

QMP 7.1 D/F



Channabasaveshwara Institute of Technology

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



Department of Mechanical Engineering

Turbo Machines Laboratory

BME502

B.E - V Semester

Lab Manual 2025-26

Name: _____

USN : _____

Batch : _____ Section : _____



Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Recognized by A.I.C.T.E. New Delhi)

(NAAC Accredited & An ISO 9001:2015 Certified Institution)

NH 206, (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka



Department of Mechanical Engineering

Turbo Machines Lab Manual

Version 2.0

August 2025

Prepared by:

Dr. Sushma. S
Assistant Professor

Reviewed by:

Dr. Nagesh S B
Assistant Professor

Approved by:

Dr. **Giridhar S Kulkarni**

Professor & Head,
Dept. of ME



Channabasaveshwara Institute of Technology

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



DEPARTMENT OF MECHANICAL ENGINEERING.

TURBO MACHINES LAB SYLLABUS

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

Course Code	BME502	CIE Marks	25
Number of Practicle Hours/Week	02	SEE Marks	0
credits	04	Exam Hours	0

Course Objectives:

Conduct basic experiments of fluid mechanics, energy conversion and understand the experimental uncertainties.

Course outcomes:

- Perform basic experiments of fluid mechanics, energy conversion and understand the experimental uncertainties.

SI.NO	Experiments
1	Performance analysis of Pelton wheel
2	Performance analysis of Francis Turbine
3	Performance analysis of Kalpan Turbine
4	Performance analysis of centrifugal blower
5	Performance analysis of centrifugal pump
6	Performance analysis of Axial fan and radial fan

Reading:

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



Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Recognized by A.I.C.T.E. New Delhi)

(NAAC Accredited & An ISO 9001:2015 Certified Institution)

NH 206, (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka



DEPARTMENT OF MECHANICAL ENGINEERING.

Course Objectives

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

Course Outcomes

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



Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Recognized by A.I.C.T.E. New Delhi)

(NAAC Accredited & An ISO 9001:2015 Certified Institution)

NH 206, (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka



DEPARTMENT OF MECHANICAL ENGINEERING

General Instructions to the Students

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



Channabasaveshwara Institute of Technology

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



DEPARTMENT OF MECHANICAL ENGINEERING

Sl. No.	Particulars	Page No
1	Performance analysis of Pelton wheel	1
2	Performance analysis of Francis Turbine	9
3	Performance analysis of Kaplan Turbine	15
4	Performance analysis of centrifugal blower	21
5	Performance analysis of centrifugal pump	27
6	Viva - Voice	33
7	References	36



Channabasaveshwara Institute of Technology

(Affiliated to VTU, Belgaum & Recognized by A.I.C.T.E. New Delhi)

(NAAC Accredited & An ISO 9001:2015 Certified Institution)

NH 206 (B.H. Road), Gubbi, Tumkur – 572 216. Karnataka.



DEPARTMENT OF MECHANICAL ENGINEERING

LECTURE PLAN

Faculty Name:

Sem. & Sec.: V 'A'

Sub: TM LAB

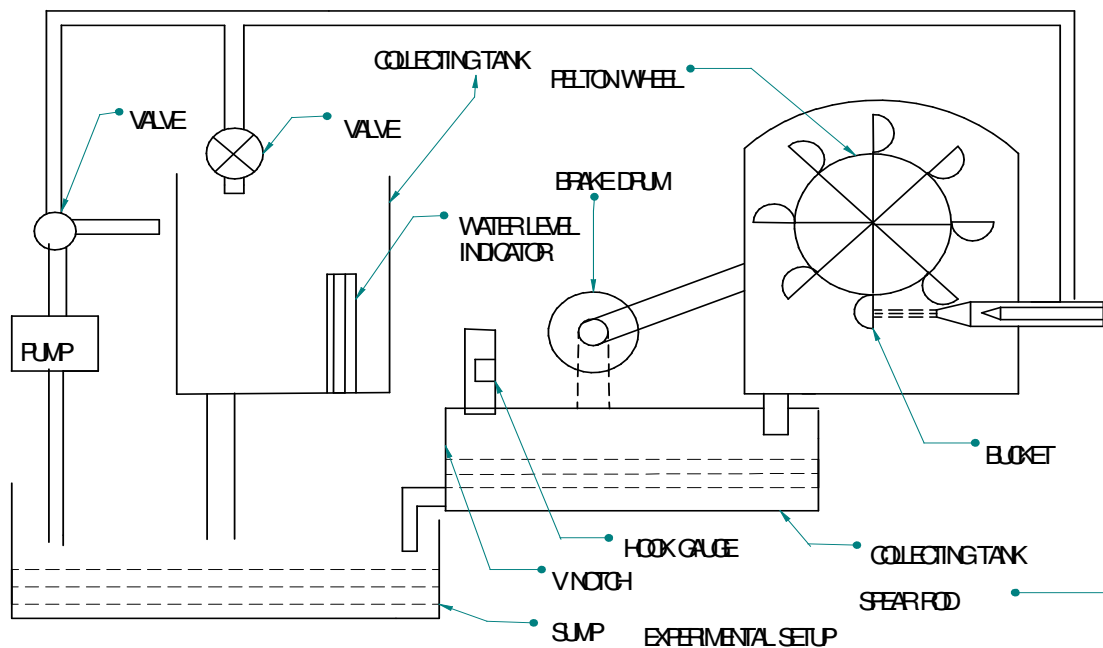
Sub. Code: BME502

Sl.No.	Date	Lesson Plan No.	Name of the Experiment	Remarks
1		LP.1	Performance analysis of Pelton wheel	
2		LP.2	Performance analysis of Francis Turbine	
3		LP.3	Performance analysis of Kaplan Turbine	
4		LP.4	Performance analysis of centrifugal blower	
5		LP.5	Performance analysis of centrifugal pump	
6		LP.6	Revision/IA	

Signature of staff

HOD

Pelton Wheel



A NOTE ON THE DESIGN OF PELTON TURBINE

DATA:

- * Maximum head available on turbine(H) = 50 m
- * Maximum flow rate available through runner(Q) = $0.005 \text{ m}^3 / \text{s}$
- * Runner Diameter (D) = 0.31 m
- * Number of Buckets = 20 no's

APPARATUS:

- a) Centrifugal pump set, sump tank, notch tank, turbine, piping to operate the turbine on closed circuit water circulating system
- b) Digital RPM indicator, pressure gauge, flow control valve, mechanical loading with Spring balance

EXPERIMENT NO. 1

PELTON TURBINE TEST RIG
(MECHANICAL BRAKEDRUM LOADING)**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 from 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	Flow rate 'Q' m ³ /s	Input power kW	Brake power Bp kW	Turbine efficiency % η_{turb}
					Kg				
					$S_2-S_1= S$				

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 $\frac{3}{4}$ th 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.

Constant Head:

Sl No	Turbine speed 'N' rpm	Pr Gauge reading 'P' Kg/cm ²	Head over turbine 'H' meters	Head over the notch h ₂ -h ₁ =h meters	Spring balanced reading Kg	Flow rate 'Q' m ³ /s	Input power kW	Brake power Bp kW	Turbine efficiency % η _{turb}
					S ₂ -S ₁ = S				

CALCULATIONS:

1. Head on turbine H:

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

$$2. \text{ Flow rate of water, } Q = \frac{2}{3} C_d b \sqrt{2g} h^{3/2} \text{ m}^3/\text{sec}$$

$$g = 9.81 \text{ m/sec}^2$$

$$C_d = 0.9$$

$$b = \text{Width of notch in m}$$

$$h = \text{Head over the notch in m}$$

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

Work Sheet

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 + 0.016)

5. Turbine efficiency

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

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

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

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

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

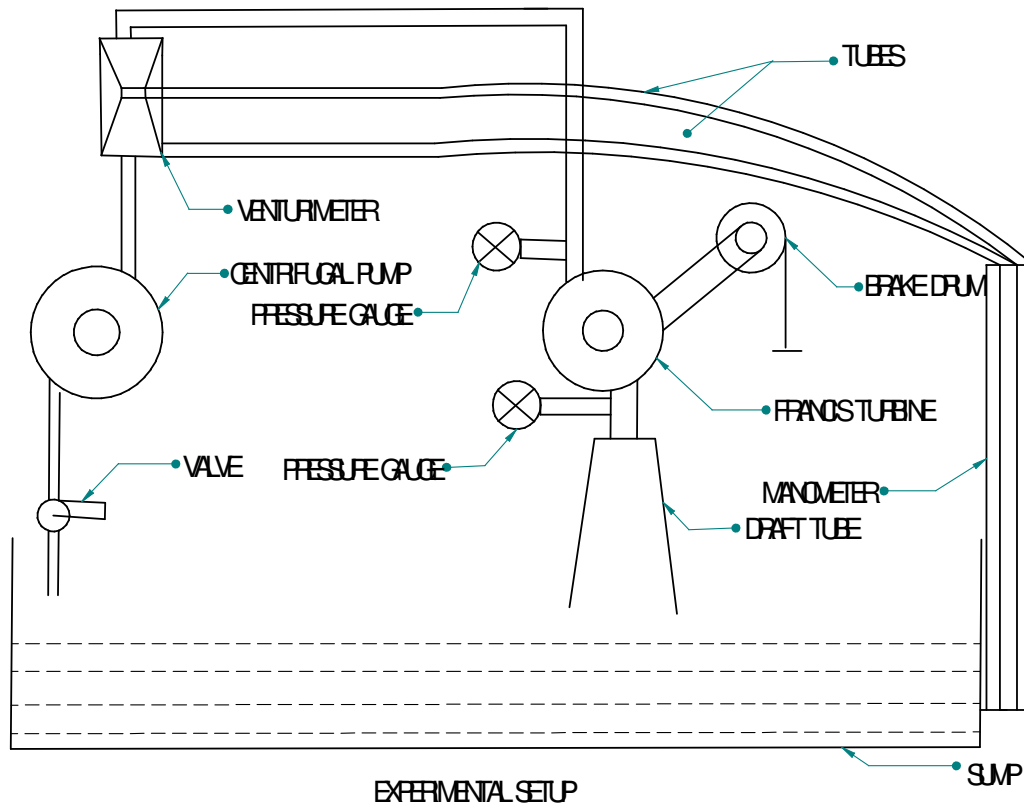
Graphs to be plotted:**Main Characteristics Curves (constant Head)**

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.

Work Sheet



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) = $0.035 \text{ m}^3 / \text{s}$
= 1200- 1500 lit / min
- * Impeller Diameter (D) = 150 mm
- * Number of Guide vanes = 8 No's (adjustable)

EXPERIMENT NO. 2

**FRANCIS TURBINE TEST RIG
(USING VENTURIMETER)****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 (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		Δh	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 $\frac{3}{4}$ th 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.

Constant Head:

Sl No	Pressure Gauge reading 'P' Kg/cm ²	Head over the turbine 'H' in m	Presser Gauge reading in Kg/cm ²		Δh	Alternator		Flow rate 'Q' m ³ /s	Input power Kw (Ip)	Output power Kw (Op)	Turbine efficiency % η_{turb}
			Across Venturimeter			V volts	I amps				
			h_1	h_2							

CALCULATION

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

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

$$Q = C_d k \sqrt{2 g h w} \quad K = \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}}$$

$$C_d = 0.94$$

$$\text{Turbine efficiency } \eta_{Tur} = \frac{\text{Output power}}{\text{Input power}} \times 100 \quad \%$$

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

$$\text{Unit discharge } Q_u = \frac{Q}{\sqrt{H}}$$

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

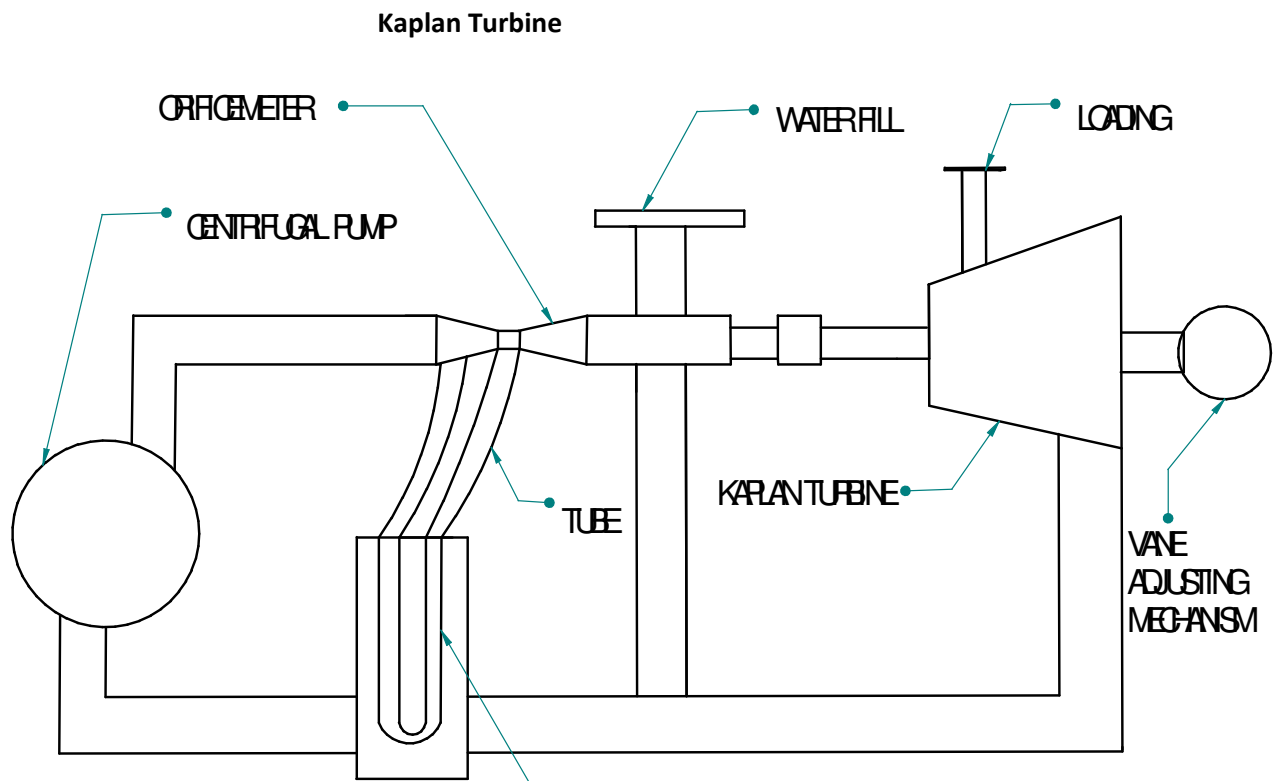
$$\text{Specific speed, } N_s = \frac{N \sqrt{P_{shaft}}}{H^{\frac{5}{4}}}$$

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.



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 m ³ / s
= 3000 lit / min |
| * Propeller Diameter (D) | = 150 mm |
| * Number of Propeller Blades | = 4 No's (adjustable) |
| * Hub Diameter (d) | = 60 mm |

EXPERIMENT NO. 3

KAPLAN TURBINE TEST RIG
(USING ORFICE METER)**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 supplies the water from the sump tank to the turbine through control valve (Butterfly valve) and passes through and orifice meter connected to a double column mercury manometer which facilitates to obtain the quantity of water discharged form the turbine unit. Water after passing through 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). A set of heaters (electrical resistance) in steps of 200 Watts each, 10 no. (Total 2Kw) with individual switches provided for loading the electrical dynamometer (in turn loading the turbine). The provisions for measurement of turbine speed (digital RPM indicator), head on turbine (pressure gauge) are built-in on the control panel.

SPECIFICATION:

Supply pump capacity : 7.5 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}
						Voltage	Current				
				L ₁	L ₂	V Volts	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}
						Voltage	Current				
				L ₁	L ₂	V Volts	I Amps				
1											
2											
3											
4											
5											

OPERATING PROCEDURE:

Install the equipment near a 3 phase 440 volts, 50 Hz, 20 amps power source & water source.

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 & discharge tank upto the flow channel level.
3. Keep the butterfly valve situated above the pump in partially closed position & turbine runner blade in full open position.
4. Start the pump, gradually open / close the butterfly valve so that the turbine achieves sufficient speed to generate 220volts on the panel voltmeter
5. Wait till the speed of the turbine & generated voltage maintained constant.
6. Open all the valves provided on the manometer fully and the valves across the orifice meter partially to release the air trapped in the manometer and observe water flowing through the air vent tubes.
7. Close both the air vent valves simultaneously and read the difference of mercury level in the manometer limbs to obtain the discharge.
8. Switch "ON" the first two electrical load switches and adjust the speed of Turbine to 220V on the panel Voltmeter by adjusting the flow control valve and record the corresponding Ammeter, Pressure gauge and manometer readings.
9. Continue increasing the load on the Turbine step by step by switching "ON" the consecutive load switches in sets of two and maintain the panel voltmeter reading at 220V by adjusting the flow control valve accordingly.
10. Record the relative voltmeter, ammeter, pressure gauge and manometer readings on each step.
11. Bring the Turbine to no load condition by switching OFF the load switches in steps.
12. Change the Turbine Runner position by operating the hand wheel situated at the rear end of the Turbine & repeat the experiment following the steps 10 to 12.
13. After the experiment is over bring the turbine to no load condition & stop the pump.
14. Tabulate all the recorded readings and calculate the output power, input power & efficiency of the Turbine.

CALCULATIONS:

1. Head on turbine H :

$H = 10 \times P$ where P is the pressure gauge reading in Kg/cm²

$$\text{Flow rate of water } Q = \frac{C_d \times a_1 \times a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh} \quad \text{m}^3/\text{s}$$

Where $g = 9.81 \text{ m/s}^2$

$$C_d = 0.62$$

$$a_1 =$$

$$a_2 =$$

$$h = (12 - 11) \times 12.6 \text{ m.}$$

$$\text{Where } \frac{\rho h g - \rho_w}{\rho_w} \times (12 - 11) \text{ m}$$

2. Input power (Hydraulic power input to Turbine)

$$I_p = \frac{WQH}{1000} \quad \text{Kw} \quad \text{where } W = 9810 \text{ N/m}^3$$

3. Output power

$$O_p = \frac{V \times I}{1000 \times \eta_{\text{gen}}} \quad \text{Kw} \quad \text{Where } \eta_{\text{gen}} = 0.7$$

4. % Turbine efficiency

$$\eta_{\text{turb}} = \frac{\text{Output power}}{\text{Input power}} \times 100$$

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

$$\text{Unit discharge } Q_u = \frac{Q}{\sqrt{H}}$$

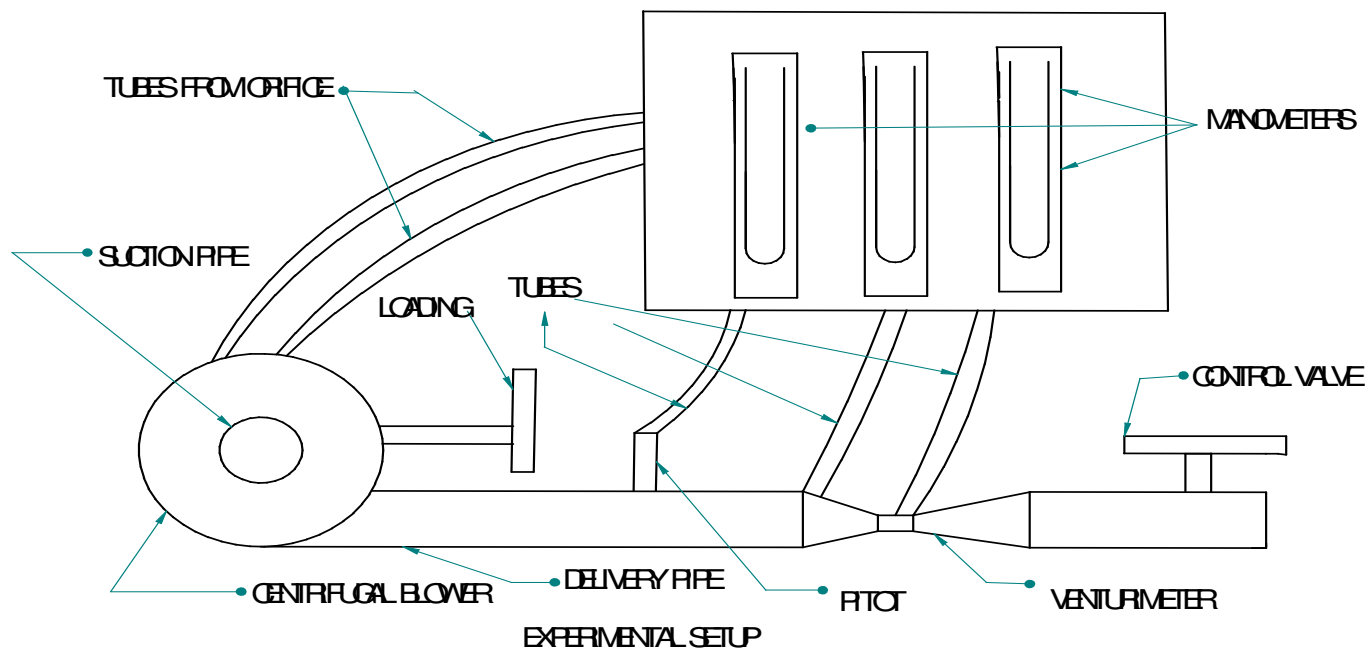
$$\text{Unit power, } P_u = \frac{P_{\text{shaft}}}{H^{\frac{3}{2}}} \quad \text{Specific speed, } N_s = \frac{N \sqrt{P_{\text{shaft}}}}{H^{\frac{5}{4}}}$$

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.



CALCULATION

1 Discharge

$$Q = A \times V \quad \text{m}^3/\text{s}$$

Where V = average of anemometer Readings
 C.S Area of the duct = 0.12m^2

2. Input power of A/C Motor

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

where : n = no of energy meter
 disc revolutions

k = energy meter constant
 t = time taken for no of in sec
k = 3600 rev / kw-hr

EXPERIMENT NO. 4

CENTRIFUGAL AIR BLOWER TEST RIG

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

INTRODUCTION:

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

PROCEDURE:

1. Connect the control panel input power cable to 3ph A.C.supply , with neutral and earth.
2. keep all the Switches /controls in Off position.
3. Switch On the mains and observe the 3ph light indicators glow.
4. Turn the rotary switch clock wise to put on the panel meters.
5. Ascertain sufficient measuring fluid (water) in manometers & the direction of rotation of the blower as indicated on the casing.
6. Keep the outlet butterfly valve fully open.
7. Switch on the starter so that the motor speed builds up to the rated rpm.
8. Keep the pitot tube half way above the center of the duct.
9. Record all the readings indicated by manometer, energy meter (Time for 2 rev) at valve full open position.
10. Change the valve to 60⁰ position and record the all readings.
11. Similarly record the readings on 30⁰ and fully closed positions.
12. Tabulate all the readings and calculate.
13. Repeat the experiment on different impellers
14. After the experiment switch off the motor and electrical mains.

3. Output power of blower O_p

$$(O_p)_{\text{Blower}} = \frac{W_a \times Q \times H}{1000}$$

$$W_a = 12.65 \text{ N/m}^3$$

$$\rho_a = 1.29 \text{ kg/m}^3$$

$$\Delta H = hw \left[\frac{\rho_w}{\rho_a} - 1 \right] \text{ m}$$

$$\text{where } hw = \Delta H \times 768.2 \text{ m}$$

$$H = hw \times \text{pitot constant} \quad \text{where pitot const.} = 5$$

4. Blower Efficiency

$$\eta_{\text{Blower}} = 100 \times \frac{O_p_{\text{Blower}}}{I_p_{\text{Blower(Ele)}}}$$

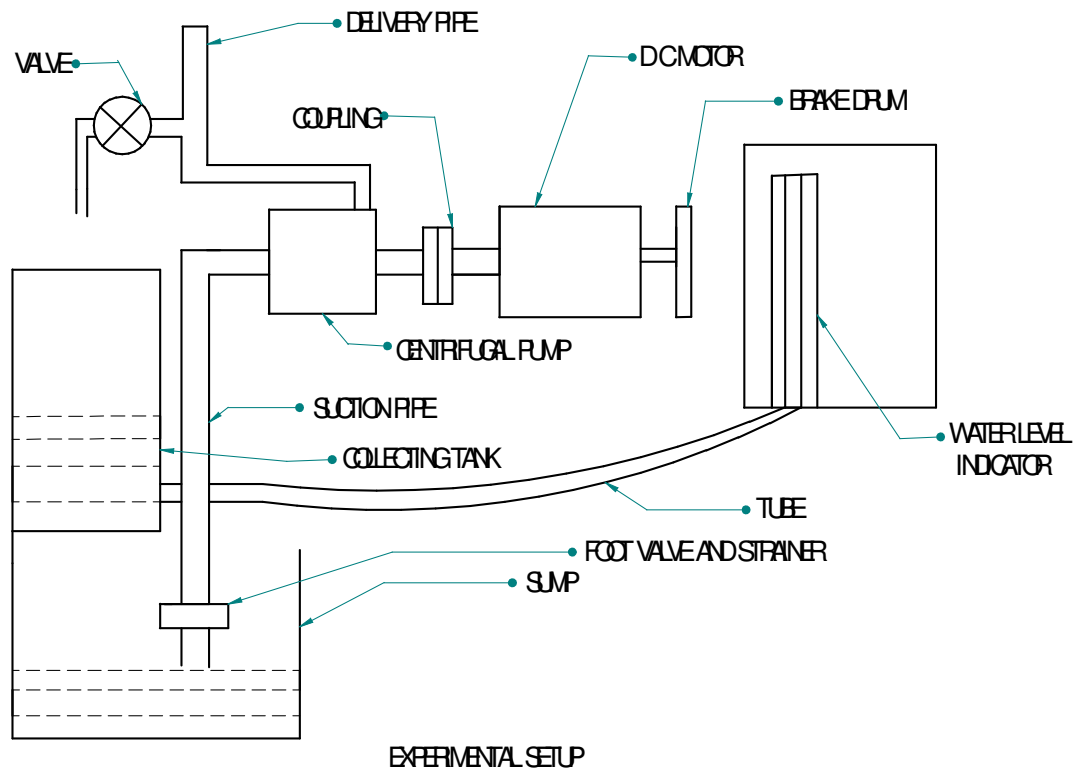
Work Sheet

TABULAR COLUMN OBSERVATION**Type of Impellers backward / forward / straight (Radial)**

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

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

Work Sheet



SPECIFICATIONS:

Single stage pump with Motor

Sump tank:

MOC: Stainless Steel,

Measuring tank:

MOC: Stainless Steel

Area of cross section: 0.125 m^2 (Measuring tank)

Drive Belt Size: - A-26

EXPERIMENT NO. 5

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 diaphragm 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:**

$$1 \text{ kg / cm}^2 = 760 \text{ mm Hg (10 m of water)}$$

$$\text{Density of water} = 1000 \text{ kg / m}^3 \text{ (9810 N / m}^3 \text{)}$$

$$\text{Area of collecting tank} = 0.125 \text{ m}^2$$

• **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**

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

$$= 10(P + P_v)$$

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

$$p = (1.032 + \text{pressure reading}) \quad P_v = (1.032 - (\text{suction pressure reading} \times 1.33 \times 10^{-3}))$$

• **Power input to motor (kW)**

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

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

$$\text{Where } \eta_{\text{motor}} = 0.70, (70 \%)$$

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**

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

Where W is 9810 N/m³

$$\% \eta_{\text{pump}} = \frac{\text{Out power} \times 100}{\text{Input power}} \quad Q \text{ is Discharge}$$

Work Sheet

Table of readings:

Speed N (rpm)	Delivery pressure p (kgf/cm ²)	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 (m ³ /s)	Power input to pump P _{in} (kW)	Power developed by pump P _p (kW)	Overall efficiency η _o (%)

Work Sheet

VIVA QUESTIONS & ANSWERS

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 fluid, 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 into 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 into hydraulic energy by sucking the liquid into 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.

REFERENCE BOOKS:

- A textbook of Fluid Mechanics by "Dr. R.K. Bansal", Laxmi publications ,2004.
- Fluid Mechanics (SI Units), Yunus A. Cengel John M Oimbala, 2nd Ed., Tata McGraw Hill, 2006.
- Fluid Mechanics and Fluid power Engineering, Kumar D.S, kataria and Sons.,2004.