KNOWLEDGE INSTITUTE OF TECHNOLOGY

KIOT Campus, NH – 47, Kakapalayam,

Salem – 637 504

DEPARTMENT OF CIVIL ENGINEERING

CE8461- HYDRAULIC ENGINEERING LABORATORY

2017 Regulation

IV Semester B.E. Civil Engineering

LAB MANUAL

KNOWLEDGE INSTITUTE OF TECHNOLOGY

[AFFILIATED TO ANNA UNIVERSITY, CHENNAI -600025]

KAKKAPALYAM (PO), SALEM-637504

LABORATORY MANUAL

SUBJECT CODE : CE 8461

SUBJECT NAME : HYDRAULIC ENGINEERING LABORATORY

NAME OF THE STUDENT :

REG. NO. :

YEAR / SEM :

GENERAL INSTRUCTIONS

The following instructions should be strictly followed by students in the Laboratory:

1. Students should wear lab coat in the laboratory.
2. Students are advised to enter the lab WITH FORMAL SHOES ONLY.
3. They are not supposed to operate the instrument in absents of professor/NTS.
4. They can also utilizes the laboratory during their free hours.
5. Students are advised to complete their record work before the next class.
6. Students are asked to switch off the instrument and fans before leaving the lab.
7. Students can access the instrument through lab technician.
8. Students have free access to use the instrument available in the lab.
9. During the laboratory hours, using mobile is strictly prohibited.
10. NON WATER Proof electronic things are strictly prohibited in the lab.

CE8461 - HYDRAULIC ENGINEERING LABORATORY L T P C 0 0 4 2

OBJECTIVE:

- Students should be able to verify the principles studied in theory by performing the experiments in lab.

LIST OF EXPERIMENTS

A. Flow Measurement

1. Calibration of Rotameter
2. Calibration of Venturimeter / Orificemeter
3. Bernoulli's Experiment

B.Losses in Pipes

4.Determination of friction factor in pipes
5. Determination of min or losses

C. Pumps

6. Characteristics of Centrifugal pumps
7. Characteristics of Gear pump
8. Characteristics of Submersible pump
9. Characteristics of Reciprocating pump

D. Turbines

10. Characteristics of Pelton wheel turbine
11. Characteristics of Francis turbine/Kaplan turbine

E. Determination of Metacentric height

12.Determination of Metacentric height of floating bodies

TOTAL: 60 PERIODS

OUTCOMES:

- The students will be able to measure flow in pipes and determine frictional losses.
- The students will be able to develop characteristics of pumps and turbines.

REFERENCES:

1. Sarbjit Singh."Experiments in Fluid Mechanics", Prentice Hall of India Pvt. Ltd, Learning Private Limited, Delhi, 2009.
2. "Hydraulic Laboratory Manual", Centre for Water Resources, Anna University, 2004.
3. Modi P.N. and Seth S.M., "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi, 2000.
4. Subramanya K. "Flow in open channels", Tata McGraw Hill Publishing.Company, 2001.

LIST OF EQUIPMENTS

1. One set up of Rotometer
2. One set up of Venturimeter/Orifice meter
3. One Bernoulli's Experiment set up
4. One set up of Centrifugal Pump
5. One set up of Gear Pump
6. One set up of Submersible pump
7. One set up of Reciprocating Pump
8. One set up of Pelton Wheel turbine
9. One set up of Francis turbines/one set of kaplon turbine
10. One set up of equipment for determination of Metacentric height of floating bodies
11. One set up for determination of friction factor in pipes
12. One set up for determination of minor losses.

INDEX

S. No	Date	Name of the Experiment	Marks	Sign
1.		Calibration of Rotameter		
2.		Calibration of Venturimeter / Orificemeter		
3.		Bernoulli’s Experiment		
4.		Determination of friction factor in pipes		
5.		Determination of min or losses		
6.		Characteristics of Centrifugal pumps		
7.		Characteristics of Gear pump		
8.		Characteristics of Submersible pump		
9.		Characteristics of Reciprocating pump		
10.		Characteristics of Pelton wheel turbine		
11.		Characteristics of Francis turbine/Kaplan turbine		
12.		Determination of Metacentric height of floating bodies		

TABULATION

Internal area of measuring tank (A) = 300mm x 300mm

Difference in level of water (h) = 50mm

S. No	Rota meter reading (lpm)	Time taken (t) for H=50 mm rise in collecting tank (sec)			Actual Discharge (m^3/sec)	Actual discharge (lit/sec)	Percentage Error of Rota meter (%)
		T_1	T_2	Mean			
						Mean	

Ex.No: 1 Date:	CALIBRATION OF ROTAMETER

AIM

To determine the percentage error in Rota meter with the actual flow rate.

APPARATUS REQUIRED

1. Rotameter (0–10LPMrange)
2. Single phase mono block pump set (0.5HP, 1440RPM)
3. Reservoir tank arrangement.
4. Measuring tank arrangement.
5. Piping System

FORMULAE

ACTUAL DISCHARGE

Actual rate of flow $Q_{act} = \frac{AH}{t}$ mm^3/sec

Where

A = Area of the measuring tank in mm^2.

h = Difference in levels of water in mm

t = Time taken for 5 cm rise of water level in collecting Tank in Seconds.

CONVERSION

Flow rate conversion:

Amount: 1 cubic millimeter per second (mm^3/sec) of flow rate.

Equals: 0.000060 liters per minute (litre/min) in flow rate.

Converting cubic meter per second to liters per minute value in the flow rate units scale.

Actual flow rate (lit/sec), $Q_{act} = Q_{act} \times 0.000060$ (litre/min)

Percentage error of Rota meter (%) $= \frac{Actual\ Discharge - Rotameter\ reading}{Rotameter\ reading} \times 100$

PROCEDURE

1. Switch on the motor and the delivery valve is opened.
2. Adjust the delivery valve to control the rate in the pipe.
3. Set the flow rate in the Rota meter, for example say 50 liters per minute
4. Note down the time taken for 5cm rise in collecting tank
5. Repeat the experiment for different set of Rota meter readings
6. Tabular column is drawn and readings are noted
7. Graphic drawn by plotting Rota meter reading Vs percentage error of the Rota meter

GRAPH:

Rota meter reading Vs percentage error

RESULT

The percentage error of the Rota meter was found to be ……………

EXPERIMENTAL SET-UP:

The set-up consists of a pipe connected to a constant head supply tank. A horizontal Venturimeter is fitted to the pipe at a distance of an atleast 30 times diameter. A regulating valve is provided at the exit to vary the discharge as shown in figure. A measuring tank is provided to determine the discharge. The difference of pressure between the inlet and the throat is measured with U- tube manometer.

Theoretical Discharge , (Q_t)

$$(Q_t) = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \ (mm^3/sec)$$

Where,

a_1= Area of inlet pipe in mm^2.

a_2= Area of throat in mm^2.

h = the pressure difference in mm.

The pressure difference h is determined from the deflection of the manometer liquid (h).

Thus

$$h = (h_1 - h_2)\left(\frac{S_m}{S_l} - 1\right) \ (mm)$$

Where

h_1 = Manometric head in one limb of the manometer in mm.

h_2 = Manometric head in other limb of the manometer in mm.

S_m = specific gravity of the manometer liquid in mm.

S_l = specific gravity of the fluid in the pipe.

g = Acceleration due to gravity in mm/sec^2.

Actual Discharge

$$(Q_a) = \frac{\text{Internal plan area of collecting tank(A)} \times \text{Rise of liquid (H)}}{\text{Time of collection (t)}} = \frac{AH}{t} \ (mm^3/sec)$$

Coefficient of discharge, C_d

$$C_d = \frac{Q_a}{Q_t} \ (No\ unit)$$

Ex.No: 2 Date:	FLOW THROUGH VENTURIMETER

AIM:

To determine the coefficient of discharge (C_d) of a given Venturimeter.

APPARATUS USED:

- A Venturimeter
- Differential U –tube manometer
- Meter Scale
- Stop watch
- Collecting tank, fitted with piezometer and control valve.

INTRODUCTION:

1. A Venturimeter is commonly used to measure discharge in closed conduits having pipe flow. It consists of a converging cone, a throat section and a diverging cone. An expression for the discharge is derived by applying the Bernoulli equation to the inlet and the throat and using the continuity equation. The discharge

$$Q = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}\,(mm^3/sec)$$

   Where

   C_d = coefficient of discharge, between 0.97 to 0.99

   a_1 = area of cross section at the inlet in mm^2

   a_2 = area of cross section at the throat in mm^2

   h = difference of piezometric heads in mm

2. The converging cone has an angle of convergence about 20°. The flow in the converging cone is accelerating and the loss of head is relatively small.
3. The diverging cone, the flow is decelerating. To avoid excessive head loss, it is essential to keep the angle of divergence small, usually 5° to 7°.
4. Throat diameter D_2 is between ¼ to ¾ times the inlet diameters D_1. The smaller the D_2/D_1 ratio, the more is the pressure difference. However, the pressure at the throat should not be allowed to drop to the vapour pressure to prevent cavitations.
5. For accurate results, the Venturimeter should be preceded by a straight and uniform length of about $30D_1$ or so. Alternatively, straightening vanes can be used in the pipe.

OBSERVATION AND CALCULATION:

Acceleration due to gravity, g = 9810 mm/sec^2

Diameter of inlet, D_1 = 25 mm

Diameter of inlet, D_2 = 15 mm

Internal plan dimension, L = 500 mm

B = 500 mm

Area of the pipe 1-1 (a_1) = 490.87 mm^2

Area of the pipe 1-1 (a_2)= 176.71 mm^2

Area of the collecting tank (A) = 250000 mm^2

Specific gravity of mercury, (S_m) = 13.6

Specific gravity, (S_l) = 1

S.No	Manometric readings (mm of mercury)			$h = (h_1 - h_2)\left(\frac{S_m}{S_l} - 1\right)$ (mm)	$\sqrt{h}$ (mm)	Time taken 't' for H=50 mm rise in collecting tank (sec)			Discharge in mm^3/sec		Coefficient of discharge $C_d = \frac{Q_a}{Q_t}$
	h_1	h_2	$h_1 - h_2$			T_1	T_2	Avg	$Q_a = \frac{AH}{t}$	$Q_t = \frac{a_1 a_2\sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$	
Mean value of C_d											

PROCEDURE:

1. Measure the inlet and throat diameters of the Venturimeter. Also measure the length and width of the measuring tank.
2. Keep the outlet valve closed and the inlet valve is opened fully.
3. The outlet valve is opened slightly and the manometric heads is both the limbs (h_1 and h_2) are noted. Measure the deflection h of the manometer liquid.
4. The outlet valve of the collecting tank is closed tightly and the time 't' and required for H rise of water in the collecting tank is observed using a stopwatch. Collect water in the measuring tank for a suitable time period.
5. Repeat step 2 and 4 for different discharges. The observation are tabulated and the coefficient and orifice meter c_d i.e. computed.

Graphs:

Plot a graph between Q and h on an ordinary graph paper, with Q as ordinate. Measure the slope of the straight line and hence determine the coefficient of discharge.

Result:

Coefficient of discharge C_d (Analytically) =

Coefficient of discharge C_d (Graphically) =

Formulae:

1. Theoretical Discharge of orifice meter

$$Q_{th} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} \text{ (mm}^3\text{/sec)}$$

Where

Q_t = Theoretical Discharge in mm^3/sec.

a_1 = Area of inlet in mm^2.

a_2 = Area of orifice in mm^2.

g = Acceleration due to gravity in mm/sec^2.

h = Orifice head in terms of following liquid in mm.

$h = (h_1 - h_2)$

h_1 = Manometric head in one limb of the manometer in mm.

h_2 = Manometric head in other limb of the manometer in mm.

2. Actual Discharge

$$Q_a = \frac{AH}{t} \text{ (mm}^3\text{/sec)}$$

Where,

A = internal plan area of collecting tank in mm^2.

H = Rise of liquid in mm.

T = time of collection in sec.

3. Coefficient of Discharge

Coefficient of orifice meter (C_d) is the ratio between the actual discharge (Q_a) and the theoretical discharge (Q_t)

$$C_d = \frac{Q_a}{Q_t} \ (No\ unit)$$

Q_a = Actual discharge in mm^3/sec.

Q_t = Theoretical discharge in mm^3/sec.

Ex.No: 3 Date:	FLOW THROUGH ORIFICE METER

AIM:

To determine the coefficient of discharge (C_d) of the given orifice meter.

APPARATUS USED:

1. Orifice meter with all accessories
2. Meter Scale
3. Stop watch
4. Collecting tank, fitted with control valve.

INTRODUCTION:

An orifice is an opening in the side wall of a tank or a vessel. The liquid flows out of the tank when the orifice is opened. In a sharp-edged orifice, there is a line contact of the liquid as it flows out. An orifice is called the orifice discharging free when it discharges into atmosphere. The jet issuing from the tank forms the vena contracta at a distance of $d/2$, where d is the diameter of the orifice.

Discharge by Bernoulli's theorem,

$$Q = C_c C_v X a \sqrt{2gh} = C_d\ a \sqrt{2gh} \quad (mm^3/sec)$$

Where,

C_c = coefficient of contraction, varies between 0.61 and 0.65

C_v = coefficient of velocity varies between 0.95 and 0.99

C_d = coefficient of discharge varies between 0.59 and 0.64

h = head causing flow. This is equal to the ratio vertical distance between the free surface in the tank and the centre of the orifice in mm.

a = area of the orifice of diameter in mm^2.

THEORY:

Orifice meter is a device used to measure the discharge or any liquid flowing through pipeline. The pressure difference between the inlet orifice meter is recorded using a differential manometer the line time is recorded for a measurement discharge.

OBSERVATIONS AND CALCULATIONS:

Acceleration due to gravity = 9810 mm/sec^2

Diameter of inlet, D_1 = 25 mm

Diameter of inlet, D_2 = 15 mm

Internal plan dimension,

Length (L) = 500 mm

Breadth (B) = 500 mm

Area of the pipe 1-1 (a_1) = 490.87 mm^2

Area of the pipe 1-1 (a_2) = 176.71 mm^2

Area of the collecting Tank (A) = 250000 mm^2

Specific gravity of mercury (S_m) = 13.6

Specific gravity of water (S_l)= 1

<table>
<tr><th rowspan="2">S.No</th><th colspan="3">Manometer reading</th><th rowspan="2">Total Head $h = (h_1 - h_2)\left(\frac{S_m}{S_l} - 1\right)$ x10 (mm)</th><th rowspan="2">$\sqrt{h}$ (mm)</th><th colspan="3">Time taken 't' for H=50 mm rise in collecting tank (sec)</th><th colspan="2">Discharge $\left(\frac{mm^3}{Sec}\right)$</th><th rowspan="2">Coefficient of discharge C_d</th></tr>
<tr><th>h_1 (cm)</th><th>h_2 (cm)</th><th>X= h_1 - h_2 (cm)</th><th>T_1</th><th>T_2</th><th>Average (sec)</th><th>Actual Discharge Q_a</th><th>Theoretical Discharge Q_t</th></tr>
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<tr><td colspan="11" align="right">Mean value of C_d=</td><td></td></tr>
</table>

PROCEDURE:

1. The dimensions of the inlet and orifice are recorded and the internal plan dimensions of the collecting tank are measured.
2. Keeping the outlet valve closed, the inlet valve is opened fully.
3. The outlet valve is opened slightly and the Manometric heads in both limbs (h_1 and h_2) are noted.
4. The outlet valve is the collecting tank is closed tightly and time is closed tightly and time required for H rise of water is the collecting tank is observed using a stop watch.
5. The above procedure is repeated by gradually increasing the flow and observing the required reading.
6. The observations are tabulated and the coefficient of orifice meterC_d is computed.

GRAPH:

Plot Q versus $\sqrt{h}$ on an ordinary graph, with Qa ordinate, and determine the value of C_d from the slope of the line.

RESULTS:

Coefficient of discharge of the orifice meter

1. C_d (Analytically =

2. C_d (Graphically) =

OBSERVATION:

Internal Plan Dimensions of collecting tank ,Length (L) = 300 mm

Breadth = 300 mm

a_1= 50x 25mm a_2= 45x25mm a_3= 36x25mm a_4= 25x 25mm a_5= 16x25mm

a_6=12.5x25mm a_7= 14x25mm a_8= 18.5x25mm a_9=23x25mm a_{10}= 29x25mm

a_{11}= 36x25mm a_{12}=41x25mm a_{13}= 46x25mm a_{14}= 50x 25mm

S.No	**Cross section area**		**Time taken 't' for H=50 mm rise in collecting tank (sec)**			**Discharge** Q = $\frac{AH}{t}$ (mm³/sec)	**Velocity** V = $\frac{Q}{a}$ (mm)	**Velocity head** $\frac{v^2}{2g}$ (mm)	**Piezometer reading** h = $\frac{p}{\gamma}$ (mm)	**Datum head Z** (mm)	**Total head** H = Z + $\frac{P}{\delta}$ +$\frac{V^2}{2g}$ (mm)
		mm²	**1**	**2**	**Avg**						
1.	a_1										
2.	a_2										
3.	a_3										
4.	a_4										
5.	a_5										
6.	a_6										
7.	a_7										
8.	a_8										
9.	a_9										
10.	a_{10}										
11.	a_{11}										
12.	a_{12}										
13.	a_{13}										
14.	a_{14}										

Ex.No: 4 Date:	FLOW THROUGH VARIABLE DUCT AREA-BERNOULLI'S EXPERIMENT

AIM

To verify the Bernoulli's theorem Flow through variable Duct Area.

APPARATUS USED

1) A supply tank of water a tapered inclined pipe fitted with no of piezometer tubes point,
2) Measuring tank
3) Scale,
4) Stopwatch.

THEORY

Bernoulli's theorem states that when there is a continues connection between the particle of flowing mass liquid, the total energy of any sector of flow will remain same provided there is no reduction or addition at any point.

FORMULA

Total Head

$H_1 = Z_1 + \frac{P}{\delta} + \frac{V^2}{2g}$ (mm)

$H_2 = Z_2 + \frac{P}{\delta} + \frac{V^2}{2g}$ (mm)

Z = Datum Head (mm)

$\frac{P}{\delta}$ = Pressure Head (mm)

$\frac{V^2}{2g}$ = Velocity Head (mm)

H = Total Head (mm)

PROCEDURE

1. Open the inlet valve slowly and allow the water to flow from the supply tank.
2. Now adjust the flow to get a constant head in the supply tank to make flow in and outflow equal.
3. Under this condition the pressure head will become constant in the piezometer tubes.
4. Note down the quantity of water collected in the measuring tank for a given interval of time.
5. Compute the area of cross-section under the piezometer tube.
6. Compute the area of cross-section under the tube.
7. Change the inlet and outlet supply and note the reading.
8. Take at least three readings as described in the above steps.

RESULT

1. When fluid is flowing, there is a fluctuation in the height of piezometer tubes, note the mean position carefully.
2. Carefully keep some level of fluid in inlet and outlet supply tank.

DESCRIPTION

The experiment is performed by using a number of long horizontal pipes of different diameters connected to water supply using a regulator valve for achieving different constant flow rates. Pressure tappings are provided on each pipe at suitable distances apart and connected to U-tube differential manometer. Manometer is filled with enough mercury to read the differential head 'h_m'. Water is collected in the collecting tank for arriving actual discharge using stop watch and the piezometric level attached to the collecting tank.

FORMULAE USED:

1). Darcy coefficient of friction (Friction factor)

$$f = \frac{2g \times D \times h_f}{4LV^2}$$

Where,

f = Darcy coefficient of friction.

g = gravity due to acceleration in mm/sec^2.

D = Diameter of the pipe in mm.

$h_f = h_m \text{ x } \left(\frac{\rho_m}{\rho} - 1\right)$ (h_m is differential level of manometer fluid measured in mm)

L = Length of pipe between the sections used for measuring loss of head in mm.

Q_a = Actual discharge measured from volumetric technique in mm^3/sec.

2. Velocity, $V = \frac{Q_a}{a}$ (mm/sec)

3. Actual discharge, $Q_a = \frac{AH}{t}$ (mm^3/sec)

Ex.No: 5 Date:	FLOW THROUGH PIPES (MAJOR LOSS)

AIM:

To determine the coefficient of friction (f) of the given pipe material.

APPARATUS REQUIRED:

1. A pipe provided with inlet and outlet valves
2. U- tube manometer
3. Collecting tank
4. Stop watch
5. Meter scale

THEORY:

When liquid flows through a pipe line, it is subjected to frictional resistance. The frictional resistance depends upon the roughness of the inner surface of the pipe. The loss of head between selected lengths of pipe is observed for a measured discharge. The coefficient of friction is calculated by using the expression.

$$h_f = \frac{4fLV^2}{2gd} \text{ (mm)}$$

Where,

h_f = Loss of head due to friction in mm.

L = Length of pipe between the sections used for measuring loss of head in mm.

D = Diameter of the pipe in mm.

f = Darcy coefficient of friction.

g = gravity due to acceleration in mm/sec^2.

h_1 = manometric head in one limb of the manometer in mm.

h_2 = manometric head in outer limb of the manometer in mm.

L = length of the pipe between pressure tapping cock's in mm.

V = velocity of flow in the pipe Q_a in mm/sec.

Q_a = Actual discharge in mm^3/sec.

A = internal plan area of the collecting tank in mm^2.

H = height of collecting on the collecting tank in mm^2.

T = time of the collection in sec.

a = across sectional area of the pipe in mm^2.

d = diameter of pipe in mm.

g = acceleration due to gravity in mm/sec^2.

Observation

Diameter of the pipe (D) = 25 mm

Length of the pipe = 3000 mm

Length of the tank (L) = 500 mm

Breadth of the tank(b) = 500 mm

Acceleration due to gravity (g) = 9810 mm/sec^2

Area of the pipe (a) = 490.625 mm^2

Area of collecting Tank (A) = 250 x 10^{3}mm^2

S.No	Manometric readings			Time taken 't' for H=50 mm rise in collecting tank (sec)	Actual discharge Q_a $\left(\frac{mm^3}{Sec}\right)$	Velocity (V) $\left(\frac{mm}{Sec}\right)$	(V^2) $\left(\frac{mm}{Sec}\right)^2$	Coefficient of friction $f = \frac{2g.D.h_f}{4LV^2}$
	h_1 (mm)	h_2 (mm)	$h_f = h_1 - h_2$ (mm)					
Mean value of C_d								

PROCEDURE:

1. The diameter of the pipe, the internal plane dimension of the collecting tank and the length of the pipe line between the pressure tapping cocks are measured.
2. Keep the outlet valve fully closed, the inlet valve is opened completely.
3. The outlet valve of the collecting tank is closed tightly and the time‘t’ required for H rise of water in the collecting tank is observed using a stop watch.
4. The above procedure is repeated by gradually increasing the flow and observing the required readings.
5. The observations are tabulated and the coefficient of friction is computed

GRAPH:

A graph h_f vs. v^2 is drawn taking v^2 on x axis

RESULTS

The coefficient of friction of the given pipe.

1. Theoretically f =
2. Graphically f =

Ex.No: 6 Date:	DETERMINATION OF MINOR LOSSES

AIM:

To determine the loss of coefficient of flow through pipe due to sudden enlargement, sudden contraction, pipe fitting such as elbows, bends & etc.

APPARATUS REQUIRED:

1. Collecting tank
2. Stop watch
3. Meter scale
4. A pipe line provided with bend, elbow, pipe fitting, etc.

THEORY:

1. The loss of energy due to friction is clarified as major losses and minor losses of energy.
2. Due to charge in velocity of fluid of fluid either in magnitude described in minor velocity.
3. In long pipes minor losses are quite small which is normally ignored however in short that loss may be some time used weight the major losses.
4. The general equations for minor loss is,

$$k = \frac{2gh}{V^2}$$

$$h_1 = \frac{kV^2}{2g} \text{ (mm)}$$

Actual discharge

$$Q_a = \frac{AH}{t} \quad mm^3/sec$$

$$V_1 = \frac{Qact}{a_1} \text{ (mm/sec)}$$

Where,

h_1 = head losses in mm.

V = velocity of fluid flowing through normal diameter in pipe in mm/sec.

K = loss of coefficient of pipe fitting and nature of change in velocity.

PROCEDURE:

1. Select the required pipe line and noted down the diameter.
2. Connect pressure tapings in any pipe line close all other pressure tappings.
3. Open the inlet valve in selected pipe line and closed valve in remaining pipe line.
4. Open the main gate valve and connect pressure taping of the bent to the manometer.

OBSERVATION

1. **Loss of head due to expansion:**

Dia of the pipe (d_1) = 15 mm — area (a_1) = $\pi/4 \times 15^2 = 176.71$ mm^2

Dia of the pipe (d_2) = 50 mm — area (a_2) = $\pi/4 \times 50^2 = 1963.5$ mm^2

Rise of water level (h) = 50 mm — Area of collecting tank (A) = 160×10^6 mm^2

S.No	Manometer reading (H)			Time taken 't' for H=50 mm rise in collecting tank (sec)	Actual discharge $Q_a = \frac{AH}{t}$ (mm^3/s)	$V_1 = \frac{Qact}{a_1}$ (mm/sec)	$V_2 = \frac{Qact}{a_2}$ (mm/sec)	Coefficient of discharge $k = \frac{2gh}{(V1-V2)^2}$
	h_1 (mm)	h_2 (mm)	$x = h_1 - h_2$ (mm)					

2. Loss of head due to contraction:

Dia of the pipe (d_1) =15 mm — area (a_1) = π/4 x 15^2 = 176.71 mm^2

Dia of the pipe (d_2) = 50 mm — area (a_2) = π/4 x 50^2 = 1963.5 mm^2

Rise of water level (h) = 50 mm — Area of collecting tank (A) = 400 x 400 = 160000 m^2

S.No	Manometer reading (H)			Time taken 't' for H=50 mm rise in collecting tank (sec)	Actual discharge $Q_a = \frac{AH}{t}$ mm^3/s	$V_1 = \frac{Qact}{a_1}$	$V_2 = \frac{Qact}{a_2}$	Coefficient of discharge $k = \frac{2gh}{(V1-V2)^2}$
	h_1 (mm)	h_2 (mm)	h or x= $h_1 - h_2$ (mm)					

3. Loss of head due to elbow:

Dia of the pipe (d) = 15 mm

Rise of water level (h) = 50 mm

Area of collecting tank (A) = 160000mm^2

Area (a) = $\pi/4 \times 15^2 = 176.71$ mm^2

S.No	Manometer reading (H)			Time taken 't' for H=50 mm rise in collecting tank (sec)	Actual discharge $Q_a = \frac{AH}{t}$ (mm^3/s)	$V = \frac{Qact}{a_1}$ (mm/sec)	Coefficient of discharge $k = \frac{2gh}{(V)^2}$
	h_1 (mm)	h_2 (mm)	$X = h_1 - h_2$ (mm)				

4. Loss of head due to bend:

Dia of the pipe (d) = 15 mm

Rise of water level (h) = 50 mm

Area of collecting tank (A) = 160000 mm^2

Area (a) = $\pi/4 \times 15^2 = 176.71\ mm^2$

S.No	Manometer reading (H)			Time taken 't' for H=50 mm rise in collecting tank (sec)	Actual discharge $Q_a = \frac{AH}{t}$ (mm^3/s)	$V = \frac{Qact}{a_1}$ (mm/sec)	Coefficient of discharge $k = \frac{2gh}{(V)^2}$
	h_1 (mm)	h_2 (mm)	$X = h_1 - h_2$ (mm)				

5. Note down the reading in left and right column of manometer.
6. Close the valve in collecting tank and note down the time taken for the h cm rise in collecting tank.
7. Repeat the experiment for 5 set reading for different flow rate.
8. Remove and connect the pressure tapings to other pipe fittings and repeat the above process.

RESULT

1. Loss of head due to expansion, k =
2. Loss of head due to contraction, k =
3. Loss of head due to elbow, k =
4. Loss of head due to bend, k =

FORMULA:

1. Total head,

$$H = H_s + H_d + X \text{ (m of water)}$$

Where

P_d = Pressure head in kg/cm^2

P_V = Vacuum head in mm Hg

X = Distance between pressure gauge and vacuum gauge.

H_s = Suction head in m = $[P_V \times 0.0136]$

H_d = Delivery head in m = $[P_d \times 10]$

2. Actual discharge, $Q_a = \frac{AH}{t} (m^3/sec)$

Where,

A = area of collecting tank in m^2.

H = rise of water level in collecting tank = 0.05 m.

t = time taken for 5 cm rise in collecting tank in sec.

3. Input power, $P_i = \left[3600 \text{ x } \left(\frac{nr}{ct}\right)\right] \text{ (watts)}$

Where,

Nr = Number of revolutions of energy meter disc = 5 rev

C = Energy meter constent = 0.75

T = time for 5 revolutions energy meter disc in sec .

EMC = Energy meter constant in rev/kwhr.

4. Output power, $P_O = W \times Q_{act} \times H$ (watts)

Where,

W = Specific weight of water 980 or 1000 (N/m^3)

Q_a = Actual discharge in m^3/sec

H = Head of water in m.

5. Efficiency of the pump, $\boldsymbol{\eta} = \left[\frac{\text{Output power}}{\text{Input power}}\right] \times 100\ (\%)$

$$\eta \qquad \boldsymbol{\eta} = \left[\frac{P_O}{P_i}\right] \times 100\ (\%)$$

Ex.No: 7 Date:	PERFORMANCE TEST ON CENTRIFUGAL PUMP

AIM:

To study the characteristics of a centrifugal pump and to draw the characteristics curve.

APPARATUS REQUIRED:

1. Centrifugal pump setup
2. Centrifugal pump with pressure gauge and vacuum gauge setup.
3. Stop Watch
4. Collecting tank
5. Steel Scale

THEORY:

A centrifugal pump is a roto dynamic pump that uses a rotating impeller to increase the pressure of a fluid. The pump works by the conversion of the rotational kinetic energy, typically from an electric motor or turbine, to an increased static fluid pressure. This action is described by Bernoulli's principle.

The rotation of the pump impeller imparts kinetic energy to the fluid as it is drawn in from the impeller eye and is forced outward through the impeller vanes to the periphery. As the fluid exits the impeller, the fluid kinetic energy is then converted to pressure due to the change in area the fluid experiences in the volute section. The energy conversion, results in an increased pressure on the delivery side of the pump, causes the flow.

DESCRIPTION:

The test pump is a single stage centrifugal pump. It is coupled with an electric motor by means cone pulley belt drive system. An energy meter is permanently connected to measure the energy consumed by the electric motor for driving the pump. A stop watch is provided to measure the input power to the pump. A pressure gauge and a vacuum gauge are fitted it the delivery and suction pipes, respectively, to measure the pressure.

1. The pump is run by a single phase motor.
2. The pressure gauge is fitted to the delivery side and a vacuum gauge to the suction side.
3. The energy input to the pump can be measured through an energy meter.
4. There is a collecting tank with a level indicator.

OBSERVATIONS AND TABULATION:

Internal plan area of collecting tank (l x b) = 700 x 700 = 0.49 m^2 Specific gravity of mercury (Sm) = 13.6 x 10^{-3}

Rise of water level in collecting tank (h) = 50 mm

Different on head between pressure & vacuum (d) = 0.37 m

Energy meter constant (C) = 200 kw/hr

Difference between pressure and vacuum gauge, x = 0.512 m

S.No	Suction head H_s (m)		Delivery head H_d (m)		Total head, H (m)	Time taken 't' for H=50 mm rise in collecting tank (sec)	Time for 5 N rev of energy meter disc (T sec)	Discharge Q_{act} $\left(\frac{m^3}{sec}\right)$	Input power, P_i (kW)	Output power, P_O (kW)	Efficiency $\eta=\frac{P_o}{P_i}\times 100$ (%)
	Vacuum gauge mm of Hg	Head suction 'm'of water	Pressure gauge (kg/cm^2)	Head 'm'of water							
										Mean value,η	

PROCEDURE:

1. Note down the area of collecting tank, position of delivery pressure gauge and arm distance of the spring from the centre of shaft.
2. Priming the pump set before starting.
3. Open the delivery valve fully pressure gauge shown (kg/cm^2) and switch on motor.
4. In above said gate openings, note switch on motor.
5. Vacuum gauge reading in mm of Hg.
6. Time taken for h cm rise in collecting tank.
7. Time taken for Nr revolution of energy meter.
8. Now close the gate valve in such a way presence gauge shown 0.5 kgh cm^2
9. The flow rate is reduced in stages and the above procedure is repeated.
10. The procedure is repeated other types of values.

GRAPHS:

The following graphs are drawn taking head (H) on X axis:

The characteristic test was conducted on the centrifugal pump and the following graphs were drawn:

i) Head vs Actual discharge

ii) Head vs Efficiency of pump

iii) Head vs Output power

RESULT:

i) Maximum efficiency of centrifugal pump, η	=	%
ii) Actual discharge, Q_{act}	=	m^3/sec
iii) Output power from the pump, P_O	=	kW
iv) Total head, H	=	m

FORMULAE:

1. ACTUAL DISCHARGE:

$$Q_{act} = \frac{A \times h}{T} \quad (m^3 / sec)$$

Where,

A = Area of the collecting tank in m^2

y = Rise of oil level in collecting tank in m

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

2. TOTAL HEAD:

$$H = H_d + H_s + Z$$

Where

H_d = Discharge head; Hd = P_d x 12.5 (m)

H_s = Suction head; Pd = P_s x 0.0136 (m)

Z = Datum head in m

P_d = Pressure gauge reading in kg / cm^2

P_s = Suction pressure gauge reading in mm of Hg

3. INPUT POWER:

$$P_i = \left(\frac{3600 \times N}{E \times T}\right) \quad (KW)$$

Where,

Nr = Number of revolutions of energy meter disc.

Ne = Energy meter constant in rev / kWhr

te = Time taken for 'Nr' revolutions in seconds.

4. OUTPUT POWER:

$$P_o = \frac{W \times Qact \times H}{1000} \ (w)$$

Where,

W = Specific weight of oil in N/m^3

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

h = Total head of oil in m.

5. EFFICIENCY:

$$\eta = \left(\frac{\text{Output power Po}}{\text{input power Pi}}\right) \times 100 \quad (\%)$$

Ex.No: 8 Date:	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

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.

TABULATION

Area of the collection tank (A) = 0.7 m X 0.7 m = 0.49m^2

Energy meter constant (k) = 200 in rev/KwH

Specific gravity of oil (S) = 0.8

S. No.	Suction Head (H_s)		Delivery Head		Total Head H (m)	Time taken 't' for H=50 mm rise in collecting tank (sec)	Actual discharge Q (m^3/sec)	Time for 3 rev of EM (Sec)	Input P_i (kW)	Output P_o (kW)	Efficiency η (%)
	V	H_s	P	H_d							
	mm of Hg	mm of H_2o	mm of Hg	mm of H_2o							
										Efficiency, η	

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

RESULT:

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

FORMULAE:

1. Total head, $H = H_s + H_d + X$ m of water

Where,

P_d = pressure head in kg/cm^2

P_V = vacuum head in mmHg

X = distance between pressure gauge and vacuum gauge, m

H_s = Suction head in m = $[P_V \times 0.0136]$

H_d = Delivery head in m = $[P_d \times 10]$

a) Actual discharge of water

$$Q_{act} = AH/t\,(m^3/sec)$$

Where,

A = area of collecting tank in m^2

H = rise of water level in collecting tank = 0.05, m

t = time taken for 5 cm rise in collecting tank in sec

b) Theoretical discharge of water,

$$Q_{the} = 2\pi d^2/4 \text{ x l x N}/(4 \text{ x } 60)$$

Where,

l = stroke length in m

d = Diameter of cyclinder in m

N_P = pump speed

Co-efficient of discharge, $C_d = Q_a/Q_t$ (No unit)

c) Slip $= Q_t - Q_a$

$slip\ (\%) = (Q_t - Q_a/Q_t) \times 100$

d) Power input to the pump,

$$P_i = \frac{[3600 \times n \times motor \times 1000]}{[T \times EMC]} \text{ (Watts)}$$

Where,

n = Number of revolutions of energy meter disc = 5 rev

motor = 1

T = time for 5 revolutions energy meter disc in sec

EMC = Energy meter constant in 750 rev/kwhr

e) Power output from the pump,

$$P_O = W \times Q_{act} \times H \text{ (watts)}$$

Where,

W = Specific weight of water 980 or 1000 in N/m^2

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

H = Head of water in m

f) Efficiency of the pump,

$$\eta = [P_O/P_i] \times 100 \quad (\%)$$

Ex.No: 9 Date:	PERFORMANCE TESTS ON RECIPROCATING PUMP

AIM:

To study the characteristics of the reciprocating pump and to determine the efficiency of the pump.

APPARATUS REQUIRED:

1. Reciprocating pump with pressure gauge and vacuum gauge setup.
2. Stop Watch
3. Collecting tank
4. Steel Scale
5. Tachometer

THEORY:

A reciprocating pump is a positive displacement type pump, because of the liquid is sucked and displaced due to the thrust exerted on it by a moving piston inside the cylinder. The cylinder has two one-way valves, one for allowing water into the cylinder from the suction pipe and the other for discharging water from the cylinder to the delivery pipe. The pump operates in two strokes.

During suction stroke, the suction valve opens and delivery valve closes while the piston moves away from the valve. This movement creates low pressure/partial vacuum inside the cylinder hence water enters through suction valve. During delivery stroke, the piston moves towards the valves. Due to this, the suction valve closes and the delivery valve opens, hence liquid is delivered through delivery valve to the delivery pipe.

DESCRIPTION:

The reciprocating pump is a displacement type of pump and consists of a piston or a plunger working inside a cylinder. The cylinder has got two valves, one allowing water into the cylinder from the suction pipe and the other allowing water from the cylinder into the delivery pipe.

During the suction stroke, a petrol vacuum is created inside the cylinder, the suction valve opens and water enters into the cylinder. During the return stroke the suction valve closes and the water inside the cylinder is displaced into the delivery pipe through the delivery valve. In case of double acting pump two sets of delivery and suction valves are

OBSERVATIONS AND TABULATION:

Length of the collecting tank (l) = 0.3m X = 0.35m

Breadth of the collecting tank (b) = 0.3m

Energy meter constants (c) = 1800 rev/KwH

Dia of the cylinder (d) = 0.045m

Stoke length (l) = 0.04m

S.No	Suction Head H_s (m)		Delivery head H_d (m)		Total Head $H=H_s+H_d+X$ (m)	Time taken 't' for H=50 mm rise in collecting tank (sec)	Speed of Pump (rpm)	Time taken for '5'rev energy meter (T in sec)	Actual Discharge Q_{act} (m^3/s)	Theoretical Discharge Q_{th} (m^3/s)	% Slip	Input power $P_i = W \times Qa \times H$ kW	Output power, $P_o = 2\pi NT/60$ kW	Efficiency $\eta = (P_o/P_i)\times 100$ (%)
	mm of Hg	m of water	Kg/cm^2	m of water										
													Efficiency, η	

provided. So for each stroke one set of valves are operated and there is a continuous flow of water.

An energy meter is provided for determination of input to the motor. The pump is belt driven by a A.C motor .The pump can be run at three different speeds by the use of V- belt and differential pulley system. The belt can be put in different grooves of pulleys for different speeds. A set of pressure gauge are provided and the required pipe lines are also provided.

PROCEDURE:

1. Select the required speed.
2. Open the gate valve in the delivery pipe fully.
3. Start the motor.
4. Throttle the gate valve to get the required head.
5. Note the following :
   a. Pressure gauge (P_d) and vacuum gauge (P_v) readings.
   b. Time taken for 5 cm rise of water in the collecting tank and 5 revolutions of the energy meter.
6. Repeat the experiment for different heads. Take atleast 5 set of readings.

GRAPHS :

The following graphs are drawn taking Total head on X axis:

The characteristic test was conducted on the reciprocating pump and the following graphs were drawn:

i) Total head vs Actual discharge

ii) Total head vs Efficiency of the pump

iii) Total head vs Power output

iv) Total head vs % Slip

RESULT:

The efficiency of the reciprocating pump at constant speed cools found out and the characteristic curves are drawn

Maximum efficiency of Reciprocating pump, = %

Maximum slip percentage, = %

FORMULA:

1. Different in head (h) = $\frac{(p1 - p2)}{\text{specific gravity of H2O x 1000}}$ x 10^4 (m)

2. Qact = $k\sqrt{H}$ (m^3/s)

   K = coefficient of venturimeter = 3.183 x10^{-3}

   H = $\frac{(\text{pressure gauge reading x } 10^4)}{(\text{sp. gravity of water x 1000})}$ (m of water)

3. Input power = W x Qact x H

   = pgQH (kW)

4. Output power, $P_o = \frac{2\pi NT}{60}$ (kW)

   $= \frac{2\pi N(F \times d/2)}{60}$ (kW) (F=ma)

   $= \frac{\pi \times N \times m \times a \times d \times 10}{60}$ (kW)

5. Efficiency (η) = $\frac{\text{Output power}}{\text{Input power}}$ x 100 (%)

Ex.No: 10 Date:	PERFORMANCE TEST OF A PELTON WHEEL TURBINE

AIM:

To conduct the load test on the given pelton wheel turbine by keeping constant gate opening and variable speed and to draw the characteristic curve.

APPARATUS REQUIRED:

1. Pelton wheel set up
2. Supply pump
3. Venturi meter with pressure gauge
4. Tachometer
5. Pressure gauge at the inlet to the turbine
6. Rope brake drum with spring balance connected to the turbine.

INTRODUCTION:

The pelton wheel is a tangential flow impulse turbine. The available head is first converted into kinetic energy by means of an efficient nozzle. The jet issuing from the nozzle strikes a series of buckets fixed on the rim of a wheel. Thus the hydraulic energy is converted to the mechanical energy. Ina a water power project, a generator is coupled to the pelton wheel for producing electricity.

When the load on the pelton wheel changes, the discharge can be changed by a spear mechanism moving in the nozzle. The water coming out the buckets is discharged into a tail race. Since the water flowing through the pelton wheel is at atmospheric pressure, the casing has no hydraulic action to perform. However, it is usually provided to prevent the splashing `of water and to guard against the accidents.

THEORY

Schematic of the Pelton turbine experimental setup is shown in Figure 8.1. The Pelton turbine consists of three basic components, a stationary inlet nozzle, a runner and a casing. The runner consists of multiple buckets mounted on a rotating wheel. The jet strikes the buckets and imparts momentum. The buckets are shaped manner to divide the flow in half and turn its relative velocity vector nearly 180°. Nozzle is controlled by the spear valve attached. A pressure gauge is attached to the water pipe entering the turbine for reading the available water head. The discharge to the setup is supplied by a pump and discharge is calculated from reading

OBSERVATION AND TABULATION:

Dia of break drum, D = 0.31m

Empty hanger weight = 2kg

Equivalent diameter = 0.325m

Coefficient of venturimeter, k = 3.183×10^{-3}

Pipe diameter = 0.015m

S.No	Inlet Head		Venturimeter readings			$Q_{act} = k\sqrt{H}$ (m^3/s)	Speed (N)	Weight of hanger (kg)	Spring Balance Reading (kg)	Net Weight (kg)	Input power $P_i = W \times Q_a \times H$ (kW)	Output power, $P_o = 2\pi NT/60$ (kW)	Efficiency $\eta = (P_o/P_i) \times 100$ (%)
	Pressure (Kg/m^2)	Head (m)	h_1 (Kg/m^2)	h_2 (Kg/m^2)	$H = h_1 - h_2$ (m)								

of pressure gauge that is attached to the venturi-meter. Power is measured from the turbine using rope brake arrangement with spring balance system.

EXPERIMENTAL SETUP:

The setup consists of a rig with a scale model of the prototype pelton wheel. Water under high head is supplied to the model by a centrifugal pump. The discharge is measured with a calibrated Venturimeter inserted on the supply pipe as shown in fig. a pressure gauge is fitted to the supply line to measure the pressure before the water enters the nozzle.

A rope brake is generally used to measure the output. The rope brake consists of a rope wound around the rim of the brake drum keyed to the shaft of the turbine. Both ends of the rope are connected to spring balances to measure the tension in the rope.

PELTON WHEEL TURBINE TEST RIG – 5 HP SPECIFICATIONS:-

1) **Turbine Power** – 5 H.P. fitted with 18 number of buckets, mounted over the sump tank provided with nozzle and spear.

2) **Pump** – 15 H.P. mono-block pump, Head 85m, Discharge 6 lps provided with semi automatic star-delta starter

3) **Measurements** –

a) Venturi meter with mercury manometer for discharge measurement.

b) Rope brake pulley dia 0.270 meter with spring balance 50 Kgs. Capacity and belt thk. 6mm.

c) Pressure gauge to note down the pressure 0 – 7 Kg/cm^2 capacity.

PROCEDURE:

1. Fill up sufficient water in the sump tank.
2. The supply pump is first started with the discharge valve fully closed.
3. The gate valve is fully opened and the head on the water supplied on the turbine is adjusted by regulating the discharge valve.
4. The following observation readings are noted

   Manometer reading, Pressure gauge reading, Shaft speed, Dead weight on the hanger, Spring balance reading
5. Load on the turbine is increased by adding weights in the hanger
6. Repeat the above steps for a five time and note the readings.

GRAPH:

Graphs are drawn,

1. Constant head vs. Unit power
2. Constant speed vs. efficiency

RESULTS:

Thus the pelton wheel turbine was conducted and the characteristics waves are plotted.

FORMULE:

1. Outlet pressure head = $\frac{\text{vacuum gauge reading x } 10^{3} \text{ x sp.gravity of mercury}}{\text{sp.gravity of the water}}$ (m)

2. Inlet pressure head = $\frac{\text{pressure gauge reading x } 10^{-4}}{\text{sp.gravity of the water x } 1000}$ (m)

3. Actual discharge, Qact = $k\sqrt{h}$ (m^3/sec)

4. Input power, P_i = W x Qact x H

   = ρg x Q x H (kW)

5. Output power, $P_o = 2\pi NT/60$ (kW)

   $= \frac{2\pi N\,(F \times d/2)}{60}$ (kW) (F=ma)

   $= \frac{\pi \times N \times m \times a \times d \times 10^{-3}}{60}$ (kW)

6. Efficiency, $\eta = \frac{\text{Output power}}{\text{Input power}}$ x 100 (%)

Ex.No: 11 Date:	FRANCIS TURBINE

AIM:

To study the characteristics of a Francis turbine and to plot the characteristics curves.

APPARATUS REQUIRED:

7. Francis turbine set up
8. Supply pump,
9. Stop watch
10. Tachometer
11. Pressure gauge

INTRODUCTION:

A Francis turbine is a radial flow reaction turbine. Because only a part of the total head is converted into kinetic energy at the inlet to the turbine and the rest remains in the form of pressure energy, a casing is absolutely necessary to enclose the turbine. Moreover, a draft tube is also required to connect the turbine exit to the tail race.

The vanes of a Francis turbine are fitted between two circular plates. The shape of the vanes is such that the water enters the runner radially at the outer periphery and leaves in the axial direction at the inner periphery.

Water from the supply pipe (called penstock) enters the scroll casing which distributes the water over the guide vanes. By regulating a shaft attached to the regulating ring, the passage between the adjacent guide vanes can be varied to change the discharge striking the vanes of the turbine.

EXPERIMENTAL SETUP:

The setup consists of a scale model of the prototype Francis turbine. Water is supplied to the Francis turbine model by a centrifugal pump of the required capacity. The discharge is measured with a Venturimeter installed on the supply pipe. A pressure gauge is fitted near the inlet to the turbine at an elevation of Z_1 above the axis of the turbine. A pressure gauge is fitted near the inlet to the turbine at an elevation of Z_1 above the axis of the turbine. A vacuum gauge is fitted near the exit of the turbine at a height of Z_2 above the axis of the turbine.

A brake drum is coupled to the shaft of the turbine to measure the output. The load is applied to the drum by tightening the rope around the drum. The speed of the turbine is measured with a tachometer.

THEORY:

A turbine is designed to work at one particular set of head H, discharge Q, speed (N) and overall efficiency η_0. In practice, the turbines may be required to run at conditions different from those for which these have been designed. The behavior of turbines under varying conditions of H, Q, P, N and η_0 may be studied by carrying out tests on the models. The results of these tests are plotted in the form of curves called the characteristics curves and it's plotted in terms of unit quantities are,

Unit discharge, $Q_u = \frac{Q}{\sqrt{H}}$ (m^3/sec)

Unit power, $P_u = \frac{P}{H^{3/2}}$ (Watt)

Unit speed, $N_u = \frac{N}{\sqrt{H}}$ (m/s)

The specific speed (N_s) is calculated from the relation

$$N_s = \frac{N\sqrt{P}}{H^{5/4}} \text{ (kW)}$$

PROCEDURE:

1. Prime the centrifugal pump and start the electric motor coupled to the pump.
2. Set the turbine at the full gate opening.
3. Gradually open the delivery valve of the pump and just it so as to attain the required head and discharge.
4. Open the inlet valve of the brake cooling system.
5. Gradually apply the load on the brake drum by tightening the rope
6. Determine the shaft speed with a tacheometer.
7. Repeat steps 5 and 6 for different loads and note the corresponding speeds.
8. Note the manometer reading h for the measurement of discharge.
9. Repeat steps 3 to 8 for 1/4, 1/2 and 3/4 gate opening.
10. While closing the system, take the following steps:
    a) Remove all spring balance tensions.
    b) Close the cooling water system valve.
    c) Close the gate opening by moving the spear wheel.
    d) Close the delivery valve of the pump.
    e) Finally switch off the electric motor.

OBSERVATIONS AND CALCULATIONS:

Brake down diameter = 0.31 m

Rope diameter = 0.015 m

Equivalent drum diameter = 0.325 m

Weight of empty hanger = 2 kg

k = 5×10^{-3}

S. No	Inlet pressure head		Outlet pressure head		Venturimeter reading			Total head $H_s + H_d$ (m of H_2O)	Speed, N (rpm)	$Q_{act} = k\sqrt{H}$ (m^3/s)	Weight of hanger (kg)	Spring Balance Reading (kg)	Net Weight (kg)	Turbine inlet P_i (kW)	Turbine output P_o (kW)	Efficiency η (%)
	(Kg/cm^2)	m of H_2O	(Kg/cm^2)	m of H_2O	P_1	P_2	$P_1 - P_2$									

GRAPHS:

Plot main characteristic curves between

1. Speed Vs discharge
2. Speed Vs head
3. Speed Vs output
4. Speed Vs efficiency

RESULTS:

Thus the performance test on Francis Turbine was calculated and the characteristic curves are plotted.

Ex.No: 12 Date:	METACENTRIC HEIGHT (CARGO &WARSHIP)

AIM:

To find metacentric height for floating body.

APPARATUS REQUIRED:

1. Model ship
2. Weight
3. Watchable
4. Meter scale
5. Hook gauge

THEORY:

Metacentric is defined as the point of which line of action of forces of buoyancy will meet the normal a is of body whose body is given smaller angular displacement the distance between the distance the center of gravity and metacentric of the body is known as metacentric height.

Total weight of warship $W = W_1 + W_0 + m$

Total weight of cargo ship $W = W_0 - W_1 + m$

Metacentric height $H = \frac{M_x}{W \tan\theta}$

Where ,

X= Distance through which the hanging weight is moved.

W_1= Dead load

A= Area of collecting

W= Total weight of model ship including weight added and dead weight

θ = Angle through which the ship is tilted.

PROCEDURE:

1. Known the initial height of water in the vessel before floating of the body.
2. Place of the model ship in vessel with water.
3. Adjust the counter weight to keep the ship in equilibrium.
4. Know the height of float
5. To find the metacentric height keep dead load on the top of the ship are other side.
6. Check whether the needle shows the difference.
7. Now the weight as the side way and note the deflection of needle.
8. Now center of horizontal the hanger’s weight on the right side.
9. Repeat the above procedure at different centers.

RESULT:

The metacentric height for Cargo ship and warship was demonstrated.

OBSERVATION:

Diameter of mouthpiece (d) = 30 mm

Area of mouthpiece (a) $= \frac{\pi}{4} \times (30)^2 = 706.85\ mm^2$

Internal plan dimension of collecting tank, Length = 500 mm Breadth = 500 mm

TABULATION:

S.NO	Head,H (mm)	Time taken 't' for H=50 mm rise in collecting tank (sec)			Discharge (mm^3/sec)		Coefficient of discharge C_d
		T_1	T_2	Avg	Actual Q_a (mm^3/sec)	Theoretical Discharge Q_t (mm^3/sec)	
						Mean, C_d	

Ex.No: 13 Date:	**FLOW THROUGH ORIFICE (CONSTANT HEAD METHOD)**

AIM

To determine the coefficient of discharge of the orifice by Constant head method.

APPARATUS REQUIRED

1. Piezometer
2. Meter scale
3. Stopwatch
4. Collecting tank fitted with controlled valve

THEORY

The orifice is a small opening closed pointer provided in a vessel through which the liquid flows. The orifice may be provided in the side of bottom of the vessel.

FORMULAE USED

COEFFICIENT OF DISCHARGE AND THEORETICAL DISCHARGE

$C_d = \frac{Q_a}{Q_t}$ (no unit)

$Q_t = a\sqrt{2gh}$ (mm^3/sec)

Where,

A = Area of internal plan in mm^2.

g = Acceleration due to gravity in mm/sec^2.

a = Area of orifice in mm^2.

H = Rise of liquid in mm.

T= Time for H rise in sec.

PROCEDURE

1. The diameter of orifice and internal plan dimension of the collecting tank are measured.
2. Supply valve to the orifice taken in regulation and water raised in allowed to full the tank.
3. The outlet valve of the collecting tank is closed tightly the time t required for H cm rice of water in collecting tank.
4. The above procedure is repeated for different head and the observations are tabulated.

GRAPH

A graph was plotted by taking discharge along the x axis and 't'sec along y axis.

RESULT

- The coefficient of discharge of the given orifice by analytical method = ……..
- The coefficient of discharge of the given orifice by graphical method = …….
-

Observation

Diameter of mouthpiece (d) = 30 mm

Internal plan dimension of collecting tank, Length(L) = 500 mm

Breadth (B) = 500 mm

Tabulation:

S.NO	Head H_1 (mm)	Head, H_2 (mm)	Time taken 't' for H=50 mm rise in collecting tank (sec)	$\sqrt{H1}$ - $\sqrt{H2}$ (mm)	Coefficient of discharge (C_d)
				Mean, C_d	

Ex.No: 13 Date:	FLOW THROUGH ORIFICE (VARIABLE HEAD METHOD)

AIM

To determine the coefficient of discharge of the orifice by variable head method.

APPARATUS REQUIRED

1. Piezometer
2. Meter scale
3. Stopwatch
4. Collecting tank fitted with controlled valve

THEORY

The orifice is a small opening closed pointer provided in a vessel through which the liquid flows. The orifice may be provided in the side of bottom of the vessel.

FORMULA USED

COEFFICIENT OF DISCHARGE

$$C_d = \frac{2A(\sqrt{H1-H2})}{TXaX\sqrt{2g}} \text{ (mm}^3\text{/sec)}$$

Where,

A = Area of internal plan in mm^2.
g = Acceleration due to gravity in mm/sec^2.
a = Area of orifice in mm^2.
H = Rise of liquid in mm.
T= Time for H rise in sec.

PROCEDURE

1. The diameter of orifice and internal plan dimension of the collecting tank are measured.
2. Supply valve to the orifice taken in regulation and water raised in allowed to full the tank.
3. The outlet valve of the collecting tank is closed tightly the time t required for H cm rice of water in collecting tank.
4. The above procedure is repeated for different head and the observations are tabulated.

GRAPH

A graph was plotted by taking ($\sqrt{H1 - H2}$) along the x axis and 't'sec along y axis.

RESULT:

- The coefficient of discharge of the given orifice by analytical method=
- The coefficient of discharge of the given orifice by graphical method =