DEPARTMENT OF CIVIL ENGINEERING

17CVCC93 - HYDRAULICS AND STRENGTH OF MATERIALS LAB (UG)

LAB MANUAL

Prepared by

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A LIST OF BASIC SAFETY RULES

1. Students should wear durable clothing that covers the arms, legs, torso and feet. (Note: sandals, shorts, tank tops etc. have no place in the lab. Students inappropriately dressed for lab, at the instructors discretion, be denied access)
2. To protect clothing from chemical damage or other dirt, wear a lab apron or lab coat. Long hair should be tied back to keep it from coming into contact with lab chemicals or flames.
3. In case of injury (cut, burn, fire etc.) notify the instructor immediately.
4. In case of a fire or imminently dangerous situation, notify everyone who may be affected immediately; be sure the lab instructor is also notified.
5. In case of a serious cut, stop blood flow using direct pressure using a clean towel, notify the lab instructor immediately.
6. Eating, drinking and smoking are prohibited in the laboratory at all times.
7. Never work in the laboratory without proper supervision by an instructor.
8. Never carry out unauthorized experiments. Come to the laboratory prepared. If you are unsure about what to do, please ask the instructor.

LABARATORY CLASSES - INSTRUCTIONS TO STUDENTS

1. Students must attend the lab classes with ID cards and in the prescribed uniform.
2. Boys-shirts tucked in and wearing closed leather shoes. Girls' students with cut shoes, overcoat, and plait incite the coat. Girls' students should not wear loose garments.
3. Students must check if the components, instruments and machinery are in working condition before setting up the experiment.
4. Power supply to the experimental set up/ equipment/ machine must be switched on only after the faculty checks and gives approval for doing the experiment. Students must start to the experiment. Students must start doing the experiments only after getting permissions from the faculty.
5. Any damage to any of the equipment/instrument/machine caused due to carelessness, the cost will be fully recovered from the individual (or) group of students.
6. Students may contact the lab in charge immediately for any unexpected incidents and emergency.
7. The apparatus used for the experiments must be cleaned and returned to the technicians, safely without any damage.
8. Make sure, while leaving the lab after the stipulated time, that all the power connections are switched off.
9. **EVALUATIONS:**
    - All students should go through the lab manual for the experiment to be carried out for that day and come fully prepared to complete the experiment within the prescribed periods. Student should complete the lab record work within the prescribed periods.
    - Students must be fully aware of the core competencies to be gained by doing experiment/exercise/programs.
    - Students should complete the lab record work within the prescribed periods.
    - The following aspects will be assessed during every exercise, in every lab class and marks will be awarded accordingly:
    - **Preparedness, conducting experiment, observation, calculation, results, record presentation, basic understanding and answering for viva questions.**
    - In case of repetition/redo, 25% of marks to be reduced for the respective component.

NOTE 1

- **Preparation** means coming to the lab classes with neatly drawn circuit diagram /experimental setup /written programs /flowchart, tabular columns, formula, model graphs etc in the observation notebook and must know the step by step procedure to conduct the experiment.
- **Conducting experiment** means making connection, preparing the experimental setup without any mistakes at the time of reporting to the faculty.
- **Observation** means taking correct readings in the proper order and tabulating the readings in the tabular columns.
- **Calculation** means calculating the required parameters using the approximate formula and readings.
- **Result** means correct value of the required parameters and getting the correct shape of the characteristics at the time of reporting of the faculty.
- **Viva voice** means answering all the questions given in the manual pertaining to the experiments.
- **Full marks will be awarded if the students performs well in each case of the above component**

NOTE 2

- Incompletion or repeat of experiments means not getting the correct value of the required parameters and not getting the correct shape of the characteristics of the first attempt. In such cases, it will be marked as **"IC" in the red ink** in the status column of the mark allocation table given at the end of every experiment. The students are expected to repeat the incomplete the experiment before coming to the next lab. Otherwise the marks for IC component will be reduced to **zero.**

NOTE 3

- Absenteeism due to genuine reasons will be considered for doing the **missed experiments.**
- In case of power failure, extra classes will be arranged for doing those experiments only and assessment of all other components preparedness; viva voice etc. will be completed in the regular class itself.

NOTE 4

- The end semester practical internal assessment marks will be based on the average of all the experiments.

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List of Experiments

Sl. No	Date	Name of the experiments	Page no	Signature
1		A comparative analysis of Coefficient of discharge using an Orifice meter & venturimeter.		
2		Determination of pipe losse (major & minor).		
3		Conducting experiments and draw the characteristic curves of centrifugal pump/submersible pump/jet pump/reciprocating pump/Gear pump (any 3 pump experiments must be done).		
4		Study about the performance characteristics of Pelton wheel and Francis turbine.		
5		Determination of Tensile strength and Compression strength on a given specimen.		
6		Determination of shear strength of Mild steel and Aluminium rods		
7		Determination of Torsional strength of mild steel rod		
8		Determination of Impact strength		
9		Conduct of Hardness test on metals - Brinell and Rockwell Hardness.		
10		Conduct of Deflection test on beams		
11		A comparative analysis of Coefficient of discharge using Orifice meter & venturimeter.		
12		Determination of pipe loses (major & minor).		

1. DETERMINATION OF THE CO-EFFICIENT OF DISCHARGE OF GIVEN ORIFICE METER

AIM:

To determine the co-efficient discharge through orifice meter

APPARATUS REQUIRED:

1. Orifice meter
2. Differential U tube manometer
3. Collecting tank
4. Stop watch
5. Scale

FORMULAE:

1. **ACTUAL DISCHARGE**:

$$Q_{act} = A \times h / t \quad (m^3 / s)$$

2. **THEORTICAL DISCHARGE**:

$$Q_{th} = a_1 \times a_2 \times \sqrt{2 g h} / \sqrt{a_1^2 - a_2^2} \quad (m^3 / s)$$

Where:

A = Area of collecting tank in m^2

h = Height of collected water in tank = 10 cm

a_1 = Area of inlet pipe in, m^2

a_2 = Area of the throat in m^2

g = Specify gravity in m / s^2

t = Time taken for h cm rise of water

H = Orifice head in terms of flowing liquid

= $(H_1 \sim H_2) (s_{m} / s_{1} - 1)$

Where:

H1 = Manometric head in first limb

H2 = Manometric head in second limb

s_m = Specific gravity of Manometric liquid

(i.e.) Liquid mercury Hg = 13.6

s_1 = Specific gravity of flowing liquid water = 1

S.No	Diameter in mm	Manometric reading		Manometric head H=(H1~H2) x 12.6 x 10^{-2}	Time taken for ‘h’ cm rise of water ‘t’ Sec	Actual discharge Q act x 10^{-3} m^3 / s	Theoretical discharge Qth x 10^{-3} m^3 / s	Co-efficient of discharge Cd (no unit)
		H1 cm of Hg	H2 cm of Hg					
							Mean Cd =	

3. **CO EFFICENT OF DISCHARGE:**

Co- efficient of discharge = Q act / Q th (no units)

DESCRIPTION:

Orifice meter has two sections. First one is of area a_1, and second one of area $a_{2,}$ it does not have throat like venturimeter but a small holes on a plate fixed along the diameter of pipe. The mercury level should not fluctuate because it would come out of manometer.

PROCEDURE:

1. The pipe is selected for doing experiments
2. The motor is switched on, as a result water will flow
3. According to the flow, the mercury level fluctuates in the U-tube manometer
4. The reading of H_1 and H_2 are noted
5. The time taken for 10 cm rise of water in the collecting tank is noted
6. The experiment is repeated for various flow in the same pipe
7. The co-efficient of discharge is calculated

MODEL CALCULATION:

RESULT:

The co efficient of discharge through orifice meter is ……… (No unit)

VIVA QUESTIONS

1. For which one, the coefficient of discharge is smaller, venturimeter or Orificemeter?

2. What is the reason for smaller value of C_d ?

3. What is Orifice meter?

4. What is the principle of Orifice meter?

5 For discharge measurement through pipes which is having cheaper arrangement and whose installation requires a smaller length?

6. What are the parts of Orifice meter?

7. What is the diameter of the orifice?

8. Where two pressure taps are provided?

9. Where upstream pressure tap is located?

2.DETERMINATION OF THE CO EFFICIENT OF DISCHARGE OF GIVEN VENTURIMETER

AIM:

To determine the coefficient of discharge for liquid flowing through venturimeter.

APPARATUS REQUIRED:

1. Venturimeter
2. Stop watch
3. Collecting tank
4. Differential U-tube
5. Manometer
6. Scale

FORMULAE:

1. **ACTUAL DISCHARGE:**

$$Q_{act} = A \times h / t \quad (m^3 / s)$$

2. **THEORTICAL DISCHARGE:**

$$Q_{th} = a_1 \times a_2 \times \sqrt{2 g h} / \sqrt{a_1^2 - a_2^2} \quad (m^3 / s)$$

Where:

A = Area of collecting tank in m^2

h = Height of collected water in tank = 10 cm

a_1 = Area of inlet pipe in m^2

a_2 = Area of the throat in m^2

g = Specify gravity in m / s^2

t = Time taken for h cm rise of water

H = Orifice head in terms of flowing liquid

$= (H_1 \sim H_2) (s_m / s_1 - 1)$

Where:

H1 = Manometric head in first limb

H2 = Manometric head in second limb

s_m = Specific gravity of Manometric liquid

(i.e.) Liquid mercury Hg = 13.6

s_1 = Specific gravity of flowing liquid water = 1

S.No	Diameter in mm	Manometric reading		Manometric head H = (H1~H2) x 12.6 x 10^{-2}	Time taken for ‘h’ cm rise of water ‘t’ Sec	Actual discharge Q act x 10^{-3} m^3 / s	Theoretical discharge Qth x 10^{-3} m^3 / s	Co-efficient of discharge Cd (no unit)
		H1 cm of Hg	H2 cm of Hg					
							Mean Cd =	

3. **CO EFFICENT OF DISCHARGE:**

Co- efficient of discharge = Q act / Q th (no units)

DESCRIPTION:

Venturimeter has two sections. One divergent area and the other throat area. The former is represented as a_1 and the later is a_2 water or any other liquid flows through the Venturimeter and it passes to the throat area the value of discharge is same at a_1 and a_2 .

PROCEDURE:

1. The pipe is selected for doing experiments
2. The motor is switched on, as a result water will flow
3. According to the flow, the mercury level fluctuates in the U-tube manometer
4. The reading of H_1 and H_2 are noted
5. The time taken for 10 cm rise of water in the collecting tank is noted
6. The experiment is repeated for various flow in the same pipe
7. The co-efficient of discharge is calculated

MODEL CALCULATION:

RESULT:

The co efficient of discharge through Venturimeter is ……… (No unit)

VIVA QUESTIONS

1. What is cavitation?
2. What is value of diameter of throat?
3. What should be done to avoid cavitation?
4. Write the formula for actual discharge.
5. Venturi meter based on which principles?
6. What is Venturi meter? And what is its use?
7. Which part is smaller, convergent cone or divergent cone? Why?
8. Where separation of flow occurs?
9. Which portion is not used for discharge measurement?
10. Which cross-sectional area is smaller than cross sectional area of inlet section?
11. Where velocity of flow greater?
12. Where pressure is low in Venturi meter?
13. How pressure difference is determined?
14. Between which sections the pressure difference can be determined? Inlet section and Throat

3. DETERMINATION OF FRICTION FACTOR OF GIVEN SET OF PIPES

AIM:

To find the friction 'f' for the given pipe.

APPARATUS REQUIRED:

1. A pipe provided with inlet and outlet and pressure tapping
2. Differential u-tube manometer
3. Collecting tank with piezometer
4. Stopwatch
5. Scale

FORMULAE:

1. **FRICTION FACTOR (F):**

$f = 2 \times g \times d \times h_f / l \times v^2$ (no unit)

Where,

g = Acceleration due to gravity (m / sec^2)

d = Diameter of the pipe (m)

l = Length of the pipe (m)

v = Velocity of liquid following in the pipe (m / s)

h_f = Loss of head due to friction (m)

$= h_1 \sim h_2$

Where

h_1 = Manometric head in the first limbs

h_2 = Manometric head in the second limbs

2. **ACTUAL DISCHARGE:**

$Q = A \times h / t$ (m^3 / sec)

Where

A = Area of the collecting tank (m^2)

h = Rise of water for 5 cm (m)

t = Time taken for 5 cm rise (sec)

S.No	Diameter of pipe mm	Manometer readings			Time for 5cm rise of water t sec	Actual discharge $Q_{act} \times 10^{-3}$ m^3 / s	Velocity V m/s	V^2 m^2 / s^2	Friction factor $f \times 10^{-2}$
		$h_1 \times 10^{-2}$	$h_2 \times 10^{-2}$	$h_f = (h1-h2) \times 10^{-2}$					
								Mean f =	

3. **VELOCITY:**

$$V = Q / a \quad (m / sec)$$

Where

Q = Actual discharge (m^3/ sec)

A = Area of the pipe (m^2)

DESCRIPTION:

When liquid flows through a pipeline it is subjected to frictional resistance. The frictional resistance depends upon the roughness of the pipe. More the roughness of the pipe will be more the frictional resistance. The loss of head between selected lengths of the pipe is observed.

PROCEDURE:

1. The diameter of the pipe is measured and the internal dimensions of the collecting tank and the length of the pipe line is measured
2. Keeping the outlet valve closed and the inlet valve opened
3. The outlet valve is slightly opened and the manometer head on the limbs h_1 and h_2 are noted
4. The above procedure is repeated by gradually increasing the flow rate and then the corresponding readings are noted.

MODEL CALCULATION:

RESULT:

1. The frictional factor ‘f ‘ for given pipe = x 10^{-2} (no unit)
2. The friction factor for given pipe by graphical method = …… x 10^{-2} (no unit)

VIVA QUESTIONS

1. Define Boundary layer Thickness.
2. List the various types of boundary layer thickness.
3. Define displacement thickness.
4. Define momentum thickness.
5. Define energy thickness
6. What is meant by energy loss in a pipe?
7. Explain the major losses in a pipe.
8. Explain minor losses in a pipe.
9. State Darcy-Weisbach equation OR What is the expression for head loss due to friction?

4.CONDUCTING EXPERIMENTS AND DRAWING THE CHARACTERISTICS CURVES OF CENTRIFUGAL PUMP

AIM:

To study the performance characteristics of a centrifugal pump and to determine the characteristic with maximum efficiency.

APPARATUS REQUIRED:

1. Centrifugal pump setup
2. Meter scale
3. Stop watch

FORMULAE:

1. **ACTUAL DISCHARGE:**

$Q_{act} = A \times y / t \quad (m^3 / s)$

Where:

A = Area of the collecting tank (m^2)

y = 10 cm rise of water level in the collecting tank

t = Time taken for 10 cm rise of water level in collecting tank.

2. **TOTAL HEAD:**

$H = H_d + H_s + Z$

Where:

H_d = Discharge head, meter

H_s = Suction head, meter

Z = Datum head, meter

3. **INPUT POWER:**

$I/P = (3600 \times N \times 1000) / (E \times T)$ (watts)

Where:

N = Number of revolutions of energy meter disc

E = Energy meter constant (rev / Kw hr)

T = time taken for 'Nr' revolutions (seconds)

S.No	Suction gauge Hs m of water	Suction head Hs \m of water	Delivery Gauge Reading (hd) m of water	Delivery Head (Hd) m of water	Total Head (H) m of water	Time taken for ‘h’ rise of water (t) S	Time taken for Nr revolution t S	Actual Discharge (Qact) x10^{-3} m^3\sec	Input Power (Pi) watt	Output Power (Po) watt	% η
										Average =	

4. **OUTPUT POWER:**

$$P_o = \rho \times g \times Q \times H / 1000 \quad \text{(watts)}$$

Where,

ρ = Density of water (kg / m³)

g = Acceleration due to gravity (m / s^2)

H = Total head of water (m)

5. **EFFICIENCY:**

$$\eta_o = (\text{Output power o/p / input power I/p}) \times 100\ \%$$

Where,

O/p = Output power kW

I/ p = Input power kW

DESCRIPTION:

PRIMING:

The operation of filling water in the suction pipe casing and a portion delivery pipe for the removal of air before starting is called priming.

After priming the impeller is rotated by a prime mover. The rotating vane gives a centrifugal head to the pump. When the pump attains a constant speed, the delivery valve is gradually opened. The water flows in a radially outward direction. Then, it leaves the vanes at the outer circumference with a high velocity and pressure. Now kinetic energy is gradually converted in to pressure energy. The high-pressure water is through the delivery pipe to the required height.

PROCEDURE:

1. Prime the pump close the delivery valve and switch on the unit
2. Open the delivery valve and maintain the required delivery head
3. Note down the reading and note the corresponding suction head reading
4. Close the drain valve and note down the time taken for 10 cm rise of water level in collecting tank
5. Measure the area of collecting tank
6. For different delivery tubes, repeat the experiment
7. For every set reading note down the time taken for 5 revolutions of energy meter disc.

GRAPHS:

1. Actual discharge Vs Total head
2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power

MODEL CALCULATION:

RESULT:

Thus the performance characteristics of centrifugal pump was studied and the maximum efficiency was found to be ______________

VIVA QUESTIONS

1. Define Centrifugal pump.

2. Define Specific speed of a centrifugal pump.

3 Efficiencies of a Centrifugal Pump:

4. Centrifugal Pump Mechanical Efficiency:

5. Centrifugal Pump Overall Efficiency:

6. Define Priming of a centrifugal pump.

5.CONDUCTING EXPERIMENTS AND DRAWING THE CHARACTERISTICS CURVES OF GEAR OIL PUMP

AIM:

To draw the characteristics curves of gear oil pump and also to determine efficiency of given gear oil pump.

APPARATUS REQUIRED:

1. Gear oil pump setup
2. Meter scale
3. Stop watch

FORMULAE:

1. **ACTUAL DISCHARGE:**

$Q_{act} = A \times y / t$ (m^3 / sec)

Where,

A = Area of the collecting tank (m^2)

y = Rise of oil level in collecting tank (cm)

t = Time taken for 'h' rise of oil in collecting tank (s)

2. **TOTAL HEAD:**

$H = H_d + H_s + Z$

Where

Hd = Discharge head; Hd = Pd x 12.5, m

Hs = Suction head; Pd = Ps x 0.0136, m

Z = Datum head, m

Pd = Pressure gauge reading, kg / cm^2

Ps = Suction pressure gauge reading, mm of Hg

3. **INPUT POWER:**

$P_i = (3600 \times N) / (E \times T)$ (kw)

Where,

Nr = Number of revolutions of energy meter disc

Ne = Energy meter constant (rev / Kw hr)

te = Time taken for 'Nr' revolutions (seconds)

S.No	Delivery pressure reading Pd kg / cm^2	Suction pressure reading Ps mm of Hg	Delivery head Hd = Pdx12.5 m	Suction head Hs = Ps x 0.0136 m	Datum head Z m	Total head H m	Time taken for 10 cm of rise of water in tank t sec	Actual discharge Q_{act} m^3/s	Time taken for N rev of energy meter disc t sec	Input power Pi kw	Output power Po kw	η %
											Mean =	

4. OUTPUT POWER:

$$P_o = W \times Q_{act} \times H / 1000 \quad \text{(watts)}$$

Where,

W = Specific weight of oil (N / m^3)

Q_{act} = Actual discharge (m^3 / s)

h = Total head of oil (m)

5. EFFICIENCY:

$$\eta\% = (\text{Output power } P_o / \text{input power } P_i) \times 100$$

DESCRIPTION:

The gear oil pump consists of two identical intermeshing spur wheels working with a fine clearance inside the casing. The wheels are so designed that they form a fluid tight joint at the point of contact. One of the wheels is keyed to driving shaft and the other revolves as the driven wheel.

The pump is first filled with the oil before it starts. As the gear rotates, the oil is trapped in between their teeth and is flown to the discharge end round the casing. The rotating gears build-up sufficient pressure to force the oil in to the delivery pipe.

PROCEDURE:

1. The gear oil pump is stated.
2. The delivery gauge reading is adjusted for the required value.
3. The corresponding suction gauge reading is noted.
4. The time taken for ‘N’ revolutions in the energy meter is noted with the help of a stopwatch.
5. The time taken for ‘h’ rise in oil level is also noted down after closing the gate valve.
6. With the help of the meter scale the distance between the suction and delivery gauge is noted.
7. For calculating the area of the collecting tank its dimensions are noted down.
8. The experiment is repeated for different delivery gauge readings.
9. Finally the readings are tabulated.

GRAPH:

1. Actual discharge Vs Total head
2. Actual discharge Vs Efficiency
3. Actual discharge Vs Input power
4. Actual discharge Vs Output power

MODEL CALCULATION:

RESULT:

Thus the performance characteristic of gear oil pump was studied and maximum efficiency was found to be. ………%.

VIVA QUESTIONS

1. How do I calculate the efficiency of a gear pump?

2 Can you use gear pumps in blown film?

3. Are there instances where you would place the gear pump prior to the screens?

4. Can a gear pump be used with very high filler content, or will pressure be a big problem?

6.CONDUCTING EXPERIMENTS AND DRAWING THE CHARACTERISTICS CURVES OF PELTON WHEEL TEST RIG

AIM:

To conduct load test on pelton wheel turbine and to study the characteristics of pelton wheel turbine.

APPARATUS REQUIRED:

1. Venturimeter
2. Stopwatch
3. Tachometer
4. Dead weight

FORMULAE:

1. **VENTURIMETER READING:**

$h = (P1 \sim P2) \times 10$ (m of water)

Where,

P1, P2 - Venturimeter reading in Kg /cm^2

2. **DISCHARGE:**

$Q = 0.0055 \times \sqrt{h}$ (m^3 / s)

3. **BRAKE HORSE POWER:**

$BHP = (\pi \times D \times N \times T) / (60 \times 75)$ (hp)

Where,

N = Speed of the turbine in (rpm)

D = Effective diameter of brake drum = 0.315 m

T = Torsion in To + T1 – T2 (Kg)

4. **INDICATED HORSE POWER:**

$IHP = (1000 \times Q \times H) / 75$ (hp)

Where,

H = Total head (m)

5. **PERCENTAGE EFFICIENCY:**

$\%\eta = (B.H.P / I.H.P \times 100)$ (%)

S.No	Pressure Gauge Reading [Hp] Kg\cm^2	Total Head [H] m of water	Venturimeter reading Kg/cm^2		H = (P1-P2) x 10 m of water	Weight of hanger To Kg	Speed of turbine N Rpm	Weigh of hanger [T1] kg	Spring Balance T2 Kg	Tension [T] Kg	Discharge Q x10^{-3} m^3/sec	B.H.P hp	I.H.P hp	η %
			P1	P2										
											Mean =			

DESCRIPTION:

Pelton wheel turbine is an impulse turbine, which is used to act on high loads and for generating electricity. All the available heads are classified in to velocity energy by means of spear and nozzle arrangement. Position of the jet strikes the knife-edge of the buckets with least relative resistances and shocks. While passing along the buckets the velocity of the water is reduced and hence an impulse force is supplied to the cups which in turn are moved and hence shaft is rotated.

PROCEDURE:

1. The Pelton wheel turbine is started.
2. All the weight in the hanger is removed.
3. The pressure gauge reading is noted down and it is to be maintained constant for different loads.
4. The Venturimeter readings are noted down.
5. The spring balance reading and speed of the turbine are also noted down.
6. A 5Kg load is put on the hanger, similarly all the corresponding readings are noted down.
7. The experiment is repeated for different loads and the readings are tabulated.

GRAPHS:

The following graphs are drawn.

1. BHP Vs IHP
2. BHP Vs speed
3. BHP Vs Efficiency

MODEL CALCULATION:

RESULT:

Thus the performance characteristic of the Pelton Wheel Turbine is done and the maximum efficiency of the turbine is ………. %

VIVA QUESTIONS

1. What are fluid machines or Hydraulic machines?
2. How are fluid machines classified?
3. What are called turbines?
4. What is known as Euler's equation for turbo-machines?
5. Define Gross Head of a turbine.
6. Define Net head of a turbine.

7.CONDUCTING EXPERIMENTS AND DRAWING THE CHARACTERISTICS CURVES OF FRANCIS TURBINE TEST RIG

AIM:

To conduct load test on Francis turbine and to study the characteristics of Francis turbine.

APPARATUS REQUIRED:

1. Stop watch
2. Tachometer

FORMULAE:

1. **VENTURIMETER READING:**

   h = (p1 - p2) x 10 (m)

   Where

   P1, P2- Venturimeter readings in kg /cm^2

2. **DISCHARGE:**

   $Q = 0.011 \times \sqrt{h}$ (m^3 / s)

3. **BRAKE HORSEPOWER:**

   $BHP = \pi \times D \times N \times T / 60 \times 75$ (hp)

   Where

   N = Speed of turbine in (rpm)

   D = Effective diameter of brake drum = 0.315 m

   T = torsion in [kg]

4. **INDICATED HORSEPOWER:**

   HP = 1000 x Q x H / 75 (hp)

   Where

   H = Total head in (m)

5. **PERCENTAGE EFFICIENCY:**

   $\%\eta$ = B.H.P x 100 / I.H.P (%)

S.No	Pressure Gauge Reading [Hp] Kg/cm^2		Total Head [H] m of water	Venturimeter reading $Kg\backslash cm^2$		H = (P1-P2) x 10 m of water	Weight of hanger To Kg	Speed of turbine N Rpm	Weigh of hanger [T1] kg	Spring Balance T2 Kg	Tension [T] Kg	Discharge Q $x10^{-3}$ $m^3\backslash sec$	B.H.P hp	I.H.P hp	η %
	H1	H2		P1	P2										
														Mean =	

DESCRIPTION:

Modern Francis turbine in an inward mixed flow reaction turbine it is a medium head turbine. Hence it required medium quantity of water. The water under pressure from the penstock enters the squirrel casing. The casing completely surrounds the series of fixed vanes. The guides' vanes direct the water on to the runner. The water enters the runner of the turbine in the dial direction at outlet and leaves in the axial direction at the inlet of the runner. Thus it is a mixed flow turbine.

PROCEDURE:

1. The Francis turbine is started
2. All the weights in the hanger are removed
3. The pressure gauge reading is noted down and this is to be
   Maintained constant for different loads
4. Pressure gauge reading is ascended down
5. The Venturimeter reading and speed of turbine are noted down
6. The experiment is repeated for different loads and the readings are tabulated.

GRAPHS:

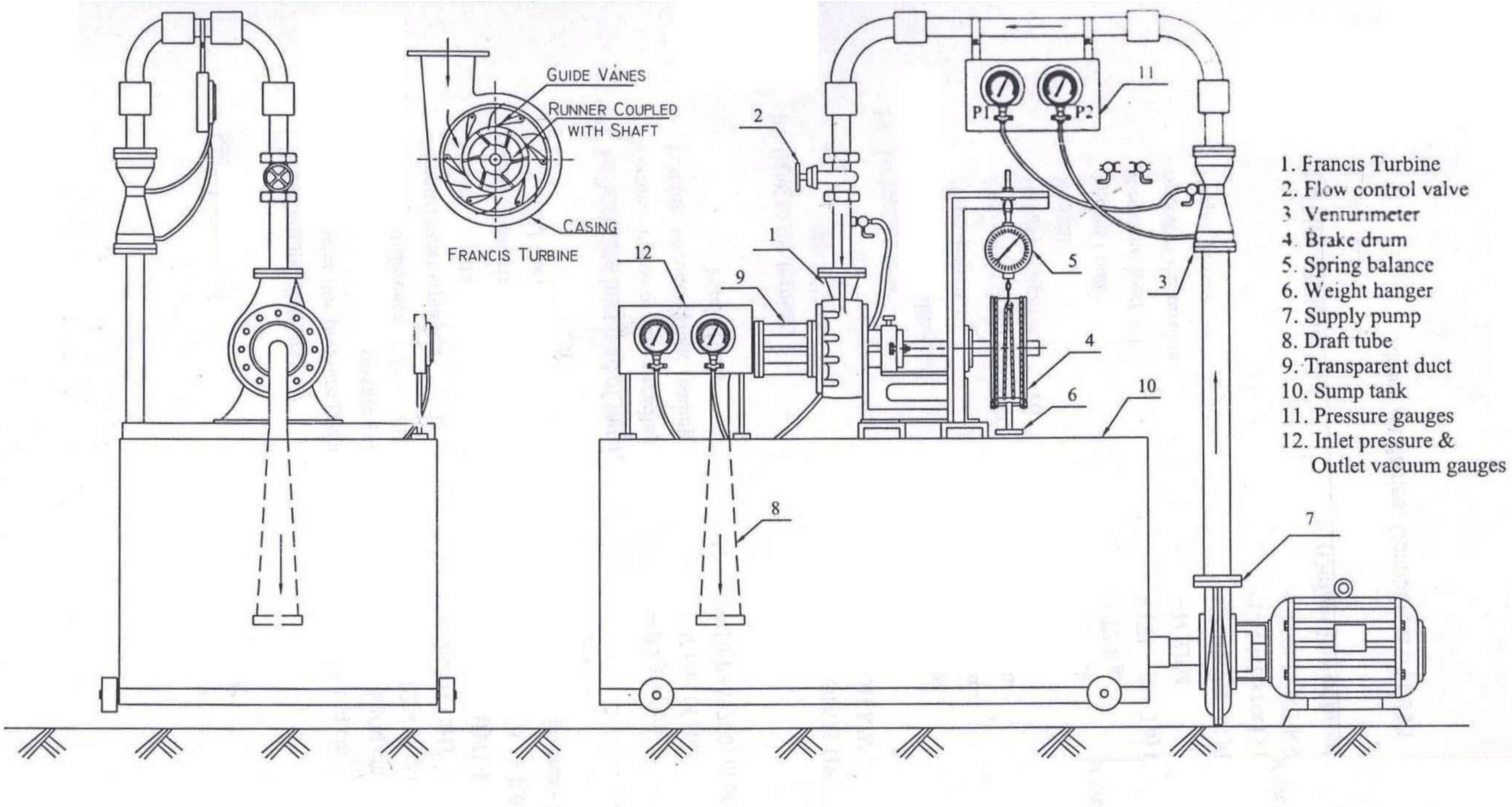
The following graphs are drawn

1. BHP (vs.) IHP
2. BHP (vs.) speed
3. BHP (vs.) % efficiency

MODEL CALCULATION:

RESULT:

Thus the performance characteristic of the Francis wheel turbine is done and the maximum efficiency of the turbine is …………. %



FRANCIS TURBINE TEST RIG

VIVA QUESTIONS

1.Define Reaction Turbine:
2. Define Jet Ratio.
3. Classification of hydraulic turbines:
4. Define Radial flow reaction turbine .
5. What are the Radial flow reaction turbine Types:

8.ROCKWELL HARDNESS TEST

AIM:

To determine the Rockwell hardness number of the given specimen.

APPARATUS REQUIRED:

1. Emery paper
2. Penetrator

THOERY:

In Rock well hardness test consists in touching an indenter of standard cone or ball into the surface of a test piece in two operations and measuring the permanent increase of depth of indentation of this indenter under specified condition. From it Rockwell hardness is deduced. The ball (B) is used for soft materials (e.g. mild steel, cast iron, Aluminum, brass. Etc.) And the cone (C) for hard ones (High carbon steel. etc.)

HRB means Rockwell hardness measured on **B scale**

HRC means Rock well hardness measured on **C scale**

PROCEDURE:

1. Clean the surface of the specimen with an emery sheet.
2. Place the specimen on the testing platform.
3. Raise the platform until the longer needle comes to rest
4. Release the load.
5. Apply the load and maintain until the longer needle comes to rest
6. After releasing the load, note down the dial reading.
7. The dial reading gives the Rockwell hardness number of the specimen.
8. Repeat the same procedure three times with specimen.
9. Find the average. This gives the Rockwell hardness number of the given specimen.

TABULATION

S.No.	Material	Scale	Load (kgf)	Rockwell hardness Number			Rockwell hardness Number (Mean)
				1	2	3	

RESULT:

Rockwell hardness number of the given material is _________

VIVA QUESTIONS

1. List out the mechanical properties?
2. Define hardness?
3. What is the principle involved in Rockwell hardness test?
4. What are the shapes of Indenters usually used for hardness tests?
5. What are the materials generally used for indenter?
6. What does HRB mean?
7. What does HRC mean?
8. What type of materials are used for test specimens in Hardness tests?
9. What precautions should be taken in case of Rockwell hardness test?
10. What is the minimum distance between the centres of the two adjacent indentations ?
11. What is the minimum thickness of the test piece in case of Rockwell hardness test?

9. BRINELL HARDNESS TEST

AIM:

To find the Brinell Hardness number for the given metal specimen.

EQUIPMENTS REQUIRED:

1. Brinell Hardness Testing Machine
2. Metal Specimens
3. Brinell Microscope.

FORMULAE:

Brinell Hardness Number (BHN) = $2P / \{\pi D [D - \sqrt{(D^2 - d^{2)}}] \}$

Where,

P = Load applied in Kgf.

D = Diameter of the indenter in mm.

d = Diameter of the indentation in mm.

DESCRIPTION:

It consists of pressing a hardened steel ball into a test specimen. In this usually a steel ball of Diameter D under a load 'P' is forced in to the test piece and the mean diameter 'd' of the indentation left in the surface after removal of load is measured. According to ASTM specifications a 10 mm diameter ball is used for the purpose. Lower loads are used for measuring hardness of soft materials and vice versa. The Brinell hardness is obtained by dividing the test load 'P' by curved surface area of indentation. This curved surface is assumed to be portion of the sphere of diameter 'D'.

TEST REQUIREMENTS:

1. Usual ball size is 10 mm $\pm$ 0.0045 mm. Some times 5 mm steel ball is also used. It shall be hardened and tempered with a hardness of at least 850 VPN. (Vickers Pyramid Number). It shall be polished and free from surface defects.
2. Specimen should be smooth and free from oxide film. Thickness of the piece to be tested shall not be less than 8 times from the depth of indentation.
3. Diameter of the indentation will be measured n two directions normal to each other with an accuracy of $\pm$ 0.25% of diameter of ball under microscope provided with cross tables and calibrated measuring screws.

PRECAUTIONS:

1. Brinell test should be performed on smooth, flat specimens from which dirt and scale have been cleaned.
2. The test should not be made on specimens so thin that the impression shows through the metal, nor should impressions be made too close to the edge of the specimen.

PROCEDURE:

1. Specimen is placed on the anvil. The hand wheel is rotated so that the specimen along with the anvil moves up and contact with the ball.
2. The desired load is applied mechanically (by gear driven screw) and the ball presses into the specimen.
3. The diameter of the indentation made in the specimen by the pressed ball is measured by the use of a micrometer microscope, having transparent engraved scale in the field of view.
4. The indentation diameter is measured at two places at right angles to each other, and the average of two readings is taken.
5. The Brinell Hardness Number (BHN) which is the pressure per unit surface area of the indentation is noted down.

OBSERVATION:

S.No.	Material	Load in Kgf	Diameter Of the Indenter in mm	Diameter of the indentation in mm			Brinell Hardness Number(BHN)
				1	2	3	

RESULT:

Thus the Brinell hardness of the Given Specimen is

1. Mild Steel = ---------- BHN
2. AL = ---------- BHN
3. Brass = ---------- BHN

VIVA QUESTIONS

1. What are the equipment and materials required for Brinell hardness test?
2. What is the purpose of microscope used in Brinell hardness test?
3. The surface area of indentation ‘A’ is dependent upon---?
4. What is the material used for ball indenter in case of Brinell hardness test?
5. What is the range of the size of ball indenter in case of Brinell hardness test?
6. What are the units for BHN?
7. What precautionary measures should be taken for the Brinell hardness test?
8. While mounting the test specimen the surface of the test specimen should be at---to the axis of the ball indenter plunger?

10.TENSION TEST ON MILD STEEL

AIM:

To conduct tension test on the given mild steel rod for determining the yield stress, ultimate stress, breaking stress, percentage of reduction in area, percentage of elongation over a gauge length and young's modulus.

APPARATUS REQUIRED:

1. Vernier caliper.
2. Scale.

THEORY:

The tensile test is most applied one, of all mechanical tests. In this test ends of test piece and fixed into grips connected to a straining device and to a load measuring device. If the applied load is small enough, the deformation of any solid body is entirely elastic. An entirely deformed solid will return to its original form as soon as load is removed. However, if the load is too large, the material can be deformed permanently. The initial part of the tension curve, which is recoverable immediately after unloading ,is termed as elastic and the rest of the curve, which represents the manner in solid undergoes plastic deformation is termed as plastic. The stress below which the deformation is essentially entirely elastic is known as the yield strength of material. In some materials the onset of plastic deformation is denoted by a sudden drop in load indication both an upper and a lower yield point. However, some materials do not exhibit a sharp yield point. During plastic deformation, at larger extensions strain hardening cannot compensate for the decrease in section and thus the load passes through the maximum and then begins to decrease. At this stage the "ultimate strengths", which is defined as the ratio of the load on the specimen to the original cross sectional are, reaches the maximum value. Further loading will eventually cause 'nick' formation and rupture.

Usually a tension testis conducted at room temperature and the tensile load is applied slowly. During this test either round of flat specimens may be used. The round specimens may have smooth, shouldered or threaded ends. The load on the specimen is applied mechanically or hydraulically depending on the type of testing machine.

FORMULA USED:

1. Original area of the rod (A_o) = (3.14/4) X $(d_o)^2$ mm^2
2. Neck area of the rod (A_N) = (3.14/4) X $(d_N)^2$ mm^2

   Where,

   d_o =original area of cross section in 'mm'

   d_N =diameter of the rod at the neck in 'mm'
3. Percentage reduction in area =

   Where,

   A_o=original cross sectional area of the rod in 'mm'

   A_N=Neck area of the rod in 'mm'
4. Percentage of Elongation =

   Where,

   L_o=Final gauge length of the rod in 'mm'

   L_o=Original gauge length of the rod in 'mm'
5. Yield stress = N/mm^2
6. Ultimate stress = N/mm^2
7. Breaking stress = N/mm^2
8. Young's modulus = N/mm^2

Where,

P=Load in 'N'

L_o=Original length in 'mm'

A_o=Original cross sectional area of the rod in 'mm'

 =Extension of the rod in 'mm'

PROCEDURE:

1. Measure the diameter of the rod using Vernier caliper.
2. Measure the original length of the rod.
3. Select the proper jaw inserts and complete the upper and lower chuck assemblies.
4. Apply some graphite grease to the tapered surface of the grip surface for the smooth motion.
5. Operate the upper cross head grip operation handle and grip fully the upper end of the test piece.
6. The left valve in UTM is kept in fully closed position and the right valve in normal open position.
7. Open the right valve and close it after the lower table is slightly lifted.

8. Adjust the load to zero by using large push button (This is necessary to remove the dead weight of the lower table, upper cross head and other connecting parts of the load).
9. Operate the lower grip operation handle and lift the lower cross head up and grip fully the lower part of the specimen. Then lock the jaws in this position by operating the jaw locking handle.
10. Turn the right control valve slowly to open position (anticlockwise) until we get a desired loadings rate.
11. After that we will find that the specimen is under load and then unclamp the locking handle.
12. Now the jaws will not slide down due to their own weight. Then go on increasing the load.
13. At a particular stage there will be a pause in the increase of load. The load at this point is noted as yield point load.
14. Apply the load continuously, when the load reaches the maximum value. This is noted as ultimate load.
15. Note down the load when the test piece breaks, the load is said to be a breaking load.
16. When the test piece is broken close the right control valve, take out the broken pieces of the test piece. Then taper the left control valve to take the piston down.

GRAPH

Draw a graph between Elongations (X-axis) and load (Y-axis).

OBSERVATIONS

1. Original gauge length of the rod (L_o) = mm.
2. Original diameter of the rod (d_o) = mm.
3. Final length of the rod = mm.
4. Load at yield point = kN.
5. Ultimate load = kN.
6. Breaking load = kN.
7. Diameter at the neck (D_N) = mm.
8. Gauge in length = mm.

TABULATION:

S.NO	Load (KN)	Extensometer reading (mm)			Stress (N/mm^2)	Strain (No Unit)	Young's modulus X 10^5 (N/mm^2)
		Left	Right	Mean			

RESULT:

1. Final length of the rod = ______ mm.
2. Diameter at the neck (D_N) = ______ mm.
3. Percentage reduction in area =______ %
4. Percentage of Elongation =______ %
5. Yield stress = ______ N/mm^2
6. Ultimate stress = ______ N/mm^2
7. Breaking stress = ______ N/mm^2
8. Young's modulus = ______ X 10^5 N/mm^2

VIVA QUESTIONS

1. What is Elasticity?
2. What is Plasticity?
3. What do you mean by ductility?
4. What do you mean by malleability?
5. What do you understand by toughness or tenacity?
6. Define Hook's law?
7. What is the limit of proportionality?
8. What do you mean by Elastic limit?
9. Define Young's modulus?
10. What do you mean by permanent set?
11. Draw the stress strain diagram for a mild steel material?
12. Draw the stress strain diagram for a brittle material?
13. Give few examples for brittle materials?
14. Give few examples for ductile materials?
15. What do you mean by percentage elongation?
16. What do you understand by strain hardening?
17. Indicate the plastic zone in stress strain diagram for mild steel material?18. What is the difference between ductile and brittle material?
19. What do you mean by percentage reduction in area?
20. Define factor of safety

11.DOUBLE SHEAR TEST ON GIVEN SPECIMEN

AIM:

To conduct shear test on given specimen under double shear.

EQUIPMENTS REQUIRED:

1. UTM with double shear chuck
2. Vernier Caliber
3. Test Specimen

DESCRIPTION:

In actual practice when a beam is loaded the shear force at a section always comes to play along with bending moment. It has been observed that the effect of shearing stress as compared to bending stress is quite negligible. But sometimes, the shearing stress at a section assumes much importance in design calculations.

Universal testing machine is used for performing shear, compression and tension. There are two types of UTM.

1. Screw type
2. Hydraulic type.

Hydraulic machines are easier to operate. They have a testing unit and control unit connected to each other with hydraulic pipes. It has a reservoir of oil, which is pumped into a cylinder, which has a piston. By this arrangement, the piston is made to move up. Same oil is taken in a tube to measure the pressure. This causes movement of the pointer, which gives reading for the load applied.

DETAILS OF UTM:

Capacity: 400 KN.

Range : 0 - 400 KN.

PRECAUTION:

The inner diameter of the hole in the shear stress attachment is slightly greater than that of the specimen.

PROCEDURE:

1. Measure the diameter of the hole accurately.
2. Insert the specimen in position and grip one end of the attachment in the upper portion and the other end in the lower portion.

3. Switch on the main switch on the universal testing machine.
4. Bring the drag indicator in contact with the main indicator.
5. Gradually move the head control lever in left hand direction till the specimen shears.
6. Note down the load at which specimen shears.
7. Stop the machine and remove the specimen.

OBSERVATION:

Diameter of the specimen (d) = ----- mm

Cross sectional area in double shear, (A) = $2 \times \pi d^2 / 4$ mm^2

Shear Load taken by specimen at the time of failure (P) = ------ KN.

$$\text{Shear strength} = \frac{\text{Maximum shear force}}{\text{Area of the specimen.}}$$

RESULT:

Shear strength of the given material = -------- N / mm^2

VIVA QUESTIONS

1. What are the factors affect the strength column?
2 .What is pure bending of a beam?
3. What is shear centre or angle of twist?
4.Explain double shear and single shear?
5.What is the speed to be maintained while testing the specimen?
6.Define double shear strength of the specimen?
7.According to the standard what is the maximum diameter of the bar that can be used in test?
8.What is the use of shear testing of the specimen?

12. IMPACT TEST - IZOD

AIM:

To determine the impact strength of the given material using Izod impact test.

APPARATUS REQUIRED:

1. Vernier caliper
2. Scale

THEORY:

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of un notched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determent by impact test. Toughness takes into account both the material. Several engineering material have to with stand impact or suddenly loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads of all types of impact tests, the notched bar test are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notched bar by applying an impulse load. The test measures the notch toughness of material under shocking loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. Still it is important to note that it provides a good way of comparing toughness of various materials or toughness of same material under different conditions. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature.

FORMULA USED:

$$\text{Impact strength} = \frac{\text{energy absorbed}}{\text{Cross sectional area}} \ \text{J/mm}^2$$

PROCEDURE:

1. Raise the swinging pendulum weight and lock it.
2. Release the trigger and allow the pendulum to swing.
3. This actuates the pointer to move in the dial.
4. Note down the frictional energy absorbed by the bearings.

5. Raise the pendulum weight again and lock it in position.
6. Place the specimen in between the simple anvil support keeping the ”U” notch in the direction opposite to the striking edge of hammer arrangement.
7. Release the trigger and allow the pendulum to strike the specimen at its midpoint.
8. Note down the energy spent in breaking (or) bending the specimen.
9. Tabulate the observation.

OBSERVATION:

Area of cross section of the given material:

S.No	Material Used	Energy absorbed by force (A) J	Energy spent to break the specimen (B) J	Energy absorbed by the specimen (A-B) J	Impact Strength J/mm^2

RESULT:

The impact strength for the given material is _________ J/mm^2

VIVA QUESTIONS

1. What is the maximum impact energy in case of Izoid test?
2. What is the angle of draft in case of Izoid impact test?
3. What is the minimum scale graduation in both the impact tests?
4. What are the units for Impact strength?
5. What do you mean by impact strength?
6. What is the least count of vernier callipers?
7. What is the equipment required to conduct Izoid impact test?
8. What Izoid precautionary measures should be taken for Izoid test?
9. With what formula one can calculate the impact strength at notch?
10. How do you detect the fault in the heat treatment process?
11. What is the Angle of draft in case of charpy impact test?
12. What is the striking velocity of the hammer in case of charpy impact test?

13. TORSION TEST ON MILD STEEL SPECIMEN

AIM:

To conduct the torsion test on the given specimen for the following

1. Modulus of rigidity
2. Shear stress

APPARATUS REQUIRED:

1. Vernier caliper
2. Scale

FORMULA USED:

1. Modulus of rigidity, C = $\frac{TL}{J\alpha}$ N/mm^2

Where,

α =angle of degree

2. Shear stress (t) =TR/L N/mm^2

PROCEDURE:

1. Measure the diameter and length of the given rod.
2. The rod is fixing in to the grip of machine.
3. Set the pointer on the torque measuring scale.
4. The handle of machine is rotate in one direction.
5. The torque and angle of test are noted for five degree.
6. Now the handle is rotated in reverse direction and rod is taken out

THEORY:

A torsion test is quite intruded in determining the values of modulus of rigidity of metallic specimen the values of modulus of rigidity can be found out through observation made during experiment by using torsion equation

$$T/G = C\alpha/L$$

OBSERVATION:

Diameter of the Specimen = mm

Gauge length of the Specimen = mm

TABULATION:

S.NO	ANGLE OF TWIST	Twist in Rod	Torque		Modulus of Rigidity (N/mm^2)	Shear Stress (N/mm^2)
			N-M	N-MM		

RESULT:

Thus the torsion test on given mild steel specimen is done and the values of modulus of rigidity and shear stress are calculated

VIVA QUESTIONS

1.What do you mean by modulus of rigidity?
2.What is shear strain?
3.Give the expression for the basic torsion equation?
4.What do you mean by polar moment of inertia?
5.What is polar modulus?
6.What is the expression for polar modulus of a circular shaft?
7.What do you mean by torsional rigidity?
8.Give the expression for power transmitted by a shaft?
9.What are the precautions that should be taken during torsion test?
10. Between which parameters a graph is plotted in case of torsion test?

14. DEFLECTION TEST ON BEAM

AIM:

To determine the Young's modulus of the given specimen by conducting bending test.

APPARATUS AND SPECIMEN REQUIRED:

1. Bending Test Attachment
2. Specimen for bending test
3. Dial gauge
4. Scale
5. Pencil / Chalk

PROCEDURE:

1. Measure the length (L) of the given specimen.
2. Mark the centre of the specimen using pencil / chalk
3. Mark two points A & B at a distance of 350mm on either side of the centre mark. The distance between A & B is known as span of the specimen (l)
4. Fix the attachment for the bending test in the machine properly.
5. Place the specimen over the two supports of the bending table attachment such that the points A &B coincide with centre of the supports. While placing, ensure that the tangential surface nearer to heart will be the top surface and receives the load.
6. Measure the breadth (b) and depth (d) of the specimen using scale.
7. Place the dial gauge under this specimen at the centre and adjust the dial gauge reading to zero position.
8. Place the load cell at top of the specimen at the centre and adjust the load indicator in the digital box to zero position.
9. Select a strain rate of 2.5mm / minute using the gear box in the machine.
10. Apply the load continuously at a constant rate of 2.5mm/minute and note down the deflection for every increase of 0.25 tonne load up to a maximum of 6 sets of readings.
11. Calculate the Young's modulus of the given specimen for each load using the following formula:

$$\text{Young's modulus, } E = \frac{Pl^3}{48I\delta}$$

Where,

P = Load in N

L = Span of the specimen in mm

I = Moment of Inertia in mm^4 ($bd^3/12$)

b = Breadth of the beam in mm.

d = Depth of the beam in mm

δ = Actual deflection in mm.

12. Find the average value of young's modulus that will be the Young's modulus of the given specimen.

OBSERVATION:

1. Material of the specimen =
2. Length of the specimen, L = mm
3. Breadth of the specimen, b = mm
4. Depth of the specimen, d = mm
5. Span of the specimen, l = mm
6. Least count of the dial gauge, LC = mm

TABULATION:

S.No	Load in		Deflection in mm			Young's Modulus in (N/mm^2)
	kg	N	Loading	Unloading	Mean	
					Average	

Result:

The young's modulus of the given specimen = ---------------------N/mm^2

VIVA QUESTIONS

1. Define beam?
2. What is meant by transverse loading on beams?
3. How do you classify the beams according to its supports? 4.What is cantilever beam?

A beam with one end free and other end fixed is called Cantilever beam

5.What is simply supported beam?

6.What is over hanging beam?

15. TENSION TEST ON CLOSED COIL HELICAL SPRING AIM:

To determine the modulus of rigidity and stiffness of the given tension spring specimen.

APPARATUS AND SPECIMEN REQUIRED:

1. Spring test machine
2. Tension spring specimen
3. Vernier caliper

PROCEDURE:

1. Measure the outer diameter (D) and diameter of the spring coil (D) for the given tension spring.
2. Count the number of turns i.e. coils (n) of the given specimen.
3. Fit the specimen in the top of the hook of the spring testing machine.
4. Adjust the wheel at the top of the machine so that the other end of the specimen can be fitted to the bottom hook in the machine.
5. Note down the initial reading from the scale in the machine.
6. Apply a load of 25kg and note down the scale reading. Increase the load at the rate of 25kg up to a maximum of 100kg and note down the corresponding scale readings.
7. Find the actual deflection of the spring for each load by deducting the initial scale reading from the corresponding scale reading.
8. Calculate the modulus of rigidity for each load applied by using the following formula:

   Modulus of rigidity, $N = \frac{64PR^3n}{d^4\delta}$

   Where,

   P = Load in N

   R = Mean radius of the spring in mm (D –d /2)

   d = Diameter of the spring coil in mm

   δ = Deflection of the spring in mm

   D = Outer diameter of the spring in mm.
9. Determine the stiffness for each load applied by using the following formula:
   Stiffness, K = P/δ
10. Find the values of modulus of rigidity and spring constant of the given spring by taking average values.

OBSERVATION:

1. Material of the spring specimen =
2. Outer diameter of the spring. D = mm
3. Diameter of the spring coil, d = mm
4. Number of coils / turns, n = Nos.
5. Initial scale reading = cm = mm

S.No	Applied Load in		Scale reading in		Actual deflection in mm	Modulus of rigidity In N/mm^2	Stiffness in N/mm
	kg	N	cm	mm			
						Average	

Result:

The modulus of rigidity of the given spring = ------------------N/mm^2

The stiffness of the given spring = ------------------N/mm^2

VIVIA QUESTION

1. State the condition under which a spring obeys Hooke's law.
2. What are the forces acting on the load that is attached to the spring which is oscillating in a vertical plane?
3. Define spring constant or force constant of a spring.
4. What is the unit of force constant?
5. What are the conditions essential for the motion of a body to be simple harmonic?
6. What are the factors on which the period of vertical oscillations of a spring depend?