NEHRU COLLEGE OF ENGINEERING AND RESEARCH CENTRE
(NAAC Accredited)
(Approved by AICTE, Affiliated to APJ Abdul Kalam Technological University, Kerala)

DEPARTMENT OF MECHANICAL ENGINEERING

Lab Manual

MEL202 FM & HM Lab

VISION OF THE INSTITUTION

To mould true citizens who are millennium leaders and catalysts of change through excellence in education.

MISSION OF THE INSTITUTION

NCERC is committed to transform itself into a center of excellence in Learning and Research in Engineering and Frontier Technology and to impart quality education to mould technically competent citizens with moral integrity, social commitment and ethical values.

We intend to facilitate our students to assimilate the latest technological know-how and to imbibe discipline, culture and spiritually, and to mould them in to technological giants, dedicated research scientists and intellectual leaders of the country who can spread the beams of light and happiness among the poor and the underprivileged.

ABOUT DEPARTMENT

- ♦ Established in: 2002
- ♦ Course offered : B.Tech in Mechanical Engineering

♦ Approved by AICTE New Delhi and Accredited by NAAC

♦ Affiliated to the University of Dr. A P J Abdul Kalam Technological University.

DEPARTMENT VISION

Producing internationally competitive Mechanical Engineers with social responsibility & sustainable employability through viable strategies as well as competent exposure oriented quality education.

DEPARTMENT MISSION

1. Imparting high impact education by providing conductive teaching learning environment.
2. Fostering effective modes of continuous learning process with moral & ethical values.
3. Enhancing leadership qualities with social commitment, professional attitude, unity, team spirit & communication skill.
4. Introducing the present scenario in research & development through collaborative efforts blended with industry & institution.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO1: Graduates shall have strong practical & technical exposures in the field of Mechanical Engineering & will contribute to the society through innovation & enterprise.

PEO2: Graduates will have the demonstrated ability to analyze, formulate & solve design engineering / thermal engineering / materials & manufacturing / design issues & real life problems.

PEO3: Graduates will be capable of pursuing Mechanical Engineering profession with good communication skills, leadership qualities, team spirit & communication skills.

PEO4: Graduates will sustain an appetite for continuous learning by pursuing higher education & research in the allied areas of technology.

PROGRAM OUTCOMES (POS)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering

problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and teamwork**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSO)

PSO1: Students able to apply principles of engineering, basic sciences & analytics including multi variant calculus & higher order partial differential equations..

PSO2: Students able to perform modeling, analyzing, designing & simulating physical systems, components & processes.

PSO3: Students able to work professionally on mechanical systems, thermal systems & production systems

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MEL202	FM & HM LAB	PCC	0	0	3	2

Preamble:

This lab is mainly focussed to develop a platform where the students can enhance their engineering knowledge in the fluid mechanics domain by applying their theoretical knowledge acquired.

Prerequisite: MET203 Mechanics of Fluids

Course Outcomes:

After the completion of the course the student will be able to

CO 1	Determine the coefficient of discharge of flow measuring devices (notches, orifice meter and Venturi meter)
CO 2	Calibrate flow measuring devices (notches, orifice meter and Venturi meter)
CO 3	Evaluate the losses in pipes
CO 4	Determine the metacentric height and stability of floating bodies
CO 5	Determine the efficiency and plot the characteristic curves of different types of pumps and turbines

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1						2	3	2		2
CO 2	2	1						2	3	2		2
CO 3	2	1						2	3	2		2
CO 4	2	1						2	3	2		2
CO 5	2	1						2	3	2		2

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Assessment	:	30 marks
Internal Test (Immediately before the second series test)	:	30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work	: 15 Marks
(b) Implementing the work/Conducting the experiment	: 10 Marks
(c) Performance, result and inference (usage of equipments and trouble shooting)	: 25 Marks
(d) Viva voce	: 20 marks
(e) Record	: 5 Marks

General instructions:

Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the University examination only on submitting the duly certified record. The external examiner shall endorse the record.

A minimum of 10 experiments are to be performed.

SYLLABUS

LIST OF EXPERIMENTS

1. Determination of coefficient of discharge and calibration of Notches.

2. Determination of coefficient of discharge and calibration of Orifice meter.

3. Determination of coefficient of discharge and calibration of Venturi meter.

4. Determination of hydraulic coefficients of orifices.

5. Determination of Chezy's constant and Darcy's coefficient on pipe friction apparatus.

6. Determine the minor losses in pipe.

7. Experiments on hydraulic ram.

8. Reynolds experiment.

9. Bernoulli's experiment.

10. Determination of metacentric height and radius of gyration of floating bodies.

11. Performance test on positive displacement pumps.

12. Performance test on centrifugal pumps, determination of operating point and efficiency.

13. Performance test on gear pump.

14. Performance test on Impulse turbines.

15. Performance test on reaction turbines (Francis and Kaplan Turbines).

16. Speed variation test on Impulse turbine.

17. Determination of best guide vane opening for Reaction turbine.

18. Impact of jet.

Reference Books

1. Yunus A. Cenegel, John M. Cimbala; Fluid Mechanics- Fundamentals and Applications (in SI Units); McGraw Hill, 2010.

2. Bansal R.K, Fluid Mechanics and Hydraulic Machines (SI Units); Laxmi Publications, 2011.

3. Modi P.N and Seth S.M, "Hydraulics and Fluid Mechanics Including Hydraulic Machines" Standard Book House, New Delhi, 20th Edition, 2015

4. Graebel. W. P, "Engineering Fluid Mechanics", Taylor & Francis, Indian Reprint, 2011

5. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, "Fluid Mechanics and Machinery", John Wiley and sons, 2015.

6. J. Frabzini, 'Fluid Mechanics with Engineering Applications', McGraw Hill, 1997.

Experiment No.	Experiment Name
1	FRICTION IN PIPES
2	ORIFICE METER
3	VENTURIMETER
4	FLOW NOZZLE APPARATUS
5	TRIANGULAR NOTCH
6	VERIFICATION OF BERNOULLI'S THEOREM
7	METACENRIC HEIGHT OF A FLOATING BODY
8	PELTON TURBINE TEST RIG
9	FRANCIS TURBINE TEST RIG
10	SINGLE STAGE CENTRIFUGAL PUMP
11	RECIPRCATING PUMP TEST PUMP
12	KAPLAN TURBINE TESTING RIG

Experiment 1: 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 $\qquad h_f = \dfrac{4fLV^2}{2gd}$

   Where, $\qquad\qquad h_f =$ loss of head due to friction

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

   $$= \frac{16}{R_e} \text{ for } R_e \langle 2000$$

   $$= \frac{0.079}{R_e^{\frac{1}{4}}} \text{ for } R_e \text{ var ying from } 4000 \text{ to } 10^6$$

   L = length of pipe
   V = mean velocity of flow
   d = diameter of pipe.

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

   Where, $\qquad$ C = Chezy's Constant

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

   $\qquad\qquad$ 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.

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

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 (m³/s)	Velocity V (m/s)	Loss of head in m	Co-efficient of Friction
	h₁	h₂	H= h₁-h₂ in m						

Experiment 2: 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

Log Q_{act} Vs log h and calculate the slope

$$x = \text{Manometer reading in m of Hg}$$

$$Q_{the} = k \times h^{\frac{1}{2}} \ m^3/s \ (\text{Where } n = 1/2)$$
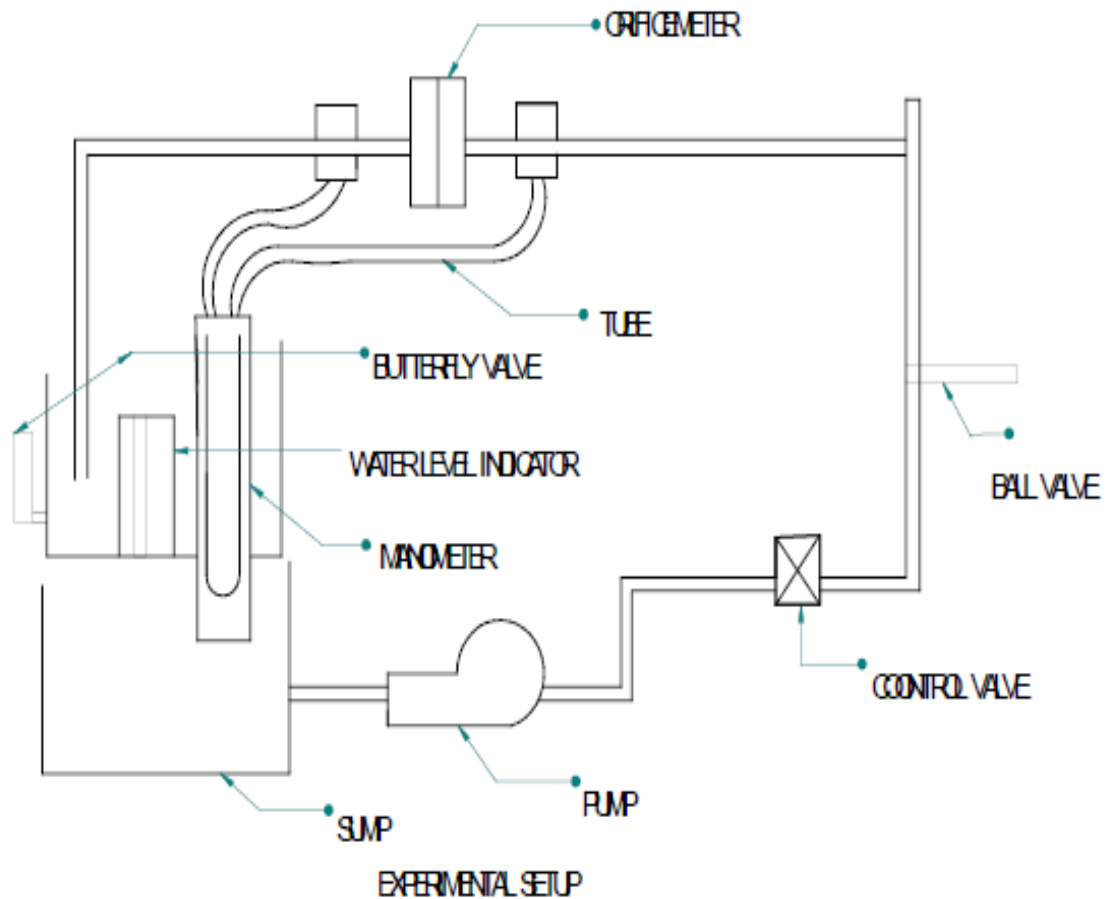
$$k = \frac{a_1 a_2 \sqrt{2g}}{\sqrt{a_1^2 - a_2^2}}$$

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

Table of readings:

Sl	R (m)	t (s)	Manometer reading x		Water Head (h) m of water
			mm	m	

Table of calculations:

Sl	Q_{act} $\left(\frac{m^3}{s}\right)$	Q_{the} $\left(\frac{m^3}{s}\right)$	$C_d = \frac{Q_{act}}{Q_{the}}$	Avg. C_d

EXPERIMENTAL SETUP

Observation and Calculation:

Internal diameter of pipe $d_1 = 0.025$ m

Orifice diameter $d_2 = 0.015$ m

Area of Collecting Tank $A = 0.0125$ m^2

Formulae:

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

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

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

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

Experiment 3: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 dia of the throat will be 0.5-0.6 times the dia 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
Log Q_{act} Vs logh and calculate the slope

$$Q_{the} = k \times h^{\frac{1}{2}} \ m^3/s \ (Where \ n = 1/2)$$
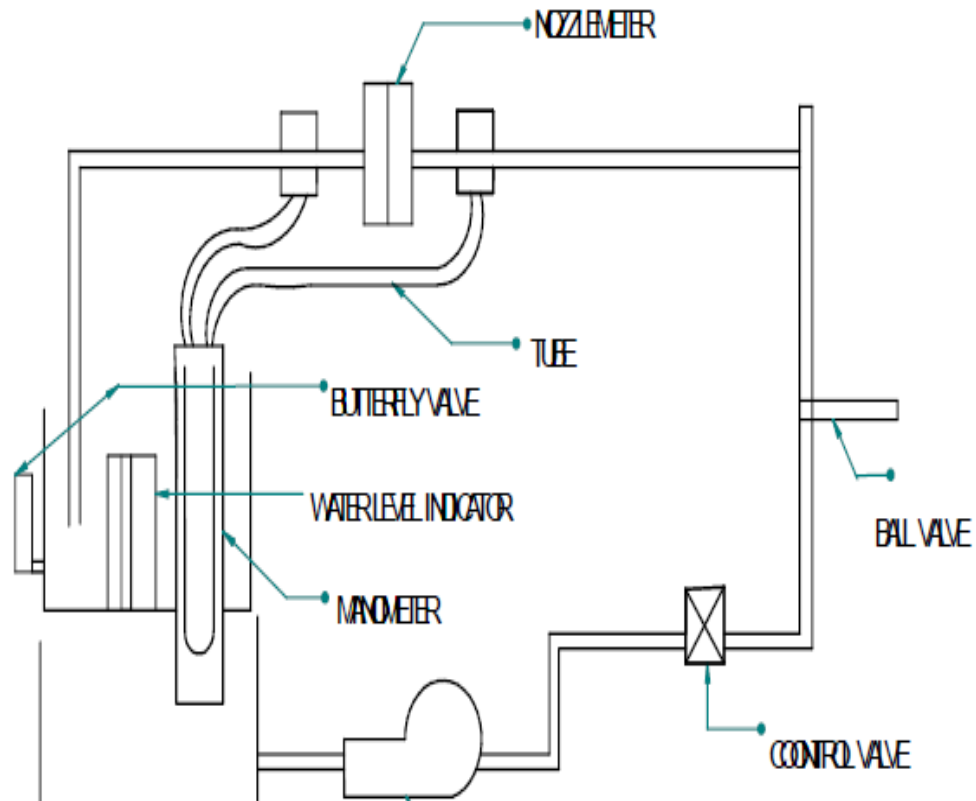
$$k = \frac{a_1 a_2 \sqrt{2g}}{\sqrt{a_1^2 - a_2^2}}$$

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

Table of readings:

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

Table of calculations:

Sl	Q_{act} $\left(m^3/s\right)$	Q_{the} $\left(m^3/s\right)$	$C_d = \frac{Q_{act}}{Q_{the}}$	Avg. C_d

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, $a_1 = \dfrac{\pi d_1^2}{4}$ m^2

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

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

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

Experiment 4: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 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

    Log Q_{act} Vs logh and calculate the slope

$$Q_{the} = k \times h^{\frac{1}{2}} \, m^3/s \, (\text{Where } n = 1/2)$$
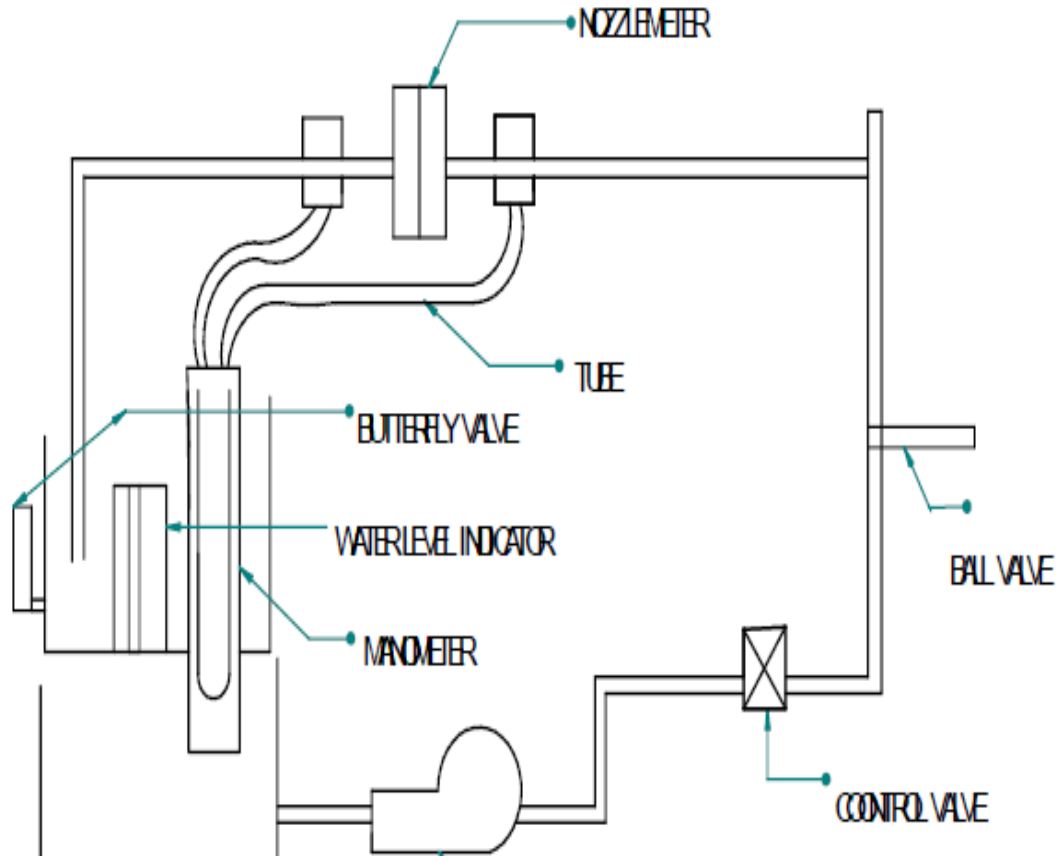
$$k = \frac{a_1 a_2 \sqrt{2g}}{\sqrt{a_1^2 - a_2^2}}$$

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

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	Q_{act} $\left(m^3/s\right)$	Q_{the} $\left(m^3/s\right)$	$C_d = \dfrac{Q_{act}}{Q_{the}}$	Avg. C_d

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, $a_1 = \dfrac{\pi d_1^2}{4}$ m^2

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

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

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

Experiment 5: 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:

b) For finding the discharge of flowing water.

c) 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.

$$i.e \; C_d = \frac{Q_{act}}{Q_{the}}$$

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

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

Apparatus Required:

2. Approach channel with baffle plate fitted with notch,

3. A Surface level gauge to measure head over notch.

4. A measuring tank to measure flow rate.

5. 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 guage reading causing flow over the notch

Observations and Calculations:

Area of collecting tank (A)   = m^2
Breadth of tank   (b)   =   m
Angle of V notch (θ)   =

Formulae:

Actual discharge, Q_{act} = $\dfrac{AR}{t}$ 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} = $\dfrac{8}{15} \tan \dfrac{\theta}{2} \sqrt{2g} \times H^{\frac{5}{2}}$ m^3/s

Where,
H = Head over notch in metre = FR - IR

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

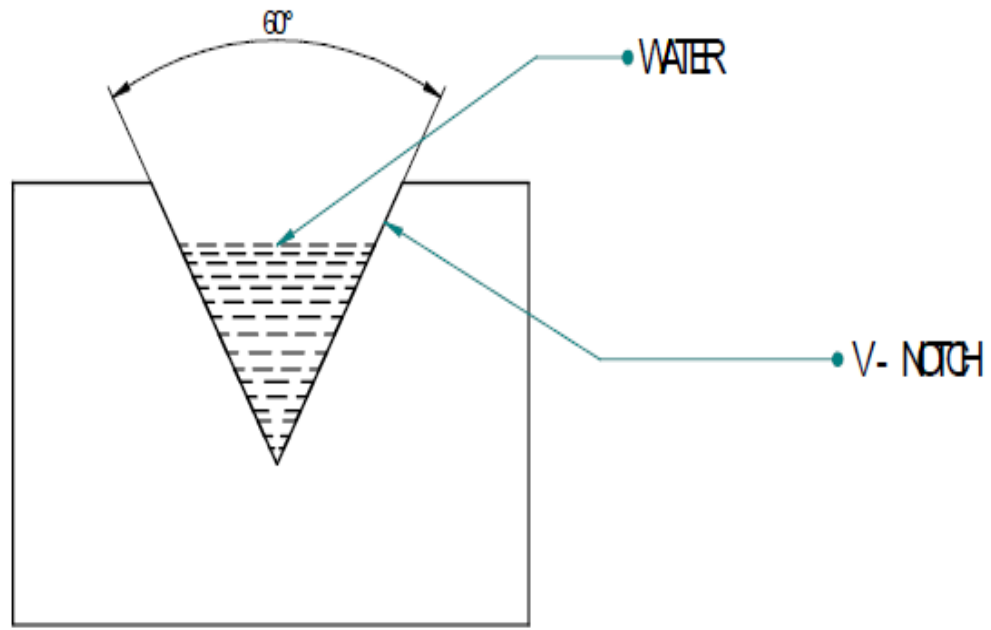### Graph to be plotted:
Log Q_{act} Vs log H and calculate the slope

Table of Readings:

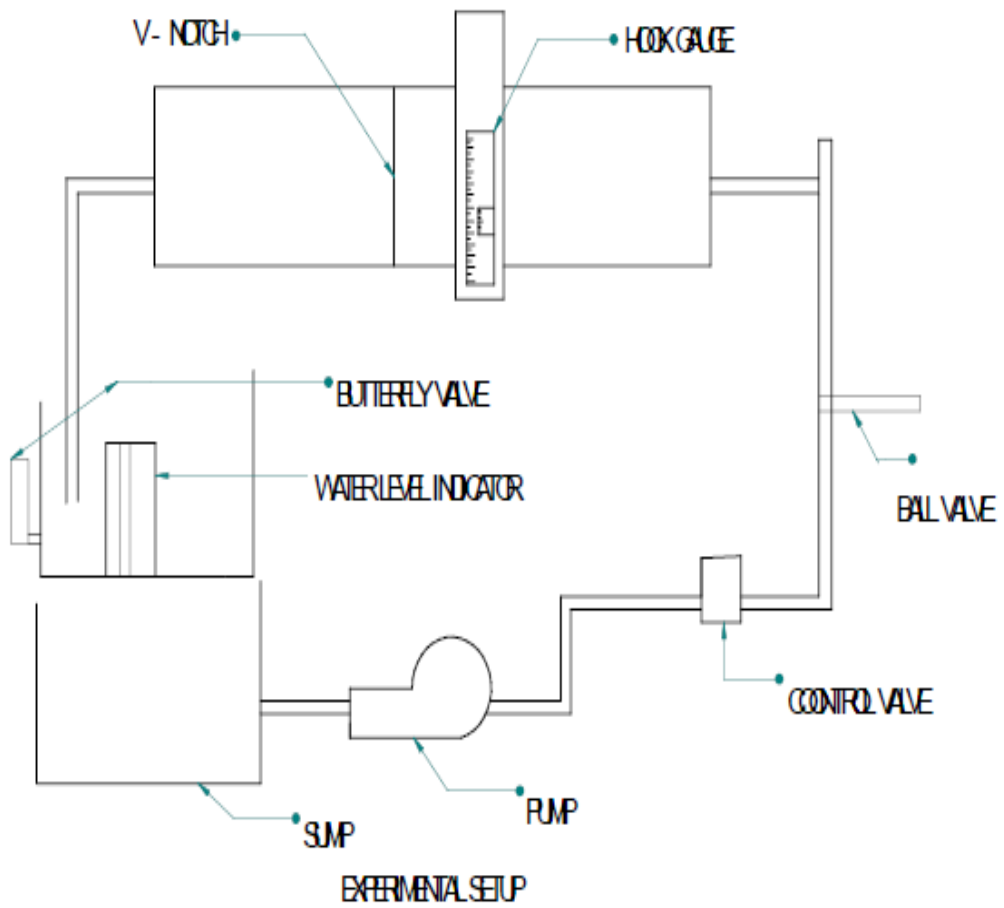| Sl. No.	Discharged water		Hook gauge reading				Head Over notch H (m)
	R (m)	t (s)	IR		FR		
			mm	m	mm	m	

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	Q_{act} $\left(m^3/s\right)$	Q_{the} $\left(m^3/s\right)$	$C_d = \dfrac{Q_{act}}{Q_{the}}$	Avg. C_d

60°

WATER

V- NOTCH

V- NOTCH

V- NOTCH

HOOK GAUGE

BUTTERFLY VALVE

WATER LEVEL INDICATOR

BALL VALVE

CONTROL VALVE

PUMP

SUMP

EXPERIMENTAL SETUP

Experimant 6: VERIFICATION OF BERNOULLI'S THEOREM

Aim :   To verify the Bernoulli's theorem and plot the graphs.

Length of pipe Vs velocity head (v^2 /2g)

Apparatus :
1. Meter Scale
2. Stop watch.

Principle : Bernoulli's theorem states that " when water is continuosly flowing through a conduit, and no   extra energy is taken out or added the total energy (or total head) will remains a constant at all   sections"

ie $H_1 = H_2$ $= H_3$ $= H$ (Total Head)

Total head H   = Potential head (Z)+

Pressure head ($\frac{p}{pg}$)+

Velocity head ($v^2/2_g$)

ie H $= Z + \frac{p}{pg} + \frac{v^2}{2g}$

Where Z   = Potential head, ie the height by which the water particle is situated from a datum.

p = intensity of pressure
S = density of water
g = acceleration due to gravity
v = velocity of flowing water

The apparatus consists of a duct of varying cross-sectional area and piezgometers are installed at various sections. A supply tank and a collecting tank are provided with the apparatus. A centrifugal pump with an electric motor is also provided to circulate the water.

Procedure
1. Observe the area of cross section and the distance of each section from a reference axis
2. Close the outlet valve of the centrifugal pump and start the pump. .
3. Open the outlet valve of the pump gradually and water is allowed to enter the supply tank, and water flows through the duct to the reservoir.
4. Maintain a steady flow through the duct by operating the outlet valves
5. Consider a datum and measure the vertical height to the level of water in the pizgometer from the datum, by using a meter scale ie (z+p/pg)..
6. Observe the dimensions of the measuring tank and close the outlet valve of the tank firmly .
7. The water flowing through the duct is collected in the measuring tank and note the time (t) taken for a particular rise in water level (x)in the measuring tank. by using a stop watch.
8. After taking the time, open the outlet valve of the measuring tank .
9. Close the outlet valve of the centrifugal pump and switched off. The pump.

Result:
Bernoulli's theorem is verified and it is found that total head decreases when the flow progresses.

Infernce:

Observation and Tabulation

Dimensions of measuring tank,

L =   B=

	1	2	3	4	5	6	7	8	9	10	11
Distance											
Area of Cross section											
$(z+\frac{P}{pg})$											
$(V^2/2g)$											
Total Head (H)											

Sample calculation (Section No.............................)

$(z+\frac{P}{pg})$ =

Dimensions of measuring tank,

L   =   B =

Area of measuring tank, (A) = L×B)

=

Rise in water level in the measuring tank, (x)=

Time taken for the water rise in the tank (t)   =

Actual Discharge (Q) $=\frac{A\times x}{t}$

Area of cross section of the duct (a)   =

velocity (v)   = Q/a

velocity head $= V^2/2_g$ $(g = 9.81 m/s^2)$

=

Total head (H) = z+ $\frac{P}{pg}$ + $\frac{V^2}{2g}$ =

Experiment 7: METACENRIC HEIGHT OF A FLOATING BODY

AIM

To determine metacentric height of floating body

OBJECTIVES :

To comprehend the metacentric height and to use the apparatus to determine the metacentric height.

THEORY

When a floating body is tilted through a small angle its centre of buoyancy will be shifted to a new position the point of intersection of the vertical line drawn through the new centre of buoyancy and centre of buoyancy is called metacentric height.

The metacentric height GM can be determined as

$$GM = \frac{w.d}{(W+w)\tan\theta}$$

Where,

W   = Weight of the floating body

w   = weight of the added body

θ   = tilt given to the floating body

d   = distance of hanger from the body

The metacentric value for ships range as follows

Merchant ship   - 0.3 to 1 m

Sailing ship   - 0.45 to 1.25 m

Battle ship   - 1 to 1.5 m

River crafte   - up to 3.5 m

PROCEDURE

1. Note the level of water in the vessel without the floating body
2. Put the floating body in the vessel and note the level of water
3. Calculate the weight of the floating body from the principle, weight of the body equal to weight of the displaced liquid
4. Adjust the pointer on zero in the protractor
5. Put a small weights in the grams on the hanger provided on any one side [left or right]
6. Note the distance of hanger from the centre
7. Note that always both the hanger should be in equal distance from the centre to avoid the movement produced by hanger
8. Note also the tilt shown by the pointer in the protractor
9. Repeat the experiment about ten time's on same side by changing the distance from the centre .

RESULT

The metacentric height of a body is determined.

The metacentric height without dead weight is   =

Inference

Experiment 8: PELTON TURBINE TEST RIG

AIM:

1) To study the working principle of Pelton (impulse) turbine
2) To understand the functional aspects of various components constituting the turbine
3) To study performance characteristics of turbine at various heads, speed and load.

INTRODUCTION:

Hydraulic (or water) Turbines are the machines, which use the energy of water (Hydro –power) and convert it into Mechanical energy. Thus the turbine becomes the prime mover to run the electrical generators to produce the electricity, viz., hydroelectric power.

The Turbines are classified as impulse & reaction types. In impulse turbine, the head of water is completely converted into a jet, which impinges on the turbine runner, it is the pressure of the flowing water, which rotates the runner of the turbine. Of many types of turbines, the Pelton turbine, most commonly used, falls into the category of impulse turbine while the Francis & Kaplan falls into the category of reaction turbines.

Normally, Pelton turbine (impulse) requires high heads and low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding heads and discharges are difficult to create in laboratory size turbine as the limitation of the pump's availability in the market. Nevertheless, at least the performance characteristics could be obtained within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind of facility.

DESCRIPTION:

The experimental setup consists of Centrifugal pump set, Turbine unit, sump tank, notch tank arranged in such a way that the whole unit works as recirculation water system. The centrifugal pump set supplies the water form the sump tank to turbine through control valve situated on the pump and a sphere valve before entering the turbine. The water after passing through the Turbine unit enters the Notch tank and then flows back to sump tank through the Notch tank which is fixed with a notch plate for measurement of flow rate.

The loading of the turbine is achieved by a brake drum with rope & spring balance, provision for measurement of turbine speed (digital RPM indicator), Head on turbine (pressure gauge) are built in on the control panel.

SPECIFICATION:

Supply pump capacity   : 7.5Hp, 3ph, 440V

Turbine capacity   : 1.1 kW

Run away speed   : 1500 rpm

Loading   : Brake drum with spring balance

OBSERVATION TABLE:

Constant Speed:

Sl No	Turbine speed 'N' rpm	Pr Gauge reading 'P' Kg/cm^2	Head over turbine 'H' in m	Head over the notch $h_2-h_1=h$ in m	Spring balance reading Kg $S_2-S_1=S$	Flow rate 'Q' m^3/s	Input power kW	Brake power Bp kW	Turbine efficiency % η_{turb}

PROCEDURE:

1) Connect the panel to the electrical source & ascertain the direction of the pump is in order (clock wise direction from shaft end) by momentarily starting the pump.
2) Fill filtered clear water into the sump tank up to ¾th its full capacity
3) Keep the control valve situated above the pump in fully closed position, and the sphere valve in half open position.
4) Start the pump; gradually open the control valve slowly so that the turbine achieves sufficient speed.
5) Wait till the speed of the turbine maintained constant.
6) Load the turbine by turning the hand wheel situated on the load frame clock wise observing the dial spring balance to any desired minimum load
7) Allow the turbine speed to stabilize
8) Record the readings indicated on pressure gauge, dial balance RPM indicator and head over the notch plate
9) Continue loading the turbine in steps up to its full load and record the corresponding readings at each steps
10) After the experiment is over bring the turbine to no load condition by rotating the hand wheel on the load frame in anti clock wise direction and stop the pump.
11) Tabulate all the recorded readings and calculate the input power, output power & efficiency of the Turbine.

Graphs to be plotted:
Main Characteristics Curves (constant Head)
1. Q_u Vs N_u
2. P_u Vs N_u
3. η_o Vs N_u

Operating Characteristics Curves (Constant Speed)
4. η_o Vs % full load.

Constant Head:

Sl No	Turbine speed 'N' rpm	Pr Gauge reading 'P' Kg/cm²	Head over turbine 'H' meters	Head over the notch $h_2-h_1=h$ meters	Spring balanced reading Kg $S_2-S_1=S$	Flow rate 'Q' m³/s	Input power kW	Brake power Bp kW	Turbine efficiency % η_{turb}

CALCULATIONS:

1. Head on turbine H:
   H = 10 x P where P is the pressure gauge reading in Kg/cm²

2. Flow rate of water, Q   =   2/3 C_d b $\sqrt{2g}$ $h^{3/2}$ m³/sec
   g   =   9.81 m/sec²
   C_d =   0.9
   b   =   Width of notch in m
   h   =   Head over the notch in m

3. Input power = WQH / 1000 kW where W = 9810 N/m³

4. Brake power

$$BP = 2\pi N (S_2-S_1) \, r \times 9.81 / 60 \times 1000 \quad \text{kW}$$

Where r = Radius of the brake drum = 0.168 m (0.152 + .016)

5. Turbine efficiency

$$\eta_{turb} = BP / IP \times 100$$

6. Unit speed, $N_u = \dfrac{N}{\sqrt{H}}$

7. Unit discharge, $Q_u = \dfrac{Q}{\sqrt{H}}$

8. Unit power, $P_u = \dfrac{P_{shaft}}{H^{\frac{3}{2}}}$

9. Specific speed, $N_s = \dfrac{N\sqrt{P_{shaft}}}{H^{\frac{5}{4}}}$

Experiment 9: FRANCIS TURBINE TEST RIG

INTRODUCTION:

Hydraulic (water) Turbines are the machines, which use the energy of water (Hydro –power) and convert it into Mechanical energy, which is further converted into electrical energy. Thus the turbine becomes the prime mover to run the electrical generators to produce electricity (Hydroelectric power).

The Turbines are classified as impulse & reaction types. In impulse turbine, the head of water is completely converted into a jet, which exerts the force on the turbine; it is the pressure of the flowing water, which rotates the Impeller of the turbine. Of many types of turbine, the Pelton wheel, most commonly used, falls into the category of impulse turbine, while the Francis & Kaplan falls into the category of reaction turbines.

Normally, Pelton wheel (impulse turbine) requires high heads and low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding heads and discharges are difficult to create in laboratory because of the limitation of required head & discharges. Nevertheless, an attempt has been made to study the performance characteristics within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind of facility.

DESCRIPTION:

While the impulse turbine is discussed elsewhere in standard textbooks, Francis turbine (reaction type) which is of present concern consists of main components such as Impeller (runner), scroll casing and draft tube. Between the scroll casing and the Impeller there are guide vanes, which guides the water on to the impeller thus rotating the Impeller shaft. There are eight guide vanes, which can be turned about their own axis so that the angle of inclination may be adjusted while the turbine is in motion. When guide vane angles are varied, high efficiency can be obtained over wide range of operating conditions.

The actual experiment facility supplied consists of a sump tank, centrifugal pump set, turbine unit and Venturimeter arranged in such a way that the whole unit works on recirculating water system. The centrifugal pump set supplies the water from the sump tank to the turbine through control valve (Gate valve). The water from the pump passes through a Venturimeter (for measurement of discharge) to the turbine unit enters the sump tank through the draft tube.

The loading of the turbine is achieved by electrical dynamometer coupled to the turbine through a V-Belt drive (V grooved pulley). The control panel is equipped with a set of heaters (electrical resistance) in steps of 200Vats each, 10 No. (200 x 10 Total 2Kw) with individual switches are provided for loading the electrical dynamometer (in turn loading the turbine). The provisions for measurement of load (by digital Voltmeter & Ammeter), turbine speed (digital RPM indicator),

differential pressure across Venturimeter (Double column Mercury Manometer) & total head on turbine (pressure & vacuum gauge).

Specification:

Supply pump capacity : 7.5 Kw (10 Hp) 3ph, 400V

Turbine capacity : 2.6 HP (2 Kw)

Run away speed : 2000 RPM

TABULAR COLUMN

Constant Speed:

Sl No	Pressure Gauge reading 'P' Kg/cm^2	Head over the turbine 'H' in m	Presser Gauge reading in Kg/cm^2 Across Venturimeter		Δ h	Alternator		Flow rate 'Q' m^3/s	Input power Kw (Ip)	Out put power Kw (Op)	Turbine efficiency % η turb
			h$_1$	h$_2$		V volts	I amps				

Procedure:

1) Install the equipment near a 3 phase 440 volts, 50 Hz, 20 amps power source & water source.
2) Connect the panel to the electrical source & ascertain the direction of the pump is in order (clock wise direction from shaft end) by momentarily starting the pump.
3) Fill filtered clear water into the sump tank up to ¾th its full capacity.
4) Keep the gate valve situated above the pump in fully closed position, turbine guide vanes in full open position.
5) Start the pump, gradually open the gate valve slowly so that the turbine achieves sufficient speed to generate 200 volts on the panel voltmeter.
6) Wait till the speed of the turbine & generated voltage maintained constant.
7) Put on the first electrical load switch and adjust the speed of Turbine to 200V on the panel Voltmeter and record the corresponding Ammeter, Pressure gauge & Head over the notch readings.
8) Continue increasing the load on the Turbine step by step by switching ON the consecutive load switches one by one, by gradually opening the Gate valve so that the Voltmeter reading shows 200V on each step. Record the corresponding readings of Ammeter, Pressure Gauge & Head over the notch.
9) Change the Turbine guide vane to any desired position (between fully open to closed conditions) by operating the hand wheel situated at the rear end of the Turbine to repeat the experiment on varied condition by following steps 7 & 8.
10) After the experiment is over bring the turbine to no load condition by switching OFF the load switches one by one and simultaneously closing the Gate valve (care must be taken to avoid sudden increase in speed / Volts while switching 'off' the load switches) & stop the pump.
11) Tabulate all the recorded readings and calculate the input power, output power & efficiency of the Turbine.

Note: Drain all the water from the sump tank, refill with fresh clean water once in a month. When the equipment is not in use for a longer duration, drain all water from the sump tank keep it clean & dry.

Graphs to be plotted:
Main Characteristics Curves (constant Head)
1. Q_u Vs N_u
2. P_u Vs N_u
3. η_o Vs N_u

Operating Characteristics Curves (Constant Speed)
4. η_o Vs % full load.

Constant Head:

S1 No	Pressure Gauge reading 'P' Kg/cm²	Head over the turbine 'H' in m	Presser Gauge reading in Kg/cm² Across Venturimeter		Δ h	Alternator		Flow rate 'Q' m³/s	Input power Kw (Ip)	Out put power Kw (Op)	Turbine efficiency % η turb
			h₁	h₂		V volts	I amps				

CALCULATION

Out put power $Op = \dfrac{V \times I}{1000 \times \eta_{Gen}}$ $\eta_{Gen} = 0.75$

Input power $Ip = \dfrac{W\,Q\,H}{1000}$ where: $w = 9810\ n/m^3$

$Q = C_d\ k\sqrt{2\,g\,h}\ w$ $K = \dfrac{a_1\,a_2}{\sqrt{a^2_1 - a^2_2}}$

$C_d = 0.94$

Turbine efficiency $\eta_{Tur} = \dfrac{Out\ put\ power}{Input\ power} \times 100$ %

Unit speed, $N_u = \dfrac{N}{\sqrt{H}}$

Unit discharge $Q_u = \dfrac{Q}{\sqrt{H}}$

Unit power, P_u $= \dfrac{P_{shaft}}{H^{\frac{3}{2}}}$

Specific speed, N_s $= \dfrac{N\sqrt{P_{shaft}}}{H^{\frac{5}{4}}}$

EXPERIMENTAL SETUP
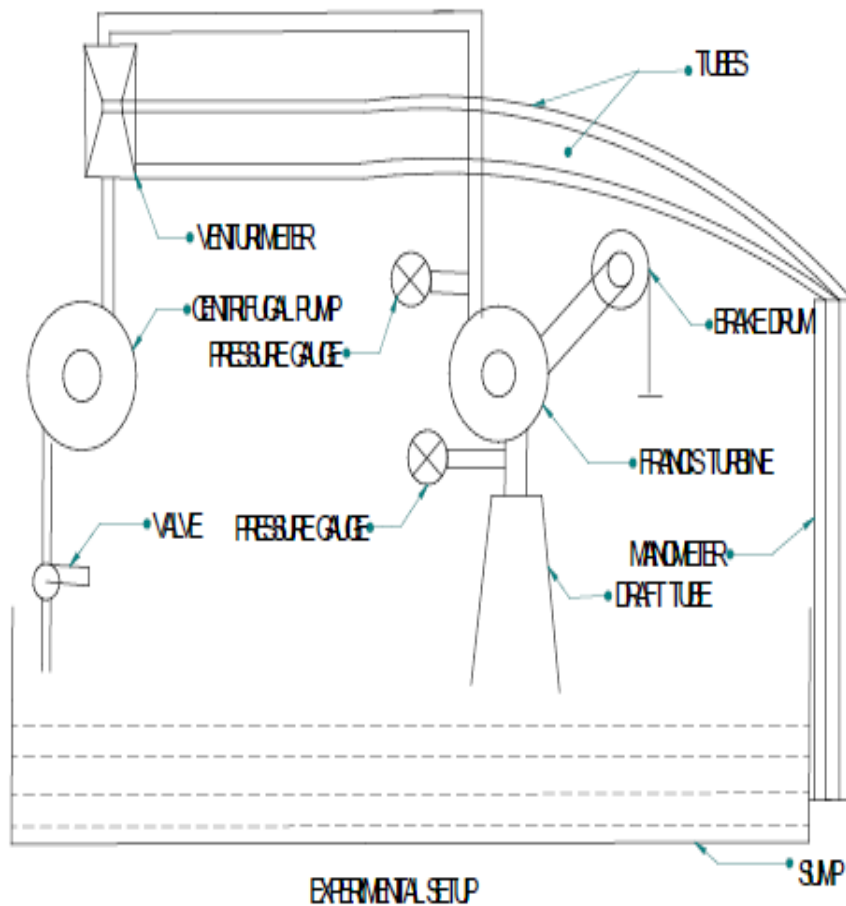
A NOTE ON THE SPECIFICATION OF FRANCIS TURBINE

Data:

* Maximum head available on turbine (H)   = 05- 09 m.

* Maximum flow rate available through Impeller (Q) = 0.035 m³ / s

                                             = 1200- 1500 lit / min

* Impeller Diameter   (D)   = 150 mm

* Number of Guide vanes   = 8 No's (adjustable)

Apparatus:

c) Centrifugal pump set, sump tank, turbine, piping system with Venturimeter to operate the Turbine on closed circuit water circulating system.

d) Digital RPM indicator, Digital Voltmeter, Ammeter, pressure gauge, flow control valve, with suitable electrical dynamometer loading with resistance bank (heaters), with switches, fan to decipate heat.

Experiment 10: SINGLE STAGE CENTRIFUGAL PUMP

AIM: To conduct performance test on a Single stage Centrifugal pump test rig.

INTRODUCTION:

A pump may be defined as mechanical device when interposed in a pipe line, converts the mechanical energy supplied to it from an external source into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential.

The pumps are of major concern to most engineers and technicians. The types of pumps vary in principle and design. The selection of the pump for any particular application is to be done by understanding their characteristics. The most commonly used pumps for domestic, agricultural and industrial are Centrifugal, axial flow, reciprocating, air jet, and diaphram and turbine pumps. Most of these pumps fall into the main class namely Rotodynamic, Reciprocating (positive displacement) and Fluid operated pumps.

THEORY:

The principle of operation of a single stage centrifugal pump is covered under Rotodynamic pump category. In this pump, the liquid is made to rotate in a closed volute chamber. Thus creating the centrifugal action, which gradually builds the pressure gradient towards outlet resulting in a continuous flow.

These pumps are of simple construction can be directly coupled to electric motor and more suitable for handling clear, semi viscous, as well as turbid liquids. The hydraulic head per stage at low flow rates is limited and hence not suitable for high heads, in case of single stage centrifugal pumps. But as the pump in this case in a multi stage construction the pressure gradually builds up in successive stages almost equally in each stage. Thus achieving considerably higher heads. The multi stage centrifugal pump test rig allows the students to understand and study the various characteristics and pressure build up pattern in individual stages.

DESCRIPTION:

The single stage Centrifugal pump test rig mainly consists of:

a) Single stage Centrifugal pump
b) AC Drive motor of suitable capacity coupled to pump by stepped pulley arrangement.
c) SS sump tank and measuring tank with a piezometer
d) G. I. Pipe connections with necessary control valve etc… mounted on a neatly painted M.S. structure. The panel board is equipped with an energy meter for measurement of power input to the motor, a digital RPM indicator to indicate the speed of the pump/motor, a Vacuum gauge to measure suction head, & pressure gauge for measurement of delivery head, a starter of suitable capacity, indicating lamps and fuse etc.

CALCULATIONS:

- **Basic data / constants:**

1 kg / cm²	=	760 mm Hg (10 m of water)
Density of water	=	1000 kg / m³ (9810 N / m³)
Area of collecting tank	=	0.125 m²

- **Discharge rate " Q " in m³ / s**

$$Q = \frac{A \times h}{t}$$

where 'h' is height of water collected in measuring tank for a time interval of 't' sec.

- **Total head " H " in m**

$$H = 10(\text{Delivery Pressure} + \text{Vacuum head})$$
$$= 10(P + Pv)$$

where P is pressure in kg / cm² , Pv is the Vacuum in mm of Hg

p=(1.032+ pressure reading)   Pv=(1.032- (suction pressure reading x 1.33 x 10⁻³))

- **Power input to motor (kW)**

Data: Energy meter constant E.M.C. = 3200 Rev/kw-h

$$I.P = \frac{K}{E.M.C.} \times \frac{60 \times 60}{t} \times \eta_{motor} = \quad kW.$$

Where η_{motor} = 0.70, (70 %)

Where 'K' is the number of revolutions energy meter disc = 10 rev
        't' is the time taken in seconds by the Energy Meter for K revolutions
        'η_m' = motor efficiency 0.70 (70%)

(1hp = 0.736 kW)
(1 kW = 1.36 hp.)

- **Output Power (delivered by the pump) kW**

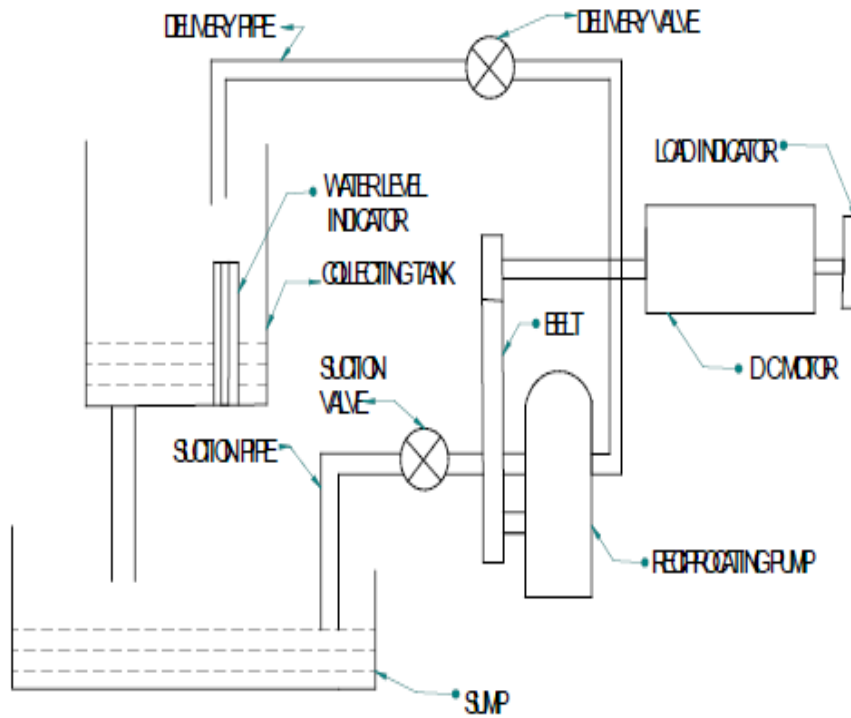$$= \frac{W \times Q \times H}{1000} \quad kW$$

Where W is 9810 N/m³

$$\% \eta_{pump} = \frac{\text{Out power } \times 100}{\text{Input power}}$$

Q is Discharge

Table of readings:

Speed N (rpm)	Delivery pressure p (kgf/cm²)	Suction pressure P_v mm of Hg	Time taken for 10 Impulse of energy meter (t_e) s	Water level rise in tank R		Discharge time t (s)
				mm	m	

Table of calculations:

Speed of pump N (rpm)	Head H m of water	Discharge Q (m³/s)	Power input to pump P_{in} (kW)	Power developed by pump P_p (kW)	Overall efficiency η_o (%)

EXPERIMENTAL SETUP

CALCULATIONS:

- Basic data / constants:

$1 kg/cm^2$	=	760 mm Hg (10 m of water)
Density of water	=	$1000 \ kg / m^3$
Area of collecting tank	=	$0.125 \ m^2$

- Discharge rate " Q " in m^3 / s

$$Q = \frac{A \times h}{t}$$

where 'h' is height of water collected in measuring tank for a time interval of 't' sec.

- Total head " H " in m

$$P_D = 1.032 + Reading$$
$$P_V = 1.032 - (Reading \times 1.315 \times 10^{-3})$$

$$H = 10 \ (\ Delivery \ Pressure + Vacuum \ head \ )$$
$$= 10 \ (\ P_D + Pv \ )$$

where P_D is pressure in kg / cm^2 , Pv is the Vacuum in mm of Hg

Experiment 11: RECIPRCATING PUMP TEST PUMP

AIM:

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

INTRODUCTION:

In general, a pump may be defined as mechanical device when connected in a pipe line, can convert the mechanical energy into hydraulic energy, thus resulting in the flow of liquid from lower potential to higher potential.

The pumps are of major concern to most engineers and technicians. The types of pumps vary in principle and design. The selection of the pump for any particular application is to be done by understanding their characteristics. The most commonly used pumps for domestic, agricultural and industrial are Centrifugal, axial flow (stage pumps), reciprocating, air jet, and diaphram and turbine pumps. These pumps fall mainly into a category of rotodynamic, reciprocating (positive displacement) and fluid operated pumps.

THEORY:

Reciprocating pump is a positive displacement pump. It mainly consists of a piston reciprocating inside a cylinder thus performing suction and delivery strokes. The cylinder is alternately filled and emptied by forcing and drawing the liquid by mechanical motion. This type is called positive type. Delivery and suction pipes are connected to a cylinder. Each of the two pipes is provided with a non-return valve. The function of which is to ensure unidirectional flow of liquid. It generally operates at low speed and is therefore to be coupled to a motor with V-belt. It is stable for small discharge and high heads. Generally these pumps are used for feeding small boilers, for lifting water to a higher heads & for pumping light oil. The present test rig allows the students to understand and draw the operating characteristics at various heads, flow rates and speeds.

DISCRIPTION:

The Reciprocating pump test rig mainly consists of:

a) Double stroke Reciprocating pump
b) AC Drive motor of suitable capacity coupled with a belt drive Variable speed stepped cone pully.
c) SS sump tank, SS measuring tank with a piezometer
d) G. I. Pipe connections with necessary control valve etc… mounted on a neatly painted M.S. structure.
e) The panel board is equipped with an energy meter for measurement of power input to the motor, a digital RPM indicator to indicate the speed of the pump, a Vacuum gauge to measure suction head , a pressure gauges for measurement of delivery head. a three phase starter of suitable capacity, main indicating lamps and fuses.

INPUT POWER   (I$_p$):

Data:

Energy meter constant E.M.C.= 1600 Imp / kw / h

$$(I_p) = \frac{n}{K} \times \frac{60 \times 60}{t} \times \eta_m$$

where 'n' is the number of impulse of energy meter

        't' is the time taken in seconds by the Energy Meter for n impulses

        'η_m' = motor efficiency 0.72 (72%)

- Output Power (delivered by the pump)

$$= \frac{W \times Q \times H}{1000}$$

where W is 9180 N/m^3

$$\% \eta_{overall} = \frac{Output\ power}{Input\ power} \times 100$$
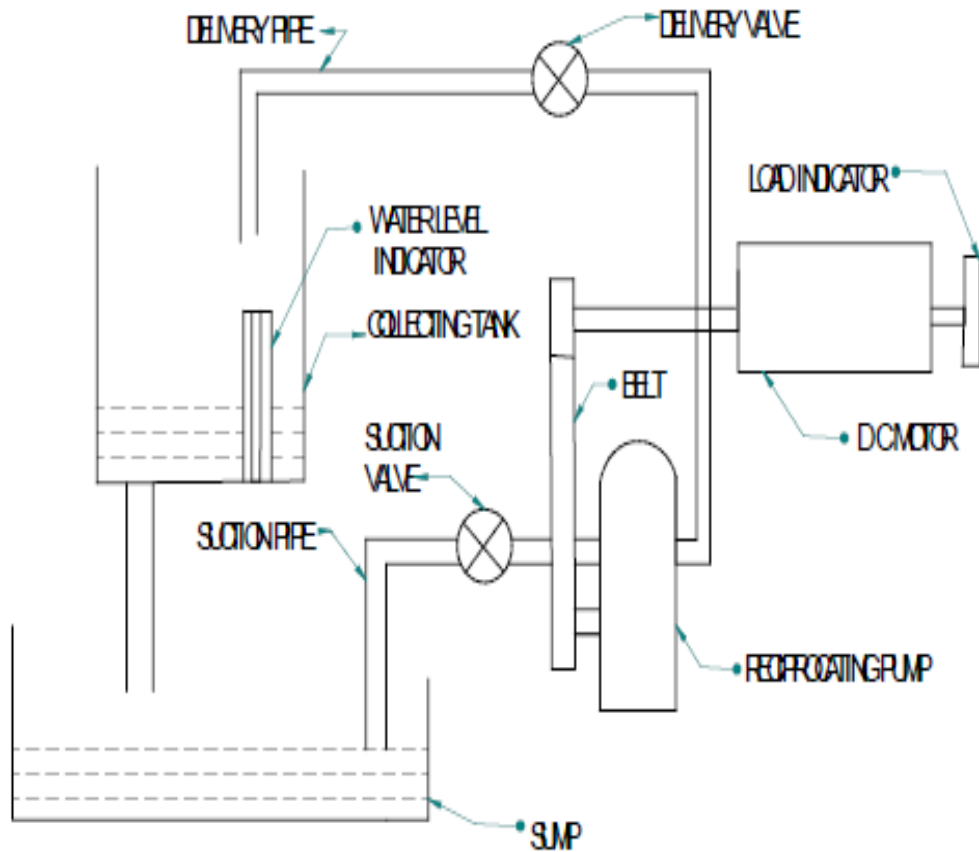
TABULAR COLUMN :

Drive Belt Size- B-53.

Sl.. No.	Speed of pump in rpm	Suction pressure 'P$_v$' (mm of Hg)	Delivery pressure 'P' Kg/cm^2	Energy meter reading for 10 pulses. 't' in sec's	10 cm raiseof water level in collecting tank 'T' in sec's
1.					
2.					
3.					
4.					

Calculated readings:

Sl.No.	I.p. (kW)	Discharge 'Q' m^3 / Sec	Head 'H' in mts of water	O.p.= $\frac{WQH}{1000}$ (kW)	%η = Op/Ip x 100
1					
2					

Procedure:

1. Connect the power cable to three phase, 440 volts, 10 Amps with earth connection
2. Fill water in air vessel.
3. Keep the delivery valve fully open.
4. Fill the sump tank with clean soft water.
5. Select the desired speed by adjusting the step cone pulley - motor base handle.
6. Switch on the mains, the mains on indicators glow, now switch on the pump, water starts flowing to the measuring tank.
7. Note down the pressure gauge, vacuum gauge reading and time for number of revolutions of energy meter disc at full opening of delivery valve.
8. Operate the butterfly valve to note down the collecting tank reading against the known time, and keep it open when the readings are not taken.
9. Repeat the experiment for different openings of delivery valve and note down the readings as above
10. Repeat the experiment for different speeds and repeat the steps from 5 to 8.
11. Tabulate the readings.
12. After the experiment is over switch off the mains and keep the delivery valves fully open.
13. Calculate the efficiency of the pump.

EXPERIMENTAL SETUP

CALCULATIONS:

- Basic data / constants:

1kg/cm^2	=	760 mm Hg (10 m of water)
Density of water	=	1000 kg / m^3
Area of collecting tank	=	0.125 m^2

- Discharge rate " Q " in m^3 / s

$$Q = \frac{A \times h}{t}$$

where 'h' is height of water collected in measuring tank for a time interval of 't' sec.

- Total head " H " in m

$$P_D = 1.032 + \text{Reading}$$
$$P_V = 1.032 - (\text{Reading} \times 1.315 \times 10^{-3})$$

$$H = 10 \, (\text{Delivery Pressure} + \text{Vacuum head})$$
$$= 10 \, (P_D + Pv)$$

where P_D is pressure in kg / cm^2 , Pv is the Vacuum in mm of Hg

---

Experiment 12.KAPLAN TURBINE TESTING RIG

AIM:

1. To study the working principle of Kaplan (reaction) turbine.
2. To understand the functional aspects of various components constituting the turbine.
To study performance characteristics of turbine at various heads, flow rates and speeds

INTRODUCTION:

Hydraulic (water) Turbines are the machines, which use the energy of water (Hydro –power) and convert it into Mechanical energy, which is further converted into electrical energy. Thus the turbine becomes the primover to run the electrical generators to produce electricity (Hydroelectric power).

The Turbines are classified as impulse & reaction types. In impulse turbine, the head of water is completely converted into a jet, which exerts the force on the turbine; it is the pressure of the flowing water, which rotates the runner of the turbine. Of many types of turbine, the Pelton wheel, most commonly used, falls into the category of impulse turbine, while the Francis & Kaplan falls into the category of reaction turbines.

Normally, Pelton wheel (impulse turbine) requires high heads and low discharge, while the Francis & Kaplan (reaction turbines) require relatively low heads and high discharge. These corresponding heads and discharges are difficult to create in laboratory because of the limitation of required head & discharges. Nevertheless, an attempt has been made to study the performance characteristics within the limited facility available in the laboratories. Further, understanding various elements associated with any particular turbine is possible with this kind of facility.

DESCRIPTION:

While the impulse turbine is discussed elsewhere in standard textbooks, Kaplan turbine (reaction type) which is of present concern consists of main components such as propeller (runner), scroll casing and draft tube. Between the scroll casing and the runner, the water turns through right angle into axial direction and passes over the runner and thus rotating the runner shaft. The runner has four blades, which can be turned about their own axis so that the angle of inclination may be adjusted while the turbine is in motion. The runner blade angles can be varied to obtain higher efficiency over wide range of operating conditions. In other words even at part loads, when a low discharge is flowing over the runner, a high efficiency can be attained in case of Kaplan turbine. Where as this provision does not exist in Francis & Propeller turbines where the runner blade angles are fixed and integral with the hub.

The actual experimental setup consist of a centrifugal pump set, turbine unit, sump tank, arranged in such a way that the whole unit works on recirculating water system. The centrifugal pump set

Specification:

Supply pump capacity   : 7.5 Kw (10 Hp) 3ph, 400V

Turbine capacity   : 2.6 HP (2 Kw)

Run away speed   : 2000 RPM

OBSERVATION TABLE

CONSTANT SPEED:

Sl No	Turbine speed 'N' rpm	Pr Gauge reading 'P' Kg/cm^2	Head over turbine 'H' in m	Manometer reading		Load		Flow rate 'Q' m^3/s	Input power kW	Brake power Bp kW	Turbine efficiency % η_{turb}
				L$_1$	L$_2$	Voltage V Volts	Current I Amps				
1											
2											
3											
4											
5											

CONSTANT HEAD:

Sl No	Turbine speed 'N' rpm	Pr Gauge reading 'P' Kg/cm^2	Head over turbine 'H' meters	Manometer reading		Load		Flow rate 'Q' m^3/s	Input power kW	Brake power Bp kW	Turbine efficiency % η_{turb}
				L$_1$	L$_2$	Voltage V Volts	Current I Amps				
1											
2											
3											
4											
5											

CALCULATIONS:

1. Head on turbine H :

   $H = 10 \times P$ where P is the pressure gauge reading in Kg/cm^2

   Flow rate of water $Q = \dfrac{Cd \times a_1 \times a_2}{\sqrt{a_1{}^2 - a_2{}^2}} \times \sqrt{2gh}$ m^3/s

   Where   g = 9.81 m/s^2
   C_d = 0.62

   a$_1$ =
   a$_2$ =
   h = $(h_2 - h_1) \times 12.6$ m

   Where $\dfrac{\rho_{hg} - \rho_w}{\rho_w} \times (h_2 - h_1)$ m

2. Input power (Hydraulic power input to Turbine)

   $Ip = \dfrac{WQH}{1000}$ Kw   where W = 9810 N/m^3

3. Output power

   $Op = \dfrac{V \times I}{1000 \times \eta_{gen}}$ Kw   Where $\eta_{gen} = 0.7$

4.   % Turbine efficiency
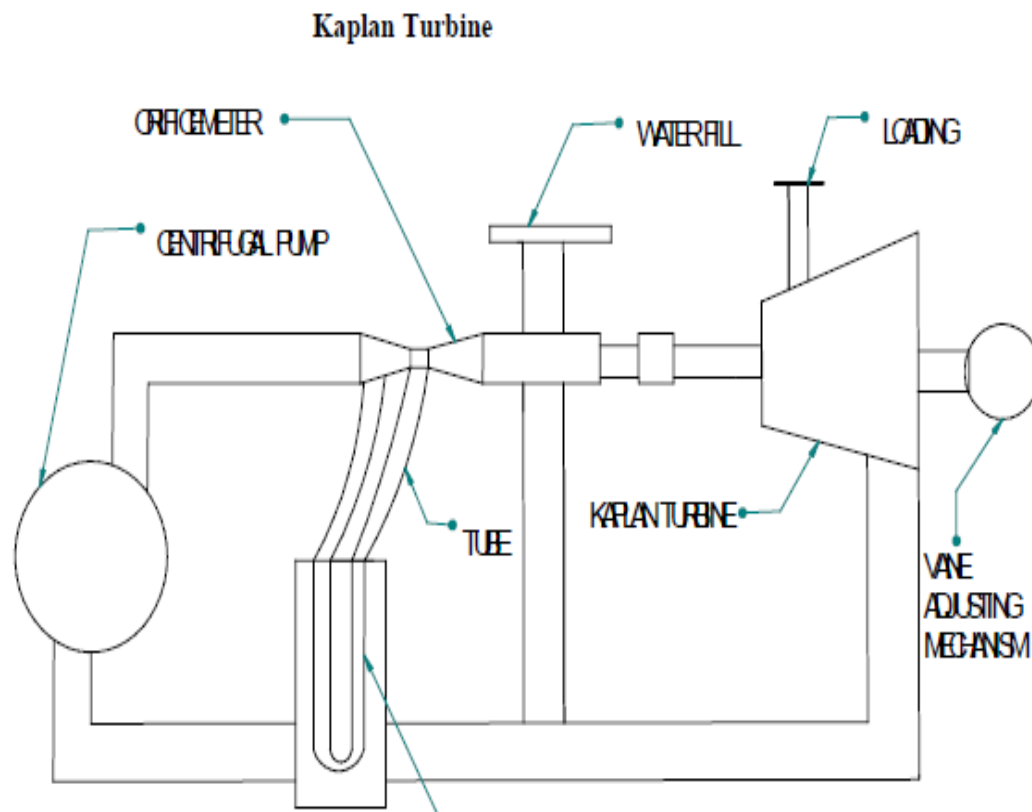
   $\eta_{turb} = \dfrac{\text{Output power}}{\text{Input power}} \times 100$

   Unit speed, N_u $= \dfrac{N}{\sqrt{H}}$

   Unit discharge Q_u $= \dfrac{Q}{\sqrt{H}}$

   Unit power, P_u $= \dfrac{P_{shaft}}{H^{\frac{3}{2}}}$ Specific speed, N_s $= \dfrac{N\sqrt{P_{shaft}}}{H^{\frac{5}{4}}}$

Kaplan Turbine

A NOTE ON THE SPECIFICATION OF KAPLAN TURBINE

DATA:

* Maximum head available on turbine(H)   = 9 - 12 m

* Maximum flow rate available through runner(Q)   = 0.05 m³ / s
                      = 3000 lit / min

* Propeller Diameter (D)   = 150 mm

* Number of Propeller Blades   = 4 No's (adjustable)

* Hub Diameter   (d)   = 60 mm

APPARATUS:

a. Centrifugal pump set, sump tank, turbine, piping system to operate the
Turbine on closed circuit water circulating system

b. Digital RPM indicator, pressure gauge, flow control valve, with suitable electrical
dynamometer loading with resistance bank (heaters), switches, fan to dissipate heat form   the
resistance (heaters) load

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.