राज्य अभियांत्रिकी एवं प्रौद्योगिकी संस्थान, नीलोखेड़ी

State Institute of Engineering & Technology, Nilokheri

(Formerly Govt. Engineering College)

LABORATORY MANUAL

FLUID MECHANICS AND FLUID MACHINES LAB

MEC-210LA

Department of Mechanical Engineering

STATE INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Affiliated to K.U. University)

NILOKHERI – 132117, KARNAL

Experiment- 1

AIM : To verify the Bernoulli's equation.

Equipment: Inlet supply tank with overflow arrangement, oulet supply tank with means of varying flow rate, Perspex duct of varying cross section and a series of piezometric tubes installed along its length.

Introduction and Theory:

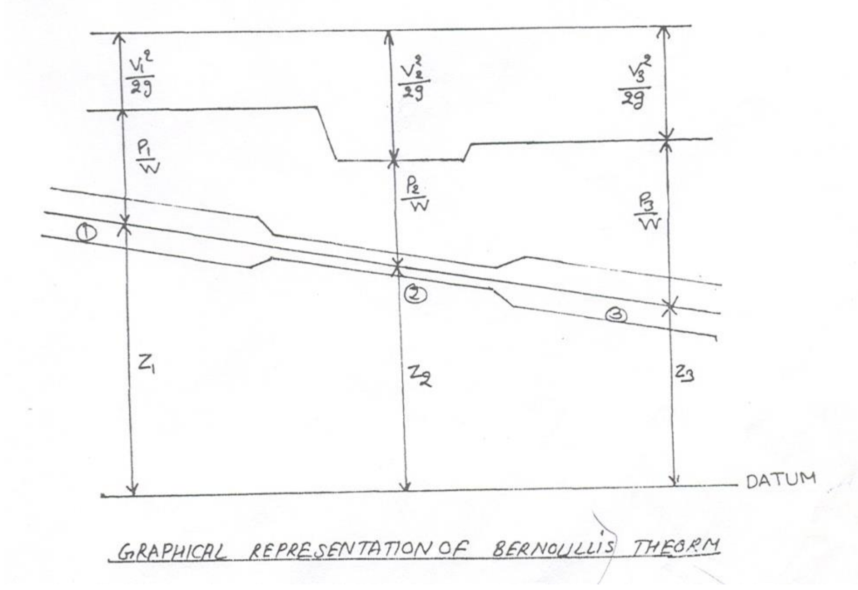
Considering friction less flow along a variable area duct, the law of conservation of energy states "for an inviscid, incompressible, irrotational and steady flow along a streamline, the total energy (or head) remains the same". This is called Bernoulli's equation.

$p/w + z + v^2/2g = \text{constant}$

The total head of following fluid consists of pressure head, velocity head and elevation head. Where p, V and z refer to the pressure, velocity and position of the duct relative to some datum at any section.

Experiment Setup:

The experimental setup consist up consist of a horizontal duct of smooth variable cross section of convergent and divergent type. The section id 40 mm x 40 mm at the entrance and exit and 40 mm and 20 mm at middle. The total length of duct is 90 cm. The piezometric pressure tubes installed at an equal distance of 7.5 cm along the length of conduit, the duct is connected with supply tanks at its entrance and exit end with flow rate. A collection tank is used to find the actual discharge.



Experimental Procedure:

1. Note down the piezometer distance from inlet section of the Perspex duct.
2. Note down the cross section area of Perspex duct at each of the piezometer tapping points.
3. The datum head is treated as constant through out the duct.
4. By maintaining suitable amount of steady head or nearby steady head condition in the supply tanks, three establishes a steady non-uniform flow in the conduit.
5. The discharge flowing in the conduit is recorded together with the water levels in each piezometer tubes.
6. This procedure is repeated for other value of discharge.

Observations and computations sheet:

Time (sec) =

Discharge (cm^3/sec) =

Tube No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Distance from inlet section (cm)											
Area of cross section of duct (cm^2)											
Velocity of flow (cm/sec) v=Q/A											
Velocity head $V^2/2g$ (cm)											
Pressure head p/w+z											
Total had $p/w+z+V^2/3g$ (cm)											

Comment: Since the duct is horizontal, the total energy at any section with reference to the datum line of conduct is sum of p/w and $V^2/2g$, where w is weight density of fluid and g is acceleration due to gravity.

Precaution:

1. Apparatus should be in leveled condition.
2. Reading must be taken in steady or nearby steady conditions and it should be noted that water level in the inlet supply tank should reach the overflow conditions.
3. There should not be any air bubble in the piezometers and in the Perspex duct.
4. By closing the regulation valve open the control valve slightly such that the water level in the inlet supply tank reaches the overflow conditions. At this state check that pressure head in each piezometeric tube is equal. If not adjust the piezometers to bring it equal.

Experiment- 2

AIM: To determine co-efficient of discharge of an orifice meter.

Equipment: Orificemeter fitted in a horizontal pipeline with means of varying flow rate, U tube differential manometer.

Introduction and theory:

The orifcemeter are devices used for measurement of rate of flow of fluid through a pipe. The basis principle, on which orificemeter work is that by reducing the cross sectional area of passage, a pressure difference is created and the measurement of the pressure difference enable the determination of the discharge through the pipe.

An orificemeter is a cheaper arrangement for measurement of discharge through pipe and its installation required a smaller length as compared with venturimeter. An orificemeter consists of a flat circular plate with a circular hole called orifice, which is concentric with the pipe axis. The upstream face of the plate is beveled at an angle lying between 30 and 45. The plate is clamped between the two pipe flanges with beveled surface facing downstream.

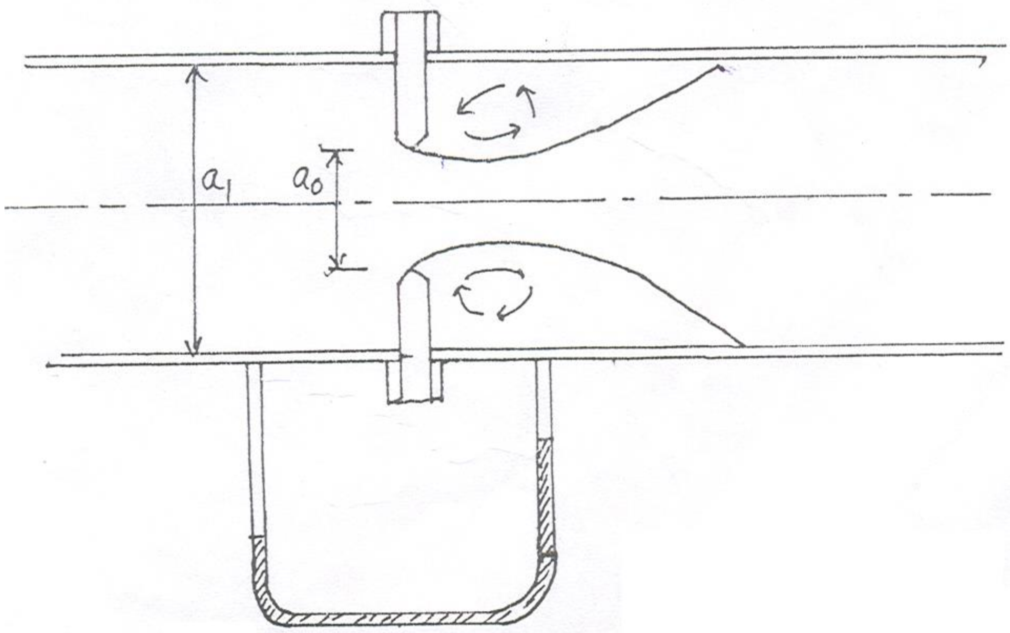
Two pressure type is provided one on the upstream side of plate and other on the downstream side of the orifice plate. A pressure difference exists between two sections, which can be measured by connecting a different manometer to the two pressure tape. The discharge coefficient can be calculated using following formula.

$Q = (C_d a_0 \sqrt{2g\Delta h}\, a_1)/ \sqrt{(a_1^2 - a_0^2)}$

Where C_d is coefficient of orifice, a_0 is cross sectional area of orifice, a_1 is cross sectional area of pipe, g is the acceleration due to gravity and Δh is the difference of head in terms of water.

Experimental setup:

The experimental setup consists of a circuit through which the fluid is circulated continuously having a orificemeter of 25 mm dia and having a d/D = 0.6. the orificemeter has two pressure tapings at upstream and downstream. A U tube mercury manometer with common manifold gives the pressure difference between two sections. A collecting tank is provided to find the actual discharge through the circuit.



Experimental Procedure:

1. Note down the relevant dimension as diameter of pipeline, dia of orifice, area of collection tank, room temperature etc.
2. Pressure tapping of orificemeter is kept open.
3. The flow rate is adjusted to its maximum value.
4. By maintaining suitable amount of steady flow in the pipe circuit, there establishes a steady no uniform flow in the conduit. Time is allowed to stabilize the levels in the manometer tube.
5. The discharge flowing in the circuit is recorded together with the water levels in left and right limbs of manometer tube.
6. The flow rate is reduces in steady by means of flow control value and the discharge & reading of manometer are recorded.
7. This procedure is repeated by closing the pressure tapping of orificemeter.

Observation and Computation Sheet:

Diameter of main pipe line, D =

The ratio d/D =

Area of cross section of orifice (a_0) =

Area of cross section of inlet section (a_1) =

Area of collecting tank =

S. No.	Discharge measurement				Manometer Reading			cd
	Initial (cm)	**Final (cm)**	**Time (sec)**	**Discharge (cm^3/sec) Q**	**Rise in left h_1(cm)**	**Rise in right limb h_2 (cm)**	**Δh in terms of water head = $12.6x(h_1-h_2)$**	
1								
2								
3								
4								

Average Cd =

Graph to Plot: Plot a graph between Q vs Δh on a log-log graph paper.

Experiment- 3

AIM: To determine the co-efficient of discharge of Venturimeter.

Equipment: Venturimeter fitted in a horizontal pipeline with means of varying flow rate, U tube differential manometer.

Introduction and theory:

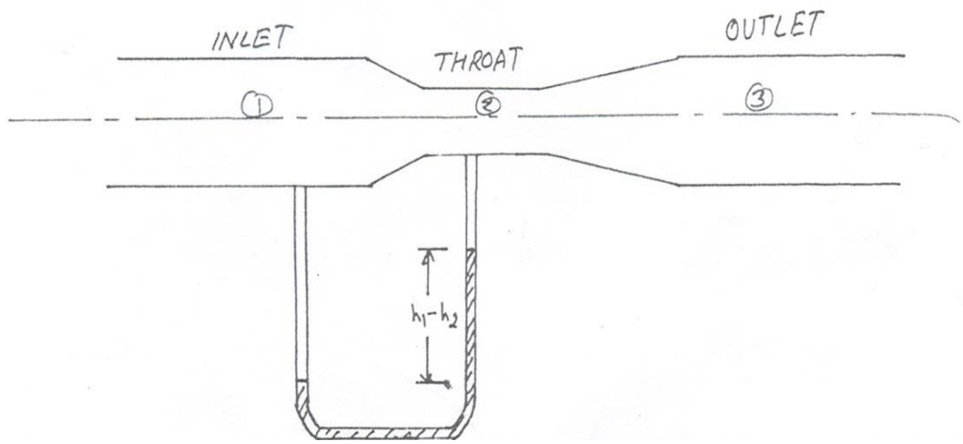
The venturimeter are devices used for measurement of rate of flow of fluid through a pipe. The basis principle, on which venturimeter work is that by reducing the cross sectional area of passage, a pressure difference is created and the measurement of the pressure difference enable the determination of the discharge through the pipe.

A venturimeter consists of (1) an inlet section followed by a convergent cone, (2) a cylindrical throat and (3) a gradually divergent cone. Since the cross sectional area of the inlet section, the velocity of flow at the throat will become greater than that at the inlet section, according to continuity equation. The increase in the velocity of flow at the throat result in the decrase in the pressure at this section. A pressure tapes provided at these sections. The measurement of pressure difference between these sections enables the rate of flow of liquid (Q) to be calculated as where a is the area of cross section of inlet section, g is acceleration due to the gravity, h is the difference of head and C_d is the coefficient of discharge of Venturimeter.

$C_d = Q\sqrt{(a_1^2 - a_0^2)} / a_0 a_1 \sqrt{(2g\ \Delta h)}$

Experimental setup:

The experimental setup consists of a circuit through which the fluid is circulated continuously having a venturimeter of 25 mm dia and having a d/D = 0.6. The venturimeter is provided with two tappings at upstream and at the throat section. A U tube mercury manometer with common manifold is provided to measure the pressure difference between two sections. A collecting tank is provided to find the actual discharge through the circuit.



Experimental Procedure:

1. Note down the relevant dimension as diameter of pipeline, throat dia of venturimeter, area of collection tank, room temperature etc.
2. Pressure tapping of venturimeter is kept open.
3. The flow rate is adjusted to its maximum value.
4. By maintaining suitable amount of steady flow in the pipe circuit, there establishes a steady non-uniform flow in the conduit. Time is allowed to stabilize the levels in the manometer tube.
5. The discharge flowing in the circuit is recorded together with the water levels in left and right limbs of manometer tube.
6. The flow rate is reduces in steady by means of flow control value and the discharge & reading of manometer are recorded.
7. This procedure is repeated by closing the pressure tapping of venturimeter.

Observation and Computation Sheet:

$C_d = Q\sqrt{(a_1^2 - a_0^2)} / a_0 a_1 \sqrt{(2g\,\Delta h)}$

Diameter of main pipe line, D =

The ratio d/D =

Area of cross section of orifice (a_0) =

Area of cross section of inlet section (a_1) =

Area of collecting tank =

S. No.	Discharge measurement				Manometer Reading			C_d
	Initial (cm)	**Final (cm)**	**Time (sec)**	**Discharge (cm^3/sec) Q**	**Rise in left h_1 (cm)**	**Rise in right limb h_2 (cm)**	**Δh in terms of water head = $12.6x(h_1-h_2)$**	
1								
2								
3								
4								

Average C_d =

Experiment- 4

AIM: To determine co-efficient of discharge of Notch (V and rectangular types).

Equipment: A constant steady water supply tank (North tank) which baffles wall, pointer gauge, collecting tank, model is 1) V Notch 2) Rectangular Notch.

Introduction & Theory:

Different types of model are available to find discharge in an open channel such as notch, venturiflume, weir etc. for calibration of either v notch or rectangular notch, trapezoidal notch. Some flow is allowed to the flume. Once the flow becomes steady and uniform discharge coefficients can be determined for any model.

In general sharp crested notches are preferred where highly accurate discharge measurements are required. For example, in Hydraulic laboratories, industry and irrigation pilot schemes which do not carry debris and sediments.

Notches are those overflow structures whose length of crest in the direction of flow is accurately shaped. They may be rectangular, trapezoidal, V notch etc. the v-notch is one of the most precise discharge measuring device suitable for a wide range of flow. The relationship between discharge and head over the weir can be developed by making the following assumptions as to the flow behavior:

a) Upstream of the weir, the flow is uniform and the pressure varies with depth according to the hydrostatic equation.

   $p = \rho g h$

b) The free surface remains horizontal as far as the plan of then weir, and all the particles passing over the weir move horizontally.

c) The pressure throughout the sheet of the liquid or nappe, which passes over the crest of the weir, is atmosphere.

d) The velocity in the approach channel is negligible.

A triangular or V-notch having a triangular or V-shaped opening provided in its body so that the water is discharged through this opening only. The line which bisects the angle of the notch should be vertical and the same distance from both sides of channel. The discharged coefficient Cd of the V-notch may be determined by applying formula:

$Cd = Q/(8/15)\ \sqrt{2g}\ H^{5/2} \tan\theta/2$

Where Q is the discharge over a triangular notch, θ is the apex angle of the notch, H is the head over the crest of the notch.

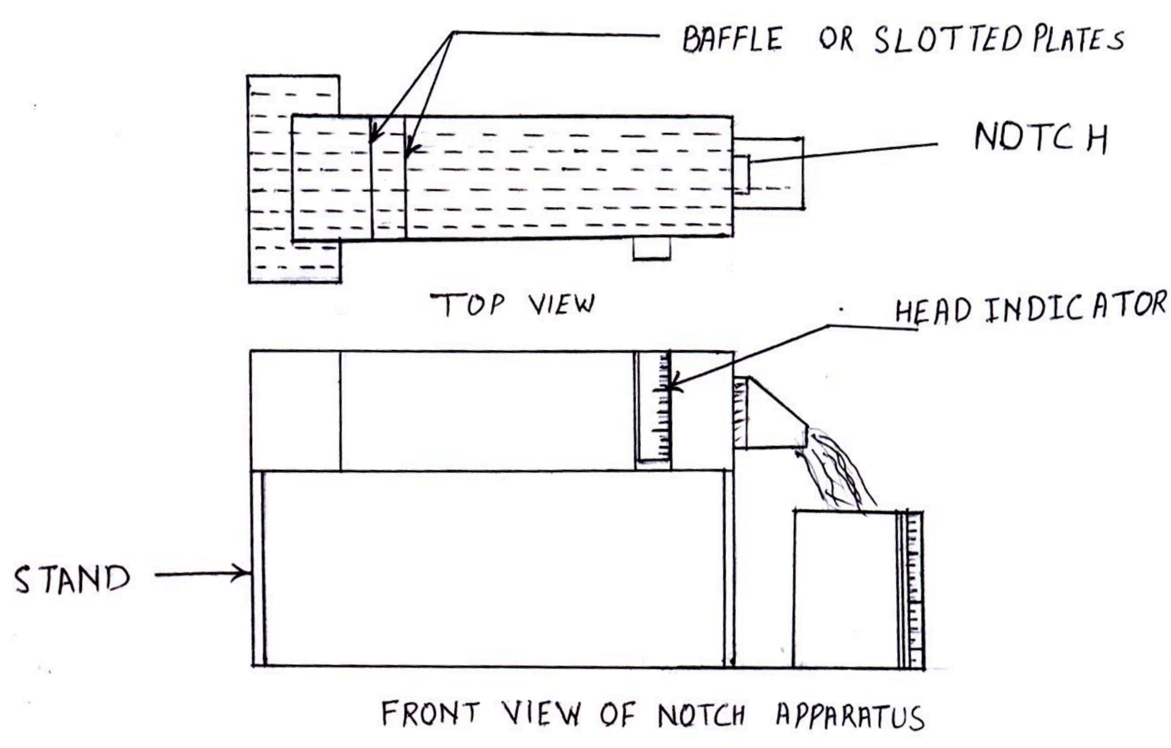
A rectangular notch, symmetrical notch symmetrically located in a vertical thin plate that is placed perpendicular to the sides and bottom of a straight channel is defined as rectangular sharp crested weirs. The discharge coefficient Cd of a rectangular notch may be determined by applying formula:

$Cd = Q/(2/3)\sqrt{2g}\, BH^{3/2}$

Where B is the width of the notch, H is the head over the crest of the notch, and g is the acceleration due to gravity.

Experimental Setup:

The experimental setup consists of a tank whose inlet section is provided with 2 no. of baffles for streamline flow. While at downstream portion of the tank one can fix a notch of either rectangular notch. A pointer gauge is used to measure the head of weir over the model. A collecting tank is used to find the actual discharge through the notch.



Procedure:

The notch is positioned at the end of a tank, in a vertical plane and with on the up stream side of the sharp edge. The tank is filled with water upto the crest level of the notch by the help of point gauge. The flow regulating valve is adjusted to give the maximum possible discharge without flooding the notch. The flow rate is reduced in stages and the reading of discharge & H were taken. The procedure is repeated for other type of notch.

Observation and computation sheet:

Triangular or V notch

Apex angle of notch (θ) =

Crest level of v notch (H_1) =

Area of collecting tank (a) =

S. No.	Discharge measurement				Final Reading of water level above the notch H2	Head over notch H = H_2-H_1(cm)	C_d = Q/ (8/15√2g$H^{2.5}$tan(θ2))
	Initial (cm) h1	Final (cm) h2	Time (sec)	Vol. (cm^3/sec) Q=vol./t			
1							
2							
3							
4							

Average C_d =

For rectangular notch

Width of notch (B) =

Crest level of V notch (H_1) =

Area of collecting tank, (a) =

S. No.	**Discharge measurement**				**Final Reading of water level above the notch H2**	**Head over notch H = H_2-H_1(cm)**	**C_d = Q/ 2/3√2g$H^{1.5}$B**
	Initial (cm) h1	**Final (cm) h2**	**Time (sec)**	**Vol. (cm^3/sec) Q=vol./t**			
1							
2							
3							
4							

Average C_d =

Experiment- 5

AIM: To find critical Reynolds number for a pipe flow.

Equipment: Supply tank with elliptical bell mouth entry, colored dye injector arrangement Perspex tubes with means of varying flow rate and collecting tank.

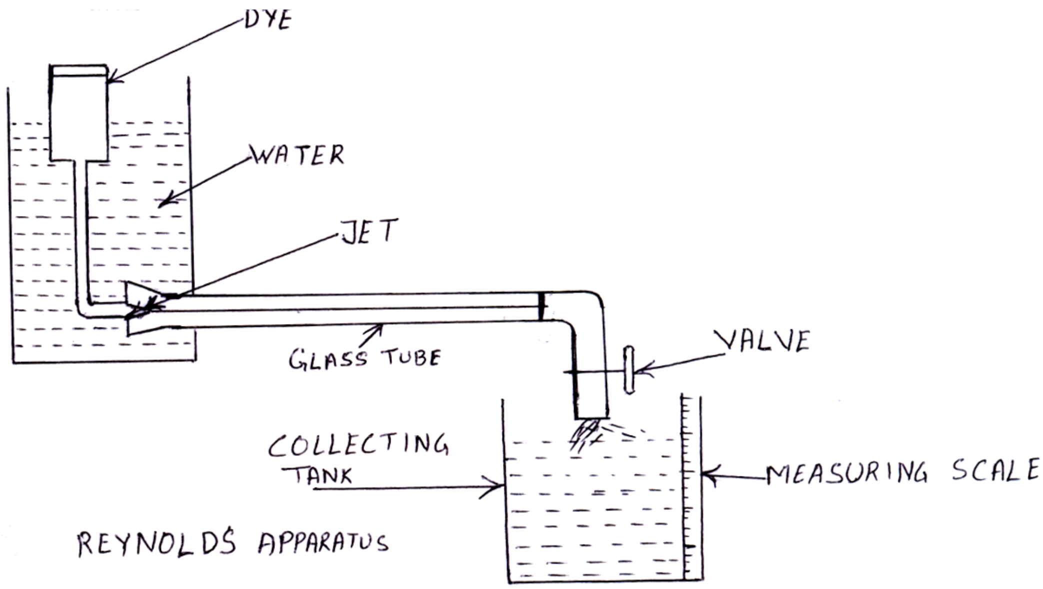
Introduction and Theory:

Depending upon the relative magnitudes of viscous and inertial forces flow can occur in two different manners viz. laminar flow and turbulent flow. In laminar flow viscous effects are more predominant than inertial increase in velocity of flow is turbulent. To identify laminar and turbulent ranges of flow a dimensionless parameter is being utilized which is a measure of the relative flow of a fluid, which is known as Reynold's number. It is equal to the ratio of inertial force to the viscous effects and vice versa. For determining different flow conditions, equipment first used by Professor Osborne Reynolds after whose name Reynolds number exists.

The motion is laminar or turbulent according as the value of Re less that or greater that a certain value. If a liquid such as water is allowed to flow a glass tubes and if one of the liquid filament is made visible by means of dye, then by watching this filament we may get insight into the actual behavior of the liquid as it moves along. After the water in the supply tank has stayed for several hours wait for it to come to rest completely. The outlet valve is slightly opened. The central thread of dye carried along by the slow stream of water as the indicating column in an alcohol thermometer. But when as a result of further opening fort he valve the water velocity passes a specific limit, a change occurs. The rigid thread of the dye begins to break up and group momentarily ill defined. The moment the dye deviated from its straight line path. Corresponds to the condition when the flow in the condition when the flow in the conduit at this moment is measured and the Reynold's number $4Q/\pi dv$ (in which the d is the diameter of the conduit and v is the kinematics viscosity of the water) is computed. This is the lower typical Reynold's number. Finally at high velocities the dye mikes completely with the water and colored mixture fills the test tube.

Experimental Setup:

Apparatus consists of storage cum supply tank. Which has the provision for supplying colored dye through jet. Perspex tube is provided to visualize the different flow conditions. The entry of water in Perspex tube is provided to visualize the different flow conditions. The entry of water in Perspex tube is provided on the down streamside of the tube to regulate the flow.



The discharge must be varied very gradually from a smaller value to a large value. A collecting tank is used to find the actual discharge through Perspex tube.

Observation and Calculations:

Inner diameter of conduit (D) =

Room Temperature =

Kinematics viscosity =

Area of collecting tank =

S.No.	Discharge Measurement			
	Initial reading (cm)	Final reading (cm)	Discharge Q (m^3)	$R_e = 4Q/\pi dv$
1				
2				
3				
4				

Experiment- 6

AIM: To find friction factor for the pipes of different diameter of same material.

Equipment: G.I pipes of different viz. 15mm, 20mm, 25mm, 32mm & 40mm manifolded together with means of varying flow rate, U tube differential manometer, collecting tank.

Introduction Theory:

When liquid flows through a pipe under pressure, some head is lost in overcoming the friction between the pipe wall and flowing fluid. The frictional resistance offered to flow depends on type of flow. Mostly the flow of fluids in pipe lines in turbulent zone. On the basis of the experimental observations the laws of fluid friction for turbulent flow are as under:

The frictional resistance in the case of turbulent flow is

1. Proportional to $(\text{Velocity})^n$ where n varies from 1.72 to 2.0.
2. Independent of pressure.
3. Proportional of density of the following fluid.
4. Slightly affected by variation of temperature of the flowing fluid.
5. Proportional to area of surface in contact.
6. Dependent on the nature of the surface in contact.

The friction loss can be estimated by the following relation.

$h_f = (4\ f\ L\ V^2) / (2\ g\ D)$

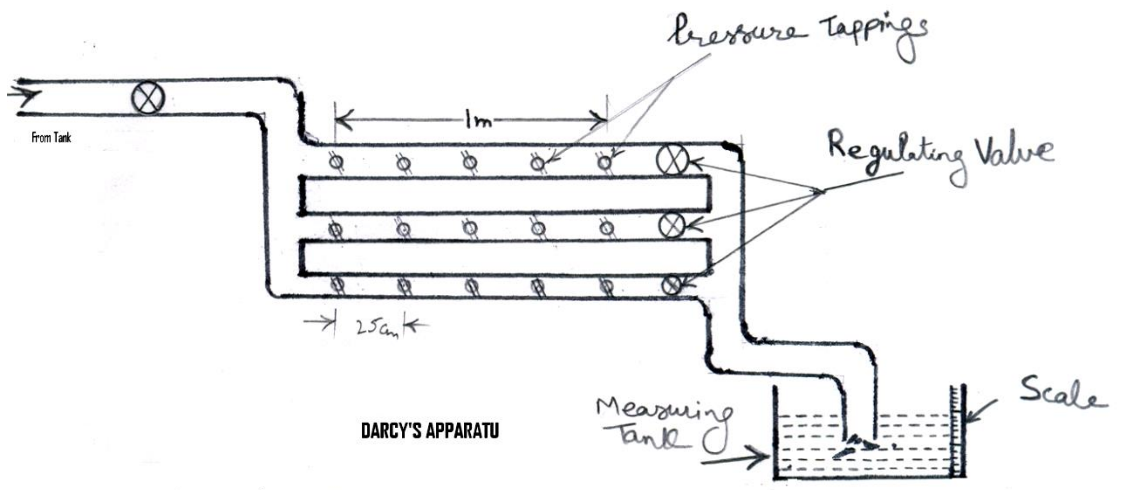
Or

$h_f = (8\ f\ L\ Q^2) / (\pi^2\ g\ D^5)$

Where f is known as friction factor which is a dimensionless quantity, L is length of pipe, v is mean velocity of flow Q is discharge through pipe, g is acceleration due to gravity and D is diameter of the pipe. The above equation is known as Darcy-Weisbach equation and is commonly used for computing loss of head due to friction in pipes.

Experimental Setup:

The apparatus consists of five G.I pipes of different diameter provided with control valve at the downstream end. The pipes are provided with two pressure tappings at a certain distance apart. A U tube differential manometer is provided to find the difference of head between two pressure tappings. The tapping may be connected to a manometer turn by turn. The discharge through a pipe can be known by measuring rise in water level in the collecting tank in a known duration of time.



Procedure:

1. Note down the relevant dimension as diameter and length of pipe between the pressure tapping, area of collection tank etc.
2. Pressure tapping of a pipe is kept open while for other three pipes it is kept closed.
3. The flow rate is adjusted to its maximum value.
4. By maintaining suitable amount of steady flow in the pipe, a steady no uniform flow in the conduit is established. Time is allowed to establish the levels in the manometer tube.
5. The discharge flowing in the circuit is recorded together with the water levels in left and right limbs of manometer tube.
6. The flow rate is reduces in steady by means of flow control value and the discharge & reading of manometer are recorded.
7. This procedure is repeated by closing the pressure tapping of pipe, together with other two pipes and for opening of another left pipe.

Observation and computational sheet:

Dia of pipe D =

Length of pipe between pressure tapping L =

Area of collecting tank =

Material of pipe =

S. No.	**Manometer Reading**			**Discharge measurement**				**f= π^2g $D^5h_f/8LQ^2$**
	Left limb h_1 (cm)	**Right limb h_2(cm)**	**Difference of head in terms of water h_f=12.6 (h_1-h_2)**	**Initial (cm)**	**Final (cm)**	**Time (sec)**	**Discharge Q (cm^3/sec)**	
1								
2								
3								
4								

Average friction factor f =

Experiment- 7

AIM: To determine the meta-centric height of a floating body.

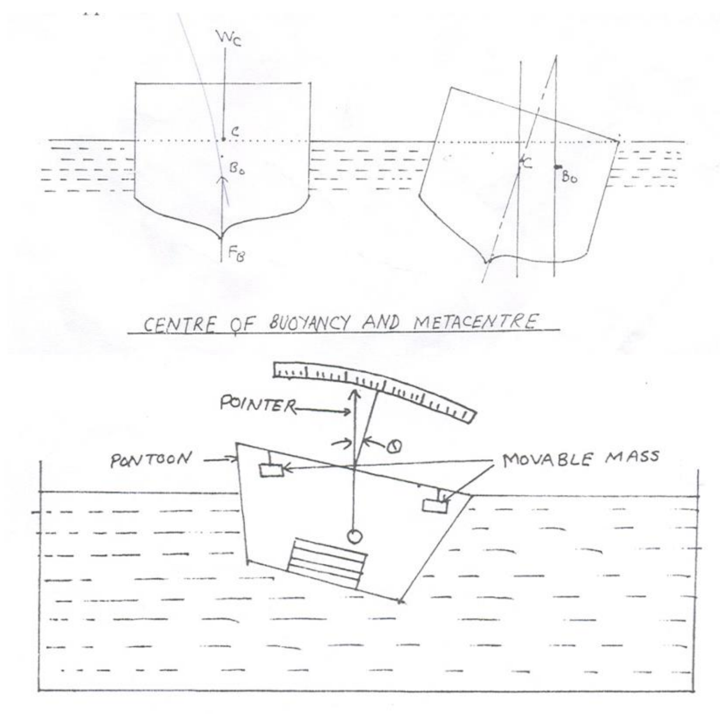
Equipment: A pontoon floating in a tank, removable strips, graduated are with pointer, movable, hangers and set of weight.

Introduction and Theory:

A body floating in a fluid is subjected to the following system of forces:

1. The downward force of gravity acting on each particle that goes to make up the weight of body, we acting through center of gravity G.
2. The upward buoyant force of the fluid acting on the various elements of the submerged surface of the floating body F_B, acting through center of buoyancy B.

For a body to be in equilibrium on the liquid surface, the two force W_C and F_B must lie in the same vertical line i.e. these must be collinear, equal and opposite. When the pontoon has been titles through an angle, the center of gravity of body G, is usually remains unchanged in its position, but B i.e. center of buoyancy will generally change its position, thus W_C and F_B in the new position cuts the axis of the body at M, which is called the metacentre and the distance GM is called the metacentric height.



The metacentric height is a measure of the static stability of the floating bodies. The metacentric height can be obtained by equating righting couple and applied moment. Here W_C is the weight of pontoon, W_M is the weight of unbalanced mass causing moment on the body, X_D is the distance of the unbalanced mass from the center of the cross bar.

Experimental Setup:

The experimental setup consists of a pontoon, which is allowed to float in M.S. tank having a transparent side. Removable steel strips are placed in tank having a transparent side. Removable steel strips are placed in the model for the purpose of changing the weight of the model. By means of pendulum (consisting of a suspended to a long pointer) the angle of tilt can be measured on a graduated arc. For titling the ship model a cross bar with two movable hangers is fixed on the model. Pendulum and graduals are suitably fixed at the center of cross bar.

Procedure:

1. Note down the relevant dimensions as area of collecting tank mass density of water etc.
2. Note down the water level in the tank when pontoon is not in the tank.
3. Pontoon is allowed to float in the tank. Note down the reading of water in the tank. Mass of pontoon can be obtained with the help of Archimedes's principle.
4. Position of unbalanced mass, weight of unbalanced mass and angle of heel can be noted down. Calculate the meta centric height of the pontoon.
5. The procedure is repeated for other position and value of unbalanced mass. Also the procedure is repeated while changing the number of strips in the pontoon.

Observation and computation sheet:

Area of tank A =

Water level (without Pontoon) Y_1 =

Unit weight of water w =

S.No.	**Reading of tank with pontoon Y_2(cm)**	**Mass of pontoon (gm) $W_C = (Y_2-Y_1)AW$**	**Unbalanced mass (gm) W_M**	**Angle of Heel (Degree)**	**Distance of unbalanced Mass X_D (cm)**	**Meta centric height (cm) $(W_M X_D)/(W_C+W_M)\tan\theta$**	**Average (cm)**

Average metcentric height:

Precautions:

1. Apparatus should be in leveled condition.

2. Reading must be taken in steady condition of water.
3. Unbalanced mass should be distributed by taking care that water should be distributed at minimum.

Experiment- 8

AIM: TO STUDY AND PERFORM TEST ON CENTRIFUGAL PUMP AND TO PLOT CURVES H, P & η vs. Q.

EQUIPMENT : Pump, pipe work system with all necessary control valves collecting tank, pressure gauge & vacuum gauge located on discharge side and pump suction, variable speed rotor drive with digital watt meter and r.p.m meter, Dynamometer on motor for measurement of load.

INTRODUCTION AND THEORY : Centrifugal pump is so named because the pressure had is generated by centrifugal action. The impelonis made up of a number of curved vanes which are supported on both sides by plates known as shrouds. It rotates inside a causing or volute. Flow enters the pump through the centre or eye of the impeller. Energy is given to the liquid as the blades of the impellor transport it outwards in a radial direction.

The volute is usually shaped in the form of a spiral to form a gradual increase in flow area so that the velocity energy at exit from the impellor is converted to additional pressure energy.

Let inlet pressure	=	P_1m
Discharge pressure	=	P_2m
Flow rate	=	Qm^3/s
Datum head	=	Z_2m
Total head across pump H	=	$(P_1-P_2) + Z_2$
Torque T	=	(load x arm distance)
Input Power P	=	(2 pai x speed in rps x T) watts
Water power P_0	=	(pg H Q) watts
Efficiency n	=	Water Power/Input Power x 100

EXPERIMENT SETUP: The experimental setup consist of a pump whose suction is provided with a vacuum gauge for measurement of suction head. While at the discharge side a pressure gauge is fitted for measurement of the delivery head. A variable speed motor drive with digital watt meter and rps meter is connected. A dynamometer is connected on motor for measurement through the pump.

EXPERIMENTAL PROCEDURE: Note down the area of collecting tank, position of delivery pressure gauge (Z_2) and arm distance of the spring from the centre of the shaft. The speed control on the motor is set to a valve and at the same time the flow regulating valve was adjusted to give the maximum possible discharge.

‘Conditions were allowed to steady before the rate of discharge Q suction head, arrange head, load on the motor anf rps value were recorded.

The flowrate is reduced in stages and the above procedure is repeated.

The procedures is repeated for other type of values.

Observation and computation sheet :

Position of delivery pressure gauge (Datum head)	=	Z_2m
Arm distance	=	0.1625m
Pg	=	9810

Area of collection tank, a = cm^2.

To plot the graph between H, P & η vs. Q.

Experiment- 9

AIM:TO STUDY AND PERFORM TEST ON RECIPROCATING PUMP AND TO PLOT THE CURVES Q, P & η vs. H.

EQUIPMENT

Pump, pipe work system with all necessary control valves, collecting tank, pressure gauge located on suction and discharge side.

INTRODUCTION AND THEORY

The reciprocating pump is a positive displacement pump, i.e., it operates on the principle of actual displacement or pushing of liquid by a piston or plunger that executes a reciprocating motion in a closely fitting cylinder. The liquid is alternately.

- Drawn from the sump and filled into suction side of the cylinder.
- Lead to the discharge side of the cylinder and emptied to the delivery pipe.

The position of plunger gets its reciprocating motion (moves backward and forward) by means of a crank and connecting rod mechanism.

In a double acting reciprocating pump suction and delivery strokes occurs simultaneously. A pump gives comparatively a more uniform discharge than the single acting pump, because of the continuity of suction and delivery strokes.

Let Discharge pressure	=	pm
Head	=	H m
Flow Rate	=	Qm^3/s
Input Power P	=	Watts
Water Power P_o	=	(pg H Q) watts
Efficiency η%	=	Water power/input x 100

EXPERIMENTAL SETUP : The experimental setup consist of a double acting reciprocating pump, on whose discharge. A pressure gauge is fitted for measurement of the delivery head. A digital watt meter may be connected to the motor of the pump as the motor of the pump as the motor is directly connected to the pump. A collecting tank is used to find the actual discharge through the pump.

EXPERIMENTAL PROCEDURES :

Note down the area of collecting tank.

Fill the reciprocating pump with the oil upto the level parked on the pointer.

Priming the pump set before starting. Priming means taking the are present in the suction and pressure pipes.

Before starting ensure that the pump is free to rotate.

Flow regulating valve was adjusted to give the maximum possible discharge.

conditions were allowed to steady before the rate of discharge Q, discharge head and load on the motor were recorded.

The flow-rate is reduced in stages and the above procedure is repeated.

S. No.	Discharge Measurement				Delivery head	Water power	Input Power	Effi.
	Initial	Final	Time	Discharge	(m)	P	P_o	η
	H_1(cm)	h_2(cm)	(sec)	(cm^3/sec)		(W)	(W)	(%)

Experiment- 10

AIM: TO STUDY AND PERFORM TEST ON GEAR PUMP AND TO PLOT THE CURVES Q, P & η vs. PRESSURE RISE.

INTRODUCTION- Gear pump is positive displacement type pump. Gear pumps are widely used for hydraulic power packs used in machine tools of testing machines, because of simplicity of construction and compactness. Also, even the pump is positive displacement type, the discharge through pump is continuous. This is an advance over the reciprocating plunger type pump. Being a positive displacement pump, it can discharge the liquid to higher discharge pressure than rotary centrifugal pumps. The DYNAMIC test rig consist of gear pump controlled to a sump tank. A valve provided on discharge side of pump controls the discharge pressure. Various measurements are provided so that performance of pump can be evaluated.

SPECIFICATIONS:

1. Gear pump-1/2” BSP connections, rated speed 1440 rpm
2. Motor-1/2 H.P., 1425rpm, 1 phase with 3 speed cone pulley and vee belt.
3. Measurement and Control-
    a) Vacuum gauge at suction of pump.
    b) Pressure gauge at discharge line of pump.0-10.6 kgf/cm.
    c) Energy meter for motor input measurement, Measurement tank with stop clock for discharge measurement.
    d) Gate valve for discharge pressure control.
    e) Valves to direct the oil either to sump tank or measuring tank.
    f) Pressure relief valve at discharge side.

 1.) Sump tank-160 ltr. Capacity.

PROCEDURE-

Fill up sufficient clean oil in the tank(SAE-40,at least 30ltr.) Before putting the oil, the tank must be clean. Rotate the belt by hand to check for freeness of operation.
Ensure that pressure control valve is fully open. Make the electrical connections. Keep the valve, which directs the oil to sump, open. Now start the motor. Set the discharge pressure with the help of valve and note down the observations. Repeat the processors for different pressures.
Take similar observations by changing the pump speed.

OBSERVATIONS-

Pump speed-

Sr.No.	Discharge Pressure kg/cm^2	Suction vacuum mm of Hg	Time for 5 ltr oil in measuring tank sec.	Time for 5rev. of energy meter sec.

CALCULATION-

1. flow rate (Discharge)
   Let time required for 10 ltr be t_m sec.
   Discharge $Q = \frac{10x10^{-3}}{t_m} m^3 / \sec.$
2. Discharge Head
   Let discharge pressure be P kg / cm^2
   1 kg / cm^2 perrssure = 12.5 m head of oil
   Suction head = $\frac{Vacume \quad mm of \quad Hg}{1000} x \frac{132435}{7850}$
   = 17 X vacume m of iol

H = Total Head
   = Suction Head + Discharge Head

3. Out put power

$$O.P. = \frac{WQH}{1000} Kw.$$

Where

W = Specific Weight of oil = 7850 N/M^3
Q = Discharge m^3 / sec.
H = Total head

4. Input Power
Let time require for the 5 revolution be t_e

$$I.P. = \frac{5}{t_e} x \frac{3600}{900} Kw$$

S.P. = I.P. X 0.7
Efficiency of the motor is 70%

5. Efficiency

$$\eta O = \frac{O.P.}{I.P.} x 100\%$$

6. Slip

Vs = Swapt volume per rev. = 1.7 X 10^{-5} m^3

$$\% slip = \frac{[NxVs] - Q}{[NxVs]} x100$$

Where

N = Rotational speed of the pump rps.

Plot the following graphs-

a.) speed V/s Discharge.
b.) Head V/s discharge.

c.) Head V/s efficiency increases.

It is seen that-

1.) Discharge is directly proportional to speed.
2.) Discharge slightly reduces with increasing head.
3.) As head rises, efficiency increases.

PRECAUTIONS-

1.) Never keep the sump lid open.
2.) Always fill up clean oil in the sump.
3.) Always use SAE-40 oil for the pump.
4.) Never disturb the setting of pressure relief valve.
5.) Never use the head above $7 kg/cm^2$ of pressure gauge.
6.) Always operate all the controls gently.

Experiment- 11

AIM: TO STUDY AND PERFORM THE TEST ON THE PELTON WHEEL AND TO PLOT CURVES Q, P & η vs. N AT FULL, THREE FOURTH AND HALF GATE OPENING.

THEORY

The Pelton wheel or Pelton turbine is a tangential flow impulse turbine. The strikes the bucket along the tangent of the runner.The energy available at the inlet of the turbine is only kinetic energy. The pressure at the inlet and outlet of the turbine is atmospheric. This turbine is used for high heads and is named after L.A. Pelton, an American Engineer.

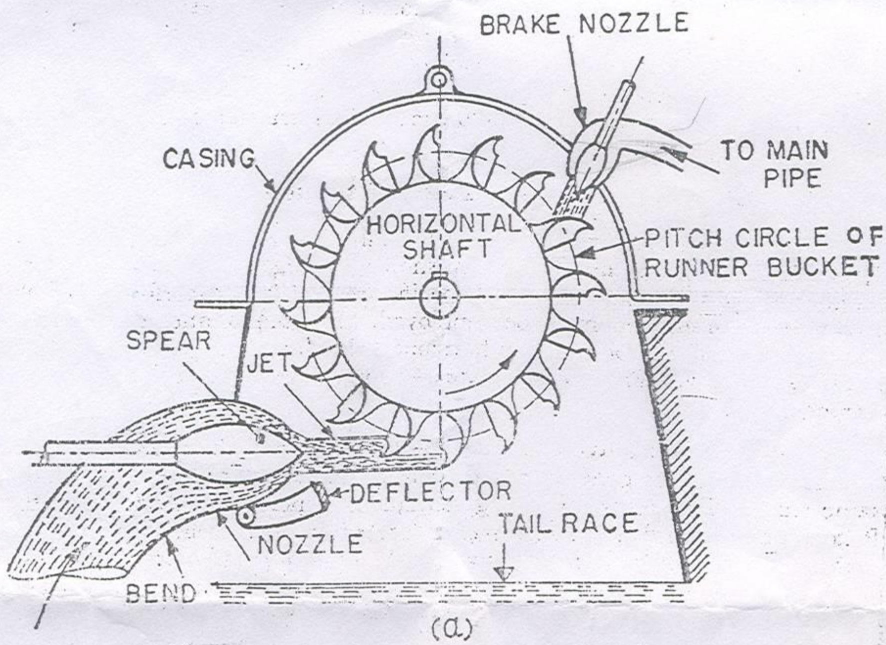
The layout of a hydro electric power plant in which the turbine is Pelton Wheel. The water from the reservoir flows through the penstocks at the outlet of which a nozzle is fitted. The nozzle increases the kinetic energy of the water flowing through the penstock. At the outlet of the nozzle, the water comes out in the form of a jet and strikes the buckets (vanes) of the runner.

INTRODUCTION

The pelton turbine test rig supplied as a complete set to conduct experiments on model Pelton turbine in Engineering colleges and Technical Institutions. It has been specially designed to conduct experiments in METRIC UNITS. The test rig mainly consists of (1) A Pelton Turbine (2) A supply pump unit to supply water to the above Pelton Turbine(3) Flow measuring unit consisting of a Venturimeter and Measuring and calibrated notch(4) Pressure gauge and (5) Piping system with recalculating arrangement.

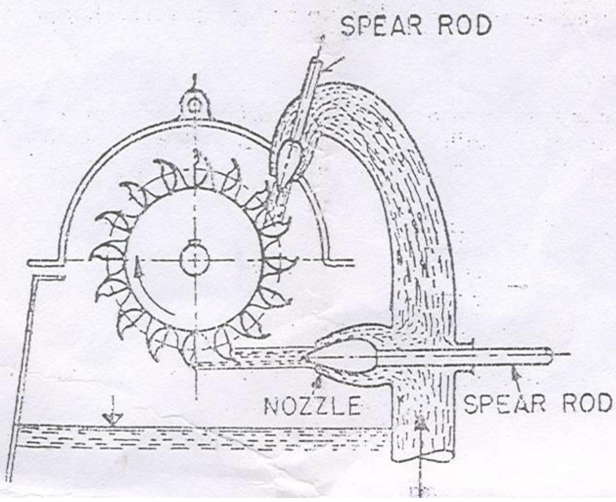
GENERAL DESCRIPTION

The unit essentially consists of casing, with a large circular transparent window kept at the front for the visual inspection of the impact of the jet on buckets, a bearing pedestal, a rotor assembly of shaft, runner and brake drum, all mounted on a suitable sturdy cast iron base plate. A rope brake arrangement is provided to load the turbine. The input to the turbine can be controlled by adjusting the spear position by means of a hand wheel fitted with indicator arrangement. The water inlet pressure is measured by a pressure gauge and for the measurement of speed a hand tachometer is to used.



(a)

Single Jet, Horizontal Shaft Pelton Turbine



CONSTRUCTIONAL SPECIFICATION

2. **Casing:** of close grained cast iron having a large circular transparent window.
3. **Runner:** of G.M. wheel fitted with accurately finished buckets and electroplated.
4. **Shaft:** of stainless steel for rust free operation and of sample size for high strength.
5. **Nozzle:** of G.M. with electroplated designed for smooth flow.
6. **Spear:** of G.M. designed for efficient operation
7. **Spear Spindle:** of EP steel of liberal size.
8. **Inlet Bend:** of casting iron, which accommodates the indicator bracket.

9. **Ball Bearing:** of single row deep groove rigid type in the casing and double row self-aligning type in the pedestal both the liberal size.
10. **Base plate:** of cast iron box type ribbed construction.
10. **Brake Arrangement** : Consist of a machined and polished brake drum (300 mm dia), cooling water pipes, internal water scoop, discharge pipe, standard cast iron dead weights, spring balance, rope brake etc, arranged for loading the turbine.
11. **Finish**: of high standard suitable for laboratory use in technical institutions.

TECHNICAL SPECIFICATION

Pelton Turbine

1.	Rated supply head	:	46.0 meters
2.	Discharge	:	840 lpm (+10%)
3.	Normal Speed	:	750 rpm
4.	Power output		3.75 KW (5 hp)
5.	Unit Speed	:	38.8 rpm
6.	Specific Speed		19 rpm (metric)
7.	Jet diameter	:	22 mm (metric)
8.	Pitch Circle diameter	:	260 mm
9.	Jet Ratio	:	260 mm
10.	No. of Buckets	:	18 Nos.
11.	Brake drum diameter	:	300 mm
12.	Rope brake diameter	:	(or 12 mm)

SUPPLY PUMPSET

1.	Rated head	:	53.0 meters
2.	Discharge	:	840 lpm
3.	Rated speed	:	2880 rpm
4.	Power required	:	15 hp (11.2 KW)
5.	Size	:	80 mm x 65 mm
6.	Type	:	High speed, Centrifugal single and suction
7.	Impeller diameter	:	206 mm

FLOW MEASURING UNIT

1.	Size of Venturimeter	:	65mm
2.	Ratio (inlet to throat)	:	0.6
3.	Manometer	:	Differential type

BALL BEARING USED

1.	In the casing	:	6308 (or its equivalent)
2.	In the bearing pedestal	:	1308 (or its equivalent)

OIL SEAL USED

1.	In the casing	:	457510

TESTING

Water turbines are tested in the hydraulic laboratory to demonstrate how tests on small water turbines are carried out to study their construction and to given the students a clear knowledge about the different types of turbines and their characteristics.

Turbines shall be first tested at constant net supply head by varying the load, speed and spear setting. However, the net supply head on the turbine may be reduced and the turbines tested in which case the power development by the turbine and the best efficiency speed will also be reduced. Though the turbines can also be tested at higher net supply heads, the supply pumpset cannot develop the higher head at the same time maintaining higher rate of flow.

The output power from the turbine is calculated from the readings taken on the brake and the speed of the shaft. The input power supplied to the turbine is calculated from the net supply head on the turbine and discharge through the turbine. Efficiency of the turbine being the ratio between the output and input power can be determined from these two readings.

The discharge is measured by the 65 mm Venturi-meter and with the Manometer while the supply head is measured with the help of the pressure gauge. The speed of the turbine is measured with a hand tachometer.

It is suggested that the turbines shall be tested at normal speed, 3 speed below normal speed. 3 speeds above normal speed (the speed of the turbine at no load and at rated condition of supply head) and the pull out torque (the maximum torque at stalled speed) may also be observed.

After supply and running the turbine at normal speed for some time, load the turbine and take the readings. Note the following.

1. Net supply head (Pressure gauge readings plus the height of the gauge centre above the centre line of jet).
2. Discharge (manometer readings)
3. Turbine shaft speed.
4. Brake weight (Dead weights plus hanger and rope weight).
5. Spring balance readings.

For any particular setting of the spear first run the turbine at light load an then gradually load it, by adding dead weights on the hanger. The net supply head on the turbine shall be maintained constant at the required value, and this can be done by adjusting the gate valve fitted just above the turbine.

Experiment	1	2	3	4	5	6
Net supply head in meters						
Setting of the speed						
Discharge in LPM						
Input						
Brake weight in kg (including the weight of the hanger and rope W_1)						
Spring balance reading in kg W_2						
Net brake weight (W_1- W_2)						
Shaft speed in rpm						
Output Power						

Efficiency (output/input)						

Remarks

Important formula

Input power = Specific weight x supply head x discharge

Brake Power = 2 π NT/60

Efficiency = Output/Input

Where N = Turbine speed in RPM

T = Torque in Kgm (effective radius of the brake in meter x the net brake load in kg.)

The value of the constant depends on units in which power is measured.

Plot the graph between Q, P & η vs. N at full, three fourth and half gate opening.

Experiment- 12

AIM: TO STUDY AND PERFORM TEST ON THE FRANCIS TURBINE AND TO PLOT CURVES Q, P & η vs. N AT FULL, THREE FOURTH AND HALF GATE OPENING.

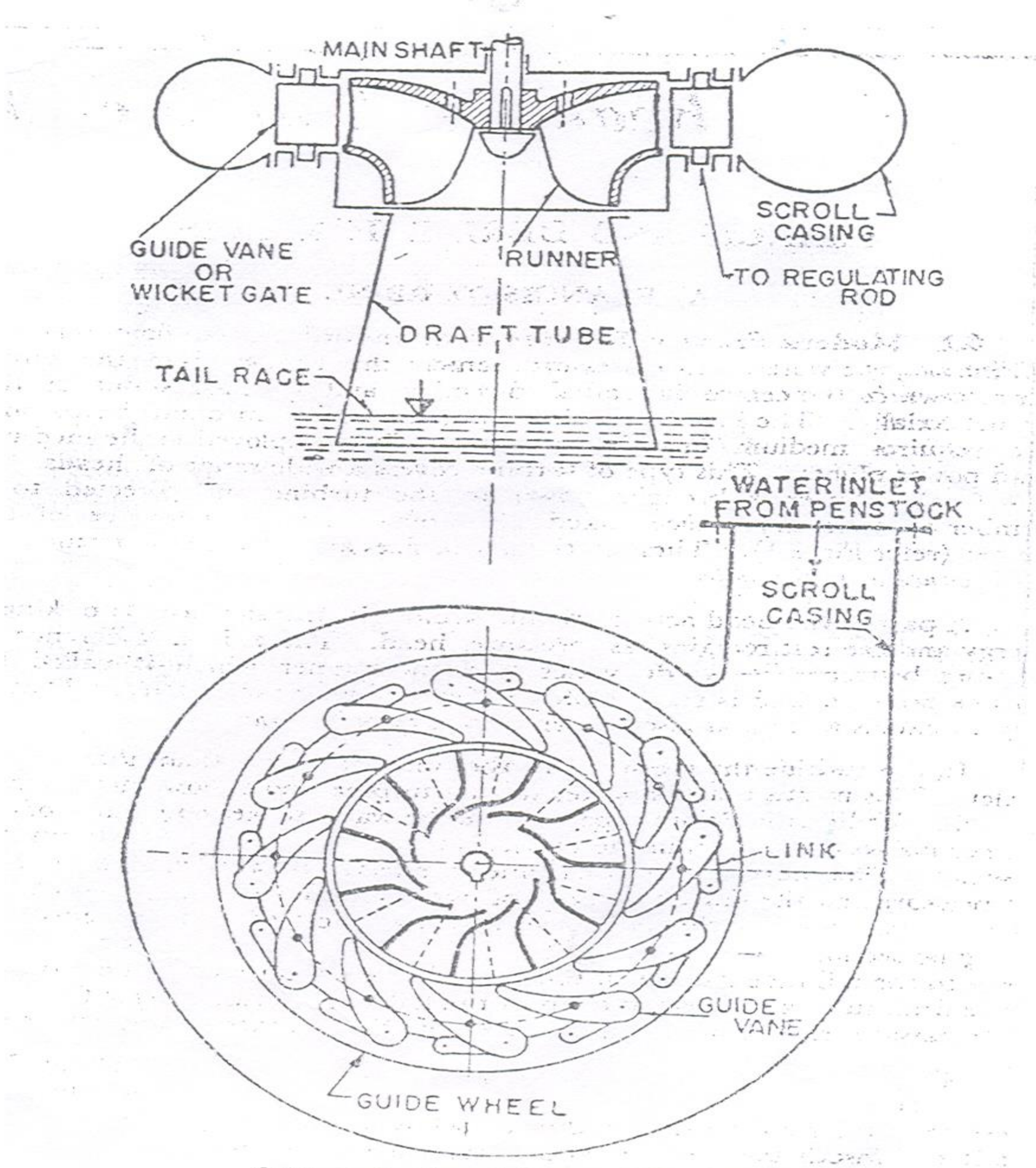
THEORY

Radial flow turbines are those turbine in which the water flows in radial direction. The water may flow radially from outward to inward or from inwards to outwards. If the water flow from outward to inward through runner, the turbine is known as outward radial flow reaction turbine.

Reaction turbine means that the water at inlet of the turbine possesses kinetic energy as well as pressure energy. As the water flows through the runner, a part of pressure energy goes on changing into kinetic energy. Thus the water through the runner is under pressure. The runner is completely closed in air tight casing and casing and runner is always full of water. Francis turbine is an inward flow reaction turbine having radial discharge at outlet. In the modern Francis turbine, the water enters the runner of turbine in radial direction at outlet and leaves in the avail direction at inlet of the runner. Thus modern Francis turbine is a mixed flow type turbine. In case of Francis turbine discharge is radial at outlet, the velocity of whirl at outlet is zero i.e. $Vw_2=0$.

And work done per second per unit weight of water striking/s = ½ (Vw_1U_1) Main parts of Radial Flow Reaction Turbine or Francis Turbine.

1. **Casing** : As mentioned above that in case of reaction turbine, casing and runner are always full of water. The water from the penstocks enters the casing which is of spiral shape in which area of cross-section of the casing goes on decreasing gradually. The casing completely surrounds the runner of the turbine. The casing as shown in figure is made of spiral shape, so that the water may enter the runner at constant velocity through out the circumference of the runner. The casing is made of concrete, cast steel or plate steel.
2. **Guide Mechanism** : It consists of a stationary circular wheel all round the runner of the turbine. The stationary guide vanes are fixed on the guide mechanism. The guide vanes fixed on the runner without shock at inlet. Also by a suitable arrangement, the width between two adjacent vanes of a guide mechanism can be altered so that the amount of water striking the runner can be varied.



Outlines of a Francis Turbine, Vertical Closed Type

3. Runner : It is a circular wheel on which a series of radial curved vanes are fixed. The surface of the vanes are made very smooth. The redial curved vanes are so shaped that the water enters and leaves the runner without shock. The runners are made of cast steel, cast iron or stainless steel. They are keyed to the shaft.

3. **Draft Tube** : The pressure at the exit of the runner of a reaction turbine is generally less than atmosphere pressure. The water at exit cannot be directly discharged to the tail race. A tube or pipe of gradually increasing area is used for discharging water from the exit of the turbine to the tail race. This tube of increasing area is called draft tube.

WORKING

Hydro- power is one of the major source of power in the world now –a-day. To convert potential energy of water into mechanical power, turbines are used. Depending upon the head and quantity of water available, various turbines are installed. When water is available, various turbines are installed. When water is available at high head, normally impulse turbine i.e.Peltan wheel turbines are used. Francis turbine is one of reaction turbines widely used. In reaction turbines, pressure of the water changes gradually as it flows through the runner.

In Francis turbine, water from the penstock enters the scroll casing, which completely surrounds the runner. From scroll casing, water passes through a series of guide vanes, which are provided around the periphery of the runner. The guide vanes are of streamlined shape.

From the guide vanes, water enter the runner radially. After flowing through the runner passages and having imparted all the energy to the runner, water leaves the runner axially. Normally, negative head is established at the exit of the runner, hence a draft tube of divergent section is fitted at exit of runner. The lower end of the draft tube is always submerged in the water. Due to divergent section of the draft tube,it converts a large portion of velocity energy into pressure energy thus makes it possible to install the turbine above the tail race without loss of head.

INTRODUCTION

1. The unit essentially consist of a spiral casing, outer bearing pedestal and rotor assembly with runner, shaft with brake drum, all mounted on a suitable sturdy cast iron base plate. A straight conical draft tube is provided for the purpose of regaining the kinetic energy from the exit water and also facilitating easy Insure that three should not any load on the turbine. Close gate valve(top of the turbine) & guide vane pointer should be in zero position.

   Press “GREEN” button of starter, hold it for 1-2 seconds and release so that pump stars running.
2. Observe direction of pump rotation during starting. It should be clockwise, as seen from fan end. If it is reverse, interchange any two phases in supply line.
3. slowly open the Venturimeter cocks and remove the air bubble. Then slowly open the ate valve.
4. Adjust the guide vanes so that turbine will start rotating.
5. open the cock for the cooling water to the loading drum.
6. Take the reading at different load. The turbine speed 1250rpm.
   (for constant speed use guide vanes.)
7. Note down the readings in observation table.
8. Repeated the procedure for different speeds also, say 1300rpm, 1400rpm,1600rpm.
9. This is a constant speed test.
10. Repeat the procedure for constant guide vane position.

OBSERVATION TABLE

1.) Constant speed-------------------- rpm
(by changing guide vanes position-AT FULL OPENING OF GATE VALVE)

SR. No.	Spring balance differance, L,kg	Manometer difference (h_w) mm of water	Pressure gauge(kg/cm^2)	Vacum gauge mm of Hg	Guide vanes position

OBSERVATION TABLE

2.) Constant Speed-------------RPM.

(By changing gate valve position –AT CONSTANT GUIDE VANES POSITION)

Sr. No.	Spring balance difference, L, kg	Manometer difference(h_w) mm of water	Pressure gauge(kg/cm)	Vacuum gauge mm of Hg	Guide vanes position

OBSERVATION TABLE

3.) Constant guide vanes position:-
(AT OPENING OF GATE VALE)

Sr. No.	Spring balance difference, L , kg	Manometer difference(h_w) mm of water	Speed (N) RMP	Pressure gauge (kg/cm)	Vacuum gauge mm of Hg

CALCULATIONS

1.) Head over the turbine:-
Since 10 mtrs. Of water head corresponds to 1 K/cm^2
So H = Pressure gauge reading (kg / cm^2) X 10 Mtr

2.) Water flow rate:

$$Q = C_d \frac{a_1 x a_2}{\sqrt{a_1^2 - a_2^2}} x\sqrt{2gh_w}$$

Q = $\underline{0.98 \text{ X } 7.854 \text{ X } 10^{-3} \text{ X } 4.417 \text{ X } 10^{-3}}$ X (2 X 9.81 X 12.6)$^{0.5}$ X (h_w)$^{0.5}$

$[(7.854 \times 10^{-3})^2 \times (4.417 \times 10^{-3})^2]^{0.5}$

$Q = 0.0824 (h_w)^{0.5}$ m^3/sec

a_1 = Inlet area of the Venturi at dia. = 0.1 m = 7.854×10^{-3} m^2

a_2 = Throat area of Venturi at dia. = 0.075 m = 4.417×10^{-3} m^2

C_d = Co-efficient of discharge = 0.98

h_w = Manometer difference (h) mtr.

3. Power supplied to turbine

P_{in} = (WHQ X 9.81) / 1000 Kw

Where

W = Specific weight of water = 1000 kg / m^3

4. Brake power

T = (Spring balance difference kgs) X 9.81 X (0.135 + 0.003) Nm

$$Brakepower = \frac{2\pi NT}{60000} Kw$$

$= 1.42 \times 10^{-4} \times N \times L$

Note:

(i) Brake drum diameter is 270 mm (0.270mtr)

(ii) Belt thickness is 6 mm (0.006mtr)

5. Overall efficiency of the turbine

$$\eta = \frac{BP}{P_{in}} x100\%$$

6. Graph

Plot the graph of load (BP) Vs efficiency.

7) **PREACUTIONS**

a.) Before switching off the supply pump set, first remove all the load.
b.) Close the cooling inlet water gate valve.
c.) Slowly close the guide vanes to its full closed position. Then close the gate valve just above the turbine.
d.) Switching off the supply of pump set. Never switch off the supply of pump set when the turbine is working under load.

Experiment- 13

AIM: TO STUDY AND PERFORM TEST ON HYDRULIC RAM AND FIND ITS RANKINE AND D, AUBUSSION η.

EQUIPMENT : Supply tank with a provision for supplying water to the hydraulic ram and provided with overflow arrangement, collecting tanks, hydraulic ram device, pressure gauge.

INTRODUCTION AND THEORY : The hydraulic ram is a contrivance utilizing the water hammer principle. Rams are used when a natural source of water like a spring or stream at low read is available at a nearby place to pump a part of water higher heads. No external energy is required by the ram. The work done by a large quantity of water in falling through a small height is used to raise a small part of water to a greater height.

A quantity of water is first allowed to pass through a long column of pipe connected to the hydraulic ram and discharged through a waste valve. The momentum of the water flowing through the pipe is then suddenly destroyed by the automatic closing of the waste value which gives rise to a greater pressure and pumps a small quantity of water to high head tank. When the moving column of water is brought to rest, the waste valve opens and cycle is repeated automatically.

The efficiency of hydraulic ram can be determined using the following expression.

$\boldsymbol{\eta} = W_2\, h_d / (W_1+W_2)\, h_8$ $\qquad\qquad$ $\boldsymbol{\eta} = W_2\,(h_d - h_g) / (W_1 + W_2).\, h_g$

Where W_2 is the discharge of water lifted up, W_1 is the discharge of water. H_4 is the head of water delivered by ram and h_8 is the head of water supplied to ram.

The hydraulic rams are most widely used in hilly regions where natural water streams are available. It requires no external energy, and the running and maintenance expenditure is practically nil.

EXPERIMENTAL SETUP : The experimental setup consist of a hydraulic ram having a spherical air vessel connected to a small rectangular chamber through a non returning valve. A waste valve is also provided in the rectangular chamber to discharge the excessive water to the collecting tank. The chamber is connected to discharge the tank. A delivery pipe is connected to the foot of air chamber to deliver the water to collecting tank to measure he discharge by the ram.

EXPERIMENTAL PROCEDURE : Note down the relevant dimensions as diameter of supply pipe & delivery pipe, area of collecting tank, supply head etc.
Start the pump and fill the supply tank and note that overflow is in the running condition and at the same time adjust the waste valve nut so that ram starts is discharged through automatically.

After a few strokes the water is discharged through the ram is recorded. At the same time the water discharged from the waste valve is also collected and recorded in the other collecting tank.

Count the number of beats of waste valve per minute. Also measure the delivery head in the pressure gauge.
Change the position of waste valve and repeat the above procedure for different readings.

Observations and Computation Sheet :

1. Supply Head h_8 =

2. Delivery Head h_4 =

3. Area of collecting tank for waste water =

4. Area of collecting tank for useful water =

S. No.	No. of Stroke	Waste water Discharge Measurement				Useful water Discharge Measurement				Efficiency (%)
		Initial (cm)	Final (cm)	Time (sec)	Discharge (cm^2/sec)	Initial (cm)	Final (cm)	Time (sec)	Discharge (cm^3/sec)	

GRAPH TO PLOT : Plot a graph between useful discharge, water discharge, waste water discharge and efficiency versus number of beats per minute.