QMP 7.1 D/F

Channabasaveshwara Institute of Technology
(Affiliated to VTU, Belgaum & Recognized by A.I.C.T.E. New Delhi)
(NAAC Accredited & An ISO 9001:2015 Certified Institution)
NH 206, (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka

Department of Mechanical Engineering

Fluid Mechanics Laboratory

BME403

B.E - IV Semester

Lab Manual 2023-24

Name: ____

USN : ____

Batch : __________________ Section : _____________

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Department of Mechanical Engineering

Fluid Mechanics Lab Manual

Version 2.0

April 2024

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DEPARTMENT OF MECHANICAL ENGINEERING.

FLUID MECHANICS LAB SYLLABUS

B.E, IV Semester, Mechanical Engineering [PRACTICAL COMPONENT OF IPCC]

Course Code	BME403	CIE Marks	50
Number of Lecture Hours/Week	02	SEE Marks	50
credits	04	Exam Hours	03

Course Objectives:

Conduct basic experiments of fluid mechanics and understand the experimental uncertainities.

Course outcomes:

- **Perform basic experiments of fluid mechanics and understand the experimental uncertainities.**

Sl.NO	Experiments
1	Determine the viscosity of oil using Red wood viscometer and Say-bolt viscometer.
2	Measurement of pressure using different Manometers for high and low pressure measurements (manometers using different manometric fluids).
3	Working principle of different flow meters and their calibration (orifice plate, venture meter, turbine, Rota meter, electromagnetic flow meter)
4	Working principle of different flow meters for open channel and their calibration
5	Determination of head loss in pipes and pipe fittings having different diameters, different materials and different roughness
6	Reynolds apparatus to measure critical Reynolds number for pipe flows
7	Effect of change in cross section and application of the Bernoulli equation
8	Impact of jet on flat and curved plates
9	Measurement of coefficient of pressure distribution on a cylinder at different Reynolds Numbers

10	Wind tunnel calibration using Pitot static tube
11	Determination of drag and lift co-efficients of standard objects using wind tunnel.
12	Use any CFD package to study the flow over aerofoil/cylinder

Reading:

1. K.L.Kumar.“Engineering Fluid Mechanics” Experiments, Eurasia Publishing House, 1997
2. JagdishLal, Hydraulic Machines, Metropolitan Book Co, Delhi, 1995
3.George E. Totten , Victor J. De Negri “Handbook of Hydraulic Fluid Technology, Second Edition, 2011.

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DEPARTMENT OF MECHANICAL ENGINEERING.

Course Objectives

1. This course will provide a basic understanding of flow measurements using various types of flow measuring devices, calibration and losses associated with these devices.
2. Energy conversion principles, analysis and understanding of hydraulic turbines and pumps will be discussed. Application of these concepts for these machines will be demonstrated. Performance analysis will be carried out using characteristics curves.

Course Outcomes

1. Perform experiments to determine the coefficient of discharge of flow measuring devices.
2. Conduct experiments on hydraulic turbines and pumps to draw characteristics.
3. Test basic performance parameters of hydraulic turbines and pumps and execute the knowledge in real life situations.

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DEPARTMENT OF MECHANICAL ENGINEERING

General Instructions to the Students

- ✓ Laboratory uniform, shoes & safety glasses are compulsory in the lab.
- ✓ Do not touch anything with which you are not completely familiar. Carelessness may not only break the valuable equipment in the lab but may also cause serious injury to you and others in the lab.
- ✓ Please follow instructions precisely as instructed by your supervisor. Do not start the experiment unless your setup is verified & approved by your supervisor.
- ✓ Do not leave the experiments unattended while in progress.
- ✓ Do not crowd around the equipment's & run inside the laboratory.
- ✓ During experiments material may fail and disperse, please wear safety glasses and maintain a safe distance from the experiment.
- ✓ If any part of the equipment fails while being used, report it immediately to your supervisor. Never try to fix the problem yourself because you could further damage the equipment and harm yourself and others in the lab.
- ✓ Keep the work area clear of all materials except those needed for your work and cleanup after your work.

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DEPARTMENT OF MECHANICAL ENGINEERING

LECTURE PLAN

Faculty Name:

Sem. & Sec.: **IV 'A'** Sub: **FM LAB** Sub. Code: **21ME43**

Sl.No.	Date	LessonPlan No.	Name of the Experiment	Remarks
1		LP.1	Determination of co-efficient of friction of flow in a pipe	
2		LP.2	Determination of minor losses in flow through pipes	
3		LP.3	Determination of force developed by impact of jets on vanes	
4		LP.4	Determination of co-efficient of discharge through orifice plate meter	
5		LP.5	Determination of co-efficient of discharge through venturimeter	
6		LP.6	Determination of co-efficient of discharge through nozzle	

7		LP.7	Determination of co-efficient of discharge through v-notch	
8		LP.8	Performance test on an air blower	
9		LP.9	Application of Bernoullis Equation	
10.		LP.10	Measurement of Reynolds Number	
11.		LP.11	Redwood Viscometer	
12.		LP.12	Saybolt Viscometer	

Signature of staff **HOD**

Nomenclature of standard terms:

Specific weight of water, $\omega = 9810\ N/m^3$

Acceleration due to gravity, $g = 9.81\ m/s^2$

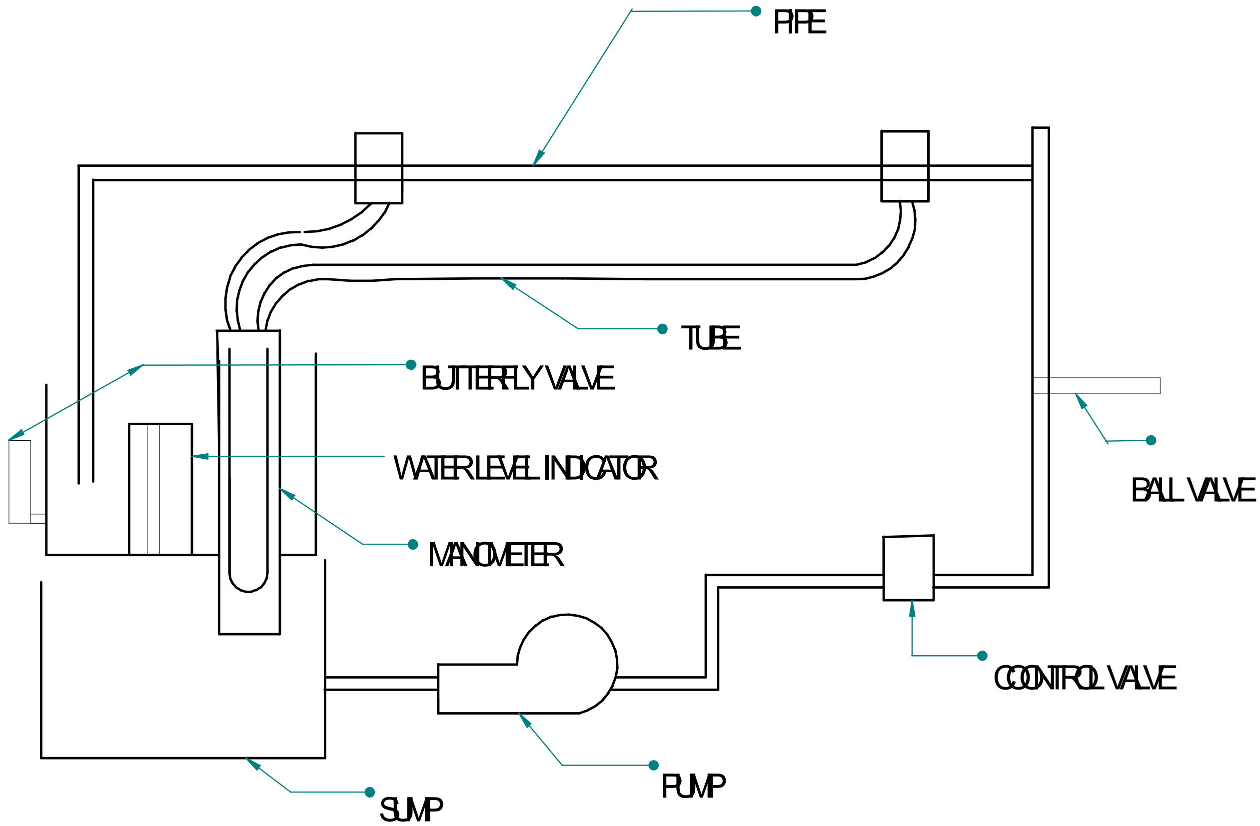
Specific gravity of mercury, $S_{Hg} = 13.6$

Specific gravity of water, $S_w = 1$

Density of water, $\rho_w = 1000\ kg/m^3$

Density of air, $\rho_a = 1.2\ kg/m^3$

Density of mercury, $\rho_{Hg} = 13600\ kg/m^3$



EXPERIMENTAL SETUP

Observations and Calculations:

Area of Tank = m^2
Length of pipe,L = m

Formulae:

Discharge Q $= \frac{AR}{t}\ m^3/s$

Where, R = Rise in water level in collecting tank. (In m)
t = time in seconds.

Velocity of flow, $V = \frac{Q}{a}\ m/s$

Q = Discharge in m^3/s

Cross sectional area of pipe $a = \frac{\pi d^2}{4}\ m^2$ where'd' is inner diameter of pipe in m.

Date:

Experiment No. 01

FRICTION IN PIPES

Aim: To determine the Co-efficient of friction in flow through pipes of various sizes.

Theory:

When a fluid is flowing through a pipe, the fluid experiences some resistance due to which some of the energy of fluid is lost. The loss of energy is classified into

1. Major energy loss: this is due to friction and it is calculated by the following formulae:

a) Darcy-Weisbach Formula $h_f = \frac{4fLV^2}{2gd}$

Where, h_f = loss of head due to friction

f = co-efficient of friction which is a function of Reynolds number.

$= \frac{16}{R_e}$ for $R_e < 2000$

$= \frac{0.079}{R_e^{1/4}}$ for R_e varying from 4000 to 10^6

L = length of pipe

V = mean velocity of flow

d = diameter of pipe.

b) Chezy's formula $V = C\sqrt{mi}$

Where, C = Chezy's Constant

m for pipe is always equal to $\frac{d}{4}$

i = loss of head due to friction/unit length of pipe.

Procedure:

1. Switch on the pump and open the delivery valve.
2. Open the corresponding ball valve of pipe under consideration.
3. Keep the ball valve of other pipeline closed.
4. Note down the differential head readings in the manometer. (Expel if any air is present by opening the drain cocks provided to the manometer).
5. Close the butterfly valve and note down the time taken for known water level rise.

where h_f is loss of head.

$h_f = H\left[\frac{S_{Hg}}{S_w} - 1\right]$ m of water.

H = Manometer reading in m of Hg

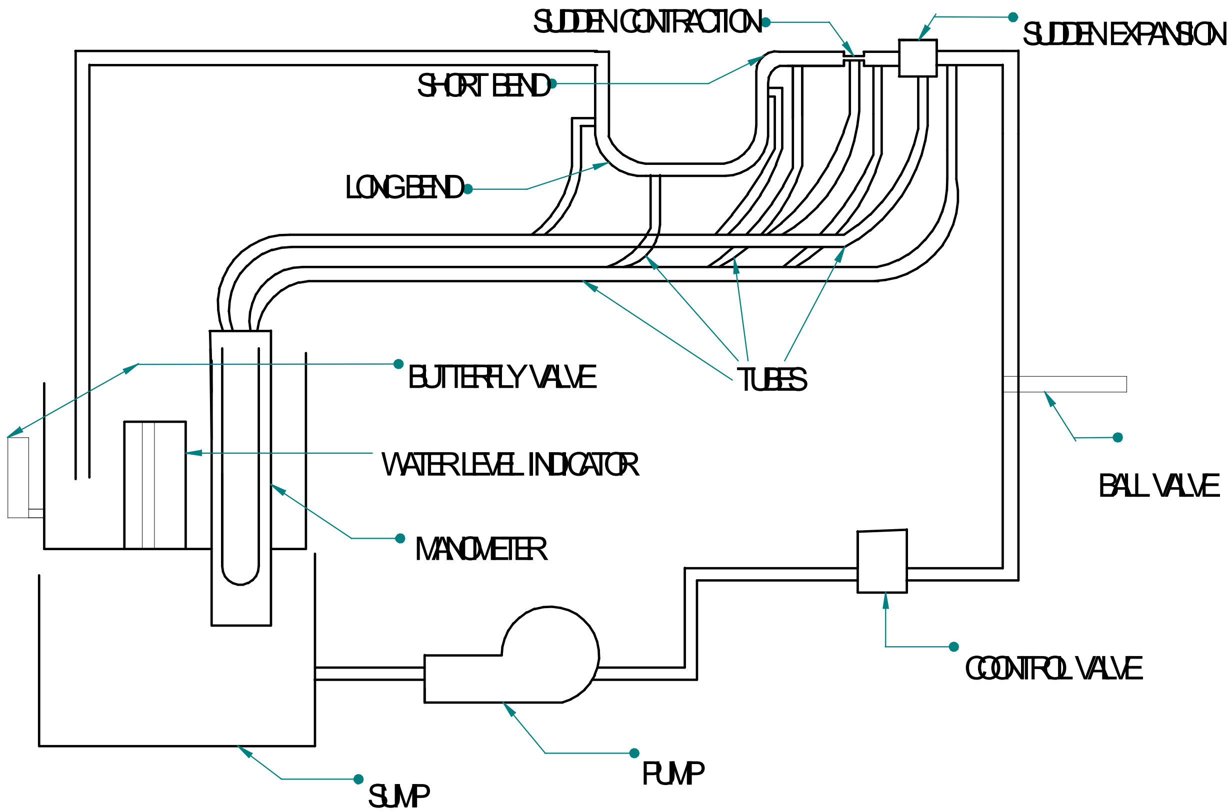
6. Change the flow rate and take the corresponding reading
7. Repeat the experiment for different diameter of pipelines.

Table of calculations:

Type	Difference in Mercury level			Rise of water in m	Time taken in sec	Discharge Q (m^3/s)	Velocity V (m/s)	Loss of head in m	Co-efficient of Friction
	h_1	h_2	H= h_1-h_2 in m						

Co efficient of friction, $f = \dfrac{h_f\, 2gd}{4LV^2}$

Work Sheet



EXPERIMENTAL SETUP

Observations.
Area of Tank, A $= 0.125 \ m^2$

Formulae:

Discharge Q $= \frac{AR}{t} \ m^3/s$

Where, R = Rise in water level in collecting tank. (In m)
t = time in seconds.

Velocity of flow, $V = \frac{Q}{a} \ m/s$

Cross sectional area of pipe $a = \frac{\pi d^2}{4} \ m^2$ where 'd' is inner diameter of pipe.

Loss of energy due to sudden expansion.

$h_L = \frac{(V_1 - V_2)^2}{2g}$ Where V_1 and V_2 are velocities of flow before and after expansion.

Experiment No. 02 **Date:**

MINOR LOSSES IN FLOW THROUGH PIPES

Aim: To determine various minor losses of energy in flow through pipes.

Theory:
When a fluid flows through a pipe, certain resistance is offered to the flowing fluid, which results in causing a loss of energy. The various energy losses in pipes may be classified as:

(i) Major losses.
(ii) Minor losses.

The minor losses of energy are those, which are caused on account of the change in the velocity of flowing fluid (either in magnitude or direction). In case of long pipes these losses are usually quite small as compared with the loss of energy due to friction and hence these are termed 'minor losses' which my even be neglected without serious error. However, in short pipes these losses may sometimes outweigh the friction loss. Some of the losses of energy that may be caused due to the change of velocity are indicated below

(a) Loss of energy due to sudden enlargement.

$$h = \frac{(V_1 - V_2)^2}{2g}$$

(b) Loss of energy due to sudden contraction

$$h = 0.375\frac{V^2}{2g}$$

(c) Loss of energy at 90^0 Elbow

$$h = 0.75\frac{V^2}{2g}$$

(d) Loss of energy at 90^0 Bend

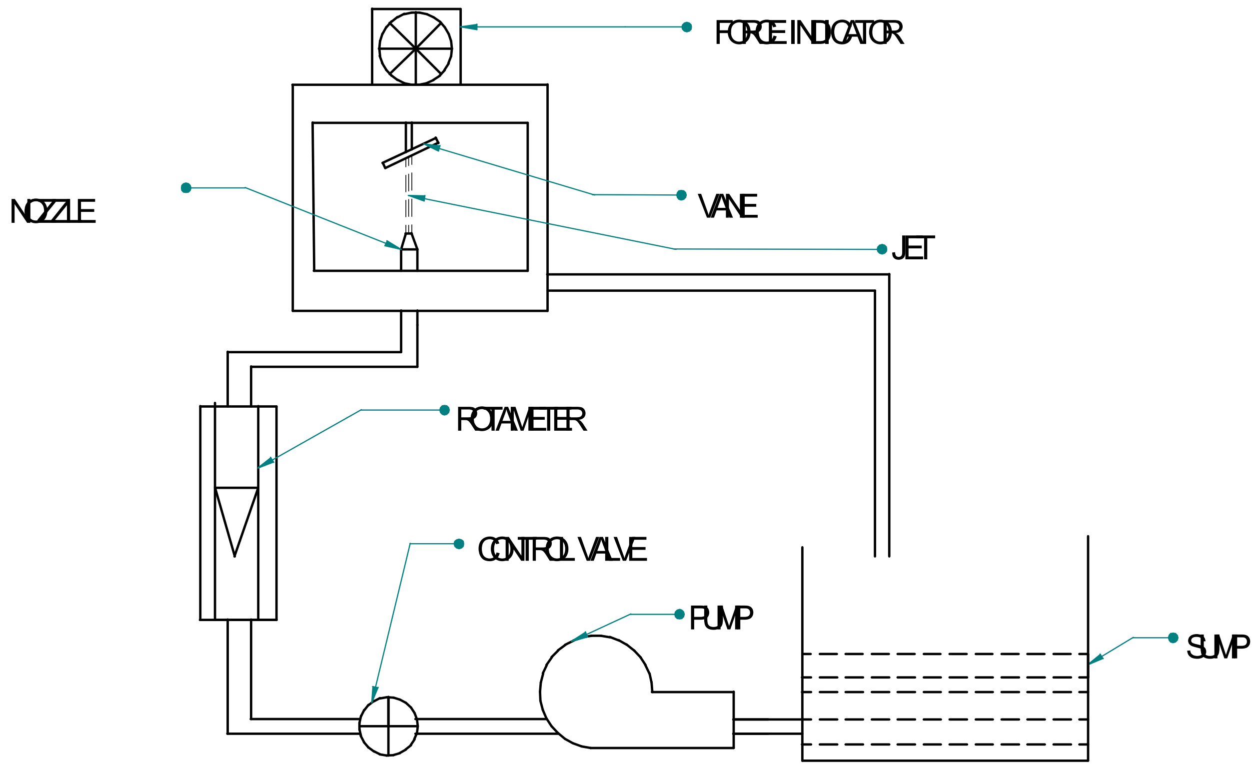
$$h = 0.45\frac{V^2}{2g}$$

Table of calculations:

Type	Difference in Mercury level			Rise of water in m	Time taken in sec	Discharge Q (m^3/s)	Velocity V (m/s)		Head loss(Δf)
	h_1	h_2	h= h_1-h_2 in m						

Procedure:

1. Switch on the pump and open the delivery valve.
2. Open the corresponding ball valve of pipe under consideration.
3. Keep the ball valves of other pipelines closed.
4. Note down the differential head readings in the manometer.(expel if any air is present by opening the drain cocks provided to the manometer).
5. Close the butterfly valve and note down the time taken for known water level rise.
6. Change the flow rate and take the corresponding reading



EXPERIMENTAL SETUP

Observations and Calculations:

Formulae:

Cross section area of jet $a = \frac{\pi d^2}{4}\ m^2$

Where, d is diameter of the jet in m.

Velocity of jet, V = Q/a m/s Where Q is discharge in m^3/s

Theoretical force,

$F_{the} = \rho a V^2$ N [flat plate]

$F_{the} = 2\rho a V^2$ N [Hemispherical plate]

$F_{the} = \rho a V^2 \sin^2\theta$ N [Inclined plate]

Actual force = F_{act} (observed in force indicator).

Co-efficient of impact, $k = \frac{F_{act}}{F_{the}}$

Experiment No. 03 **Date:**

IMPACT OF JET ON VANES

Aim: To determine the co-efficient of impact on vanes

Theory:

The liquid comes out in the form of a jet from the outlet of a nozzle, which is fitted to a pipe through which the liquid is flowing under pressure. If some plate, which may be fixed or moving, is placed in the path of the jet, the jet on the plate exerts a force. This force is obtained from Newton's second law of motion or from impulse momentum equation. Thus impact of jet means the force excited by the jet on a plate, which may be stationary or moving.

a) Force exerted by the jet on a stationary plate is when,
   i) Plate is vertical to jet   ii) plate is inclined to jet
   iii) Plate is curved.
b) Force exerted by the jet on a moving plate is when
   i) Plate is vertical to jet   ii) plate is inclined to jet.
   iii) Plate is curved.

Apparatus used:

1. Vanes (flat, inclined with $\theta = 30^0$ and hemispherical), experimental setup comprising rotameter, nozzles of different diameter, steady supply of water using pump.

Procedure:

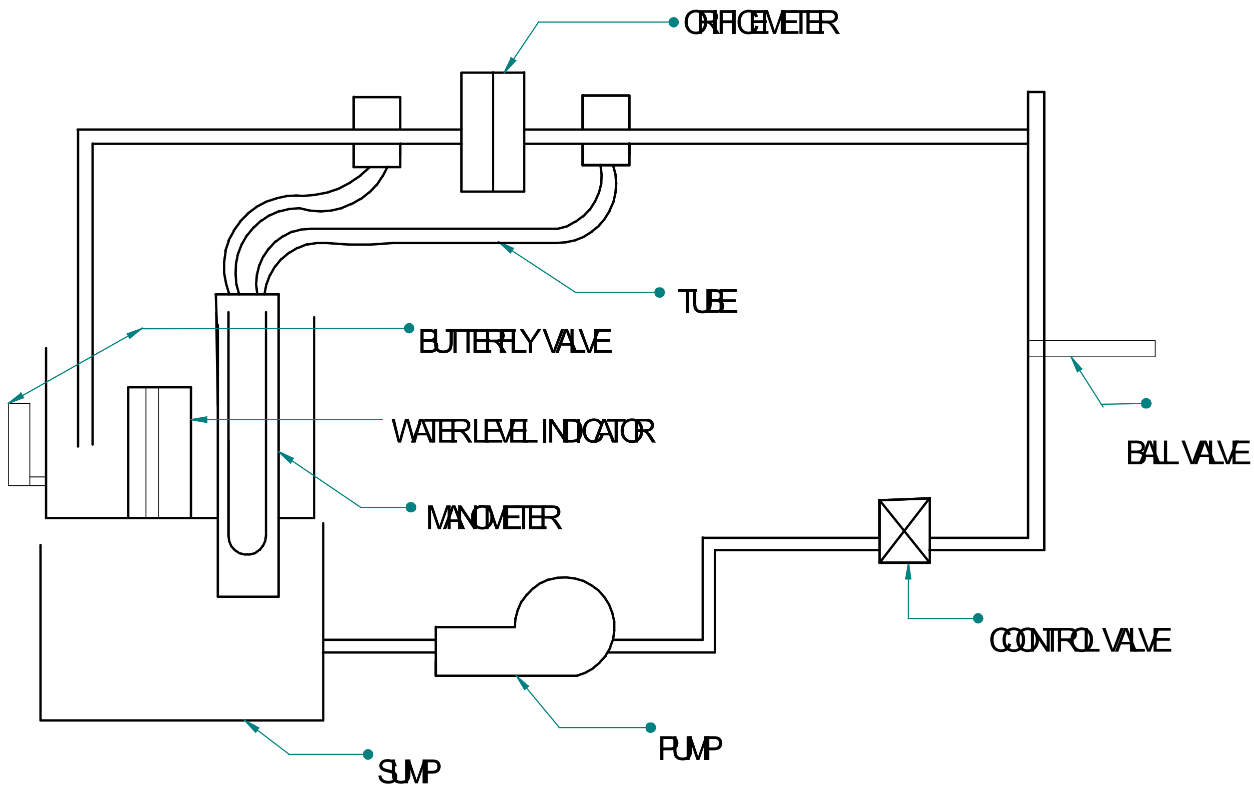
1. Fix the required diameter of nozzle and the vane of the required shape in position.
2. Bring the force indicator position to zero.
3. Keep the delivery valve closed and switch on the pump.
4. Close the front transparent glass tightly.
5. Open the delivery valve and adjust the flow rate.
6. Observe the force as indicated on the force indicator.
7. Note down the diameter of the pipe of the jet and shape of the vane and the discharge is calculated.

Table of readings:

Type of Vane	Dia of Jet, d (m)	Q	Force indicator F_{act}	
		m^3/s	kgf	N
Hemispherical				
Flat				
Inclined				

Table of calculations:

Type of vane	Dia of jet d(m)	F_{the}	$k = \frac{F_{act}}{F_{the}}$	Avg. k



EXPERIMENTAL SETUP

Observation and Calculation:

Internal diameter of pipe	$d_1 = 0.025$ m
Orifice diameter	$d_2 = 0.015$ ms
Area of Collecting Tank	$A = 0.0125\ m^2$

Formulae:

Cross sectional area of pipe, $a_1 = \frac{\pi d_1^2}{4}\ m^2$

Cross sectional area of orifice, $a_2 = \frac{\pi d_2^2}{4}\ m^2$

Actual discharge, $Q_{act} = \frac{AR}{t}\ m^3/s$ where R is rise in water level in collection tank (in m).

Theoretical discharge, $Q_{the} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}\ m^3/s$ where head, $h = x\left[\frac{S_{Hg}}{S_w} - 1\right]$ m of water.

x = Manometer reading in m of Hg

Experiment No. 04 Date:

ORIFICE METER

Aim: To determine the co-efficient of discharge through orifice meter.

Theory:

Orifice meter is a device used to measure discharge in a pipeline or a closed conduit. Orifice is a hole through which liquid is made to pass through. It works on Bernoulli's principle or venturi effect and continuity equation.

Orifice meter consists of a flat plate with a circular hole at the centre. The circular hole is called orifice. The edges of the orifice are bevelled. The orifice plate is fixed using flanges. The section of flow where the area is minimum is called venacontracta. At venacontracta the velocity is maximum.

Merits and Demerits of orifice meter over venturimeter.

- Orifice meter occupies less space than venturimeter.
- Simple in construction and hence cheaper than venturimeter.
- In case of orifice meter expansion and contraction are sudden and hence loss of energy is more.
- The co-efficient of discharge of venturimeter is high (about 0.9) where as that of orifice meter is low (about 0.6).

Apparatus used:

1. Orifice meter
2. Pump and motor for steady supply of water.
3. Clock to record the time
4. Measuring tank.

Procedure:

1. Fill the sump with clean water. Keep the delivery valve closed. Open the corresponding ball valve of the orifice meter pipeline.
2. Adjust the flow through the control valve of pump.
3. Open the corresponding ball valve fitted to orifice meter tank tapings.
4. Note down the difference head readings in manometer.
5. Operate the butterfly valve to note down the time taken for a known amount of rise in water level in collecting tank.
6. Change the flow rate and repeat the experiment.
7. Calculate co –efficient of discharge using relevant formula.

Graph to be plotted

Q_{act} Vs Q_{theo} and Compare the result

$$Q_{the} = k \times h^{\frac{1}{2}} \ m^3/s \text{(Where n = 1/2)}$$

$$k = \frac{a_1 a_2 \sqrt{2g}}{\sqrt{a_1^2 - a_2^2}}$$

Co – efficient of discharge, $C_d = \frac{Q_{act}}{Q_{the}}$

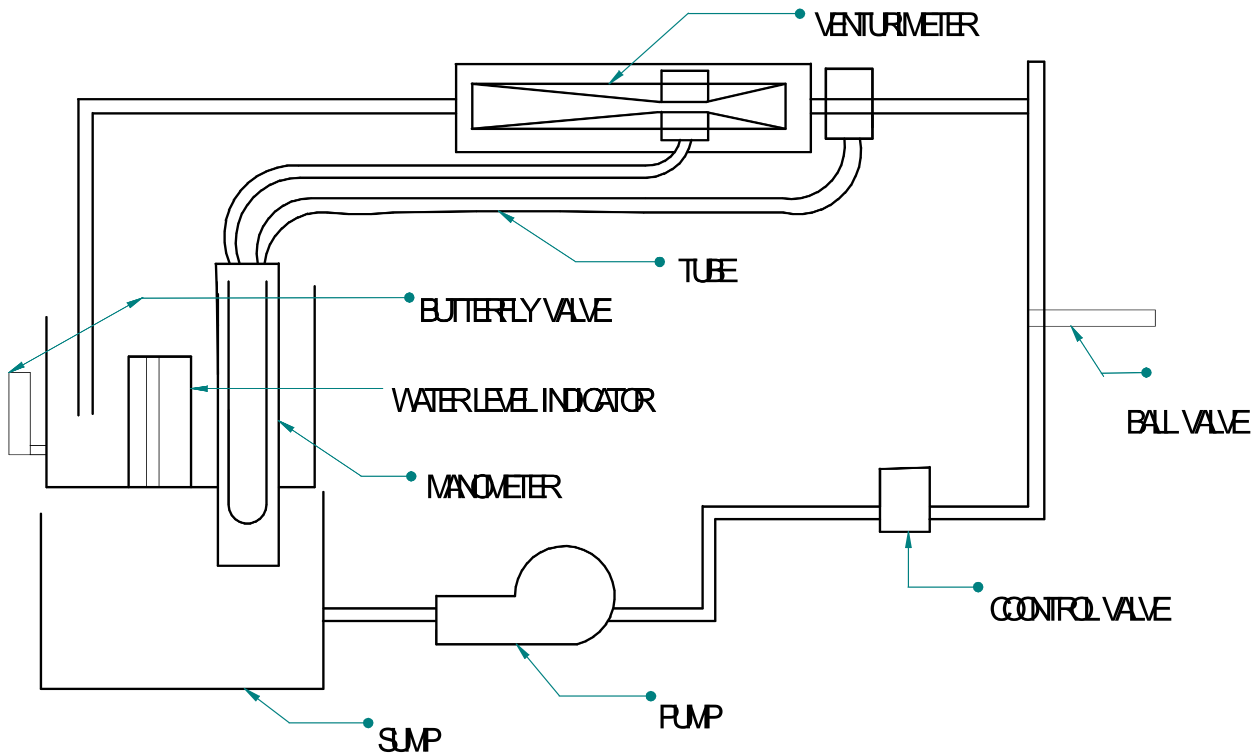
Table of readings:

Sl.No.	R (m)	t (s)	Manometer reading x		Water Head (h)m of water
			mm	m	

Table of calculations:

Sl.No.	Q_{act} (m^3/s)	Q_{the} (m^3/s)	$C_d = \frac{Q_{act}}{Q_{the}}$	Avg. C_d

Work Sheet



EXPERIMENTAL SETUP

Observation and Calculation:

Inlet diameter of venturimeter, $d_1 =$ m
Throat diameter of venturimeter, $d_2 =$ m
Area of Collecting Tank, $A =$ m^2

Formulae:

Cross sectional area of inlet, $a_1 = \frac{\pi d_1^2}{4}$ m^2

Cross sectional area of throat, $a_2 = \frac{\pi d_2^2}{4}$ m^2

Actual discharge $Q_{act} = \frac{AR}{t}$ m^3/s where R is rise in water level in collection tank (in m).

Theoretical discharge, $Q_{the} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3/s where head, $h = x\left[\frac{S_{Hg}}{S_w} - 1\right]$ m of water.

x = Manometer reading in m of Hg

Date:

Experiment No. 05

VENTURIMETER.

Aim: To determine the co-efficient of discharge through Venturimeter.

Theory:

Venturimeter is a device used to measure discharge of fluid in a closed conduit or pipeline. It consists of a convergent cone, throat and divergent cone. As the area of the flow decreases in the convergent cone, velocity of flow increases and pressure decreases. The measurement of pressure difference between the inlet section and throat section leads to the measurement of discharge. The angle of divergent cone will be 60^0 and that of convergent cone will be about 20^0. The length of the divergent cone will be more than the length of convergent cone. The diameter of the throat will be 0.5-0.6 times the diameter of the pipeline or the inlet section.

If a fluid is made to flow through a varying section due to the variation in pressure, there will be variation in velocity and this effect is known as venture effect.

Apparatus used:

1. Venturimeter
2. Pump and motor for steady supply of water.
3. Clock to record the time
4. Measuring tank.

Procedure:

1. Fill the sump with clean water. Keep the delivery valve closed. Open the ball valve of the venturimeter pipeline.
2. Adjust the flow through the control valve of pump.
3. Open the corresponding ball valve fitted to Venturi meter tank tappings.
4. Care should be taken, such that there should be not any air bubble, while the liquid is passing through the manometer.
5. The differential reading of the manometer is noted down from the level of Hg in two limbs.
6. Then the time required to collect 200 mm of water in the collecting tank is noted down.
7. Finally the procedure is employed for different discharge through the pipeline.

Graph to be plotted

Q_{act} Vs Q_{theo} and Compare the result

$$Q_{the} = k \times h^{\frac{1}{2}}\ m^3/s \text{(Where n = 1/2)}$$

$$k = \frac{a_1 a_2 \sqrt{2g}}{\sqrt{a_1^2 - a_2^2}}$$

Co – efficient of discharge, $C_d = \frac{Q_{act}}{Q_{the}}$

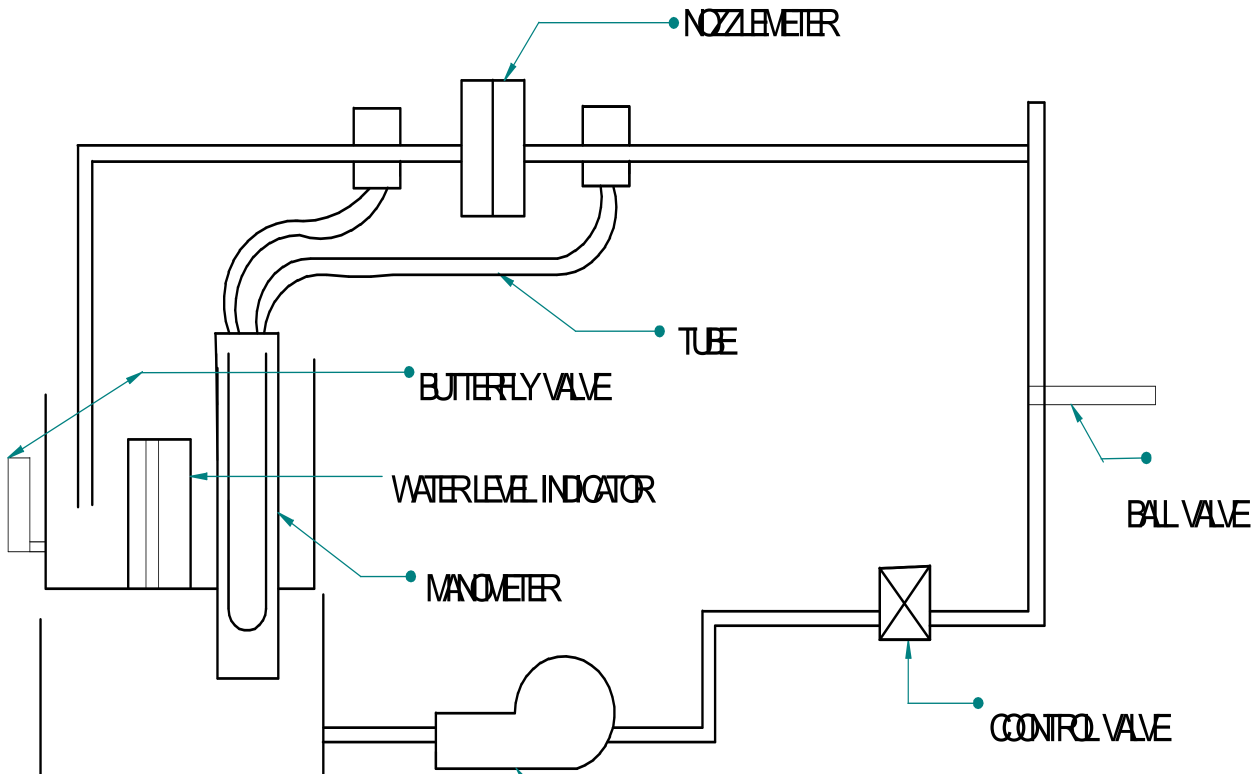
Table of readings:

Sl.No.	R(m)	t(s)	Manometer Reading (x)		Water Head (h)m of water
			mm of Hg	m of Hg	

Table of calculations:

Sl.No.	Q_{act} $\left(m^3/s\right)$	Q_{the} $\left(m^3/s\right)$	$C_d = \frac{Q_{act}}{Q_{the}}$	Avg. C_d

Work Sheet



Observation and Calculation:

Inlet diameter of Nozzle, $d_1 =$ m
Exit diameter of Nozzle, $d_2 =$ m
Area of Collecting Tank, A = m^2

Formulae:

Cross sectional area of inlet, $a_1 = \frac{\pi d_1^2}{4}$ m^2

Cross sectional area of exit, $a_2 = \frac{\pi d_2^2}{4}$ m^2

Actual discharge $Q_{act} = \frac{AR}{t}$ m^3/s where R = rise in water level in collection tank (in m).

Theoretical discharge, $Q_{the} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$ m^3/s where head, $h = x\left[\frac{S_{Hg}}{S_w} - 1\right]$ m of water.

x = Manometer reading in m of Hg

Date:

Experiment No. 06

FLOW NOZZLE APPARATUS.

Aim: To determine the co-efficient of discharge through a nozzle meter.

Theory:

Flow nozzle is a device used to measure discharge of fluid in a closed conduit or pipeline. It is mainly used for metering fluids flowing under high pressure thorough lines of minimum size due to some reason, another advantage of flow nozzle is that it requires smaller piping before & after the primary element as compared that of an orifice meter.

Apparatus used:

1. Nozzle meter
2. Pump and motor for steady supply of water.
3. Clock to record the time
4. Measuring tank.

Procedure:

1. Fill the sump with clean water. Keep the delivery valve closed. Open the ball valve of the venturimeter pipeline.
2. Adjust the flow through the control valve of pump.
3. Open the corresponding ball valve fitted to Venturimeter tank tappings.
4. Care should be taken, such that there should be not any air bubble, while the liquid is passing through the manometer.
5. The differential reading of the manometer is noted down from the level of Hg in two limbs.
6. Then the time required to collect 200 mm of water in the collecting tank is noted down.
7. Finally the procedure is employed for different discharge through the pipeline.

Graph to be plotted

Q_{act} Vs Q_{theo} and Compare the result

$Q_{the} = k \times h^{\frac{1}{2}}$ m^3/s(Where n = 1/2)

$$k = \frac{a_1 a_2 \sqrt{2g}}{\sqrt{a_1^2 - a_2^2}}$$

Co – efficient of discharge, $C_d = \frac{Q_{act}}{Q_{the}}$

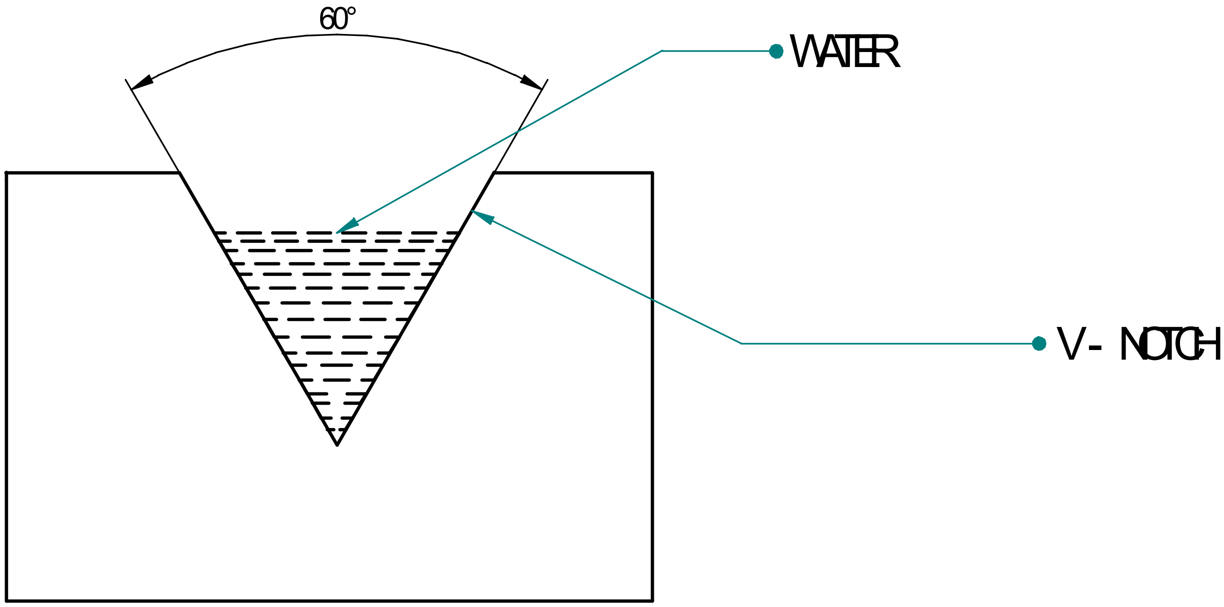
Table of readings:

Sl.No.	R(m)	t(s)	Manometer Reading (x)		Water Head (h) m of water
			mm of Hg	m of Hg	

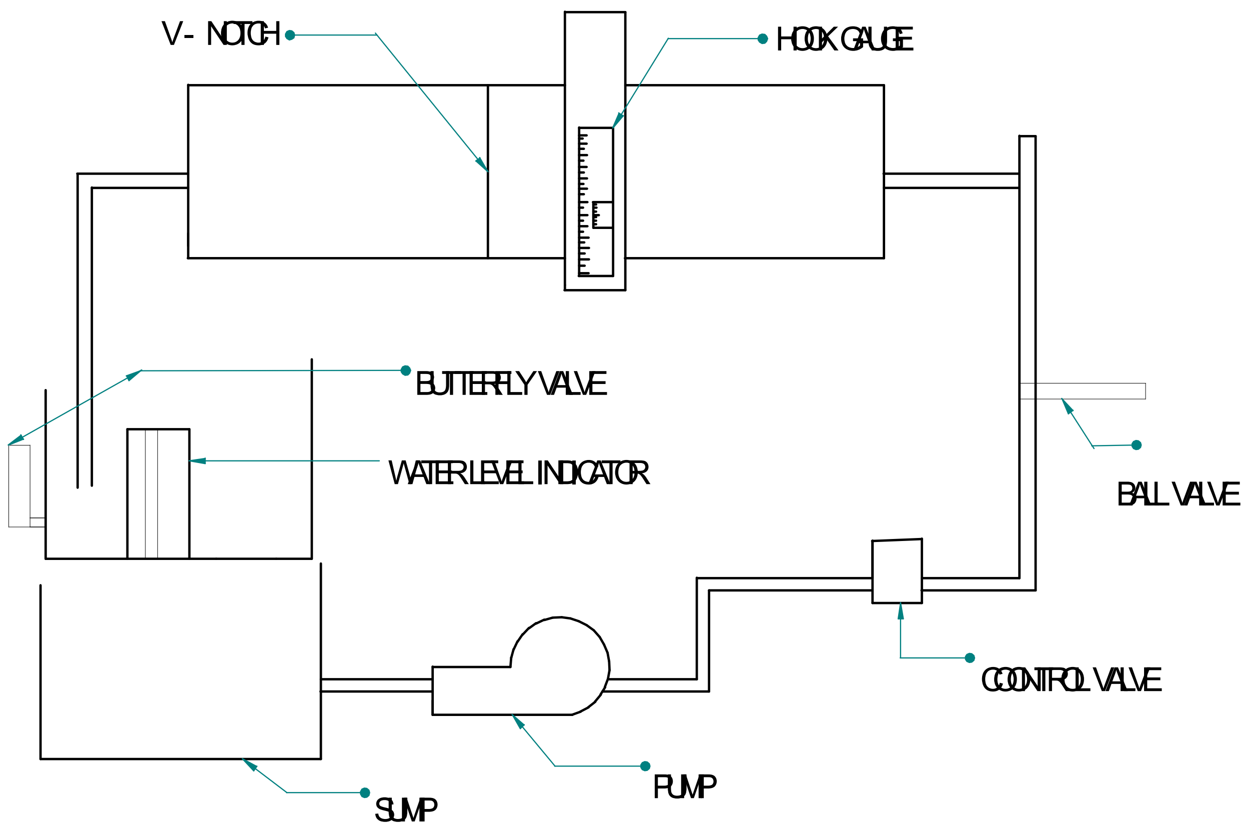
Table of calculations:

Sl.No.	Q_{act} $\left(m^3/s\right)$	Q_{the} $\left(m^3/s\right)$	$C_d = \frac{Q_{act}}{Q_{the}}$	Avg. C_d

Work Sheet



V- NOTCH



EXPERIMENTAL SETUP

Experiment No. 07 **Date:**

TRIANGULAR NOTCH

Aim: To Determine the Co-efficient of Discharge through triangular notch and to calibrate given triangular notch

Theory:

A notch is a device used for measuring the rate of flow of liquid through a small channel (or) a tank.

Applications:

a) For finding the discharge of flowing water.
b) Velocity of flowing water can be determined.

Advantages:

b) Easy to calculate discharge.
c) Can be used in wide channels too.

Disadvantages:

a) Ventilation for notch is necessary.
b) Less accurate results are obtained, while measuring discharge.

Co-efficient of discharge is defined as the ratio of the actual discharge to the theoretical discharge. It is denoted by C_d.

$$\text{i,e } C_d = \frac{Q_{act}}{Q_{the}}$$

Expressions for Q_{the} for triangular notch(V notch) is given as,

$$Q_{the} = \frac{8}{15} \tan\frac{\theta}{2} \sqrt{2g} \times H^{\frac{5}{2}}$$

Apparatus Required:

1 Approach channel with baffle plate fitted with notch,
2 A Surface level gauge to measure head over notch.
3 A measuring tank to measure flow rate.
4 A constant steady supply of water with using pump.

Procedure:

1. Fix the triangular notch at the end of the approach channel with sharp edge on the upstream side.
2. Fill the channel with water up to the crest level and adjust the hook gauge reading to zero.
3. Adjust the flow by control valve to give maximum possible discharge and wait until head over the sill of the notch. Note down the final hook gauge reading causing flow over the notch

.

Observations and Calculations:

Area of collecting tank (A) = m^2

Angle of V notch (θ) =

Formulae:

Actual discharge, $Q_{act} = \frac{AR}{t}\ m^3/s$

Where,

A = Area of collecting tank in metre.

R = Rise of water level in collecting tank in metre.

t = time in seconds.

Theoretical discharge, $Q_{the} = \frac{8}{15} \tan\frac{\theta}{2} \sqrt{2g} \times H^{\frac{5}{2}}\ m^3/s$

Where,

H = Head over notch in metre = FR - IR

Co – efficient of discharge, $C_d = \frac{Q_{act}}{Q_{the}}$

Graph to be plotted:

Q_{act} Vs Q_{theo} and Compare the result

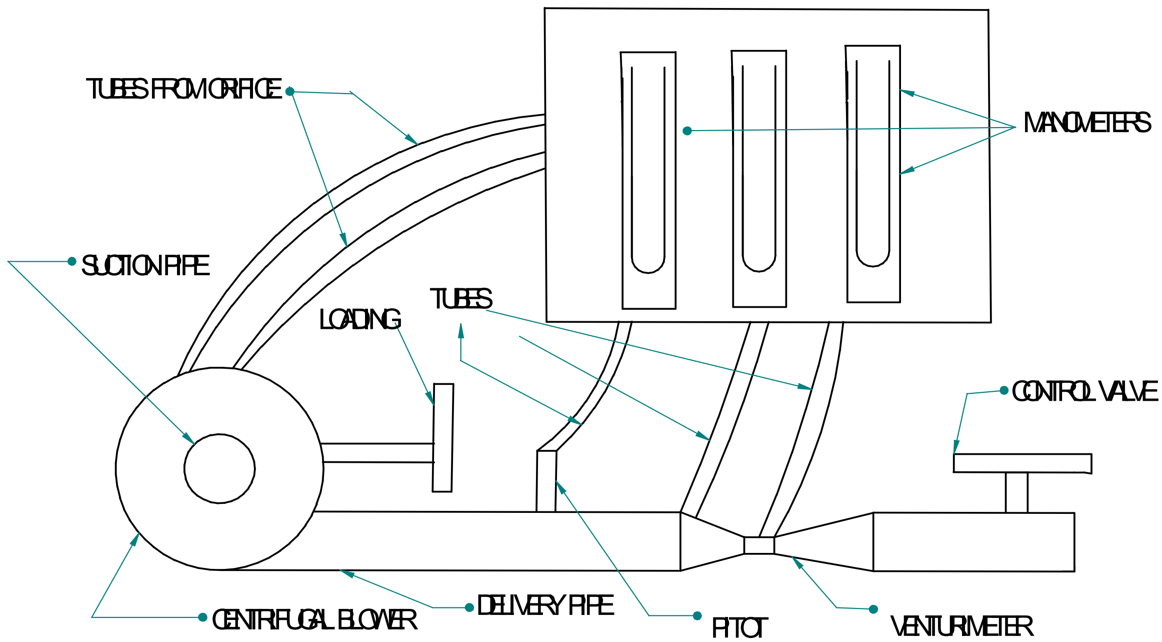
Table of Readings:

Sl.No.	Discharged water		Hook gauge reading				Head Over notch H (m)
	R (m)	t (s)	IR		FR		
			mm	m	mm	m	

4) Collect the water flowing over the notch in the measuring tank and measure the rise in water level ‘R’ in the tank for ‘t’ sec.
5) Lower the water level in approach channel in stages by varying the flow by control valve and record the series of readings.

Table of Calculations:

Sl.No.	Q_{act} $\left(m^3/s\right)$	Q_{the} $\left(m^3/s\right)$	$C_d = \frac{Q_{act}}{Q_{the}}$	Avg. C_d



CALCULATION

1 Discharge

Q = A x V m^3/s

Where V = average of anemometer Readings

C.S Area of the duct = $0.12m^2$

2. Input power of A/C Motor

$$Ip = \frac{n \times 60 \times 60}{k \times t}$$

where : n = no of energy meter impulses

k = energy meter constant

t= time taken for no of impulses in sec

k = 1200 imp / kw-hr

Date:

Experiment No. 8

CENTRIFUGAL AIR BLOWER TEST RIG

AIM: To study the performance of a centrifugal air blower at various operating conditions

INTRODUCTION:

The equipment has been designed as an experimental unit to study the performance characteristics of centrifugal Blower at various operating conditions. The test rig mainly consists of centrifugal blower handling air as the medium of flow and is driven by a foot mounted A.C. Motor. The test rig has provisions for varying the following parameters like discharge and impellers of the blower. Three interchangeable impellers (backward, forward, and straight) have also been supplied for studying the performances. These parameters have been used to draw the standard performance curves; covering the head Vs flow rate and Efficiency Vs flow rate at constant Speed.

PROCEDURE:

1. Connect the control panel input power cable to 3phase A.C.supply , with neutral and earth.
2. keep all the Switches /controls in Off position.
3. Switch On the mains and observe the 3ph light indicators glow.
4. Turn the rotary switch clock wise to put on the panel meters.
5. Ascertain sufficient measuring fluid (water) in manometers & the direction of rotation of the blower as indicated on the casing.
6. Keep the outlet butterfly valve fully open.
7. Switch on the starter so that the motor speed builds up to the rated rpm.
8. Keep the pitot tube half way above the center of the duct.
9. Record all the readings indicated by manometer, energy meter (Time for 10 impulses) at valve full open position.
10. Change the valve to 60^0 position and record the all readings.
11. Similarly record the readings on 30^0 and fully closed positions.
12. Tabulate all the readings and calculate.
13. Repeat the experiment on different impellers
14. After the experiment switch off the motor and electrical mains.

3. Output power of blower Op

$$(Op)_{Blower} = \frac{Wa \ x \ Q \ x \ H}{1000}$$

$Wa = 12.65 N/m^3$

$\rho_a = 1.29 kg/m^3$

$$\Delta H = hw\left[\frac{\rho w}{\rho a} - 1\right] \ \text{m}$$

where hw = Δ H x 768.2 m

H = hw x pitot constant where pitot const. = 5

4. Blower Efficiency

$$\eta_{Blower} = 100 \times \frac{Op_{Blowe}}{Ip_{Blower(Ele)}}$$

TABULAR COLUMN OBSERVATION

Sl. No.	Speed of Blower RPM	Time for 10 impulse in Sec	Pitot		h_w in m	Gate Opening
			h_1	h_2		

Gate opening	Discharge	Input power of AC Motor	Blower output power	Blower Efficiency

OBSERVATIONS AND CALCULATIONS:

1. $Qact = \frac{A \, X \, h}{t}$

2. Cross section area of collecting tank =___ m^2

TABULAR COLUMN:

Sl No	Head		Time Taken For5 Cm Rise	Piezometer (static head) in mm											Qact m^3/s
	Tank 1	Tank 2		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	
1.															
2.															
3.															

TABULAR COLUMN:

Diameter of test section	Area of test section m^2	Velocity of flow for different cross sections V = Q/A (m/s)	Velocity Head $V_h = V^2/2g$ (m)	Total Head E = Ph + Vh
D_1 = 25 mm	A_1	V_1		
D_2 = 22.7 mm	A_2	V_2		
D_3 = 20.4 mm	A_3	V_3		
D_4 = 18.4 mm	A_4	V_4		
D_5 = 15.8 mm	A_5	V_5		
D_6 = 13.5 mm	A_6	V_6		
D_7 = 15.8 mm	A_7	V_7		
D_8 = 18.4 mm	A_8	V_8		
D_9 = 20.4 mm	A_9	V_9		
D_{10} = 22.7 mm	A_{10}	V_{10}		
D_{11} = 25 mm	A_{11}	V_{11}		

Date:

Experiment No. 9

APPLICATION OF BERNOULLIS EQUATION

AIM: To verify Bernoulli's Theorem

APPARATUS: Bernoulli's experimental set up, stop clock

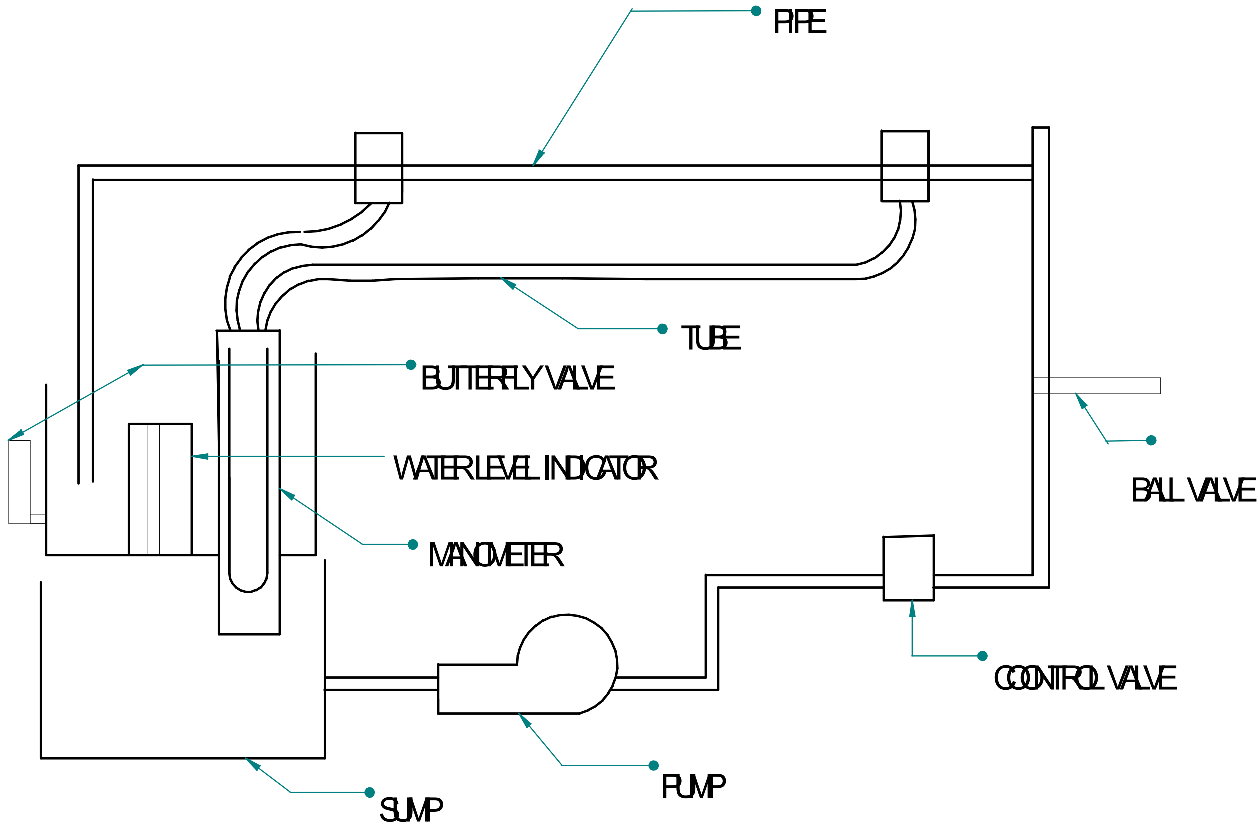
THEORY: The Bernoulli's theorem states that for a perfect incompressible liquid flowing in pipe line the total energy of a particle remains constant while the particle moves from one point to another, assuming that there are no frictional losses in the pipe line. Mathematically Bernoulli's theorem states,

$$Z + \frac{V^2}{2g} + \frac{P}{W} = \text{Constant}$$

PROCEDURE:

1. Switch on the pump.
2. Partially close the "by pass" valve, water flows into the supply tank.
3. As the water level rises in the supply tank water starts flowing into the reservoir tank throughthe venture test section and the water level in the receiving tank also rises.
4. When the water level in both the tank reaches their respective over flow level, control the "bypass" valve.
5. Allow the water flow to become steady.
6. Record the readings of peizometer and the flow rate from the receiving tank against time byclosing the outlet valve of measuring tank for 5cm rise of water level.
7. Repeat the experiment for different discharge.
8. Tabulate all the readings and calculate to verify Bernoulli's theorem.

RESULT:



EXPERIMENTAL SETUP

Observations and Calculations:

Area of Tank = m^2
Length of pipe,L = m

Formulae:

Discharge Q = $\frac{AR}{t}\ m^3/s$

Where, R = Rise in water level in collecting tank. (In m)
t = time in seconds.

Velocity of flow, V = $\frac{Q}{a}\ m/s$

Q = Discharge in m^3/s

Cross sectional area of pipe a = $\frac{\pi d^2}{4}\ m^2$ where'd' is inner diameter of pipe in m.

Date:

Experiment No. 10

REYNOLDS NUMBER

Aim: To determine the Reynolds Number in flow through pipes of various sizes using U-shaped manometer.

Theory:

The purpose of this experiment is to illustrate the influence of Reynolds number on pipe flows. Reynolds number is a very useful dimensionless quantity (the ratio of dynamic forces to viscous forces) that aids in classifying certain flows. For incompressible flow in a pipe Reynolds number based on the pipe diameter, Generally, laminar flows correspond to ReD < 2100, transitional flows occur in the range 2100 < ReD < 4000, and turbulent flows exist for ReD > 4000. Critical Reynolds number is 4000. However, disturbances in the flow from various sources may cause the flow to deviate from this pattern. This experiment will illustrate laminar, transitional, and turbulent flows in a pipe.

Procedure:

1. Switch on the pump and open the delivery valve.
2. Open the corresponding ball valve of pipe under consideration.
3. Keep the ball valve of other pipeline closed.
4. Note down the differential head readings in the manometer. (Expel if any air is present by opening the drain cocks provided to the manometer).
5. Close the butterfly valve and note down the time taken for known water level rise.
6. Change the flow rate and take the corresponding reading
7. Calculate the Reynolds Numbers using the formula
8. $R_e = \frac{\rho V d}{\mu}$

Where ρ =1000kg/m^3, μ =Absolute viscosity=0.55x10^{-3} Nm/sec^2

9. Repeat the experiment for different diameter of pipelines.

Table of calculations:

Type	Difference in Mercury level			Rise of water in m	Time taken in sec	Discharge Q (m^3/s)	Velocity V (m/s)	Reynolds Number (R_e)
	h_1	h_2	$H = h_1 - h_2$ in m					

Work Sheet

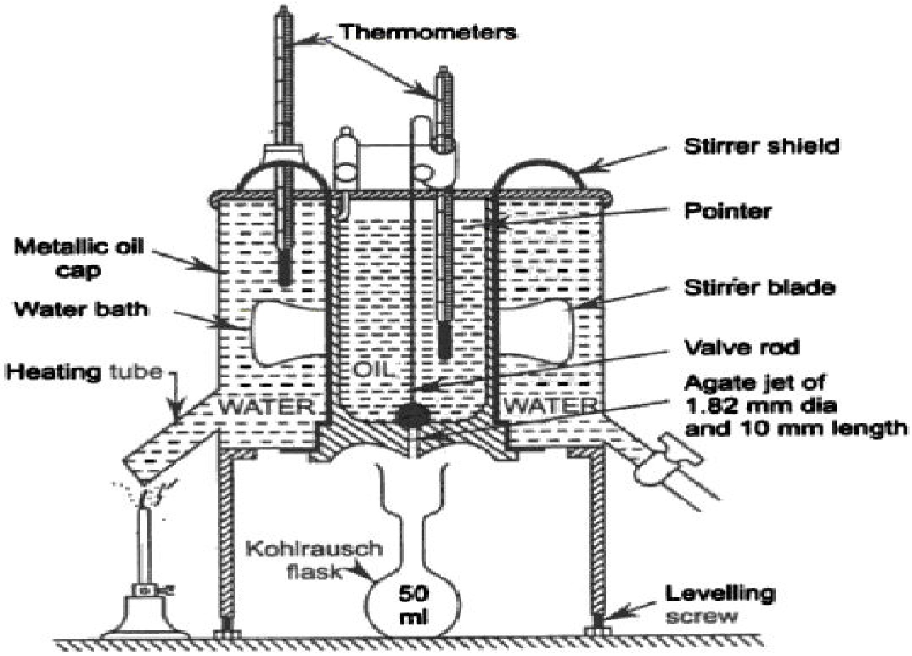


Figure: Experimental Setup

OBSERVATION:

Type of oil used:

TABULAR COLOUMN:

Sl. No.	Temperature of oil in ^0C	Time for collecting 50 ml.of oil in t (sec)
1.		
2.		
3.		

Experiment No 11

REDWOOD VISCOMETER

AIM:

To determine the viscosity of the given oil using redwood viscometer at different temperatures. Expressed in terms of Redwood seconds

APPARATUS:

Redwood Viscometer, 50ml Receiving flask, thermometers and stopwatch

DESCRIPTION OF THE APPARATUS:

Redwood viscometer Consists of a cylindrical oil cup furnished with a gauge point, agate / metallic Orifice jet at the bottom having a concave depression from inside to facilitate a ball with stiff wire to act as a valve to start or stop oil flow. The outer side of the orifice jet is convexed, so that the oil under test does not creep over the lower face of the oil cup. The oil cup is surrounded by a water bath with a circular electrical immersion heater and a stirring device. Two thermometers are provided to measure water bath temp. & oil temperature under test. A round flat-bottomed flask of 50ml marking, to measure 50 ml of oil flow against time. The water bath with oil cup is supported on a tripod stand with leveling screws.

PROCEDURE:

1) Clean the oil cup with a solvent preferably C.T.C (Carbon Tetra chloride) and wipe it dry thoroughly with a paper napkins or a soft cloth (do not use cotton waste) and the orifice jet with a fine thread.
2) Keep the water bath with oil cup on the tripod stand and level it.
3) Pour water into the water bath up to 15 to 20mm below the top portion
4) Keep the ball (valve) in position and pour clean filtered oil sample (use strainer not coarser than BS 100 mesh) to be tested into the oil cup up to the gauge point and cover it with the lid.
5) Take a clean dry 50ml flask and place it under the orifice jet of the oil cup and center it.
6) Lift the ball (valve) and simultaneously start a stop watch and allow the oil into the receiving flask.
7) Adjust the receiving flask (50ml) in such a way that the oil string coming out of the jet strikes the neck of the flask to avoid foaming (formation of air bubbles) on the oil surface.
8) Wait till the oil level touches the 50 ml mark stop the watch and record the time in sec.
9) Repeat the experiment at different temperatures above ambient.

CALCULATION

$$V = A.t - \frac{B}{t} \quad \text{in} \quad m^2 / s$$

Where V= Kinematic viscocity of the oil in m^2 / s
t= Time for filling of 50ml of sample oil in sec.

Commonly used values of A & B for Viscometers are:

Viscometer	A X 10^6	B X 10^6
Redwood	0.26	172
Saybolt	0.24	190

GRAPH:

Plot the graph of temperature verses Kinematic viscocity

CONCLUSION:

Work Sheet

EXPERIMENTAL SETUP

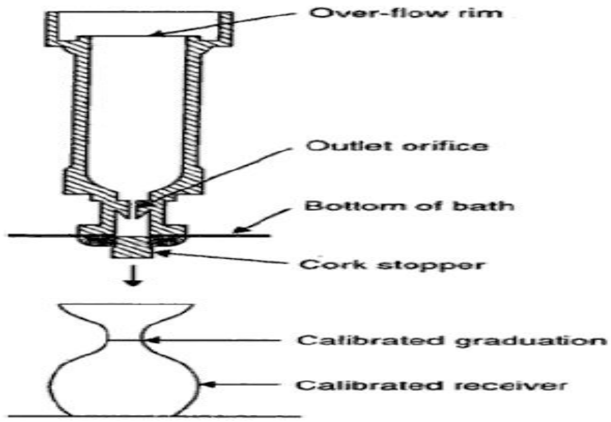


Figure: Saybolt Viscometer

OBSERVATION:

Type of oil used:

TABULAR COLUMN:

Sl. No.	Temperature of oil in ^0C	Time for collecting 60 ml.of oil in t (sec)
1.		
2.		
3.		

Experiment No 12

SAYBOLT VISCOMETER

AIM:

To determine viscosity of the given oil using Say Bolt Viscometer at different temperatures expressed in terms of Saybolt seconds.

APPARATUS:

Say Bolt Viscometer, 60ml receiving flask, thermometers & stopwatch.

DISCRIPTION:

The apparatus mainly consists of a standard cylindrical oil cup surrounded with a water bath with an immersion heater and a stirring device. The apparatus is supplied with two S.S. Orifice jets namely Universal jet & Furol jet, which can be fitted at the bottom of the oil cup as per our requirement. A rubber cork stopper arrangement is provided also at the bottom to facilitate start and stop the oil flow from the Viscometer. Two thermometers are provided to measure water bath temperature and oil temperature under test. A round flat-bottomed flask with a 60-ml marking on the neck is provided to measure 60 ml of oil flow against time. The oil cup with the water bath is supported on a stand with levelly screws.

PROCEDURE:

1) Clean the oil cup with a solvent preferably C.T.C (Carbon Tetra chloride) and wipe it dry thoroughly with a paper napkins or a soft cloth (do not use cotton waste) and the orifice jet with a fine thread.
2) Keep the water bath with oil cup on the tripod stand and level it.
3) Pour water into the water bath up to 15 to 20mm below the top portion.
4) Close the Orifice opening from bottom with the rubber cork provided. Pour oil to be tested into the strainer by keeping the strainer on the oil cup until the oil fills up in the oil cup as well as in side well. Withdraw the excess oil in the side well and position the thermometers in water bath and oil cup.
5) Take a clean dry 60ml flask and place it under the orifice jet of the oil cup and center it.
6) Pull the rubber cork open and simultaneously start a stopwatch and allow the oil into the receiving flask.
7) Adjust the receiving flask (60ml) in such a way that the oil string coming out of the jet strikes the neck of the flask to avoid foaming (formation of air bubbles) on the oil surface.
8) Wait till the oil level touches the 60 ml mark, stop the watch and record the time in sec.
9) Repeat the experiment at different temperatures above ambient.

CALCULATION

$$V = At - \frac{B}{t} \quad \text{in } m^2 / s$$

Where V= Kinematic viscocity of the oil in m^2 / s
t= Time for filling of 60 ml of sample oil in sec.

Commonly used values of A & B for Viscometers are:

Viscometer	A X 10^6	B X 10^6
Redwood	0.26	172
Saybolt	0.24	190

GRAPH:

Plot the graph of temperature verses Kinematic viscocity

CONCLUSION:

Work Sheet

VIVA QUESTIONS

1. Define density?
   It is defined as the ratio of mass per unit volume of the fluid.

2. Define viscosity?
   It is defined as the property of fluid which offers resistance to the movement of fluid over
   another adjacent layer of the fluid.

3. Differentiate between real fluids and ideal fluids?
   A fluid, which is incompressible and is having no viscosity, is known as ideal fluid while the fluid, which possesses viscosity, is known as real fluid.

4. What is a venturimeter?
   It is a device which is used for measuring the rate of flow of fluid flowing through pipe.

5. What is a notch?
   A notch is a device used for measuring the rate of flow of a fluid through a small channel or a tank.

6. Define buoyancy?
   When a body is immersed in a fuid, an upward force is exerted by the fluid on the body.This upward force is equal to the weight of the fluid displaced by the body.

7. Define meta-centre?
   It is defined as the point about which a body starts oscillating when the body is tilted by a small angle.

8. Define a pump?
   The hydraulic machine which converts the mechanical energy into hydraulic energy is called a pump.

9. Define centrifugal pump?
   The pump which converts the mechanical energy in to hydraulic energy, by means of centrifugal force acting on the fluid is known as centrifugal pump.

10. Define reciprocating pump?
    The pump which converts the mechanical energy in to hydraulic energy by sucking the liquid in to a cylinder in which a piston is reciprocating ,which exerts the thrust on the liquid and increases its hydraulic energy is known as reciprocating pump.

11. What is impact of jet means?
    It means the force exerted by the jet on a plate which may be stationary or moving.

12. What is a turbine?
    A turbine is a hydraulic machine which converts hydraulic energy in to mechanical energy.

13. What is tangential flow turbine?
    If the water flows along the tangent of the runner, the turbine is know as tangential flow turbine.

14. What is radial flow turbine?
    If the water flows in the radial direction through the runner, the turbine is called radial flow turbine.

15. State Newton's law of viscosity?
    It states that the shear stress on a fluid element layer is directly proportional to the rate of shear strain.

16. What are the devices used for pressure measurement?
    The devices used are manometers, diaphragm pressure gauge, dead weight pressure gauge etc

17. Why blower is used?
    Blower is used to discharge higher volume of air at low pressure.

18. State continuity equation?
    For a fluid flowing through a pipe at all the cross section, the quantity of fluid per second is constant.

19. What are the methods of describing fluid motion?
    The fluid motion is described by two methods. They are lagrangian method and eulerian method.

20. Where the notches are used?
    Notches are usually used in tanks or small channels.

21. What is a weir?
    Weir is a concrete structure placed in an open channel over which the flow occurs.

22. What do you understand by the term major loss in pipes?
    When a fluid is flowing through a pipe, some of the energy is lost due to friction, this is termed as major loss.

23. What do you understand by the term minor loss in pipes?
    When a fluid is flowing through a pipe, some of the energy is lost due to sudden expansion of pipe, sudden contraction, bend and pipe fitting, these are termed as minor loss.

24. Define the term hydraulic gradient?
    It is defined as the line which gives the sum of pressure head and datum head of a flowing fluid in a pipe with respect to some reference line.

25. Define the term total energy line?
    It is defined as the line which gives the sum of pressure head, datum head and kinetic head of a flowing fluid in a pipe with respect to some reference line.

26. What is a draft tube?
    It is a pipe of gradually increasing area which connects the outlet of the runner to the tail race. It is used for discharging water from the exit of the turbine to the tail race.

27. Define co-efficient of velocity of jet.
    It is defined as the ratio between the actual velocity of a jet of liquid at vena-contracta and the theoretical velocity of jet.

28. Define co-efficient of contraction of orifice meter.
    It is defined as the ratio of the area of the jet at vena-contracta to the area of the orifice.

29. Define co-efficient of discharge of orifice meter.
    It is defined as the ratio of the actual discharge from an orifice to the theoretical discharge from the orifice.

30. What is vena-contracta?
    It is a section at which the stream lines are straight and parallel to each other and perpendicular to the plane of the orifice.

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