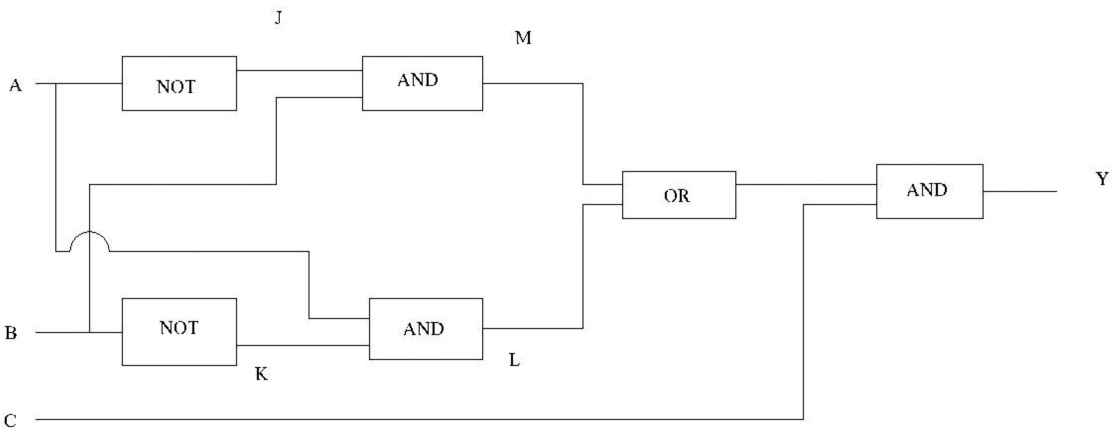


Fig 6 EX-OR GATE IC 7486

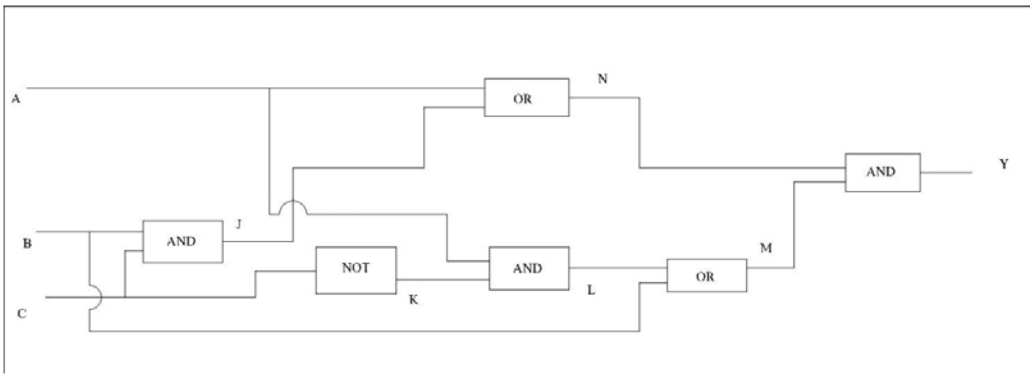
RUN 2:

To determine output of the given logical circuit.



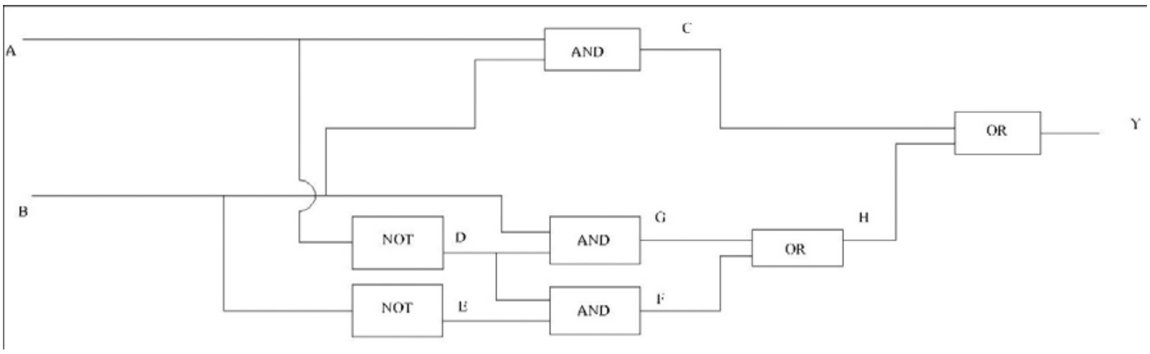
A	B	C	J	K	L	M	N	Y
0	0	0						
0	1	0						
1	0	0						
1	1	0						
0	0	1						
0	1	1						
1	0	1						
1	1	1						

RUN 3:



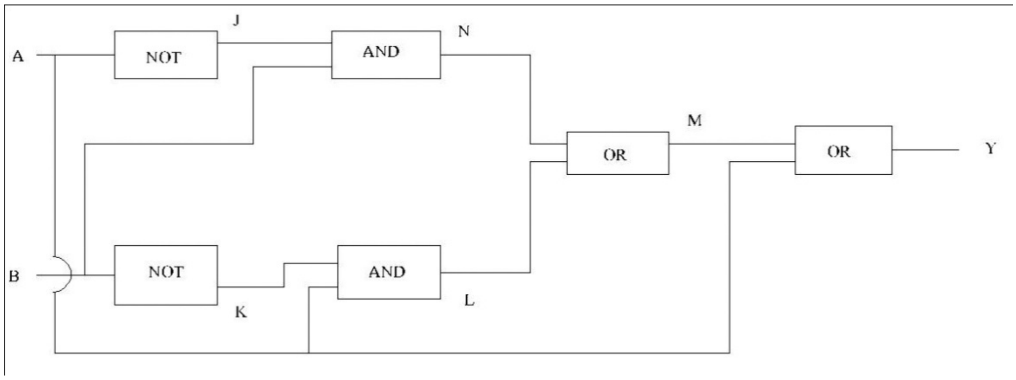
A	B	C	J	K	L	M	N	Y
0	0	0						
0	1	0						
1	0	0						
1	1	0						
0	0	1						
0	1	1						
1	0	1						
1	1	1						

RUN 4:



A	B	C	D	E	F	G	H	Y
0	0	0						
0	1	0						
1	0	0						
1	1	0						
0	0	1						
0	1	1						
1	0	1						
1	1	1						

RUN 5:



A	B	J	K	L	M	N	Y
0	0						
0	1						
1	0						
1	1						

CONCLUSION:

PRECAUTIONS:

1. Do not keep the circuit on for prolong length of time. It leads to overheating and may corrupt the IC.
2. Ensure the circuit is closed.

EEE –2

TEST ON A SINGLE PHASE INDUCTION MOTOR

OBJECTIVE:

To operate and measure parameters in a single phase induction motor.

ACCESSORIES:

Single phase capacitor starts induction motor, voltmeter, ammeter, wattmeter and tachometer.

THEORY:

In induction motors, alternating current is directly applied to the stator winding. Rotor currents are then produced by induction i.e. transformer action. Induction motor is a widely used motor; it is used in compressors, refrigerators, air conditioners, fans, heat pumps, pumps, washers and dryers. Its performance as a generator is unsatisfactory and hence not used as a generator. When a stator winding is excited by a sinusoidal varying current in time at electrical frequency ω_e, the space fundamental mmf distribution is given by the following expression.

$$\mathcal{F}_{ag1} = \mathcal{F}_{max} \cos(\theta_{ae}) \cos(\omega_e t)$$

This expression can be resolved into two rotating mmf waves each of amplitude one half the maximum amplitude of $\mathcal{F}_{ag1}$ with one $\mathcal{F}^{+}_{ag1}$ travelling in $+\theta_{ae}$ direction and the other $\mathcal{F}^{-}_{ag1}$ travelling in $-\theta_{ae}$ direction, both with angular velocity ω_e.

$$\mathcal{F}^{+}_{ag1} = \frac{1}{2} \mathcal{F}_{max} \cos(\theta_{ae} - \omega_e t)$$

$$\mathcal{F}^{-}_{ag1} = \frac{1}{2} \mathcal{F}_{max} \cos(\theta_{ae} + \omega_e t)$$

Each of these component mmf waves produces induction action, but the corresponding torques are in opposite directions. With the rotor at rest, the forward and backward air gap flux waves created by the combined mmf's of the stators and rotor currents are equal, the component torques are equal and hence no starting torques is produced. If the motor is started by auxiliary means, it would produce torque in whatever direction it was started.

PROCEDURE:

TEST 1

1. Make connections as per the circuit diagram.
2. R1, R2 are the running windings.
3. S1, S2 are the stationary windings.

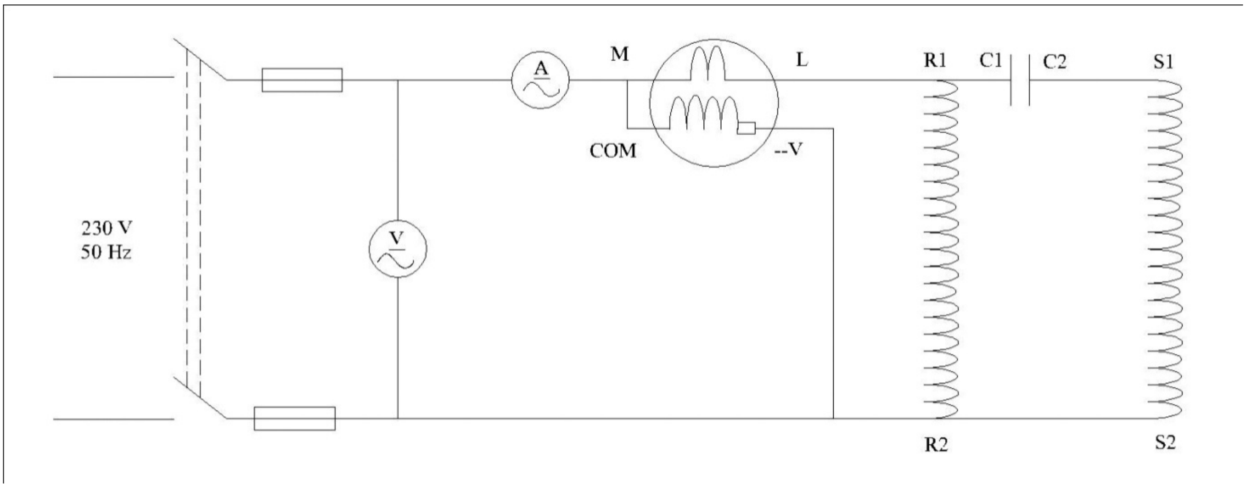
4. C1, C2 are the terminals of a non-polarized capacitor.
5. Check the scales and ranges on the measuring equipments used.
6. Switch on the supply.
7. Measure the required parameters.

TEST 2

1. Switch off supply.
2. Interchange the connections at S1 and S2.
3. Switch on the supply.
4. Measure the required parameters.

TEST 3

1. Switch off supply.
2. Disconnect the circuit.
3. Now connect only the ammeter and the rotor coils R1 and R2 in series.
4. Ensure the circuit is closed.
5. Switch on the supply.
6. See if the motor rotates.
7. Hold the shaft by hand and feel direction of torque. Then switch off supply.
8. Rotate shaft manually in clockwise direction and switch on the supply. Note direction of rotation. Then switch off supply. Let it come to rest.
9. Now rotate shaft manually in anticlockwise direction and switch on the supply. Note direction of rotation.



OBSERVATION:

VOLTMETER:

No. of scales	
Ranges	

AMMETER:

No. of scales	
Ranges	

WATTMETER:

No. of scales	
Ranges	

TACHOMETER:

No. of scales	
Ranges	

TEST 1:

Direction of rotation	
Voltage (V)	**V**
Current(I)	**A**
Power (P)	**W**
Speed (N)	**Rpm**
Power factor = W/ (V I)	

TEST 2:

Direction of rotation	
Voltage (V)	**V**
Current (I)	**A**
Power (P)	**W**
Speed (N)	**Rpm**
Power factor = W/ (V I)	

TEST 3:

Current (I)	**A**
Speed (N)	**Rpm**

Does the motor rotate initially?

YES / NO

Does the motor continue to rotate in the same direction when rotated manually in the clockwise direction?

YES / NO

Does the motor continue to rotate in the same direction when rotated manually in the anticlockwise direction?

YES / NO

CONCLUSION:

PRECAUTIONS:

1. Ensure the circuit is closed.
2. Do not make changes in the circuit wiring while the supply is still switched on.
3. Make sure that the power supply is switched off before making changes to the circuit.

EEE - 3

HARDWARE FAMILARITY, COMPONENT STUDY AND STUDY OF OPERATIONAL AMPLIFIER CIRCUITS

OBJECTIVE:

Hardware familiarity and component study. Study of operational amplifier circuits.

ACCESSORIES:

AF signal generator, Digital multimeter(DMM), Bread Board ,Op. Amp (μA741), resistances.

THEORY:

Resistors:

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. The current through a resistor is in direct proportion to the voltage across the resistor's terminals. This relationship is represented by Ohm's law:

`$$I = \frac{V}{R}$$

where I is the current through the conductor in units of amperes, V is the potential difference measured across the conductor in units of volts, and R is the resistance of the conductor in units of ohms. The ratio of the voltage applied across a resistor's terminals to the intensity of current in the circuit is called its resistance, and this can be assumed to be a constant (independent of the voltage) for ordinary resistors working within their ratings.

Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors can be made of various compounds and films, as well as resistance wire (wire made of a high-resistivity alloy, such as nickel-chrome). Resistors are also implemented within integrated circuits, particularly analog devices, and can also be integrated into hybrid and printed circuits.

Color code of Resistors

Color	First Digit 1	Second Digit 2	Multiplier 3	Resistance Tolerance Percentage 4
Silver	-	-	10^{-2}	10%
Gold	-	-	10^{-1}	5%
Black	0	0	10^{0}	-
Brown	1	1	10^{1}	1%
Red	2	2	10^{2}	2%
Orange	3	3	10^{3}	3%
Yellow	4	4	10^{4}	4%
Green	5	5	10^{5}	5%
Blue	6	6	10^{6}	6%
Violet	7	7	10^{7}	7%
Grey	8	8	10^{8}	8%
White	9	9	10^{9}	9%

Operational amplifier:

An operational amplifier (op-amp) is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output. An op-amp produces an output voltage that is typically hundreds of thousands of times larger than the voltage difference between its input terminals.

The op-amp is one type of differential amplifier. Operational amplifiers had their origins in analog computers where they were used to do mathematical operations in many linear, non-linear and frequency-dependent circuits.

In an inverting amplifier, the output voltage changes in an opposite direction to the input voltage.

In a non-inverting amplifier, the output voltage changes in the same direction as the input voltage.

AF signal generator:

Signal generators, also known variously as function generators, RF and microwave signal generators, pitch generators, arbitrary waveform generators, digital patter generators or frequency generators are electronic devices that generate repeating or non-repeating electronic signals (in either the analog or digital domains).Audio-frequency signal generators generate signals in the audio-frequency range and above.

Digital multimeter(DMM):

Modern multimeters are often digital due to their accuracy, durability and extra features. In a digital multimeter the signal under test is converted to a voltage and an amplifier with electronically controlled gain preconditions the signal. A digital multimeter displays the quantity measured as a number, which eliminates parallax errors.

PROCEDURE:

- Inverting amplifiers :
    1. Make connections as per Fig.(3)
    2. Feed a signal of 1KHz at the input through AF signal generator.
    3. Measure input and output signals using Digital multimeter and record the same in the observation table. Hence calculate voltage gain(A_v).
    4. Try changing values of R_f and R_i , verify your result. Frequency may also be altered.

Note: A D.C power supply may also be connected at the input. You should get the D.C output as per the values of R_f and R_i with a reversed polarity.

- Non-Inverting amplifiers :
    1. Make connections as per Fig.(4)Type equation here.
    2. Feed a signal of 1KHz at the input through AF signal generator.
    3. Measure input and output signals using Digital multimeter and record the same in the observation table. Hence calculate voltage gain(A_v).
    4. Try changing values of R_f and R_i , verify your result. Frequency may also be altered.

Figure:

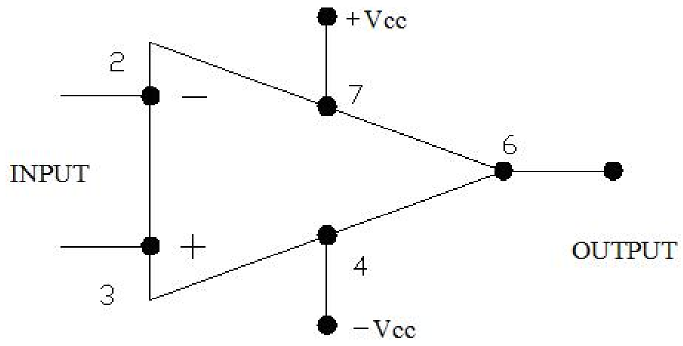


Fig.(1)

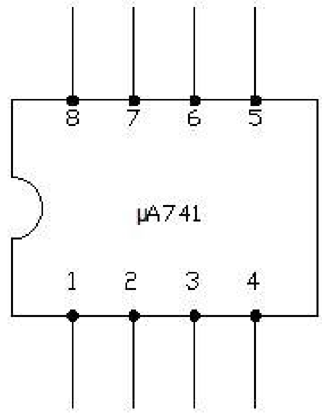


Fig.(2)

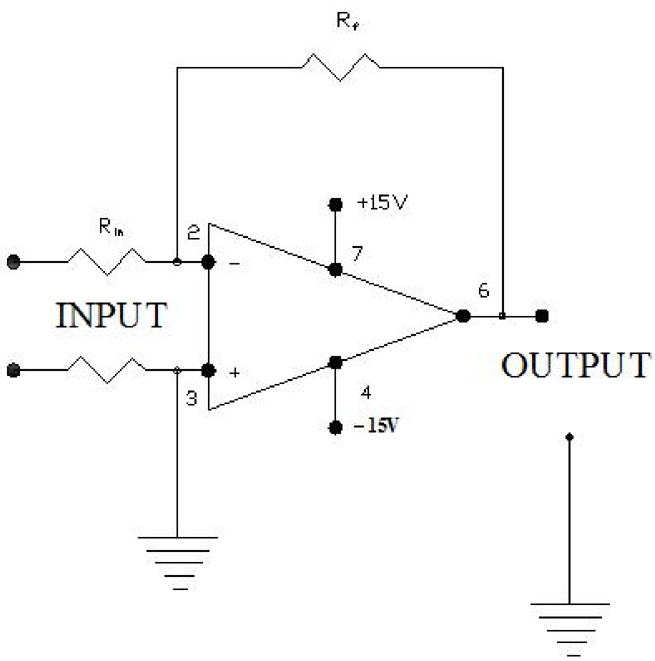


Fig.(3)

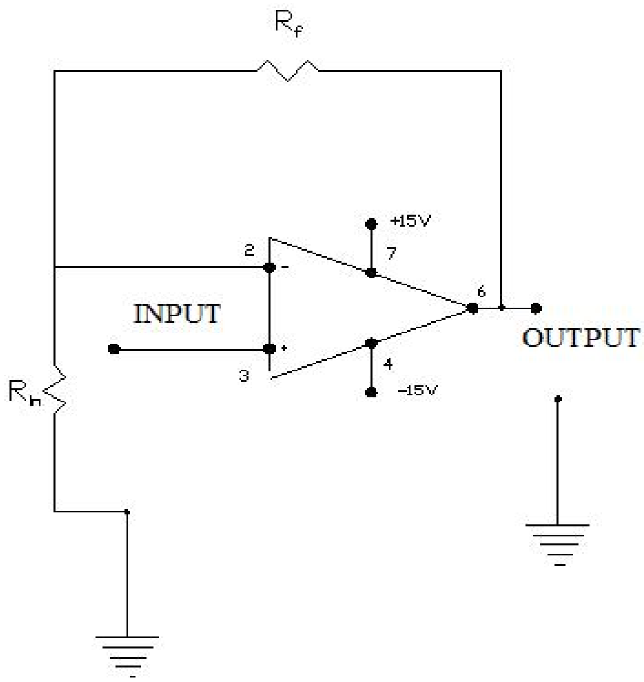


Fig.(4)

OBSERVATION TABLE:

- **Inverting :-**

S.No.	V_{in}	V_{out}	$A_v = V_{out}/V_{in}$	R_f	R_{in}	$A_v = -R_f/R_{in}$
1						
2						
3						
4						

- **Non-inverting :-**

S.No.	V_{in}	V_{out}	$A_v = V_{out}/V_{in}$	R_f	R_{in}	$A_v = 1+R_f/R_{in}$
1						
2						
3						
4						

CALCULATION:

- Inverting amplifiers :

$$A_v = V_{out}/V_{in} = -R_f/R_{in}$$

- Non-Inverting amplifiers :

$$A_v = V_{out}/V_{in} = 1+R_f/R_{in}$$

RESULTS:

PRECAUTIONS:

1. Handle operational amplifier with care.
2. Check the setting of AF signal generator before taking the readings.
3. Check the wiring before taking the reading.
4. The digital multimeter does not display a negative sign.

EEE-4

MEASUREMENT OF ELECTRICAL VARIABALES IN

SINGLE PHASE CIRCUIT

OBJECTIVE:

- Study of terminals and controls available in given voltmeter, ammeter, wattmeter, Variac (autotransformer).
- Measurement of electrical quantities in single phase circuit with –
    1. Resistive load
    2. RC & RL load
    3. RLC load

ACCESSORIES:

Voltmeter, ammeter, variac, double pole single throw (DPST)switch, wattmeter, R,L&C components and connecting wires

THEORY:

Wire wound Resistor:

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. The current through a resistor is in direct proportion to the voltage across the resistor's terminals.

A wire wound resistor is an electrical passive component that limits current. The resistive element exists out of an insulated metallic wire that is winded around a core of non-conductive material. The wire material has a high resistivity, and is usually made of an alloy such as Nickel-chromium (Nichrome) or a copper-nickel-manganese alloy called Manganin. Common core materials include ceramic, plastic and glass. Wire wound resistors are the oldest type of resistors that are still manufactured today. They can be produced very accurate, and have excellent properties for low resistance values and high power ratings.

Capacitor:

A capacitor (originally known as condenser) is a passive two-terminal electrical component used to store energy in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors separated by a dielectric (insulator); for example, one common construction consists of metal foils separated by a thin layer of insulating film. Capacitors are widely used as parts of electrical circuits in many common electrical devices.

When there is a potential difference (voltage) across the conductors, a static electric field develops across the dielectric, causing positive charge to collect on one plate and negative charge on the other plate. Energy is stored in the electrostatic field. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them.

Inductor:

An inductor (also choke, coil or reactor) is a passive two-terminal electrical component that stores energy in its magnetic field. For comparison, a capacitor stores energy in an electric field, and a resistor does not store energy but rather dissipates energy as heat.

Any conductor has inductance. An inductor is typically made of a wire or other conductor wound into a coil, to increase the magnetic field.

When the current flowing through an inductor changes, creating a time-varying magnetic field inside the coil, a voltage is induced, according to Faraday's law of electromagnetic induction which by Lenz's law opposes the change in current that created it. Inductors are one of the basic components used in electronics where current and voltage change with time, due to the ability of inductors to delay and reshape alternating currents.

PROCEDURE:

1. First take the basic observations about the different measuring instrument (ammeter, voltmeter etc.).
2. Make connections as per Fig.(1) and connect the output of variac to a single phase load.
    - For first set of readings take resistance(R) as load. Fig.(3)
    - For second set of readings take resistance(R) and inductor(L) as load. Fig.(5)
    - For third set of readings take resistance(R) and capacitor(C) as load. Fig.(6)
    - For forth set of readings take resistance(R), inductor(L) and capacitor(C) as load. Fig.(7)

    Note : all the loads are connected in series.
3. Connect voltmeter, ammeter and wattmeter with proper connection.

4. We keep the voltmeter terminals free so that one voltmeter can be used for measuring voltage anywhere on the circuit by touching its terminals at the two points between which voltage is to be measured.

Figure:

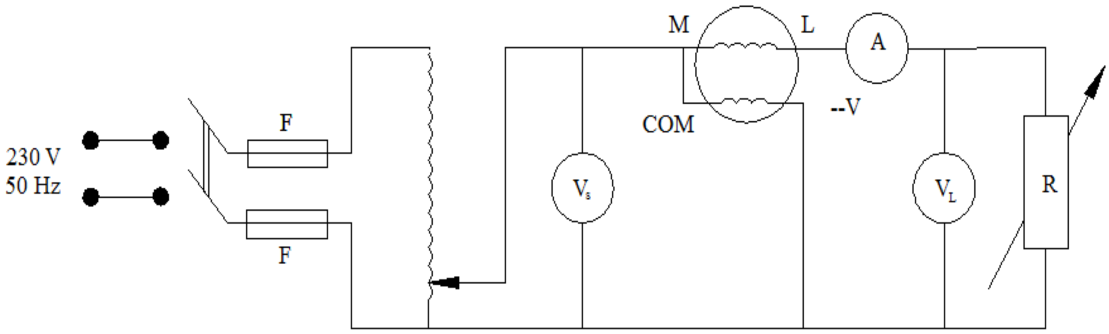


Fig.(1)

Fig.(2)

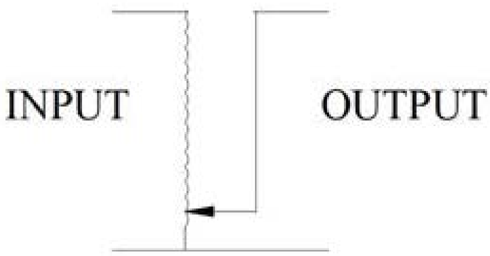


Fig.(3)

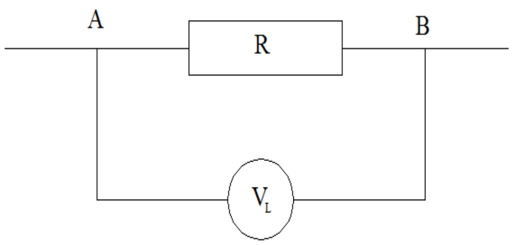


Fig.(4)

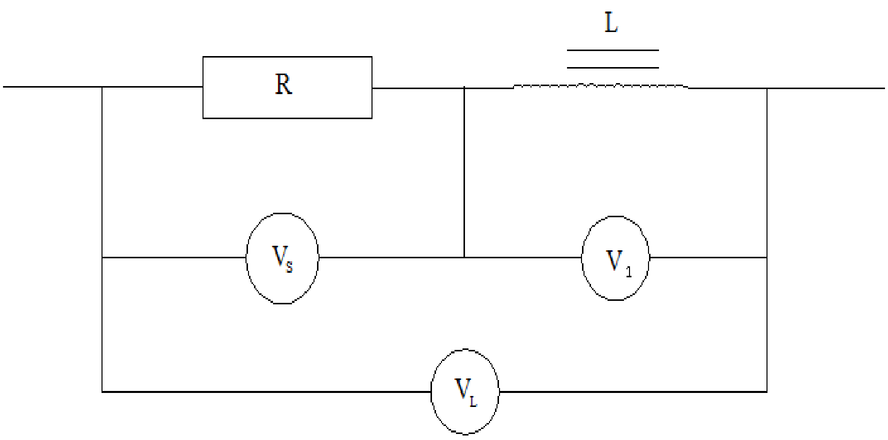


Fig.(5)

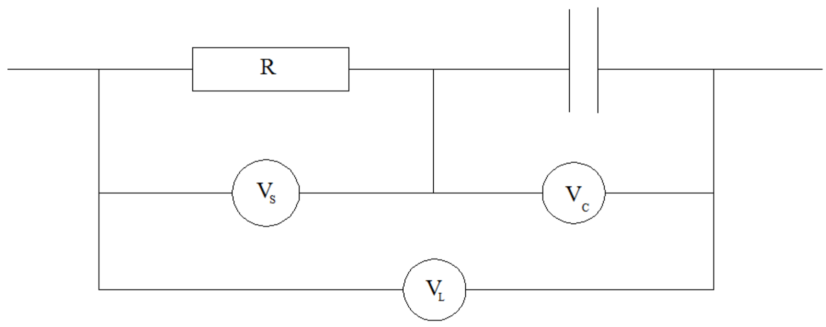


Fig.(6)

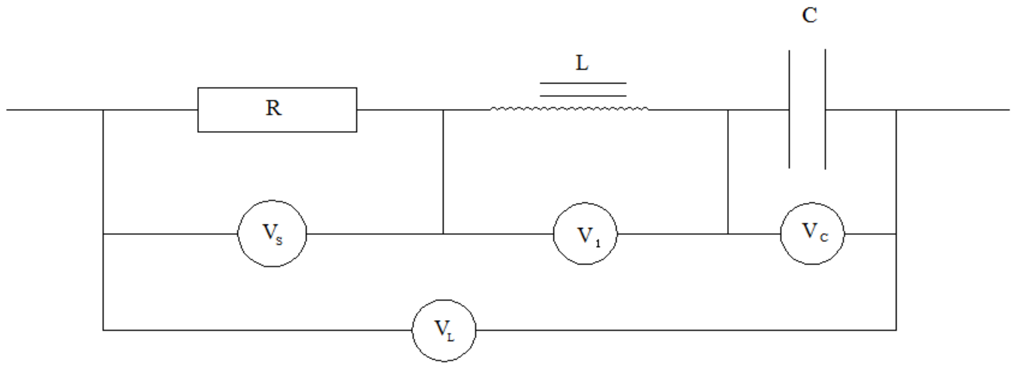


Fig.(7)

OBSERVATION:

- Voltmeter :
    1. It measures only ac/dc voltage, both ac and dc voltage
    2. It's scale is linear/non-linear
    3. Voltage range available are
    4. It reads the rms/peak/dc voltage
    5. It is connected in series/ parallel with load(fig.3)
    6. Input impedance of voltmeter is very large/small as compared to load.
- Ammeter :
    1. It measures only ac/dc voltage, both ac and dc voltage
    2. It's scale is linear/non-linear
    3. Current range available are
    4. It reads the rms/peak/dc voltage
    5. It is connected in series/ parallel with load(fig.2)
    6. Input impedance of voltmeter is very large/small as compared to load.
- Variac(Autotransformer) :

1. Input ac voltage given to the variac(fig.4) ________________.
2. Variable output ac voltage is from to V (rms)

- Wattmeter :

  It has four terminals coming out of it, two for the pressure coil(pc)(marked as ‘COM’ and ‘—V’) and two for current coil(cc) (marked as ‘M’ and ‘L’)(fig.1). The readings of the digital mete are in KW.

OBSERVATION TABLE:

Frequency of the source voltage observed is _____________.

Loads	**V_s**	**V_L**	**V_r**	**V_c**	**V_I**	**I_L**	**W**
R				-	-		
R and L				-			
R and C					-		
R,L & C							

RESULT:

1. Draw the phasor diagram for V_L, V_r, I_L of R load on(fig.a).
2. Draw the phasor diagram for V_r, I_L, V_I of R,L load on(fig.b).
3. Draw the phasor diagram for V_r, V_c, I_L of R, C load on(fig.c).
4. Draw the phasor diagram for V_r, V_c, I_L, V_I of R,C,L load on(fig.d).

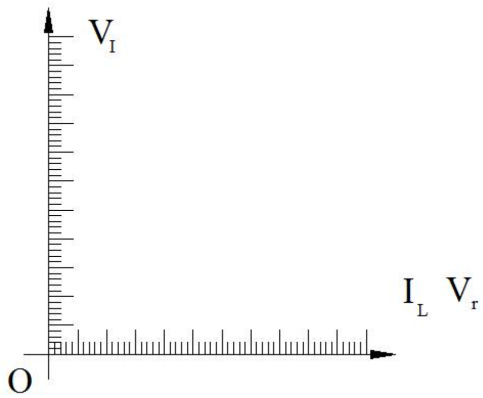


Fig.(a) Fig.(b)

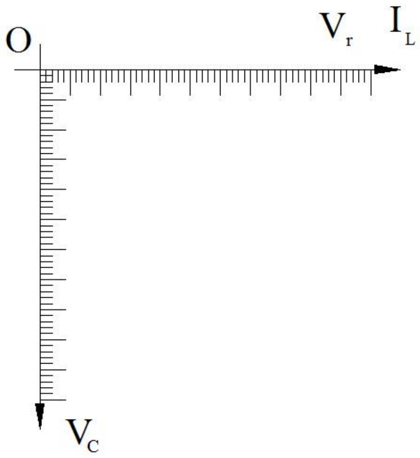


Fig.(c)

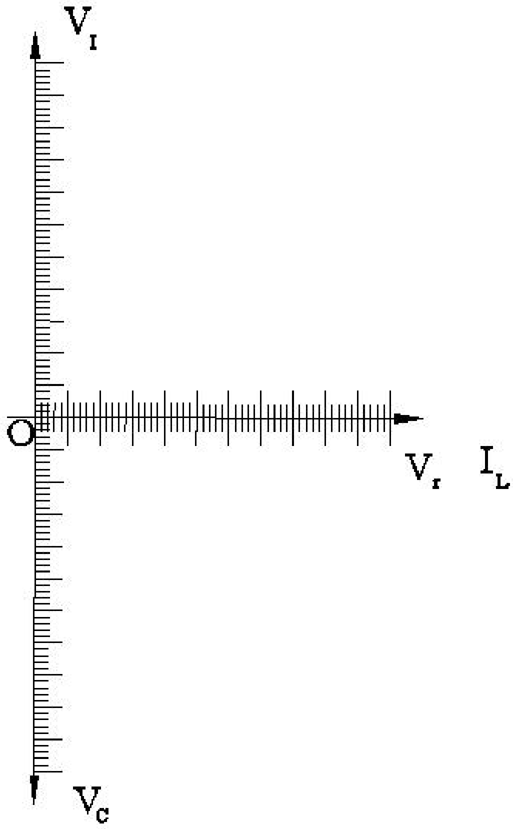


Fig.(d)

PRECAUTIONS:

1. We keep the voltmeter terminals free so that one voltmeter can be used for measuring voltage.
2. Check the connections before taking the readings.
3. Keep hands off the terminals once the power is switched on.

EEE-5

DETERMINATION OF SENSITIVITY OF LVDT

OBJECTIVE

To Determine sensitivity of the LVDT transducer

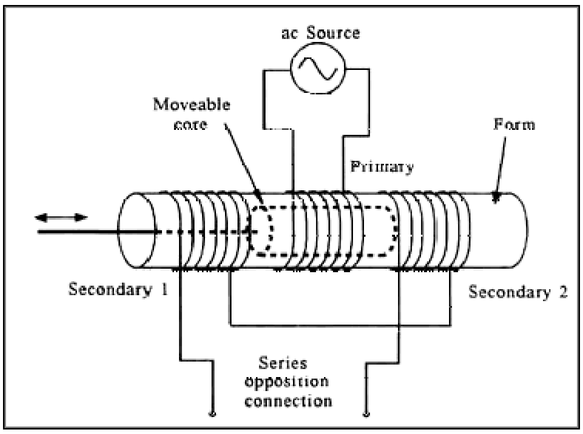
THEORY

A transducer is a device that converts one form of energy to another. Energy types include electrical, mechanical, electromagnetic (including light),chemical, acoustic or thermal energy. While the term transducer commonly implies the use of a sensor/detector, any device which converts energy can be considered a transducer. Transducers are widely used in measuring instruments

What Is An LVDT?

The letters LVDT are an acronym for Linear Variable Differential Transformer, a common type of electromechanical transducer that can convert the rectilinear motion of an object to which it is coupled mechanically into a corresponding electrical signal.

Linear variable differential transformers (LVDT) are used to measure displacement. LVDTs operate on the principle of a transformer. As shown in Figure , an LVDT consists of a coil assembly and a core. The coil assembly is typically mounted to a stationary form, while the core is secured to the object whose position is being measured. The coil assembly consists of three coils of wire wound on the hollow form. A core of permeable material can slide freely through the center of the form. The inner coil is the primary, which is excited by an AC source as shown. Magnetic flux produced by the primary is coupled to the two secondary coils, inducing an AC voltage in each coil. The two secondary coils are in phase opposition with each other.

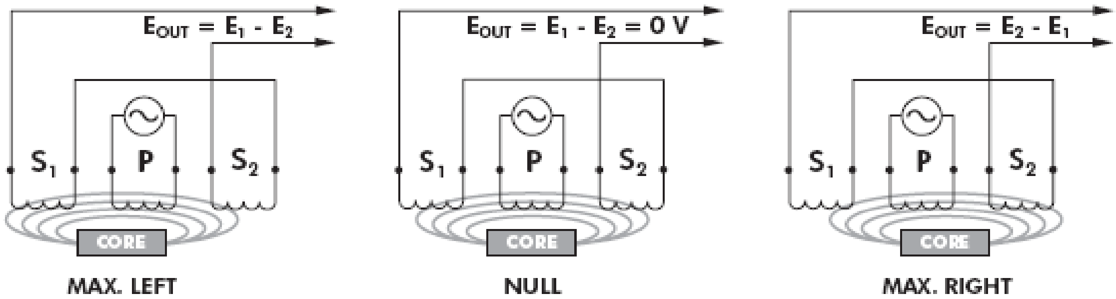


(1) *General LVDT Assembly*

How Does An LVDT Work?

Figure 2 illustrates what happens when the LVDT's core is in different axial positions. The LVDT's primary winding, P, is energized by a constant amplitude AC source. The magnetic flux thus developed is coupled by the core to the adjacent secondary windings, S1 and S2. If the core is located midway between S1 and S2, equal flux is coupled to each secondary so the voltages, E1 andE2, induced in windings S1 and S2 respectively, are equal. At this reference midway core position, known as the null point, the differential voltage output, (E1 - E2), is essentially zero.

As shown in Figure 2, if the core is moved closer to S1 than to S2, more flux is coupled to S1 and less to S2, so the induced voltage E1 is increased while E2 is decreased, resulting in the differential voltage (E1 - E2). Conversely, if the core is moved closer to S2, more flux is coupled to S2 and less to S1, so E2 is increased as E1 is decreased, resulting in the differential voltage (E2 - E1).



Figure(2)

The main advantage of the LVDT transducer over other types of displacement transducer is the high degree of robustness. Because there is no physical contact across the sensing element, there is no wear in the sensing element.

Because the device relies on the coupling of magnetic flux, an LVDT can have infinite resolution. Therefore the smallest fraction of movement can be detected by suitable signal conditioning hardware, and the resolution of the transducer is solely determined by the resolution of the data acquisition system.

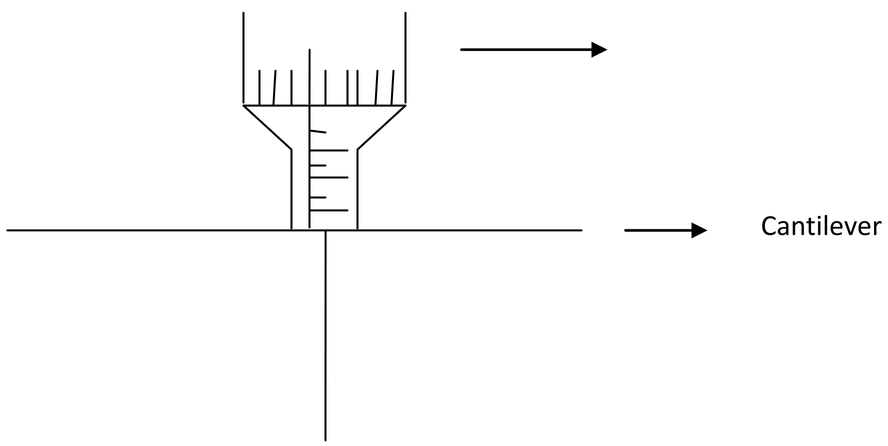
ACCESSORIES

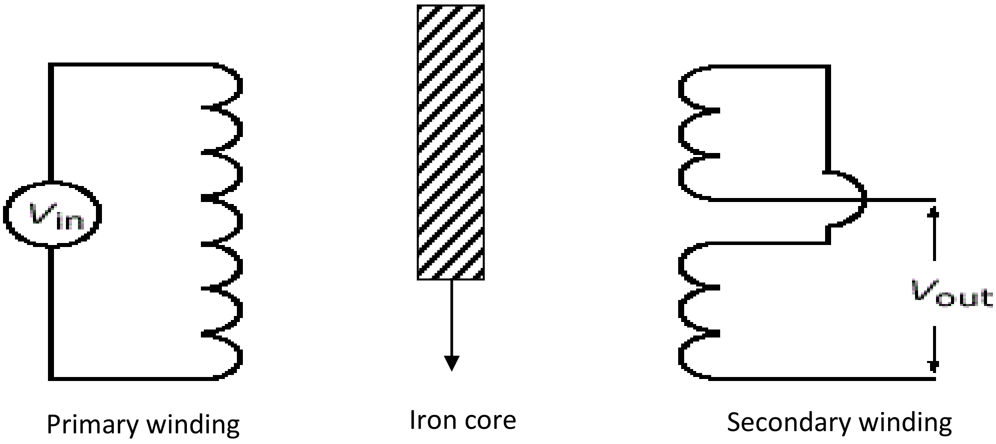
LVDT transducer, AF signal generator, CRO and connecting wires.

PROCEDURE

1. Study the following carefully:
    a. Least count of the screw gauge.
    b. Frequency (range) and output of the AF
       Signal.
    c. Controls of CRO, particularly Volts/Division on Y-input
2. Set Volts/Div control to 1 Volt/Div.
3. Connect Y input to CAL-IV terminal. You will see two dotted lines on the horizontal screen one division apart from each other.
4. Hook up the connections as per circuit diagram (1) and switch on the mains supply.
5. Feed a signal of 1 KHz at 10Volts from the signal generator and notice a sine wave on the CRO screen. Change Volts/Div., if necessary.
6. Adjust screw gauge for a straight horizontal line. This indicates ZERO output (Null point). Note down the reading of screw gauge at null point.
7. Shift cantilever plate up and down by means of the screw gauge noting CRO reading and the corresponding displacement on screw gauge with reference to null point reading in the observation table.
8. Plot graph for displacement vs output and thereby determine the slope of the graph.

    (Slope=$\Delta y/\Delta x$)
9. Slope of the graph = Sensitivity of LVDT trans





OBSERVATION TABLE

1. Least count of the screw gauge ____________ mm.
2. Sensitivity of the CRO _____________Volts/div.
3. Null point reading _____________mm.

S.No.	**Displacement of cantilever plate w.r.t Null point reading**		**CRO reading**		**Output (mV)**
	Up(mm)	Down(mm)	Up(div)	Down(div)	

EEE-6

TEST ON SINGLE PHASE TRANSFORMER

OBJECTIVE:

To conduct tests on a single phase transformer and determine its :-

i. Turns Ratio
ii. Voltage Ratio
iii. Current Ratio
iv. No load losses
v. Percentage Regulation

THEORY:

Transformer terminology

- A transformer is an apparatus for converting electrical power in an ac system at one voltage or current into electrical power at some other voltage or current without the use of rotating parts.
- The primary winding is the winding of the transformer which is connected to the source of power. It may be either the high- or the lowvoltage winding, depending upon the application of the transformer.
- The secondary winding is the winding of the transformer which delivers power to the load. It may be either the high- or the low-voltage winding, depending upon the application of the transformer.
- The core is the magnetic circuit upon which the windings are wound.
- The high-tension winding is the one which is rated for the higher voltage.
- The low-tension winding is the one which is rated for the lower voltage.
- A step-up transformer is a constant-voltage transformer so connected that the delivered voltage is greater than the supplied voltage.
- A step-down transformer is one so connected that the delivered voltage is less than that supplied voltage.
- An **autotransformer** (sometimes called ***auto step down transformer***) is an electrical transformer with only one winding. The "auto" (Greek for "self") prefix refers to the single coil acting on itself and not to any kind of automatic mechanism. In an

autotransformer portions of the same winding act as both the primary and secondary. The winding has at least three taps where electrical connections are made. Autotransformers have the advantages of often being smaller, lighter, and cheaper than typical dual-winding transformers, but autotransformers have the disadvantage of not providing electrical isolation.

- **Regulation Of Transformer**

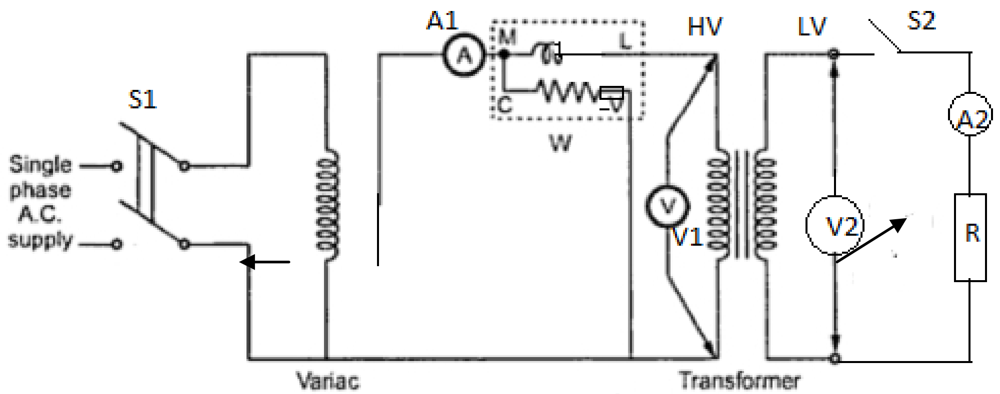
The regulation of a transformer is the change in secondary voltage from no load to full load. It is generally expressed as a percentage of the full-load secondary voltage.

- **Efficiency Of Transformer**

The efficiency of a transformer is, as with any other device, the ratio of the output to input or, in other words, the ratio of the output to the output plus the losses.

$$\text{Efficiency} = \frac{\text{output}}{\text{Input}} = \frac{\text{output}}{\text{output} + \text{copper loss} + \text{iron loss}}$$

- The copper loss of a transformer is determined by the resistances of the high-tension and low-tension windings and of the leads. It is equal to the sum of the watts of I^2R losses in these components at the load for which it is desired to compute the efficiency.
- The iron loss of a transformer is equal to the sum of the losses in the iron core.These losses consist of eddy- or Foucault-current losses and hysteresis losses. Eddy-current losses are due to currents generated by the alternating flux circulating within each lamination composing the core, and they are minimized by using thin laminations and by insulating adjacent laminations with insulating varnish. Hysteresis losses are due to the power required to reverse the magnetism of the iron core at each alternation and are determined by the amount and the grade of iron used for the laminations for the core.
- Transformer ratings. Transformers are rated at their kilovolt-ampere (kVA) outputs.



CIRCUIT DIAGRAM

ACCESSORIES

Single Phase Transformer, Single Phase autotransformer, voltmeter, ammeter, wattmeter, load and switches

PROCEDURE

1. Connect the circuit as shown in diagram.
2. Switch on the supply and take readings for no load.
3. Now take readings in load conditions

OBSERVATIONS

RUN 1

1. Voltmeter I

   Voltage ranges available ______________

   It's scale is linear/ non-linear/digital display

   It measure only ac/dc

2. Voltmeter II

   Voltage ranges available ______________

   It's scale is linear/non-linear/ digital display

   It measure only ac/dc/both

3. Ammeter I

   Current ranges available __________________

   It's scale is linear/non-linear/ digital display

   It measures only ac/dc/both

4. Ammeter II

   Current ranges available __________________

   It's scale is linear/non-linear/ digital display

   It measures only ac/dc/both

5. Wattmeter

   1) It is Dynamometer/induction type/ digital

   2) It reads only dc/active/reactive power on same scale

   3) It's scale is linear/non-linear/ digital display

4) Number of division on scale is ______________ divisions

5)Wattmeter has four terminals coming out of it-two for the pressure coil (pc) (marked as COM and –V) and two for current coil (cc) marked M (for mains) and L (for load) fig.3-1 shows the wattmeter connections for power measurement in a single phase circuit. We observe that:

a) M of cc is connected to	incoming line/neutral/load terminal
b) L of cc is connected to	live/neutral/load terminal
c) V of pc is connected	terminal M/terminal L/ neutral N.
d) COM of pc is connected	terminal M/terminal L/ neutral N.
e) Load current will pass through	cc/pc
f) Load voltage appears	cc/pc

6) Available pressure coil ranges are ___________________________

7) Available current coil ranges are ___________________________

8) Specified power factor (pf)for the given Wattmeter is (Normal power factor 1, if not specified on wattmeter) ___________________________

9) Multiplication factor (MF) of the wattmeter)

$$= \frac{\text{Pressure coil range X current coil range X pf}}{\text{Total no. of divisions on the scale}}$$

10) Wattmeter reading in watts

= ______________________

Autotransformer:

Range: Input ____________

Output____________

Transformer name plate details:

Voltage(HV) _____________

Voltage(LV) _____________

KVA rating _______________

RUN 2 (No load test)

i. Connect meters, transformers, load etc. As shown in fig. 3-1

ii. Keep the variac position near ‘0’i.e. no voltage is applied to the circuit.

Load switch (S2) must be off.

Iii Switch on the supply, (Switch S1) increase the input voltage with the help of variac,

a) Voltage on HV side: (reading in V1) _______________volts

b) Voltage on LV side (reading in V2) _______________volts

c) No load current (reading in A1) _______________volts

d) Current in LV side (reading in A2) _______________volts

e) No load losses (reading in W) ________________watt

(This is the no-load loss, since the transformer is not converting any energy to the load circuit).

f) Turns ratio = $\frac{\text{Voltage on HV side}}{\text{Voltage on LV side}}$

(Turns ratio = voltage ratio)

g) Current ratio = 1/Turns ratio

RUN 3 (Load Test)

Close the switch (S2) on LV side.

Note down:

a. HV side voltage ___________________V

b. LV side voltage ___________________V

%Regulation= $\frac{\text{Change in LV side Voltage from no load to LV side voltage from load}}{\text{No-load voltage}}$ X100

c. HV side current ________________A

d. LV side current ________________A

e. Power consumed ________________W

RESULTS AND DISCUSSION

PRECAUTIONS:

1. Be as neat a possible. Keep the work area and workbench clear of items not used in the experiment.
2. When disassembling a circuit, first remove the source of power.
3. Keep the body, or any part of it, out of the circuit.
4. Always check to see that the power switch is OFF before plugging into the outlet. Also, turn instrument or equipment OFF before unplugging from the outlet.

APPENDIX I

HARDNESS-STRENGTH CONVERSION PLOTS (*courtesy of The American Society for Metals.*)

APPENDIX II

CHART FOR VICKER'S HARDNESS TEST

APPENDIX III

Question bank

MECHANICAL

1. What is the limitation of Brinell hardness test?
2. Which is the hardest material ? and how ?
3. Can we predict the tensile strength of a material if its hardness in known ?
4. What is the unit of B.H.N?
5. Which ball size is recommended for Brinell test?
6. In what way the values of impact energy will be influenced if the impact tests are conducted on two specimens, one having smooth surface and the other having scratches on the surface ?
7. What is the effect of temp. on the values of rupture energy and notch impact strength ?
8. What is resilience? How is it different from proof resilience and toughness?
9. What is the necessity of making a notch in impact test specimen ?
10. If the sharpness of V-notch is more in one specimen than the other, what will be its effect on the test result ?
11. Which steel have you tested in tensile testing ? what is its carbon content ?
12. What general information are obtained from tensile test regarding the properties of a material.
13. Which stress have you calculated during tensile, compression and bending test: nominal stress or true stress ?
14. What kind of fracture has occurred in the tensile specimen and why ?
15. Which is the most ductile metal ?How much is its elongation ?

16. Compression tests are generally performed on brittles materials-why ?

17. Which will have a higher strength : a small specimen or a full size member made of the same material ?

18. What is column action ? how does the h/d ratio of specimen affect the test result ?

19. How do ductile and brittle materials in their behaviour in compression test ?

20. What are bi-modulus materials ? Give examples

21. What is deflection ? how will define ?

22. What is moment of inertia ?

23. What is young modulus ?

24. Write Euler’s formula.

25. Does the shear failure in wood occur along the 45° shear plane ?

CHEMICAL

1. What are the various forces that act on a float in a rotameter?
2. What is drag force?
3. What is buoyancy force?
4. Can a rotameter be placed horizontally?
5. Why should be a rotameter placed vertically?
6. What are the directions of the various forces acting on the float of a rotameter?
7. What is dynamic viscosity?
8. What is the principle of a viscometer?
9. What is the unit of dynamic viscosity?
10. Reynolds number importance?
11. Describe the Reynolds number experiment to demonstrate the two types of flow?
12. Define laminar, transition and turbulent flow?
13. What is critical velocity?
14. Properties of fluid on which Reynolds number is dependent?
15. Why is the dye used in the experiment?
16. What happens when fluid of high viscosity is used?
17. Give a practical example of laminar flow?
18. What do you mean by dynamic response of a measuring instrument?
19. What do you mean by first order instruments?
20. Name one first order instruments?
21. What do you mean by time constant of a thermometer?
22. How is the time constant determined?
23. Discuss effect of variation of τ on response of the instrument?
24. Properties of mercury?
25. 1) Bernoulli's equation holds good for non ideal fluids

    a) True   b) False

26. The pressure head is given by

a) P/γ b) $V^2/2g$

27. Bernoulli’s theorem deals with law conservation of momentum

a) True b) false

28. What is piezometeric tube?

29. Where piezometric head comes to be minimum ?

30. What is the principle of flow measurement in orificemeter?

31. Define parallax error?

32. What is coefficient of discharge?

33. What is coefficient of velocity?

34. Define vena-contracta?

EEE

1. How many pins does each IC given in this experiment have?
2. Which gate is IC 7400?
3. Which gate is IC 7402?
4. Which gate is IC 7404?
5. Which gate is IC 7408?
6. Which gate is IC 7432?
7. Which gate is IC 7486?
8. How many logic gates are there in an IC 7404 (NOT)?
9. How many logic gates are there in an IC 7432 (OR)/7400/7402/7408/7486?
10. Define Power Factor.
11. What is the unit of power factor?
12. In what unit is the True power expressed?
13. What is the unit of apparent power?
14. What is the power factor of a purely resistive circuit?
15. What is the power factor of a purely capacitive circuit?
16. What is the power factor of a purely inductive circuit?
17. What do you mean by operational amplifier (op-amp)?
18. What do you mean by inverting amplifier?
19. What do you mean by non-inverting amplifier?
20. What is the use of AF signal generator?
21. What is the use of Digital multimeter(DMM)?
22. What do you mean by voltage gain?
23. What type of input is given to the circuits?
24. What is the output shown in the multimeter?
25. What is the use of color code of resistors?
26. What do you mean by resistor?

27. What do you mean by capacitor?

28. What do you mean by inductors?

29. What does a phasor diagram indicate?

30. What happens to voltage across the load when the no of loads increase?

31. What happens to current across the load when the no of loads increase?

32. What are the different measuring instruments used in the experiment?

33. Define the term sensitivity as it relates to a transducer.

34. Define what the null position of an LVDT is.

35. Determine the sensitivity of the LVDT. Generate a plot of the output voltage vs. input displacement of the core.

36. If the LVDT has a linear input range of +/- 3 inches with a correspondingoutput range of +/- 10 V dc, what nominal sensitivity should this instrument have?

37. Is the calibrated sensitivity different from the expected value? Why may these values differ?

38. Determine the sensitivity of the accelerometer.

39. What means can be used to determine if the accelerometer was calibrated at100Hz?

40. How accurate are the experimental sensitivities of the LVDT and accelerometer? Discuss the sources for error.

41. Discuss an alternate means of calibrating an accelerometer.

42. Discuss types of losses in transformer?

43. What is variac?

44. What do you mean by step up and step down transformer?

45. What value of voltage and frequency is used in India?

46. Give relationship between turns ratio and current ratio?

PERFORATED SECTION

Name: ID No.

Marks Obtained Date

Instructor's Signature____________________.

EXPERIMENT NO.

MEASUREMENT OF MODULUS OF ELASTICITY

OBJECTIVE:-

To measure tensile strain by Ewing's extensometer during tension test on an M.S specimen and to determine the value of modulus of elasticity.

OBSERVATION :-

Gauge length of specimen l = ------mm.

Least count of extensometer= 0.0002 inch

Diameter of specimen d = 0.8 inches =

Area of cross section of specimen =

OBSERVATION TABLE

S.No.	Load on specimen (T)	Stress (T/in^2)	Extensometer reading (division)	Strain X 10^{-5}

RESULT :-

The Young's modulus of the given specimen = -------GPa

PRECAUTIONS :-

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the compression plates.
3. Take reading carefully.
4. After failed specimen stop to m/c.

Name: ID No.

Marks Obtained Date

Instructor's Signature____________________.

EXPERIMENT NO.

MEASUREMENT OF MODULUS OF ELASTICITY

Objective:-

To measure bending strain by dial-gauge indicator during bending test on an M.S specimen and to determine the value of modulus of elasticity.

OBSERVATION :-

Least count of dial-gauge indicator = 0.1 mm

Length of beam (L) =

Width of beam (b) = ------

Thickness of beam (t) = ------

OBSERVATION TABLE

Sl no.	**Load on specimen (Kg)**	**Stress (Kg/cm^2)**	**Dial gauge indicator reading**	**Strain X 10^{-5}**

CALCULATION:-

$$\sigma = \frac{My}{I_{xx}}$$

$$I_{xx} = \frac{bh^3}{12}$$

$$y = \frac{t}{2}$$

$$E = \frac{11l^3}{568I}\left(\frac{w}{\delta}\right)$$

RESULT :-

The Young’s modulus of the given specimen = -------GPa

PRECAUTIONS :-

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the compression plates.
3. Take reading carefully.
4. After failed specimen stop to m/c.

Name: ID No.

Marks Obtained Date

Instructor's Signature____________________.

EXPERIMENT NO.

COMPRESSION TEST

OBJECTIVE:-

To Perform compression test on UTM.

OBSERVATION :-

Initial length or height of specimen h = ------mm.

Initial diameter of specimen do = ------------mm.

Applied load (P) in Newton =

Recorded change in length (mm)=

CALCULATION :-

Original cross-section area Ao = -----

Final cross-section area Af = --------

Stress = -------

Strain = -------

Draw stress-strain (ζ-ε) curve in compression,

RESULT :-

The Young's modulus of the given specimen = -------GPa

PRECAUTIONS :-

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the compression plates.
3. Take reading carefully.
4. After failed specimen stop to m/c.

Name: ID No.

Marks Obtained Date

Instructor's Signature____________________.

EXPERIMENT NO.

IZOD TEST

OBJECTIVE:-

To study the Impact Testing m/c and Perform Izod impact test.

APPARATUS :-

Impact testing m/c, Izod test specimens of mild steel, Aluminium, Vernier calliper, specimen setting fixture.

SPECIFICATION OF M/C AND SPECIMEN DETAILS :

Its specifications along-with their typical values are as follows:

Impact capacity =

Least count of capacity (dial) scale =

Weight of striking hammer =

Swing diameter of hammer =

Angle of hammer before striking =

Distance between supports =

Striking velocity of hammer =

Specimen size =

Type of notch = V-notch

Angle of notch = 45°

Depth of notch =

OBSERVATION :-

S.No	Initial Energy (E1) in joule	Residual Energy (E2) in joule	E1-E2

CALCULATION :-

• Notch impact strength = Absorb energy / Effective cross section area

RESULT :-

The impact strength of given specimen = -------joule/mm2

PRECAUTIONS :-

1. The specimen should be prepared in proper dimensions.
2. Take reading more frequently.
3. Make the loose pointer in contact with the fixed pointer after setting the pendulum.
4. Do not stand in front of swinging hammer or releasing hammer.
5. Place the specimen proper position.

Name: ID No.

Marks Obtained Date

Instructor's Signature____________________.

EXPERIMENT NO.

ROCKWELL HARDNESS TEST

OBJECTIVE:

To measure the hardness of the given samples and to correlate them with the Ultimate Tensile Strength (UTS) of the materials using Rockwell Hardness Testing Machine.

OBSERVATIONS:

Materials given =

Diameter of Indenter = mm

Load applied (P) = Kg

Reading of scale B or C =

Sl. No	Material	e (=100-E)

RESULT:-

PRECAUTION :-

1. At least two preliminary tests should be performed before beginning any measuring, in order to acclimatize the indenter, raising/lowering screw, and specimen platform.
2. Ensure that contact surfaces such as the indenter attachment face, between the specimen and specimen platform, and between the specimen platform and raising/lowering screw are continually maintained in a clean state.
3. Wipe all contact surfaces thoroughly with a clean cloth before performing tests.
4. The specimen measurement location must be spaced at least 4d (where d is the indentation diameter) from the center of indentations already present.

Name: ID No.

Marks Obtained Date

Instructor's Signature____________________.

EXPERIMENT NO.

VICKER'S HARDNESS TEST

OBJECTIVE:

To measure the hardness of the given materials using Vicker's Hardness Testing Machine.

OBSERVATIONS:

Materials given =

Type of indenter =

Load on specimen = Kgf

Sl. No	Length of diagonal d1 (mm)	Length of diagonal d2 (mm)	Avg. length of diagonal d= (d1+d2)/2

RESULTS :

Vicker's Hardness Number =

Ultimate Tensile Strength of the specimen =

PRECAUTION :

1. When doing the hardness tests the minimum distance between indentations and the distance from the indentation to the edge of the specimen must be taken into account to avoid interaction between the work-hardened regions and effects of the edge.
2. Wipe all contact surfaces thoroughly with a clean cloth before performing tests.

Name: ID No.

Marks Obtained Date

Instructor's Signature____________________.

EXPERIMENT NO.

TORSION TEST

OBJECTIVE:-

To find the angle of twist and to obtain some of the mechanical properties of the given material by conducting torsion test.

OBSERVATION:-

Length of the member, l =

Diameter of the member, d =

Polar moment of inertia, J = $\frac{\pi d^4}{32}$ =

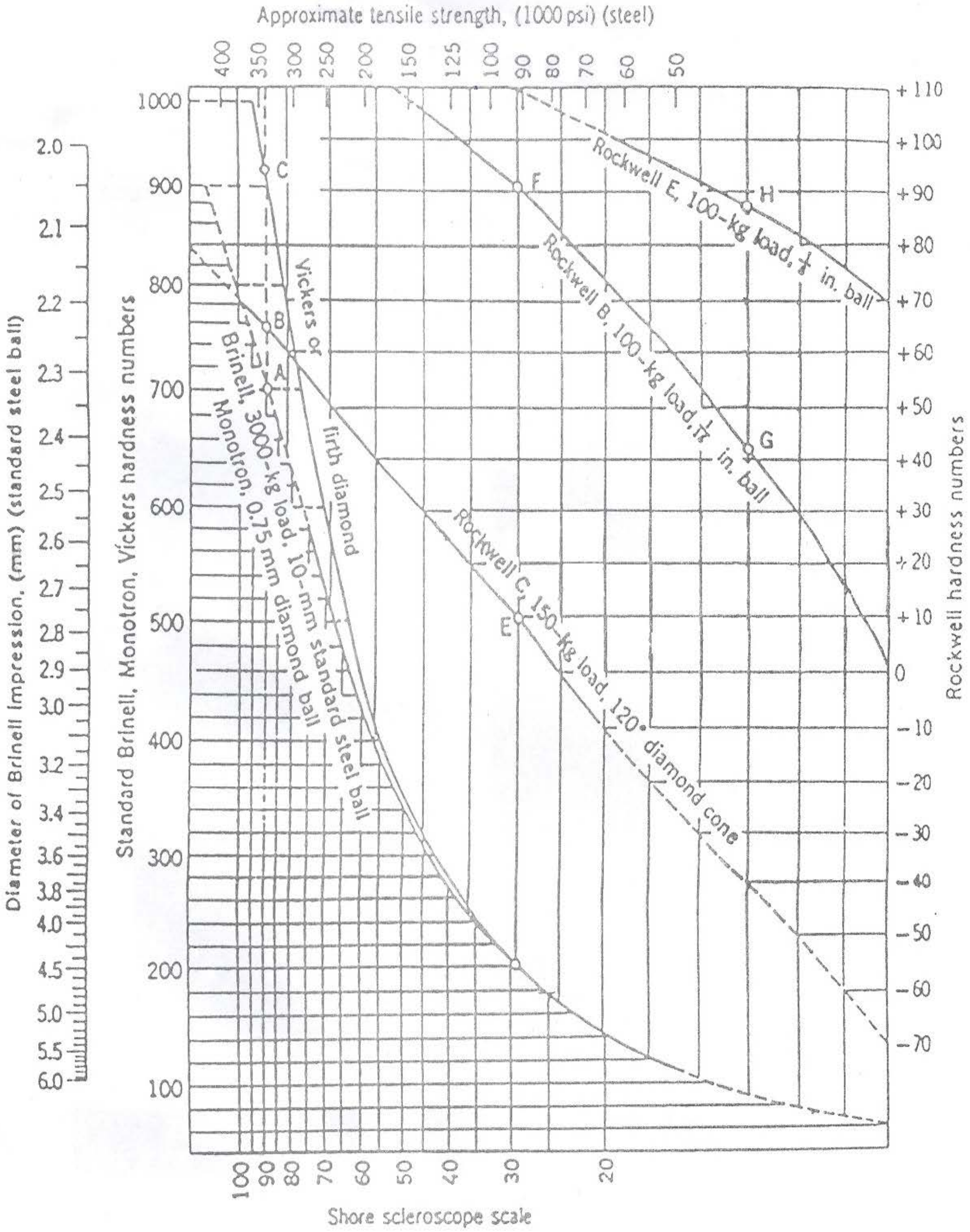
S.No	Load in ft. lbs	No. of Divns. In right hand chuck. Θ1	No. of Divns. In left hand chuck. Θ2	Actual θ = Θ1-Θ2

CALCULATION :-

RESULT:-

From torque-twist graph,

Modulus of rigidity of the material =



Hardness-strength conversion plots. (Courtesy of The American Society for Metals.)

VICKERS HARDNESS NUMBER

Eindruck Diagonale HV (5 Kg)

d (mm)	0	1	2	3	4	5	6	7	8	9
0.08	1449	1413	1379	1346	1314	1283	1253	1225	1197	1171
0.09	1145	1120	1095	1072	1049	1027	1006	986	966	946
0.10	927	908	891	874	857	841	825	810	795	781
0.11	766	752	739	726	713	701	689	677	666	655
0.12	644	633	623	613	603	593	584	575	566	558
0.13	549	540	532	524	516	509	502	494	487	480
0.14	473	466	460	454	447	441	435	429	423	418
0.15	412	407	401	396	391	386	381	376	371	367
0.16	362	358	353	349	345	341	336	332	329	325
0.17	321	317	313	310	306	303	299	296	293	289
0.18	286	283	280	277	274	271	268	265	262	260
0.19	257	254	251	249	246	244	241	239	236	234
0.20	232	229	227	225	223	221	219	216	214	212
	Eindruck Diagonale				**HV (10 Kg)**					
d (mm)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0.11	1533	1505	1478	1452	1427	1402	1378	1354	1332	1310
0.12	1288	1267	1246	1226	1206	1187	1168	1150	1132	1115
0.13	1097	1081	1064	1048	1033	1018	1003	988	974	960
0.14	946	933	920	907	894	882	870	858	847	835
0.15	824	813	803	792	782	772	762	752	743	734
0.16	724	715	707	698	690	681	673	665	657	649
0.17	642	634	627	620	613	606	599	592	585	579
0.18	572	566	560	554	548	542	536	530	525	519
0.19	514	508	503	498	493	488	483	478	473	468
0.20	464	459	455	450	446	442	437	433	429	425
0.21	421	417	413	409	405	401	397	394	390	387
0.22	383	380	376	373	370	366	363	360	357	354
0.23	351	348	345	342	339	336	333	330	327	325
0.24	322	319	317	314	312	309	306	304	302	299

indruck Diagonale HV (15 Kg)

d (mm)	0	1	2	3	4	5	6	7	8	9
0.12	1932	1905	1866	1838	1808	1780	1752	1724	1697	1671
0.13	1646	1617	1598	1572	1549	1526	1504	1482	1460	1439
0.14	1418	1397	1376	1360	1341	1323	1305	1287	1270	1253
0.15	1236	1219	1204	1188	1173	1158	1143	1128	1114	1100
0.16	1086	1073	1062	1047	1034	1021	1009	997	985	974
0.17	962	952	940	929	919	908	898	888	878	868
0.18	858	848	840	830	821	812	804	795	787	779
0.19	770	762	754	747	739	731	724	717	709	702
0.20	695	688	682	675	668	662	655	649	643	637
0.21	630	625	619	613	607	602	596	591	585	580
0.22	574	570	564	559	554	549	544	540	535	530
0.23	526	521	517	512	508	504	499	495	491	487
0.24	483	479	475	471	467	463	460	456	452	449
0.25	445	441	438	434	431	428	424	421	418	415
	Eindruck Diagonale				**HV (20 Kg)**					
d (mm)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0.14	1892	1865	1839	1813	1788	1764	1740	1716	1693	1670
0.15	1648	1626	1605	1584	1564	1543	1524	1504	1485	1467
0.16	1448	1431	1413	1396	1379	1362	1346	1330	1314	1298
0.17	1283	1268	1253	1239	1225	1211	1197	1184	1170	1157
0.18	1144	1132	1119	1107	1095	1083	1072	1060	1049	1038
0.19	1027	1016	1006	995	985	975	965	955	946	936
0.20	927	918	909	900	891	882	874	865	857	849
0.21	841	833	825	817	810	802	795	787	780	773
0.22	766	759	752	746	739	732	726	720	713	707
0.23	701	695	689	683	677	671	666	660	655	649
0.24	644	638	633	628	623	618	613	608	603	598
0.25	593	589	584	579	575	570	566	561	557	553
0.26	549	544	540	536	532	528	524	520	516	512
0.27	509	505	501	498	494	490	487	483	480	476