Vidya Jyothi Institute of Technology

(Accredited by NBA, Approved by AICTE New Delhi)

Aziz nagar Gate, C.B. Post, Hyderabad-500 075

DEPARTMENT OF MECHANICAL ENGINEERING

REGULATION	**:**	R15
BATCH	**:**	2017-2021
ACADEMIC YEAR	**:**	2018-19
PROGRAM	**:**	B.TECH (MECHANICAL ENGINEERING)
YEAR/SEM	**:**	II &II
COURSE NAME	**:**	Mechanics of Fluids and Hydraulic Machines
COURSE CODE	**:**	A14385

NAME OF THE FACULTY:

DESIGNATION: **ASSISTANT PROFESSOR**

S.No	Items
1	Course Outcomes
2	Timetable
3	List of Experiments
4	List of Equipment in Laboratory
5	Laboratory Manual
6	Experiment Schedule
7	Day to Day Evaluation
8	Rubrics for evaluation of experimental work
9	Sample Copy of Lab Record
10	Direct Attainment
11	Course Exit Survey for Indirect Attainment
12	Course Closure report

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MOFHM LAB CO'S II Year - II – SEMESTER

Mechanics of Fluids and Hydraulic Machines Lab A14385	**CO1**	Practical exposure of using components like vacuum gauge, pressure gauge, manometers, pipes, motors, pumps, turbines.
	CO2	Measure fluid flow using Ventutimeter and Orificemeter.
	CO3	Understand friction factor and minor losses in a pipe line
	CO4	Understand and calculate performance of turbines and pumps at constant speed and head.
	CO5	Know and understand the impact of jet on vanes and Bernoulli's theorem.

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CO PO MAPPING OF MOFHM LAB

		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
Mechanics of Fluids and Hydraulic Machines Lab A14385	CO1	3	3	3	3		2	2	1	3	3		3		2
	CO2	3	3	3	3		2	2	1	3	3		2		2
	CO3	3	3	3	3		2	2	1	3	3		1		
	CO4	3	3	3	3	-	-	-	2	3	3	-	3	-	3
	CO5	3	3	3	3	-	3	2	2	3	3	-	3	-	3
AVG		**3**	**3**	**3**	**3**	**-**	**3**	**2.67**	**2**	**3**	**3**	**-**	**3**	**-**	**3**

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DEPARTMENT OF MECHANICAL ENGINEERING

ENGINEERING WORKSHOP LAB

TIME TABLE

MECHANICAL ENGINEERING DEPARTMENT

TIMETABLE 2019-20 w.e.f. 09-12-2019

II B.Tech II Sem SECTION-A

TIME/ DAY	9.00- 9.55	9.55- 10.50	10.50- 11.45	11.45- 12.30	12.30- 01.25	01.25- 02.20	02.20- 03.15	03.15- 04.05
MON	BEE	PS	KOM		TE	MFHM	GS	SAE
TUE	MFHM	BEE	TE		KOM	PS	VAC/GUEST LEC	
WED	KOM	TE	BEE		MFHM	MD&D		
THU	PS	KOM	MFHM		BEE	MFHM/BEE LAB		
FRI	MFHM/BEE LAB				TE	KOM	PS	BEE
SAT	TE	MFHM	PS		GS	MD&D		

SL.NO	SUBJECT	FACULTY
1	THERMAL ENGINEERING	Mr.K. RAVI KUMAR
2	KINEMATICS OF MACHINES	Mr.S. VENKATESH
3	MECHANICS OF FLUIDS AND HYDRAULIC MACHINES	Mr.C. NAVEEN RAJ
4	MACHINE DRAWING AND DRAFTING	Mr.T. PAVAN KUMAR/ Mr.RAMAKANTH
5	BASIC ELECTICAL ENGINEERING	S.CHAITANYA
6	PROBABILITY AND STATISTICS	ANURADHA
7	MECHANICS OF FLUIDS AND HYDRAULIC MACHINES-LAB	S.Prasad/ Mr.J.PRADEEPKUMAR
8	BASIC ELECTICAL ENGINEERING-LAB	S.CHAITANYA
9	GENDER SENSITIZATION	SUNEETHA
10	VALUE ADDED COURSE - II (VAC-II)	
11	SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)	

MECHANICAL ENGINEERING DEPARTMENT

TIMETABLE 2019-20 w.e.f. 09-12-2019

II B.Tech II Sem SECTION-B

TIME/ DAY	9.00- 9.55	9.55- 10.50	10.50- 11.45	11.45- 12.30	12.30- 01.25	01.25- 02.20	02.20- 03.15	03.15- 04.05
MON	TE	KOM	KOM		BEE	PS	MFHM	SAE
TUE	PS	TE	BEE		MFHM	KOM	VAC/GUEST LEC	
WED	MFHM	TE	BEE		GS	MFHM/BEE LAB		
THU	MD&D				TE	BEE	GS	PS
FRI	KOM	PS	MFHM		TE	MD&D		
SAT	MFHM/BEE LAB				PS	MFHM	BEE	KOM

SL.NO	SUBJECT	FACULTY
1	THERMAL ENGINEERING	Mr.K.ASHOKACHARY
2	KINEMATICS OF MACHINES	Ms.P. PAVANI
3	MECHANICS OF FLUIDS AND HYDRAULIC MACHINES	Mr.K. RAJESH KUMAR
4	MACHINE DRAWING AND DRAFTING	S.Prasad/ Mr.J.PRADEEPKUMAR
5	BASIC ELECTICAL ENGINEERING	Mr.L.RAJU
6	PROBABILITY AND STATISTICS	Mrs. FOUSIA
7	MECHANICS OF FLUIDS AND HYDRAULIC MACHINES-LAB	Mr.K.RAJESH KUMAR/Dr.B.PHANINDRA
8	BASIC ELECTICAL ENGINEERING-LAB	Mr.L.RAJU
9	GENDER SENSITIZATION	SUNEETHA
10	VALUE ADDED COURSE - II (VAC-II)	
11	SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)	

MECHANICAL ENGINEERING DEPARTMENT

TIMETABLE 2019-20 w.e.f. 09-12-2019

II B.Tech II Sem SECTION-C

TIME/ DAY	9.00- 9.55	9.55- 10.50	10.50- 11.45	11.45- 12.30	12.30- 01.25	01.25- 02.20	02.20- 03.15	03.15- 04.05
MON	MFHM	TE	KOM		PS	MD&D		
TUE	KOM	PS	TE		MFHM	BEE	VAC/GUEST LEC	
WED	MFHM/BEE LAB				BEE	MFHM	KOM	GS
THU	TE	BEE	MFHM		GS	KOM	PS	SAE
FRI	PS	KOM	BEE		TE	MFHM/BEE LAB		
SAT	MD&D				BEE	PS	MFHM	TE

SL.NO	SUBJECT	FACULTY
1	THERMAL ENGINEERING	Mr.K. NARENDRA REDDY
2	KINEMATICS OF MACHINES	Mr.M. MALLESH
3	MECHANICS OF FLUIDS AND HYDRAULIC MACHINES	Mr.CH.RAKESH
4	MACHINE DRAWING AND DRAFTING	Mr.N. PRAVEEN KUMAR/ Mr.S.VENKATESH
5	BASIC ELECTICAL ENGINEERING	K.SWAPNA
6	PROBABILITY AND STATISTICS	Mrs. FOUSIA
7	MECHANICS OF FLUIDS AND HYDRAULIC MACHINES-LAB	Mr.CH.RAKESH/ Mr.M.MALLESH
8	BASIC ELECTICAL ENGINEERING-LAB	K.SWAPNA
9	GENDER SENSITIZATION	MOUNIKA
10	VALUE ADDED COURSE - II (VAC-II)	
11	SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)	

MECHANICAL ENGINEERING DEPARTMENT

TIMETABLE 2019-20 w.e.f. 09-12-2019

II B.Tech II Sem SECTION-D

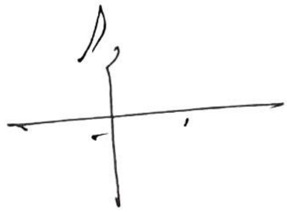
TIME/ DAY	9.00- 9.55	9.55- 10.50	10.50- 11.45	11.45- 12.30	12.30- 01.25	01.25- 02.20	02.20- 03.15	03.15- 04.05
MON	KOM	PS	BEE		TE	MFHM/BEE LAB		
TUE	MD&D				MFHM	KOM	VAC/GUEST LEC	
WED	GS	MFHM	TE		BEE	PS	KOM	SAE
THU	TE	MFHM	PS		BEE	MD&D		
FRI	MFHM	MFHM	KOM		PS	TE	BEE	GS
SAT	PS	KOM	BEE		TE	MFHM/BEE LAB		

SL.NO	SUBJECT	FACULTY
1	THERMAL ENGINEERING	Mrs.C.L.SINDUJA
2	KINEMATICS OF MACHINES	Ms.G. SRAVYA
3	MECHANICS OF FLUIDS AND HYDRAULIC MACHINES	Mr.HASAN
4	MACHINE DRAWING AND DRAFTING	Dr.G. SREERAM REDDY/ Mr.T.PAVAN KUMAR
5	BASIC ELECTICAL ENGINEERING	Mr.B.RAJESH
6	PROBABILITY AND STATISTICS	Mr.SADANANDAM
7	MECHANICS OF FLUIDS AND HYDRAULIC MACHINES-LAB	Mr.HASAN/S.Ramakrishna
8	BASIC ELECTICAL ENGINEERING-LAB	Mr.B.RAJESH
9	GENDER SENSITIZATION	MOUNIKA
10	VALUE ADDED COURSE - II (VAC-II)	
11	SOCIETY OF AUTOMOTIVE ENGINEERS (SAE)	

II YEAR / II SEMESTER
Academic Year: 2018-19

TIME/ DAY	9.00-10.00	10.00-11.00	11.00-12.00	12.00-01.00	01.00-01.45	01.45-02.45	02.45-03.45
MON			PT/FMHM LAB- B		LUNCH BREAK	PT/FMHM LAB- D	
TUE			PT/FMHM LAB- C			PT/FMHM LAB- D	
WED						PT/FMHM LAB- B	
THU			PT/FMHM LAB- A			PT/FMHM LAB- C	
FRI			PT/FMHM LAB- A				

SL. NO	SUBJECT	FACULTY
1	**FMHM LAB- A**	**Dr.B. Ramesh Babu/Mr. Hasan**
2	**FMHM LAB- B**	**Dr.B. Ramesh Babu/Mr. K.Rajesh**
3	**FMHM LAB -C**	**G.Ambika/Mr.J.Pradeep Kumar**
4	**FMHM LAB -D**	**G.Ambika/Mr. Sunil Kumar**



LIST OF EXPERIMENTS

S.No	NAME OF THE EXPERIMENT
1	Impact of Jets on Vanes
2	Performance Test on Pelton Wheel
3	Performance Test on Kaplan Turbine
4	Performance Test on Single Stage Centrifugal Pump
5	Performance Test on Multi Stage Centrifugal Pump
6	Performance Test on Reciprocating Pump
7	Calibration of Venturimeter
8	Calibration of Orifice meter
9	Determination of loss of head due to sudden contraction in a pipeline. (Minor losses)
10	Determination of friction factor for a given pipe line (Major losses)
	CONTENT BEYOND SYLLABUS
11	Verification of Bernoulli’s Theorem

DEPARTMENT OF MECHANICAL ENGINEERING

LIST OF EQUIPMENT

S.No.	List of Equipments
1	Impact of Jet Vanes Apparatus
2	Calibration of Venturimeter
3	Calibration of Orifice meter
4	Major Losses Apparatus
5	Minor Losses Apparatus
6	Reciprocating Pump
7	Single stage Centrifugal Pump
8	Multi Stage Centrifugal Pump
9	Kaplan Turbine Test Rig
10	Pelton Wheel Test Rig
11	Bernoulli‟s Equation Apparatus

LABORATORY MANUAL

1.Impact of Jet on Vanes

Aim: -To find the coefficient of impact of jet on flat, hemispherical vane.

Apparatus: stop clock, meter scale, Impact of jet on vane setup

Introduction

This apparatus is specially designed for conducting experiments on the impact of jet of water on fixed vane. The dynamic force in the direction of the jet can be practically determined and could be verified with the theoretical force gives the co-efficient of the impact of jet on the vanes. Nozzles of 6 mm and flow control valve for varying the velocity of jet are provided for carrying out the tests extensively.

General Description

INSTALLATION

Fix the transparent tube on the measuring tank with the help of four bolts and nuts provided. Make sure that the discharge spout is exactly center of the vane and connect the necessary piping to the apparatus.

BEFORE COMMISSIONING

- Check whether the nozzle housing, discharge pipe flange etc are fitted with gaskets to prevent water leakage**.**
- Check the gauge glass and meter scale assembly of the Measuring tank and see that it is fixed water tight and vertical

The equipment consists of a high efficiency gunmetal muzzle fitted to a 25mm dia. pipe supply line with a gate valve. Vertically above the nozzle, a gun metal vane is fitted to a bracket of a differential lever which balances the upward force of the jet from the nozzle. The lever is provided with an o load screw mechanism. The force due to the jet on the lever is center balanced by metric weights placed on a hanger. Different types of vanes can be fitted to the bracket.

The complete assemble is enclosed in a framed structure housing with a transparent window for visual observation. The water deflected by the vane is collected in the collecting tank.

For experimental purposes a brass nozzles with 8mm nozzle diameter and gunmetal vane of the following shape is provided.

Hem-spherical vane (180 deg. angle of deflection)

Theory:

The jet of water impinging on vane exerts force on it. The force exerted on it is derived by applying impulse momentum equation to control volume of water. The force exerted by a jet of fluid on symmetric vane is given by

$$F_{th} = \rho a V^2$$

The apparatus is primarily designed for measuring the force on vane due to the impact of jet of water. Aluminum Vane is supplied to study the effect of the deflection of the impinging jet on the vane. The actual discharge is measured by using the measuring tank, by noting the time for a definite rise of water level when the water is collected in the tank. One gunmetal Nozzle of diameter 8 mm is provided. The *CO*-efficient of contraction of the nozzle can be taken as 0.67. The actual impinging jet velocity (V) inmeters per second be calculated from the above flow rate and the area of the nozzle (a) in square mm.. The theoretical force (F1 in Kg) on the vane in the direction of the jet is equal to the change of momentum per second.

Formulae for Calculations: -

1. Area of collecting tank (A) = 0.3x0.3sq m

Rise in water level (R) = 0.1m (say)

Time taken = 1 seconds

Actual flow rate (Q) = (A x R)/t cu.m/sec

Actual mass flow rate (M) =1000 Q kg/sec

2. Nozzle diameter=d m (assumed = 0.006m)

Nozzle area 'a' = 3.14 d^2/4 sq.m

Jet velocity (V)=Q/a m/sec

3. Angle of deflection of the vane to the jet = $(T_1\text{-}T_2)^o$

Mass flow rate of the water = M kg/sec

The lifting force= change in momentum per sec in vertical direction

$F = mxv\ [\sin T_1 - \sin t_2]$

For horizontal flat vane $T_1 = 90^o$ and $t2 = 0^o$

F= (m x v)/g

For semicircular vane $t_1 = 90^o$ and $T_2 = 90^o$

F= (2 x m x v)/g

4. Actual lifting force measured = w x lever arm ratio kg

Fact = 20w

5. The efficiency of the jet= F_{act}/F

Procedure:

1. Insert the required vane on the lever
2. Measure the differential lever arms and calculate the ratio of lever arms (2.0in this case).
3. Balance the lever system by means of counter weight for no load.
4. Place a weight on the hanger.
5. Open the gate valve and adjust the jet, so that the weight arm is balanced
6. Collect water in the collecting tank.
   Note: (a) the pressure gauge reading P

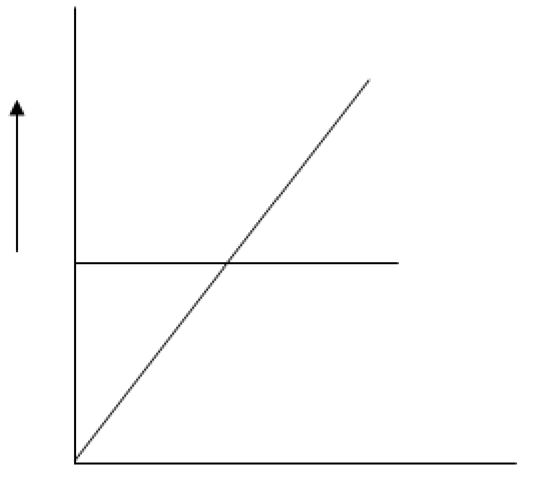
   t the weight placed W

u time for 5 cm. rise in the collecting tank t

7. Calculate the discharge by weight.
8. Calculate the vertical force.

Graphs:

Draw a graph for Actual force Vs theoretical force.



Observation table:

Table for Observations and Calculations: - Table:1

S.No.	Vane type	Inlet pressure . Kg/sq. cm	Time for R cm rise t sec	Flow rate „Q" cu. m/sec	Mass flow rate m.kg/sec	Jet velocity V m/sec	Input force „F" kg	Counter load „W" kg	Vane efficiency 2w/F η%
1	Semi circular								
2	Semi circular								

Result:

The actual value of force is always lesser than the theoretical calculated because:

a. The velocity of water making the impact reduces due to gravity.
b. There are losses due to viscosity/friction.
c. Some water drops may not hit the blade at all.

The average co-efficient of impact was calculated and found to be

a. For flat plate -----
b. For hemispherical plate ----

Precautions:

1. Do not start the pump of the voltage is less than 180v.
2. The lower end of the suction pipe must always be submerged under water in the sump tank.
3. Do not forget to give the electric neutral and earth connections correctly.
4. Frequently at least once in a three months Greece oil the rotating parts.
5. The machine should be operated at least some time to avoid clogging.
6. Leakages in the piping and nozzle housing should be checked regularly.

Applications:

The force of impact calculated in this experiment is useful in calculating the work done and torque by the jet of water on moving vanes in impact turbines (pelt on wheel). The experiment can be used to test the forces excreted on different shapes of plates.

Viva Questions:

1. Which shape of plate has the maximum force of impact?
2. Why are hemispherical vanes not used in pelt on wheel?
3. What is the effect of density of fluids on force of impact?
4. What is the relation between Newton force and kg force?
5. What is the difference between mass and weight?
6. Why actual force value is less than the theoretical force?
7. What is a nozzle?
8. What is the formula for force if you know the momentums of the fluid before and after impact?

2. PELTON WHEEL TURBINE

Aim: **-** To study the constructional details of a Pelton Wheel turbine and to study the characteristics of Pelton wheel turbine.

Apparatus Used: Stop clock, meter scale, Pelton wheel turbine setup, 3-phase power supply.

Introduction:

Pelton Turbine is of improved version. This system has several advantages, like does not require foundation; trench work etc. so that the experiments can be conducted with the unit soon after arrival of the equipment and it can be placed anywhere in the laboratory.

The Pelton wheel Turbine Test Rig is supplied as a complete set to conduct experiments on model Pelton Turbine Test Rig in Engineering Colleges and Technical Institutions. It has been specially designed to conduct experiments in S.I units.

The Pelton wheel Turbine Test Rig is supplied as a complete set to conduct experiments on model Pelton Turbine Test Rig in Engineering Colleges and Technical Institutions. I t has been specially designed to conduct experiments in S.I units. The test rig mainly consists of 1) A Pelton Turbine, 2) A Supply pump unit to supply water to the above Pelton Turbine, 3) Flow Measuring unit consisting of a Venturimeter and Pressure Gauges, 4) Piping system and (5) Sump.

Description:

Pelton turbine is an impulse turbine, that uses water available at high heads (pressure) for generation of electricity. All the available potential energy of water is converted into kinetic energy by a nozzle arrangement. The water leaves the nozzle as a jet and strikes the buckets of the Pelton wheel runner. These buckets are in the shape of double cups, joined at the middle portion in a knife edge. The jet strikes the knife edge of the buckets with least resistance and shock and glides along the path of the cup, deflecting through an angle of 106 ti 170 deg. The deflection of water causes a change in momentum runner attached to the buckets moves, rotating the shaft. The specific speed of the Pelton wheel varies from 10 to100.

In the test rig the Pelton wheel is supplied with water under high pressure by a centrifugal pump. The water flows through a venturimeter to the Pelton wheel. A gate valve is used to control the flow rate to the turbine. The venturing=meter with pressure gauges connected to it is used to determine the flow rate of water in the pipe. The nozzle opening can be decreased or increased by operating the spear wheel at the entrance side of turbine.

The turbine is loaded by applying dead weights on the brake drum. This is done by placing the weights on the weights hanger, the inlet head is read from the pressure gauge. The speed of the turbine is measured with a tachometer.

CONSTRUCTIONAL SPECIFICATIONS

CASING: of a iron having a large circular transparent Window.

RUNNERS: of electroplated MS disc fitted with accurately finished electroplated buckets.

SHAFT: of Stainless steel for rust free operation and for high strength.

NOZZLE: designed for smooth flow and efficient operation.

SPEAR: of stainless steel designed for efficient operation.

BALL BEARINGS: of double row deep groove rigid type in the casing and double row self aligning type in the pedestal both of liberal size.

Theory:

Hydraulic machines are defined as those machines which convert either hydraulic energy (energy possessed by water) into mechanical energy or mechanical energy into hydraulic energy.

Turbines are defined as hydraulic machines which convert hydraulic energy into mechanical energy. Hydraulic turbines are of different types according to specification and Pelton wheel or turbine is one of the types of hydraulic turbines.

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

Constructional Details: -
The main parts of the Pelton turbine are: -

1. Nozzle and flow regulating arrangement.
2. Runner and buckets.
3. Casing.
4. Breaking Jet.

1. <u>Nozzle and flow regulating arrangement</u>:

The amount of water striking the buckets of the runner is controlled by providing a spear in the nozzle. The spear is a conical needle which is operated either by a hand wheel or automatically in an axial direction depending upon the size of the unit. When the spear is pushed forward into the nozzle the amount of water striking the runner is reduced. On the other hand if the spear is pushed back, the amount of water striking the runner increases.

2. Runner with buckets:

It consists of a circular disc on the periphery of which a number of buckets evenly spaced are fixed. The shape of the buckets is of a double hemispherical cup or bowl. Each bucket is divided into two hemispherical parts by a dividing wall which is known as splitter.

3. Casing:

The function of the casing is to prevent the splashing of the water and todischarge water to tail race. It also acts as a safeguard against accidents. It is made of cast iron or fabricated steel plates. As pelton wheel is an impulse turbine, the casing of the pelton wheel does not perform any hydraulic function.

4. Breaking Jet:

When the nozzle is completely closed by moving the spear in the forward direction the amount of water striking the runner reduces to zero. But the runner due to inertia goes on revolving for a long time. To stop the runner in a short time, a small nozzle is provided which directs the Jet of water on the back of the buckets. This Jet of water is called breaking Jet.

Working of Pelton wheel Turbine:

The water from the reservoir flows through the penstocks at the outlet of which a nozzle is fitted. The nozzle increases the kinetic energy of the water flowing through the penstock by converting pressure energy into kinetic energy. At the outlet of the nozzle, the water comes out in the form of a Jet and strikes on the splitter, which splits up the jet into two parts.

These parts of the Jet, glides over the inner surfaces and comes out at the outer edge. The buckets are shaped in such a way that buckets rotates, runner of the turbine rotates and thus hydraulic energy of water gets converted into mechanical energy on the runner of turbine which is further converted into electrical energy in a generator/alternator.

Precautions before starting up:

1. Check whether all the joints are perfectly matched.

2. Check whether all the electric connection is correct.

3. See that the gauges are mounted on the correct position and their cocks are closed.

STARTING UP

Pour adequate water in the sump. Make sure before starting that the pipe lines are free from foreign matter. Also note whether all the joints are water tight and perfectly matched. Prime the pump and start it with closed gate valve. Then slowly open the gate valve situated above the turbine and open the cock fitted to the pressure gauge and so that the pump develops the rated head. If the pump develops the required head, slowly open the turbine spear by rotating the hand wheel until the turbine attains the normal rated speed (1000 RPM). Run the turbineat the normal speed for about 10 minutes and carefully note the following:

1. Operation of the bearings, temperature rise, noise etc.,

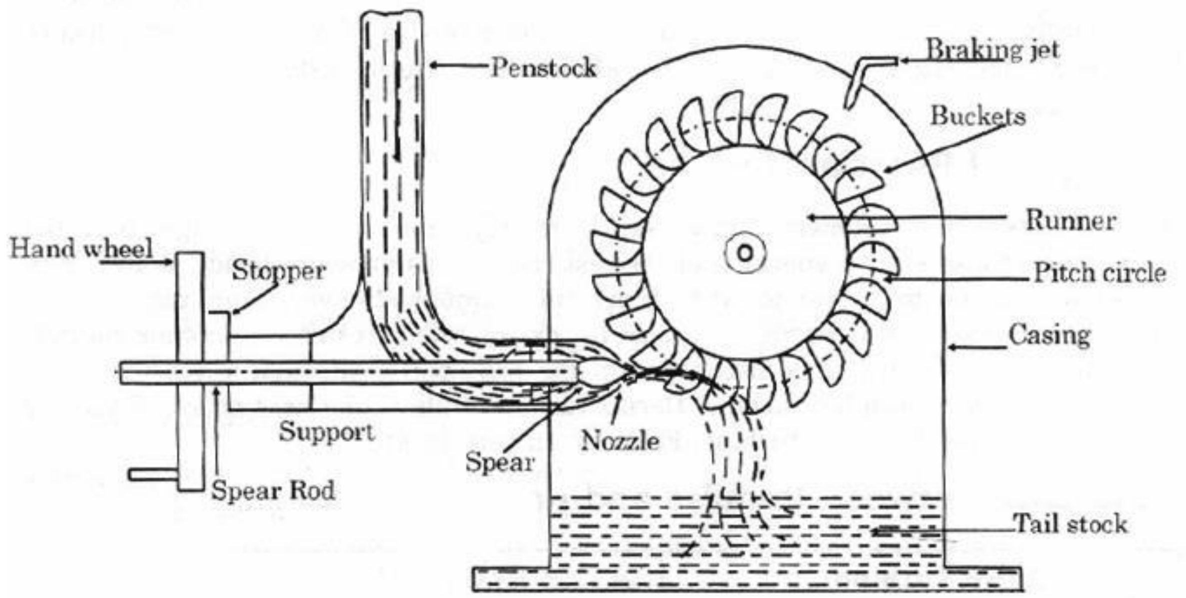
2. Vibration of the unit.

3. Steady constant speed and speed fluctuations if any.

In addition to this, on the sump side note the operation of the stuffing box. (The stuffing box should show an occasional drip of water. If the gland is over tightened, the leakage stops but the packing will heat up burn and damage the shaft.) .If the operation of the above parts is normal, load the turbine slowly and take readings. Open the water inlet valve and allow some cooling water through the brake drum when the turbine runs under load, so that the heat generated by the brake drum is carried away by the cooling water. Do not suddenly load the turbine, load the turbine gradually and at the same time open the spear to run the turbine at normal speed.

SHUT DOWN

Before switching off the supply pump set, first remove the load on the brake down. Close the cooling inlet water Jet valve. Slowly close the spear to its full closed position. Then close the gate valve just above the turbine. Pressure Gauge cocks and Venturimeter cocks should be closed in order to isolate the pump set when the turbine is working under load. If the electric line trips off when the turbine is working first unload the turbine, close all the valves and cocks. Start the electric motor against, when the line gets the power and then operate the turbine by opening the valve in the order said above.



Formulae for Calculations: -

1. To determine discharge:

Venturimeter line pressure gauge reading = P_1 kg/sq.cm

Venturimeter throat pressure gauge reading = P_2 kg/sq.cm

Pressure difference (dH) = (P_1-P_2) x 10 m of water

Venturimeter equation = $0.00324\ (dH)^{0.5}\ m^3$ / sec

Note:

Discharge (Q) = $Cd \times A \times B^2 \times \{(2 \times 9.81 \times dH)/(1-B^4)\}^{0.5}$

Where,

Cd = Venturimeter discharge coefficient= 0.96

A = inlet area = $(3.14/4) \times D^2$

Where,

Inlet dia, D =50mm;

Throat dia ratio, B = 0.6

2. To determine Head:

Turbine Pressure gauge reading = P kg/sq.cm

Total Head (H) = P x 10 m of water

3. Input to the turbine:

Input = 9.81 Q x H KW

4. Turbine Output:

Brake drum diameter = 0.20m.

Rope diameter = 0.015m.

Equivalent drum diameter = 0.215m

Hanger weight (T_o) = 1 Kg.

Weight = T_1 kg.

Spring Load = T_2 Kg.

Resultant load = $(T_1 - T_2 + T_0)$ kg

Speed of the turbine = N rpm

Turbine Output = (3.14 x D x N x T)/(102 x 60) KW

= 0.00011 NT KW

5. Turbine efficiency = Output/Input x 100 %

Venturimeter Constant = 0.00324

Brake drum dia = **0.2m**

Rope dia = **0.015m**

Equivalent drum dia = **0.215m**

Wt. Of empty hanger = **1 Kg**

Model Calculation:

Input total head (H) = **10(P) m of water**

Venturimeter (dH) = **10 (P_1-P_2) m of water**

Discharge (Q) = **$0.00324(dH)^{0.5}$cu.m/sec**

Input Power (I) = **9.81 x Q x H KW**

Brake drum net wt. (T) = **(T_0 + T_1 - T_2) Kg**

Turbine output (O) = **3.14 x D x N x T/(102x60) KW**

= **0.00011NT KW**

Efficiency = Output/Input x 100 %

Procedure:

1. Close the delivery gate valve completely and start the pump.
2. Add minimum load to the weight hanger of the brake drum – say 1kg.
3. Open the gate valve while monitoring the inlet pressure to the turbine. Set it for the design value of 3.0 kg/sq.cm.
4. Open the cooling water valve for cooling the crake drum.
5. Measure the turbine rpm with tachometer.
6. Note the pressure gauge reading at the turbine inlet,
7. Note the venturimeter pressure gauge readings, P1 and P2.
8. Add additional weights and repeat the experiments for other loads.
9. For constant speed tests, the main valve has to be adjusted to reduce or increase the inlet head to the turbine for varying loads.

Observation Table:

S.No.	Inlet pressure P Kg/cm²	Outlet vacuum „U‟ mm of Hg	Total head „H‟ m of water	Venturimeter meter pressure gauge			Flow rate Q Cu.m/sec	Speed „N‟ rpm	Wt. on spring balance T_2 kg	Net wt. „T‟ Kg	Turbine output „O‟ KW	Wt hangover T_1 kg	Input I KW	Efficiency η%
				P_1 Kg/cm²	P_1 Kg/cm²	dH m of water								
1.														
2.														

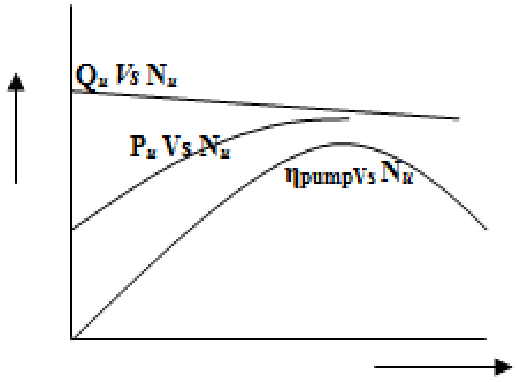
Graphs: -To study constant head characteristic curves of a Pelton wheel Turbine plot the following graphs,

i). Unit Speed, N_u on X-axis *Vs* Unit Power, P_u on Y-axis

ii). Unit Speed, N_u on X-axis *Vs* Unit discharge, Q_u on Y-axis

iii). Unit Speed, N_u on X-axis *Vs*$\eta_{overall}$ on Y-axis

Expected Graphs:



Precautions:

1. Always operate the turbine with a load. Since the runaway speed of the turbine is very high, running the turbine without any load will lead to excess vibrations and noise.
2. Provide cooling water for the break drum when it is loaded. Absence of cooling water will cause break drum heating and even charring of the rope under extreme conditions. Amount of cooling water should be controlled to avoid excessive spillage and splashing.
3. The motor is provided with DOL starter to trip under over load, low voltage, uneven phase supply conditions. If the motor trips check for voltage conditions. Also, Do not run the supply pump at fully open valve conditions, as this is an overload condition for the pump.
4. Do not start a motor without priming.
5. Do not starting the motor without closing the delivery gate valve completely.
6. Only after the starter has changed to delta mode from the start mode ,the delivery gate valve should be open.

Note: do not operate the motor at very low voltage of 350V and below as this will draw excessive current, leading to motor coil burn out.

Result: 1.The constant head characteristic curves have been obtained

The maximum efficiency of the Pelton wheel is =

Applications:

Pelton wheels are the preferred turbine for hydro-power, when the available water source has relatively high hydraulic head at low flow rates. Pelton wheel could be used to lift water from a lower source (lake or something) to pour into a high place. Another use, it could be used to dig into the earth, the wheel has the shape of a milling cutter, it can open channels in the ground or something. It could also be used to measure the speed of a fluid, if connected to a dynamo meter; the speed of flow could be read via voltage.

Viva Question:

1. What do you mean by an impulse turbine?
2. How does an impulse turbine differ from a reaction turbine?
3. Why is a pelton wheel suitable for high head only?
4. What is the specific speed range of a pelton wheel?
5. What is meant by a speed ratio of a pelton wheel and what is the speed ratio for pelton?
6. What is the no of buckets taken for pelton wheel?
7. What is the no of jets taken for pelton wheel?
8. Draw the velocity triangles for pelton wheel?
9. When and why do we go for pelton wheel and its applications?

3. KAPLAN TURBINE (**at Constant head condition)**

Aim - To study the characteristic curves of a *Kaplan turbine* at constant head condition.

Apparatus: - stop clock, meter scale, Kaplan turbine setup, 3-phase power supply.

Description:

Kaplan turbine is an axial flow reaction turbine used in dams and reservoirs of low height to convert hydraulic energy into mechanical and electrical energy. They are best suited for low head say from 10m to 50m. he specific speed ranges from 200 to 1000.

The test rig consists of 1Kw [1034HP] Kaplan turbine supplied with water from a suitable 5HP pump through pipelines, a valve, and a flow measuring venturimeter. The turbine consists of a cast iron body with a volute casing, an axial flow gunmetal runner, a ring of adjustable guide vanes and a draft tube. The runner consists of three vanes of aerofoil section. The guide vanes can be rotated about their axis by means of hand wheel. A rope brake down drum is mounted on the turbine shaft to absorb the power developed. Suitable dead wts. and a hanger arrangement, a spring balance and cooling water arrangement is provided for the brake drum,

Water under pressure from pump enters through the volute casing and the guide vanes into the runner. While passing through the spiral casing and guide vanes, a portion of the pressure energy (potential energy) is converted into velocity energy (kinetic energy) water thus enters the runner at a high velocity and as it passes through the runner vanes, the remaining potential energy is converted into kinetic energy. Due to the curvature of the vanes, the kinetic energy is transformed into the mechanical energy i.e. the water head is converted into mechanical energy and hence the runner rotates, the water from the runner is then discharge into the draft tube.

The flow through the pipe lines into the turbine is measured with the venturimeter fitted in the pipe line. Two pressure gauges are provided to measure the pressure difference across the venturimeter, the net pressure difference across the turbine inlet and exit is measured with a pressure gauge and vacuum gauge. The turbine output torque is determined with the rope brake durum. A tachometer is used to measure the rpm.

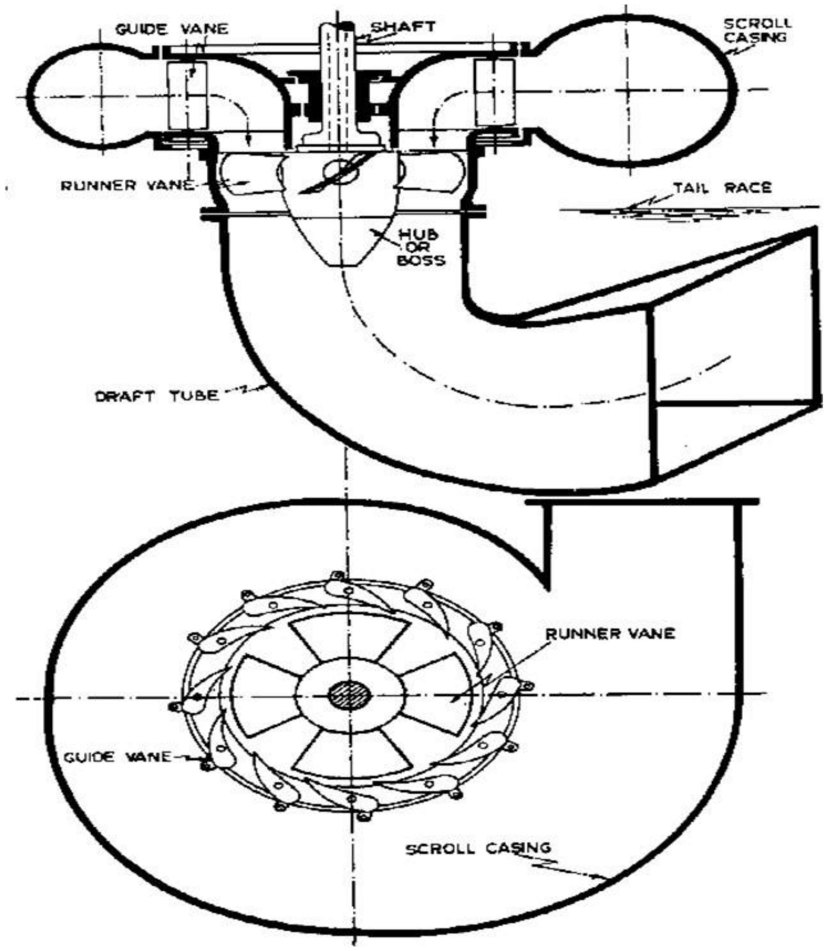


Fig: **Sectional arrangement of Kaplan Turbine**

Theory: -

Axial flow Turbine: - 1. Kaplan Turbine
(Adjustable blades)2. Propeller (Blades are fixed)

Kaplan Turbine: - Kaplan Reaction turbines are axial flow turbines in which theflow is parallel to the axis of the shaft. They are low head, high discharge turbine. In this water turn at right angles between the guide vanes, runner & then flow parallel to the shaft. It is inward flow reaction turbine. The flow was along the radius from periphery to the centre of the runner. (From outer dia to the inner dia of runner). It is capable of giving high efficiency at overloads (up to 15-20%), at normal loads (up to 94%). The runner of this turbine is in the form of boss or hub which extends in a bigger dia. Casing with proper adjustment of blades during running. The blade angles should be properly adjusted so that water enters & flow through the runner blades without shock.

Constructional details:-

1. **Penstock**
2. **Spiral or scroll casing**
3. **Guide mechanism**
4. **Runner**
5. **Draft tube**

1. **Penstock:** - It is the water way used to carry the water from the reservoir tothe turbine. At the inlet of the penstock trash cracks are used to prevent the debris from going into the turbine.
2. **Spiral or Scroll casing:** - In case of reaction turbine casing and runner arealways fullof water. The water from the penstock enters the casing which is of spiral shape in which area of cross-section of the casing goes on decreasing gradually. The casing completely surrounds the runner of the turbine. The casing is made of spiral shape, so that the water may enter the runner at constant velocity through out the circumference of the runner.
3. **Guide Mechanism:** - It consists of a stationary circular wheel all round therunner of the turbine. The stationary guide vanes are fixed on the guide mechanism. The guide vanes allow the water to strike the vanes fixed on the runner without shock at inlet. Also by a suitable arrangement, the width between two adjacent vanes of a guide mechanism can be altered so that the amount of water striking the runner can be varied. A space, called whirl Chamber, is provided between the guide vanes and the runner. In this chamber, the flow turns by 90□ & move as a free vortex i.e without the aid of any external torque. The radial component changes into axial component due to the guidance from the fixed housing.
4. **Runner:** - It is a circular wheel, also called „hub" or „bass" on which a seriesof radial curved vanes are fixed. The surface of the vanes is made very smooth. The radial curved vanes are so shaped that water enters and leaves the runner without shock. The runners are made of cast steel, cast iron or stainless steel. In Kaplan turbine, the shaft is the extended part of runner with smaller diameter.
5. **Draft tube:** - The pressure at the exit of an axial turbine is generally lessthan atmospheric pressure. The water at exit cannot be directly discharged to the tail race. A tube or pipe of gradually increasing area is used for discharging water from the exit of the turbine to the tail race. This tube of increasing area is called draft tube.

Working of the Kaplan Turbine:

The working head of water is low so large flow rates are allowed in the Kaplan Turbine. The water enters the turbine through the guide vanes which are aligned such as to give the flow a suitable degree of swirl determined according to the rotor of the turbine. The flow from guide vanes pass through the curved passage which forces the radial flow to axial direction with the initial swirl imparted by the inlet guide vanes which is now in the form of free vortex.

The axial flow of water with a component of swirl applies force on the blades of the rotor and looses its momentum, both linear and angular, producing torque and rotation (their product is power) in the shaft. The scheme for production of hydroelectricity by Kaplan Turbine is same as that for Francis Turbine.

Formulae for calculation:

Venturimeter constant= 0.0131

Brake drum diameter = 0.2m

Rope diameter= 0.015m

Weight of empty hanger T_0=1Kg

1. To determine discharge:

Venturimeter line 'P' gauge reading = P_1 Kg/cm^2

Venturimeter throat 'P' gauge reading = P_2 Kg/cm^2

Pressure difference (dH) = (P_1-P_2) x 10m of water

Venturimeter equation (Q)= 0.0131 x $(dH)^{0.5}$ m^3/sec

2. To determine inlet head of water:

Turbine Pressure gauge reading = P kg/cm^2

Turbine pressure gauge reading = V mm of Hg

Total head (H) = 10[(p+V)/760]m of water

3. Input to the turbine:

Input power = 1000 (Q x H)/75 HP

4. Turbine Output:

Break drum diameter= 0.2cm

Rope diameter = 0.015m

Equivalent drum diameter = 0.215m

Hanger weights T_0 = 1Kg

Weights T_1 Kg = 1Kg, 2Kg

Spring Load = T_2 Kg = 0.45, 0.45

Resultant load T = [T_1-T_2+T_0] Kg

Speed of turbine N rpm =

Output Power = (3.14x D x N x T)/(75x60) HP

Procedure:

1. Close the delivery gate valve completely and start the pump.
2. Add minimum load to the weight hanger of the brake drum say 1kg
3. Open the gate valve which m0nitoring the inlet pressure to the turbine. Set it for the design valve of 3.0kg/sq.cm
4. Open the cooling water valve for cooling the brake drum.
5. Measure the turbine rpm with tachometer.
6. Note the pressure gauge reading P_1 and P_2.
7. Note the venturimeter pressure gauge reading P_1 and P_2
8. Add additional weight and repeat the experiments for other loads.
9. For constant speed tests, the min valve has to be adjusted to reduce or increase the inlet head to the turbine for varying loads.

Table For Observations & Calculation:

S.No.	Inlet pressure P Kg/cm^2	Outlet vacuum „U" mm of Hg	Total head „H" m of water	Venturimeter meter pressure gauge			Flow rate Q Cu.m/sec	Speed „N" rpm	Wt. on spring balance T_2 kg	Net wt. „T" Kg	Turbine output „O" KW	Wt hango ver T_1 kg	Input I KW	Efficiency η%
				P_1 Kg/cm^2	P_1 Kg/cm^2	dH m of water								
1.														
2.														

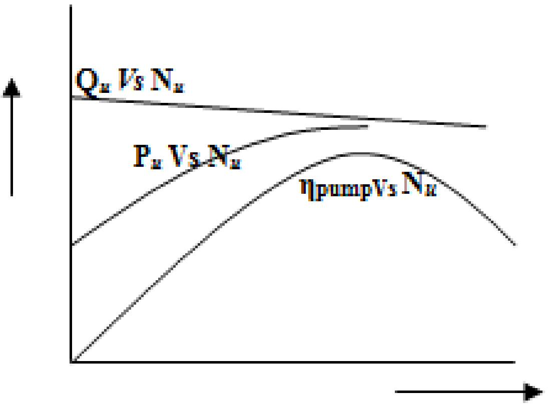
Graphs: To study constant head characteristic curves of a Francis Turbine plot the following graphs,

i). Unit Speed, N_u on X- axisVs Unit Power, P_u, on Y- axis

ii). Unit Speed, N_u on X- axisVs Unit discharge, Q_u on Y- axis

iii). Unit Speed, N_u on X- axisVs$\eta_{overall}$ on Y- axis

Expected Graphs: -



Result: -. 1. The constant head characteristic curves have been obtained

2. The maximum efficiency of the Kaplan Turbine is =

Precautions:

1. Always operate the turbine with a load. Since the runaway speed of the turbine is about 400rpm, running the turbine without any load will lead to excess vibrations a noise.
2. Provide cooling water for the brake drum when it is loaded. Absence of cooling water will cause brake drum heating and even charring of the rope under extreme conditions.
3. The motor is provided with DOL starter to trip under overload, low voltage uneven phase supply. If the motor trips, check then for voltage conditions. Also, do not run the supply pump at fully open valve conditions as this is an overload condition for the pump.
4. Do not start a motor without priming.
5. Do not starting the motor without closing the delivery gate valve completely.
6. Only after the starter has changed to delta mode from the start mode ,the delivery gate valve should be open.

Note: do not operate the motor at very low voltage of 350V and below as this will draw excessive current, leading to motor coil burn out.

Applications:

Used in Irrigation and mainly used in flood prone area. Kaplan turbine are the preferred turbine for hydro-power, when the available water source has relatively high hydraulic head at low flow rates. Steel, Concrete, Spiral or Syphon intake.

Viva Questions:-

1. What is a parallel flow turbine?
2. How is a Kaplan turbine different from a Francis turbine?
3. What is the speed ratio of Kaplan turbine?
4. What do you mean by an reaction turbine?
5. Why are hydraulic losses less in a Kaplan turbine then in a Francis turbine?
6. When do you prefer Kaplan turbine?
7. What are the applications of Kaplan turbine?
8. What is the flow ratio of Kaplan turbine?
9. No of blades to be taken?
10. What is the head and specific speed to be preferred?

4. SINGLE-STAGE CENTRIFUGAL PUMP TEST RIG

Aim: - To plat the operational characteristic curves of a single stage centrifugal pump.

Apparatus:- single stage centrifugal pump test set-up, stop clock, steel rule etc.

Introduction

Closed Circuit Self-sufficient portable package system Experimental single stage Centrifugal pump Test Rig is designed to study the performance of the single stage Centrifugal pump. In this equipment one can study the relationship between

1. Discharge Vs. Head
2. Discharge Vs. Input power
3. Discharge Vs. Efficiency

This unit has several advantages like does not require any foundation, trench keeping in the laboratory.

General Description

The Test Rig mainly consists of
(1) Centrifugal pump set
(2) Panel Board,
(3) Pressure and vacuum gauges to measure the head
(4) SS Measuring Tank to measure the discharge
(5) Energy meter to measure the input to the motor and .
(6) SS Sump

A centrifugal pump consists of an impeller rotating inside a casing. The impeller has a number of curved vanes. Due to the centrifugal force developed by the rotation of the impeller, water entering the center flows outwards to the periphery. Here it is collected in a gradually increasing passage in the casing known as a volute chamber. Thus chamber converts a part of the velocity head [kinetic energy] of the water into pressure head [potential energy] For higher heads, multistage centrifugal pumps having two or more impellers in series well have to be used.

The test pump is a single stage centrifugal pump of size 1^{11} x $1^{11=}$ (25mm x 25mm). It is coupled to a 1HP capacity single phase AC motor by means of a cone pulley belt drive system.

An energy meter and a stopwatch are provided to measure the input to the motor and a collecting tank to measure the actual discharge. A pressure gauge and a vaccum gauge are fitted in the delivery and suction pipelines to measure the pressure.

An energy meter and a stopwatch are provided to measure the input to the motor and a collecting tank to measure the actual discharge. A pressure gauge and a vaccume gauge are fitted in the delivery and suction pipelines to measure the pressure.

NOTE: since the centrifugal pump is not self-priming the pump must be fitted with water (priming) before getting. For this reason, water should not be allowed to drain and a foot valve is provided.

Theory: -

The hydraulic machine which converts the mechanical energy into pressure energy by means of centrifugal force acting on the fluid is called centrifugal pump. The centrifugal pump acts as a reverse of an inward radial flow reaction turbine. This means that the flow in centrifugal pump is in the radial outward directions. The centrifugal pump works on the principle of forced vertex flow which means that when a certain mass of liquid is related by an external torque, the rise in pressure head of the rotating liquid takes place. The rise in pressure head at any point of the rotating liquid is proportional to the square of the tangential velocity of the liquid at that point. Thus at the outlet of the impeller radius is more, the rise in pressure head will be more and the liquid will be discharged at the outlet with a high pressure head. Due to this pressure head, the liquid can be lifted to a high level.

Constructional details:-

Main part of a centrifugal pump:-

1. Impeller:-The rotating part of a centrifugal pump is called "Impeller". Itconsists of a series of backward curved vanes. The impeller is mounted on a shaft which is connected to the shaft of an electric motor.
2. Casing: - The casing of a centrifugal pump is similar to the casing of areaction turbine. It is an air-tight passage surrounding the impeller and is designed in such a way that the kinetic energy of the water discharged at the outlet of the impeller is converted in to pressure energy before the water leaves the casing and enters the delivery pipe. The following three types of casing are commonly adopted:-
    - (i) Volute casing
    - (ii) Vortex casing
    - (iii) Casing with guide blade
3. Suction pipe with a foot-valve and a strainer: - A pipe whose one end is connected to the inlet of the pump and other end dips in to water in a sump is known as suction pipe. A foot valve which is a non-return valve or one way valve is fitted at the lower end of the suction pipe. The foot valve opens only in the upward direction. A strainer is also fitted at the lower end of the suction pipe.

4. Delivery pipe: - A pipe whose one end is connected to the outlet of the pump and other end delivers the water at a required height is known as delivery pipe.

CONSTRUCTIONAL SPECIFICATION

CENTRIFUGAL PUMPSET

The pump set is of special design, horizontal spindle, and vertical split case. The pump is of such a size, type & design that 1) The total head 2) Discharge and 3) Power requirements at normal speed is well suited for the experimental purposes in technical institutions.

A.C. MOTOR

The electric motor suitable for operation on 50 cycles A.C. Supply is provided.

GAUGES

Suitable range of pressure and vacuum gauges to measure the total head on the pump with reasonable accuracy.

SS MEASURING TANK

Te SS Measuring Tank is provided to measure the discharge of the water from the pump. The tank is complete with gauge glass and scale arrangement.

PIPING SYSTEM

Suitable piping system with pipes, bends and valves are provided. A Simple strainer valve is provided on the suction side to prevent any foreign matter entering into the pump. The gate valve is provided in the delivery side to control the head on the pump. While starting the motor always keep the valve in close position.

PANEL BOARD

The Panel Board houses all the necessary electrical items, like switch, starter for the above pump set and an energy meter to read the power input and it is fitted with the unit on a strong iron base with sufficient height.

INPUT POWER MEASUREMENT

A Kilowatt-hour meter is provided to measure the power input to the motor. The energy meter constant (The Number of Revolutions per minute of the energy meter Disc) is stamped on the meter from this the input power can be easily calculated.

SS SUMP

Is provided to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

BEFORE COMMISSIONING

- Check whether all the joints are leak proof and watertight.
- Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertically.
- Check whether all the electric connection is correct.
- See that the gauges are mounted on the correct position and their cocks closed.

STARTING

Before starting the required electrical connection should be done correctly

Formulae for Calculations: -

1. Discharge:

Area of tank (A)	**= 0.5 X 0.5 sq.m**
Rise of level (h)	**= 0.1 m**
Volume collected	**= Axh cu.m (Assumed = 0.025 cu.m)**
Time taken	**= t secs**
Discharge(Q	**= Volume/Time**
	= 0.025/t cu.m/sec

2. Head:

Total Head H	**= 10 (P + (V/760)) m of water**

3. Output of the pump:

Output	**= 9.81 x Q x H KW**
	Or ρg QH watts
	or 9810 x QH watts

4. Input of the Motor:

Energymeterconstant N	**= 1200 revs per KWH**
Time foe 10 revolutions	**= T secs**
Input to motor	**= (3600 x 10) / (NxT) KW**
Efficiency of motor	**= 80% (assumed)**
Transmission Efficiency	**= 90% (assumed)**
Pump Input	**= Motor output x 0.80 x 0.9 KW**
	= 3600 x 10 x 0.8 x 0.9 / (1200xT)
	= 21.6/T KW
5. Pump Efficiency	**= Pump Output / Pump Input**

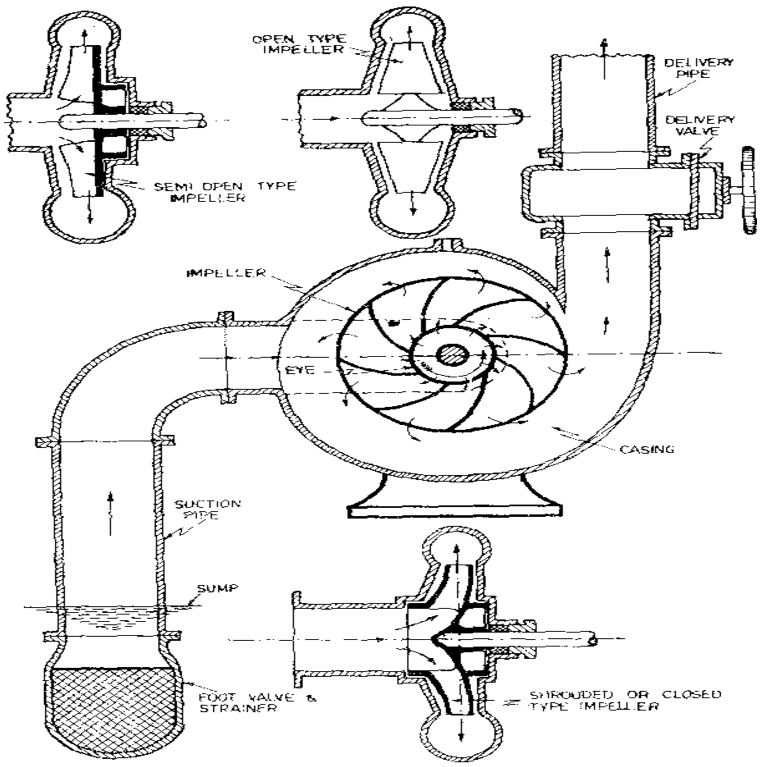
MODEL CALCULATIONS:

Collecting tank area	**= 0.5x0.5 sq.m**
Energymeterconstant N	**= 1200 revs per KWH**
Discharge Q	**= Ar/t = 0.25x0.2/t = 0.050t cu.m/sec**
Total Head H	**= 10 (P + (V/760)) m of water**
Pump Output	**= 9810 x QH watts**
Pump Input	**= Motor output x 0.80 x 0.9 KW**
	= 3600 x 10 x 0.8 x 0.9 / (1200xT)
	= 21.6/T KW
Efficiency	**= Output / Input**

Procedure:

1. Loosen the v-belt by rotating the hand wheel of the motor bed and position the v-belt in the required groove of the pulley.
2. Prime the pump with water if required
3. Close the delivery gate valve completely.
4. Start the motor and adjust the gate valve to required „p‟ and delivery.
5. Note the following readings
   (a) The pressure gauge reading „p‟ kg/sq.cm
   (b) The vacuum gauge readings v mm of Hg
   (c) Time for 10 revolutions of energy meter disc-T-secs
   (d) Time for 10 cm rise in the collecting tank-t secs
   (e) Pump speed in RPM

Take 3 or 4 sets of readings by varying the head from a maximum at shut off to a minimum where gate valve is fully open. The experiment is repeated for other pump speeds.



Component parts of a centrifugal pump

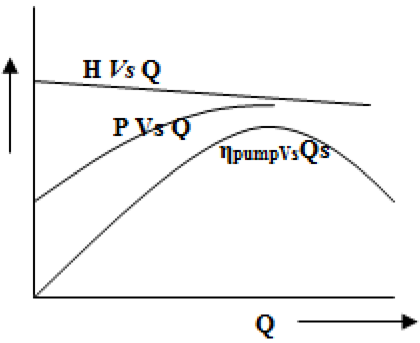
Observation Table:

S.NO	Speed (N) rpm	Pressure gauge (P) kg/cm^2	Vaccume gauge (V) mm of Hg	Total heat (H) 'n' of water	Time for 10cm rise in coil tank 't' sec	Discharge 'Q'=0.025/t m^3/sec	Time for 10rev of energy meter dics 'T' sec	Input 21.6/T (KW)	Output 9.81 (Q) (H) KW	Efficiency = η
1.										
2.										
3.										

Graphs:

1. Discharge Vs Head
2. Discharge Vs Input power
3. Discharge Vs Efficiency.

Expected Graphs: -



Result: The overall efficiencies for different speeds were calculated and graphs plotted.

Precautions:

1. Don"t start the pump if the voltage is less than 180V.
2. Don"t forget to give neutral and earth connections to the unit.
3. Frequently (at least once in three months) grease/oil the rotating parts.
4. At least once in a week, operate the unit & avoid clogging of moving parts.
5. Replace the water possibly once in a month.
6. Don"t exceed 1.5 kg/cm^2 on pressure gauge reading and never fully close the delivery valve.
7. In case of any major fault, it is suggested to contact the manufacturer before taking up any major repairs.

Applications :

The most commonly used pumps for domestic, agriculture and industrial purposes are centrifugal pumps. These pumps fall in to the main class, namely Roto-dynamic pumps.

Viva Questions:

1. What is pump?
2. The centrifugal pump is works on which principle?
3. What is meant by roto-dynamic machine?
4. What are mechanical hydraulic and monomeric efficiency‟s?
5. What type of fluids is pumped by centrifugal pump and from where does the fluid enters?
6. What are pumping characteristic of a centrifugal pump?
7. What is meant by a efficiency of a pump?
8. When do we go for centrifugal pumps?
9. What are applications of centrifugal pumps?
10. Why casing is required and what are vortex and volute casing?
11. What is the vane exit angle of an pump?

5. MULTISTAGE CENTRIFUGAL PUMP TEST RIG.

Aim: - To plot the operational characteristic curves of a multistage centrifugal pump.

Apparatus:-Multistage (2-stage) centrifugal pump test set-up, stop clock, steel rule etc.

Description:

Two stage centrifugal pumps are used in application where high delivery pressures are required. Water coming out of the first stage is fed into the inlet of the second stage and this results in a cumulative increase of pressure producing a higher delivery pressure at the second stage outlet, more than two stages are used when even higher delivery pressures are required as in boiler feed water pumps, etc. multistage pump efficiencies are lower than single stage pump efficiencies due to higher losses in the narrow connecting passages between stages.

The test pump is a self-priming type monoblock two stage centrifugal pump of size 1"x1" operating on 220v, 50Hz. The two impellers are connected to a single shaft driven by an electric motor. Each impeller is encased separately and suitable passages connect the first stage outlet to the second stage inlet. An energy meter and a stop watch are provided to measure the input to the motor and a collecting tank to measure the actual discharge. A pressure gauge and a vacuum gauge are fitted in the delivery and suction pipe line to measure the pressure.

Theory:

In general a pump may be defined as a mechanical device which, when interposed in a pipe line, converts the mechanical energy supplied to it from some 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 pump 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 purposes are: Centrifugal, Piston, Axial flow (stage pumps), Air jet, Diaphragm and Turbine pumps. Most of these pumps fall into the main class, namely; Roto-dynamic, reciprocating (positive displacement), Fluid (air) operated pumps. While the principle of operation of other pumps is discussed elsewhere, the Multistage Centrifugal Pump which is of present concern falls into the category of Roto-dynamic pumps. In this pump, the liquid is made to rotate in a closed chamber (volute casing) thus creating the Centrifugal action which gradually builds the pressure gradient towards outlet thus resulting in the continuous flow. These pumps compared to reciprocating pumps are simple in construction, more suitable for handling viscous, turbid (muddy) liquids, can be directly coupled to high speed electric motors (without any speed reduction), easy to maintain. But, their hydraulic heads per stage at low flow rates is limited, and hence not suitable for very high heads compared to reciprocating pumps of same capacity and stage. But, as the pump is of Multistage (Four-stage) construction, the pressure gradually builds up in successive stages, all most equally in stage.

Procedure:

1. Prime the pump with water if required.
2. Open the delivery gate valve completely.
3. Start the motor and adjust the gate valve to required pressure and delivery
4. Note the following readings:
   (a) The pressure gauge reading P kg/sq.cm
   (b) The vacuum gauge reading Vkg/sq.cm
   (c) Time for 10revolutions of energy meter disc – T secs.
   (d) Time for 10 cm rise in the collecting tank –t secs.

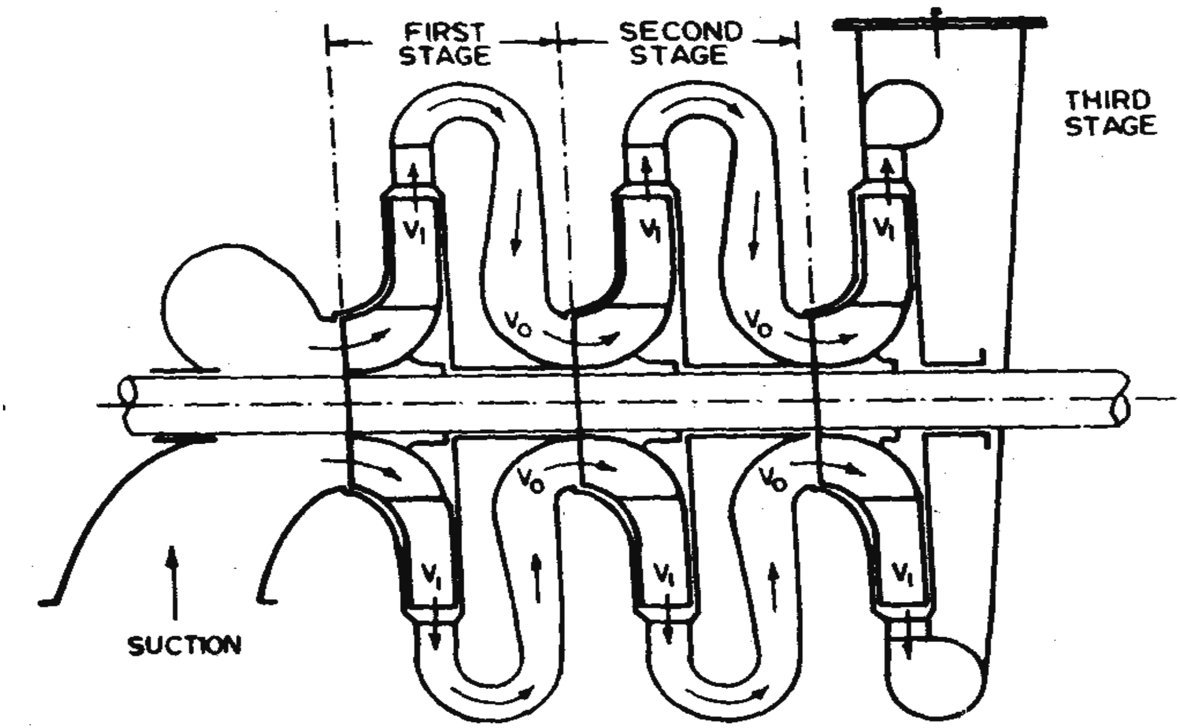
Take 3 or 1 sets of reading by varying the head from a minimum to maximum of about 3kg/sq.cm

Formulae for Calculations: -

1. Discharge

Area of tank (A)	**= 0.5 X 0.5 sq.m**
Rise of level (h)	**= 0.1 m**
Volume collected	**= A h cu.m (Assumed=0.025 cu.m)**
Time taken	**= t secs**
Discharge (Q)	**= Volume/Time =(0.025/t) cu.m/sec**
2. Head	
Total Head (H)	**= 10 (P + (V/760)) m of water**
3. Output of the pump	
Pump Output	**= (9.81 QH) KW**
	= (1000.QH) / 75 HP
4. Input of the Pump:	
Energy meter constant (N)	**= 1200 revs per KWH**
Time foe 10 revolutions	**= T secs**
Input to motor	**= (3600 x 10) / (N x T) KW**
	= (3600 x 10 x 1.36) / (N x T) KW
Efficiency of motor	**= 80% (assumed)**
Pump Input	**= Motor output x 0.80**
	= (24.0/T) KW
5. Pump Efficiency	**= Pump Output / Pump Input**
MODEL CALCULATIONS:	
Collecting tank area	**= 0.5x0.5 sq.m**

Energymeterconstant N	**= 1200 revs / KW Hr**
Discharge Q	**= Ar/t = 0.25x0.1/t cu.m/sec**
	= 0.025/t cu.m/sec
Total Head H	**= 10 (P + (V/760)) m of water**
Pump Output	**= 9.81 x QH KW**
Input	**= (3600 x 10 x 0.8) / (1200xT) KW**
	= 24/T
Efficiency	**= (Output / Input) X 100%**



Three-stage centrifugal pump

Table for Observations: -

S.No.	Pressure gauge (P) kg/cm^2	Vaccume gauge (V) mm of Hg	Total heat (H) 'n' of water	Time for 10cm rise in coil tank 't' sec	Discharge Q=10^{-3} m^3/sec	Time for 10rev of energy meter dics 'T' sec	Input (KW)	Output KW	Efficiency η

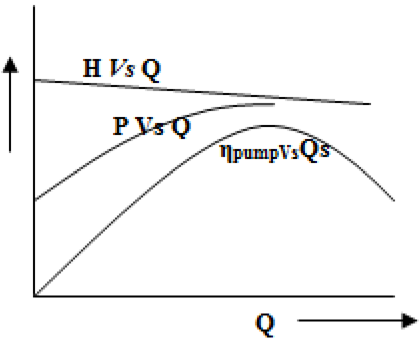
Graphs: -To analysis the operating characteristic curves of a multi stage centrifugal pump, plot the following graphs,

i). Discharge, „Q" on X-axis *Vs* Manometric Head, „H" on Y-axis

ii). Discharge, „Q" on X-axis *Vs* Input power on Y-axis

iii). Discharge, „Q" on X-axis *Vs*$\eta_{overall}$ on Y-axis

Expected Graphs: -



Result: - 1. The operational characteristic curves of centrifugal pump have been obtained

2. The maximum efficiency of the Centrifugal pump is = ___________

Precautions

1. Do not start the pump if the voltage is less than 300V.
2. Initially, put clean water free from foreign material, and change once in three months

NOTE: as the pump is of self priming type, do not operate the pump with the gate valve fully closed.

Applications:

As the multistage pump works as 2 pumps In series , it has a capacity to develop very high heads which is not possible for a single stage pump. These pumps finds applications where high heads is required. The number of stages can be decided based on the requirement. However it has been found that the increasing the stages can be decided on the requirement. However it has been found that increasing the stages beyond limit reduces the efficiency drastically.

Viva Questions:

1. How are pumps connected in series and parallel?
2. What is the advantage of series connection?
3. How can we obtain high discharge at low heads?
4. What happens when the efficiency as the number of stages are increased?
5. What is Mechanical/Hydraulic/Volumetric/Overall efficiency?
6. What is NSPH?
7. Compared to single stage how much power does a multistage pump use?
8. What is a positive pump and is this a positive pump?
9. How do you find output power of a pump and explain in all terms?
10. What is cavitation and where does cavitation takes place in pumps?
11. How does cavitation in pumps different from turbines?
12. How do you reduce cavitation in pumps?

6. RECIPROCATING PUMP TEST RIG.

Aim: -To obtain the operational characteristic curves of a Reciprocating pump.

Apparatus:-Reciprocating pump test set-up, stop clock, meter scale etc.

Description:

Reciprocating pump is a positive displacement pump, which causes a fluid to move by trapping a fixed amount of it then displacing that trapped volume into the discharge pipe. The fluid enters a pumping chamber via an inlet valve and is pushed out via a outlet valve by the action of the piston or diaphragm. They are either single acting; independent suction and discharge strokes or double acting; suction and discharge in both directions Reciprocating pumps are self priming and are suitable for very high heads adjusting the rpm of the driver. These pumps deliver a highly pulsed flow. If a smooth flow is required then the discharge flow system has to include additional features such as accumulators. An automatic relief valve set at a safe pressure is used on the discharge side of all positive displacement pumps.

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

Specification of the pump

Type: Double acting single cylinder

(a) Piston stoke L =1 ¾”(44.5mm)
(b) Piston Diameter d = 1 ½(38mm)
(c) Suction pipe = 1” (25mm)
(d) Delivery pipe = ¾” (18mm)

An energy meter is provided to determine input power to the motor. The pump is belt driven by the motor. The pump can be run at four different speeds by the use of V-belt and the differential pulley system. Special arrangement is provided for quick alteration of speed. The belt can be put in different grooves of the pulleys for different speeds quickly by loosening the belt. A set of pressure gauge and vacuum gauges are provided along with the required pipelines.

Theory:-

The reciprocating pump is positive displacement pump i.e. itoperates on the principles of actual displacement or pushing of liquid by a piston or plunger that executes a reciprocating motion in a closely fitted cylinder. The liquid is alternatively drawn from the pump and filled into suction side of the cylinder. The liquid fed to discharge side of the cylinder and emptied to the delivery pipe. The piston or plunger gets its reciprocating motion by means of a crank and connecting rod mechanism.

Working:

To start with when the crank angle$\theta$is zero or the piston istowards extreme left as the crank moves from inner dead to outer dead centre i. e. from $\theta=0^o$ to $\Theta=180$. The piston moves from extreme left to extreme right end. This movement of piston called backward stroke. So during the backward stroke, volume of air in the cylinder increase and resulting fall in pressure or partial vacuum. The air in suction pipe being at atmospheric pressure rush to the cylinder.

This by the end of backward stroke air in the suction pipe and the cylinder is rearranged and started otherwise partial pressure of some degree is created .During the forward stroke of the piston as the crank moves from $\theta = 180^o$ to $\theta = 360^o$.The air in cylinder is forced out through the delivery pipe. Thus after a few backward stroke and forward stroke sufficient partial vacuum is created. A stage come in backward stroke, the liquid due to the atmospheric pressure existing on the surface is sucked in and forced out during the backward stroke, the liquid sucked is forced out through the non return delivery valve it is called discharge stroke or delivery stroke Formulae for From above we find that pump has a capacity to create partial vacuum resulting in the suction of the liquid by itself property is called self priming.
It may be observed that a single acting single cylinder pump liquid is swept and only once in one revolution of the crank where is in double acting, it is swept twice for each revolution of the crank.

Formulae for Calculations: -

1. Pump output

Time for 10 cm rise	**= t sec**
Area of the tank A	**= 0.4 x 0.4 sq.m**
Pump discharge Q	**= (0.16 x 0.1) / t m^3/s**
Delivery pressure	**= P kg/sq.cm**
Suction pressure	**= V mm of Hg**
Pump delivery head H	**= $(P+\frac{V}{760})$ x 10 m of water**
Output of the pump	**= 9.81 x H x Q KW**

2. Pump Input:

Energy meter constant N	**= 1200 revs/K.Whr**
Time for 10 revolutions	**= t secs**
Input to the motor	**= 3600 x 0.8 x 10 / NT KW**

Where, 0.9 is the belt transmission efficiency

3. Efficiency:

Overall Efficiency	**= Output/Input x 100 %**

Procedure:

1. Select the required speed
2. Open the gate valve in the delivery pipe fully
3. start the motor
4. Throttle the gate valve to get the required head
5. Note the following readings
   (a) The speed of the pump(n)
   (b) Pressure gauge (P) and vacuum gauge readings(V)
   (c) Time taken for 10 revolutions of energy meter disc
   (d) Time taken for 10cm rise in collecting tank
6. Take at least 3 4 sets of readings by varying the head
7. Repeat the experiment for other speeds.

Observation Table:

S.NO	Speed (N) rpm	Pressure gauge (P) kg/cm^2	Vaccume gauge (V) mm of Hg	Total heat (H) m of water	Time for 10cm rise in coil tank 't' sec	Discharge 'Q X 10^{-3} m^3/sec	Time for 10rev of energy meter dics 'T' sec	Input (KW)	Output KW	Efficiency η

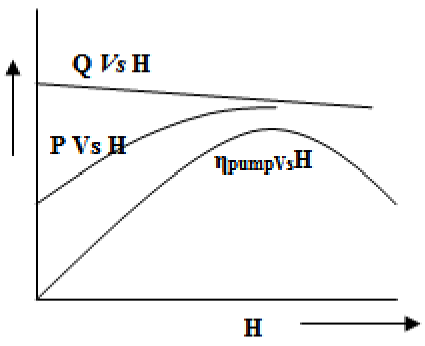
Graphs:- To study the operating characteristic curves of a Reciprocating pump, plot the following graphs,

i). Total head, „H" on X-axis *Vs* Discharge, „Q" on Y-axis

ii). Total head, „H" on X-axis *Vs* Shaft Input power, on Y-axis

iii). Total head, „H" on X-axis *Vs* η_{pump} on Y-axis

Expected Graphs:



Result: -

1. The operational characteristic curves of Reciprocating pump have been obtained
2. The maximum efficiency of the Reciprocating pump is =

PRECAUTIONS:

1. Don"t start the pump if the voltage is less than 180V.
2. Don"t forget to give neutral and earth connections to the unit.
3. Frequently (at least once in three months) grease/oil the rotating parts.
4. At least once in a week, operate the unit & avoid clogging of moving parts.
5. Replace the water possibly once in a month.
6. Don"t exceed 2 kg/cm^2 on pressure gauge reading and never fully close the delivery valve.
7. In case of any major fault, it is suggested to contact the manufacturer before taking up any major repairs.

Applications :

These are positive pumps because there is a fixed amount of fluid flow for a complete rotation of a crank shaft. As there is no fluid flow for zero displacement and vice versa the Head developed is Proportional to the load applied. These pumps find it application in

1. To drill from deep wells.
2. To pump any liquid that is free from debris.
3. To pump precise amounts of fluids Ex: Petrol pumps.

Viva Questions:-

1. What is priming?
2. The reciprocating pump is based on which principle?
3. Applications of reciprocating pump?
4. When do we go for reciprocating pump instead of c pump?
5. What are air filters and why do we use it?
6. What is meant by positive displacement pump?
7. What are the pumping characteristics of a reciprocating pump?
8. What is the normal efficiency of a reciprocating pump?
9. What are the precautions to be taken while operating the pump?
10. Why do we plot graphs and characteristics curves?

7. CALIBRATION OF VENTURIMETER

Aim: To find the coefficient of discharge for the given venturimeter and to calibrate it.

Apparatus:

Venturimeter fixed in a pipeline, manometer, collecting tank, stop watch.

Description:

The apparatus has a measuring Tank to measure the flow rate, and pipe line with a Venturimeter. Tapping with Ball valves are provided at Inlet & Outlet of the Venturimeter and these are connected to manometer. A constant steady supply of water is provided using mono block pump with a means of varying the flow rate.

Venturimeter is a flow meter used to measure the flow rate of fluid in a pipe. Venturimeter consists of a short length of pipe tapering to a narrow throat in the middle and then diverging gradually to the original diameter of the pipe. As the water flows through the meter velocity is increased due to the reduced area and hence there is a pressure drop. By measuring the pressure drop with a manometer the flow rate can be calculate by Appling the Bernoulli‟s equation.

The experimental setup consists of 2 gun venturimeter and orificimeter of the following dimensions [d/D ration – 0.56]

1. 25mm inlet dia and throat dia 20mm
2. 20 mm inlet dia and throat dia 15mm

The meters are fitted in the piping system with sufficiently ling pipe lengths (greater than 10 dia) upstream of the meters. Each pipe has the respective with quick action cocks for pressure tapping‟s. These pressure tapings are connected to a common middle chamber, Which in turn is connected to a differential manometer. Each pipe is provided with a flow control value. Water is supplied to the pipe lines from a sump tank by a 0.5HP monoblock pump. Outlet water is collected in an M>S collecting tank of cross sectional area 0.4 X0.4 mm provided with gauge glass scale fitting and drain value. The complete unit is moveable and is separated by a strong iron stand. A differential manometer of 1m length is provided to measure the pressure drop.

Theory:

A **Venturimeter** is a device which is used for measuring the rate of flow of fluid through pipe line. The basic principle on which a venture meter works is that by reducing the cross-sectional area of the flow passage, a pressure difference is created between the inlet and throat & the measurement of the pressure difference enables the determination of the discharge through the pipe.

A Venturimeter consists of.

1. An inlet section followed by a convergent cone,
2. A Cylindrical throat &
3. A gradually divergent cone.

The inlet section of the Venturimeter is of the same diameter as that of the pipe which is followed by a convergent cone. The convergent cone is a short pipe which tapers from the original size of the pipe to that of the throat of the Venturi meter. The throat of the venturi meter is a short parallel side tube having its cross-sectional area smaller than that of the pipe. The divergent cone of the venture meter is gradually diverging pipe with its cross-sectional area increasing from that of the throat to the original size of the pipe. At the inlet section & the throat, of the venture meter, pressure taps are provided through pressure ring.

Venturimeter provides a constriction in the flow area which produces an accelerated flow. Consequently, there will be a fall in static pressure. Hence, the measurement of drop in static pressure provides an accurate measure of the flow rate in the pipe. The application of Bernoulli‟s Equation between the inlet section and the throat section and the use of continuity equation leads to the following expression for the flow rate.

Venturimeter Head is directly related to the flow rate.

CONSTRUCTIONAL SPECIFICATION
MEASURING TANK

Measuring tank with gauge glass and scale arrangement for quick and easy measurement.

DIFFERENTIAL MANOMETER

Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.

SUMP

Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

BEFORE COMMISSIONNING

- Check whether all the joints are leak proof and water tight.
- Fill the manometer to about half the height with mercury
- Close all the cocks, pressure feed pipes and manometer to prevent damage and over loading of the manometer.
- Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertically.
- □□□Check proper electrical connections to the switch, which is internally connected to the motor.

Formulae for Calculations: -

1. Theoretical Discharge

Diameter of flow meter(D) = 0.025 m

Inlet area (a_1) = (3.14 /4)x D^2sq.m

Throat diameter = d m

Throat area (a_2) = (3.14/4) x d^2 sq.m

Difference in manometer level = hm

The equivalent pressure drop = h (13.6-1) m of water

dH = 12.6 x h m of water

Theoretical discharge (Q_t) = $A \times B^2 \times ((2 \times 9.81 \times dH) / (1-B^4))^{0.5}$

A – inlet area – 3.14 x D^2/4

B – diameter ratio – d/D

$$Q_t = C\,(dH)^{0.5}$$

Where, for 25mm venturimeter / Orificemeter, (C) = 0.000839

For 20mm venturimeter / Orificemeter, (C) = 0.000537

2. Actual Discharge

The area of collecting tank (A) = 0.4 x 0.4 sq.m

Rise in water level (R) = 0.1 m

Time taken = t sec

The actual discharge (Q_a) = AR/t

Where, K is the flowmeter constant

Hence, flowmeter co-efficient K = Q_a/Q_t

MODEL CALCULATIONS

Pressure drop dH = 12.6 (h_1-h_2) m of water

Actual discharge(Q) = A x R/t cu.m/sec

Theoretical discharge (Q_t) = C x $(dH)^{0.5}$

For 20mm venturimeter / Orificemeter (C) = 0.000537

For 25mm venturimeter / Orificemeter (C) = 0.000839

Meter constant K = Q/Q_t

Procedure:

1. Fill-in the sump tank with clean water.
2. Keep the delivery valve closed.
3. Connect the power cable to 1 Ph, 220 V, 10 Amps with earth connection.
4. Switch-ON the Pump & open the delivery valve.
5. Open the corresponding ball valve of the Venturimeter pipe line.
6. Adjust the flow through the control valve of the pump.
7. Open the corresponding ball valves fitted to Venturi / Orifice tappings.
8. Note down the differential head reading in the Manometer. (Expel if any air is there by opening the drain cocks provided with the Manometer).
9. 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.
10. Change the flow rate & repeat the experiment.

Note : While measuring the readings the reference point (water or mercury levels), continues vibrations may occur due to voltage changes, valves etc. in such cases average readings may be taken.

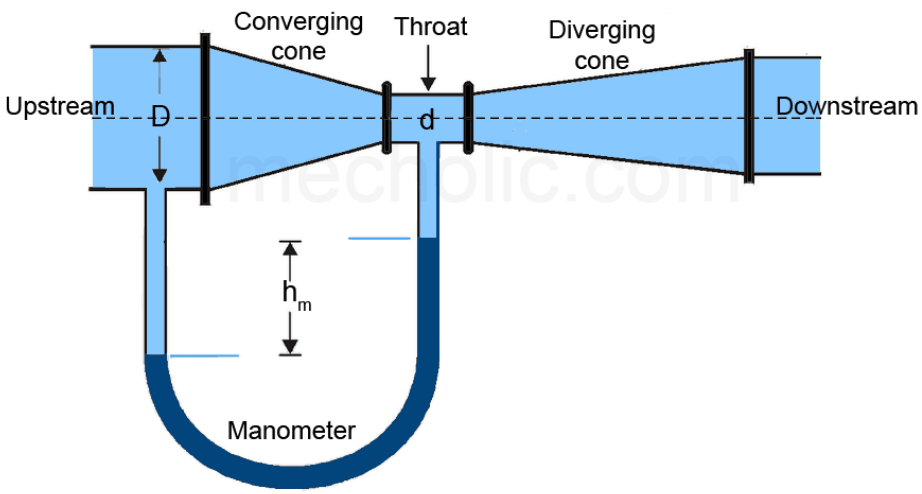


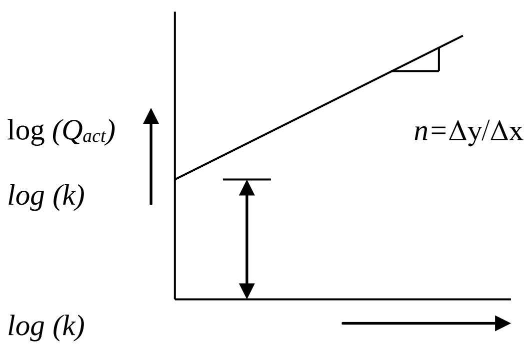
Table for observations: -

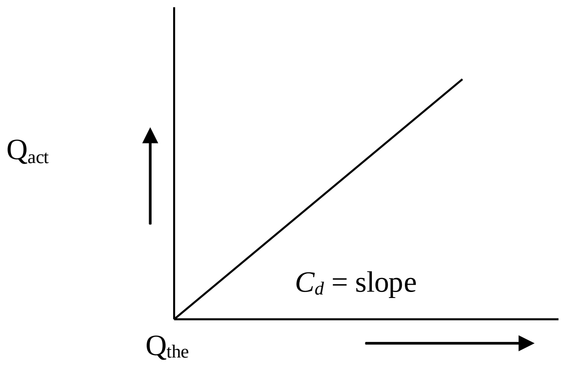
Experiment	Manometer reading		Pressure Drop (dh) m of Hg	Time for 'R' cm rise in 't' sec	Actual flow rate Q X 10^{-3} cu.m/sec	Theoretical flow rate Q_{th} x 10^{-3} cu.m/sec	Meter constant 'k'
	h_1 m of Hg	h_2 m of Hg					

Graphs:

Draw a graph of Actual discharge Vs theoretical Discharge and find the slope the resultant straight line, which represents the coefficient of discharge.

Expected Graphs: -





Result:

1. The average coefficient of discharge was calculated and found out to be ------
2. The slope of the straight line in the curve is found to be

Precautions:

1. Do not start the pump of the voltage is less than 180v.
2. The lower end of the suction pipe must always be submerged under water in the sump tank.
3. Do not forget to give the electric neutral and earth connections correctly.
4. Frequently at least once in a three months Greece oil the rotating parts.
5. Initially put the clean water free from materials & change once in three months.
6. At least every week operate the unit for five minutes to prevent clogging of the moving parts.

Applications:

Venturimeter is to measure the flow rate in pipelines carrying different fluids under pressure where it is not possible to make use of a collecting tank & stop watch .

Example: Petroleum pipe line, water pipe line etc,
In places like dams pressure needs to be retained for conversion of mechanical power and hence a venturimeter is a best replacement for collecting tank.

As a set up coast of a venturimeter is high, it is only used where the losses have to maintain minimum & coast is not a problem.

Viva Questions:

1. What is the aim of the experiment?
2. What are the applications of venturimeter?
3. What is the working principle of venturimeter?
4. What are the various sections of the venturimeter?
5. What are the losses on account of flow through a venturimeter?
6. What is the normal range of coefficient of discharge for a venturimeter?
7. What are the precautions to be taken while performing the experiment?
8. What is an convergent and divergent.

8.CALIBRATIONOF ORIFICEMETER

Aim: -To calibrate and to study the variation of coefficient of discharge of a given Orifice meter**.**

Apparatus: Orifice meter fixed in a pipeline, manometer, collecting tank, and stopwatch.

Description:

The orifice meter consists of a flat orifice plate with a circular hole drilled in it. The construction is very simple and so cost is low compared to other obstruction meters. There is a pressure tap upstream from the orifice plate and another just downstream. Reduction of cross-section of the flowing stream in passing through orifice increases the velocity head at the expense of pressure head. This reduction of pressure between taps is measured using a differential manometer and it gives a measure of the discharge. The pressure recovery is poor compared to the Venturimeter. The expression for discharge through any obstruction flow meter can be theoretically obtained using the continuity and Bernoulli"s equations together. The Bernoulli"s equation is defined for steady, incompressible and in viscid regions of flow. Since the Bernoulli"s equation is a simplified form of energy equation, the assumptions used for simplification must be satisfied when using it for practical.

Orificemeter is a flowmeter used to measure the flowrate of fluid in a pipe. Orificemeter consists of an orifice plate housed between two flanges. As the water flows through the meter, velocity is increased due to the reduced area and hence there is a pressure drop. By measuring thepressure drop with a manometer the flow meter rate can be calculated by applying Bernoulli"s equation.

The experimental setup consists of 2 gun metal venturimeter and Orificemeter of the following dimensions [d/D ratio – 0.56]

1. 25mm inlet dia and throat dia 20mm
2. 20mm inlet dia and throat dia 15mm

The meters are fitted in the piping system it sufficiently long pipe length [greater than 10dia] upstream of the meters. Each pipe has the respective Orificemeter with quick action cocks for pressure tapping"s. These pressure tapping"s are connected to a common middle chamber, which is in turn connected to a differential manometer. Each pipe line is provided with a flow control valve. Water is supplied to the pipe line =s from a sump tank by a 0.5HP monoblock pump. Outlet water is collected for an M.S collecting tank of area cross-sectional 0.4X0.4 m provided with gauge glass scale fitting and drain valve. The complete unit is movable and is supported by a strong iron stand. Differential manometer of 1m length is provided to measure the pressure drop.

Theory :

The apparatus is primarily designed for conducting experiments on the coefficient of discharge of flow meters. Each flow meter can be connected to the manometer through the pressure feed opening and the corresponding cocks.

While taking readings, close all the cocks in the pressure feed pipes except the two (Down-stream and upstream) cocks which directly connect the manometer to the required flow meter, for which the differential head is to be measured. (Make sure while taking reading that the manometer is properly primed. Priming is the operation of filling the manometer upper part and the connecting pipes with water and venting the air from the pipes).

First open the inlet gate valve of the apparatus. Adjust the control valve kept at the exit end of the apparatus to a desired flow rate and maintain the flow steadily.

The actual discharge is measured with the help of the measuring tank. The differential head produced by the flow meter can be found from the manometer for any flow rate.

CONSTRUCTIONAL SPECIFICATION

MEASURING TANK

Measuring tank with gauge glass and scale arrangement for quick and easy measurement.

DIFFERENTIAL MANOMETER

Differential manometer with 1 mm scale graduations to measure the differential head produced by the flow meter.

SUMP

Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

BEFORE COMMISSIONNING

Check whether all the joints are leak proof and water tight.

1. Fill the manometer to about half the height with mercury.
2. Close all the cocks, pressure feed pipes and manometer to prevent damage and over loading of the manometer.
3. Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertically.
4. Check proper electrical connections to the switch, which is internally connected to the motor.

Formulae for Calculations: -

1. Theoretical Discharge

Diameter of flow meter(D) = 0.025 m
Inlet area (a_1) = (3.14 x/4) D^2 sq.m
Throat diameter = d m
Throat area (a_2) = (3.14 x/4) d^2 sq.m

Case: 1

<u>1. Theoretical discharge:</u>
Difference in manometer level = h m
The equivalent pressure drop = h (13.6-1) m of water
dH = 12.6 h m of water

Theoretical discharge (Q_t) = A x B^2 x ((2 x 9.81 x dH) / (1-B^4))$^{0.5}$
A – Inlet area – 3.14 x D^2/4
B – Diameter ratio – d/D

Q_t = C (dH)$^{0.5}$

Where, for 25mm venturimeter / Orificemeter, C = 0.000839
For 20mm venturimeter / Orificemeter, C = 0.000537

2. Actual Discharge

The area of collecting tank (A) = 0.4 x 0.4 sq.m
Rise in water level (R) = 0.1 m
Time taken = t sec
The actual discharge(Q_a) = AR/t
Hence, flowmeter co-efficient K = Q_a/Q_t
Where, K is the flowmeter constant

Case: 2

1. Theoretical discharge:
Difference in manometer level = hm
The equivalent pressure drop = h (13.6-1) m of water
dH = 12.6 h m of water

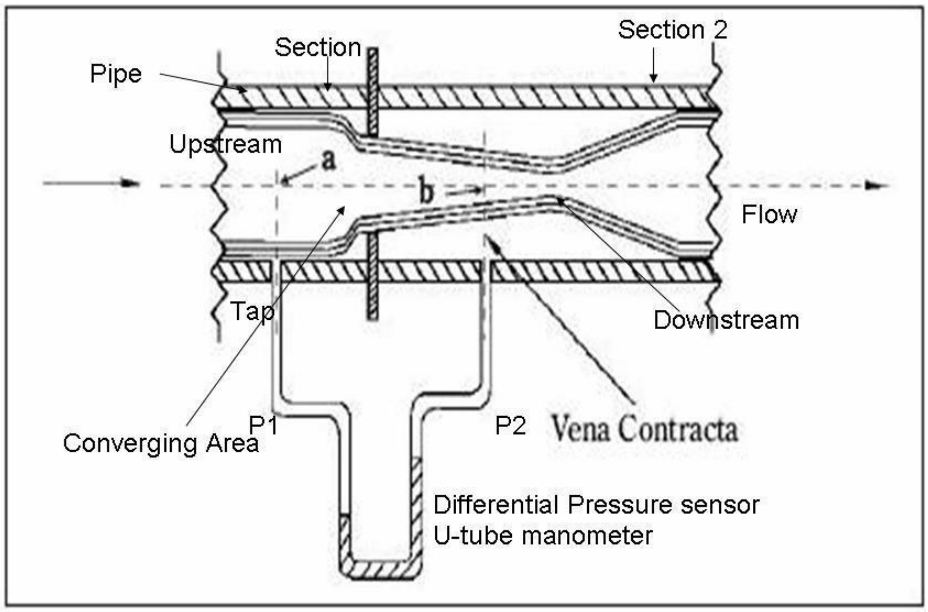
Theoretical discharge (Q_t) = C (dH)$^{0.5}$

2. Actual Discharge
Time taken = t sec
The actual discharge (Q_a) = AR/t
Flowmeter co-efficient K = Q_a/Q_t

Procedure:

1. Select the required venturimeter
2. Open its cocks and close the other cocks. So that only pressure for the meter in use is communicated to the manometer.
3. Open the flow control value and allow a certain flow rate
4. Vent the manometer it required.
5. Observe the water in the manometer level hm of Hg and determine the difference in manometer level hm of Hg.
6. Collect the water, drain value and find the time taken for Rm rise in tank.

Orifice Flow Meter



ORIFICEMETER

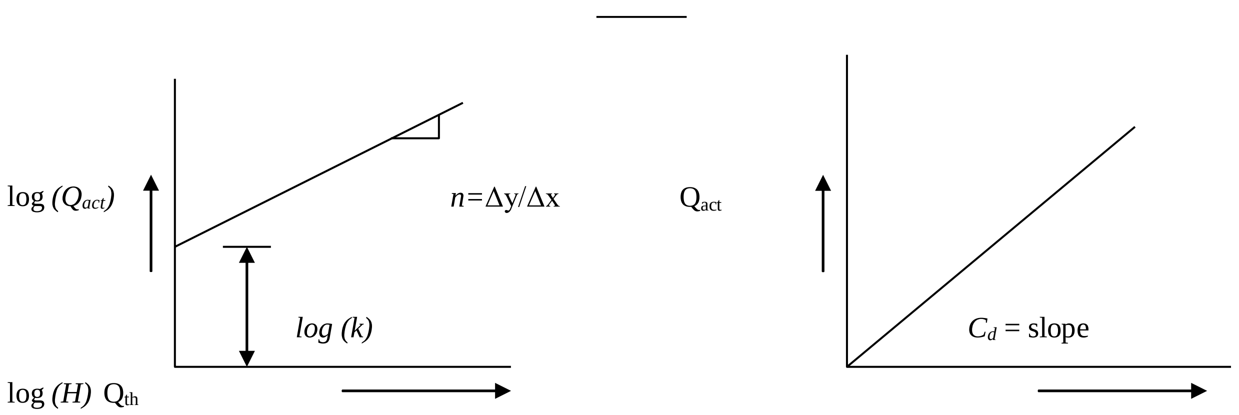
Table for observations: -

Experiment	Manometer reading		Pressure Drop (dh) m of Hg	Time for 'R' cm rise in 't' sec	Actual flow rate Q X 10^{-3} cu.m/sec	Theoretical flow rate Q_{th} x 10^{-3} cu.m/sec	Meter constant 'k'
	h_1 m of Hg	h_2 m of Hg					

Graphs :

Draw a graph of Actual discharge Vs theoretical Discharge and find the slope the resultant straight line, which represents the coefficient of discharge.

Expected Graphs: -



Result:

1. The average coefficient of discharge was calculated and found out to be ------
2. The slope of the straight line in the curve is found to be ---

Precautions :

1. Do not start the pump of the voltage is less than 180v.
2. The lower end of the suction pipe must always be submerged under water in the sump tank.
3. Do not forget to give the electric neutral and earth connections correctly.
4. Frequently atleast once in a three months Greece oil the rotating parts.
5. Initially put the clean water free from materials & change once in three months.
6. At least every week operate the unit for five minutes to prevent clogging of the moving parts.

Applications:

Orifice meter is to measure the flow rate in pipelines carrying different fluids under pressure where it is not possible to make use of a collecting tank & stop watch .
Example: Petroleum pipe line, water pipe line etc.

In places like dams pressure needs to be retained for conversion of mechanical power and hence Orificemeter is a best replacement for collecting tank.
The space and coast up an orifice meter is considerably less when compared to venturimeter but its coefficient of discharge is less, so it is used at places where low coast is preferred and power loss is not a problem.

Viva Questions:

1. What is the aim of the experiment?
2. What are the applications of orifice meter
3. What is the working principle of orifice meter?
4. What are the various sections of the orifice meter?
5. What are the losses on account of flow through an orifice meter?
6. What is the normal range of coefficient of discharge for a orifice meter.
7. Where do we go for orifice meter instead of venturimeter?
8. Where losses are more reduced compared to venturimeter.

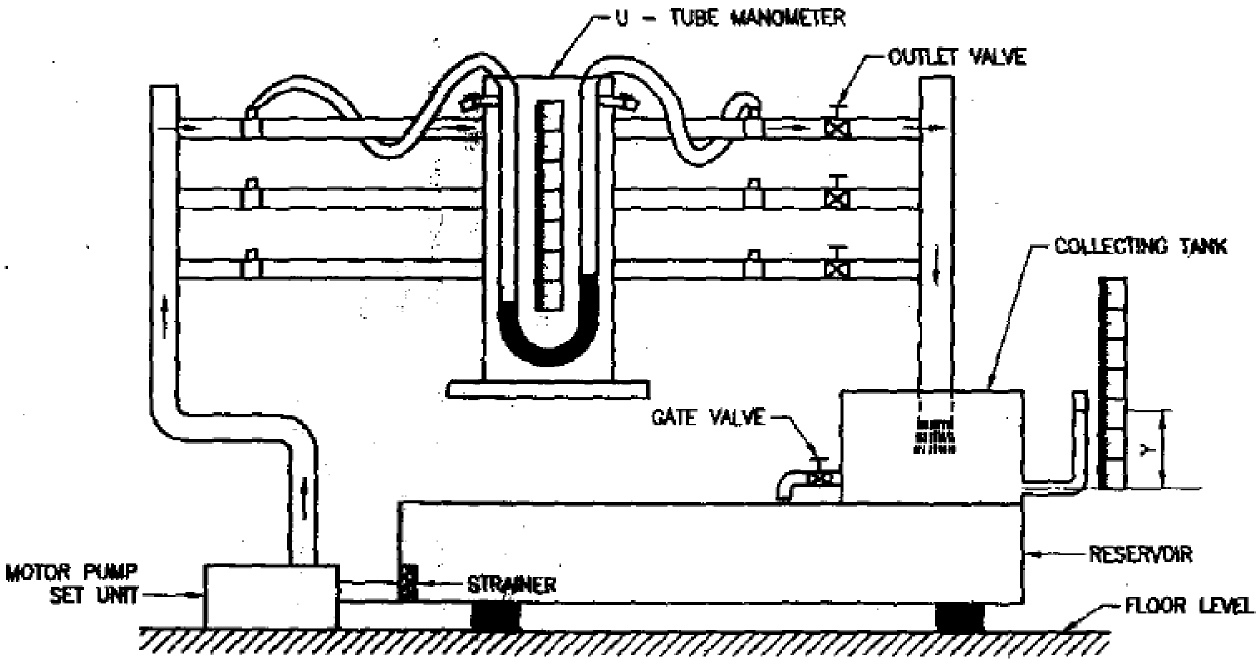
9. FRICTION FACTOR FOR A GIVEN PIPE LINE

Aim: - To calculate the friction factor for a given pipe line.

Apparatus: - experimental set-up, stop watch.

Introduction

The Closed Circuit Self- sufficient portable package system Apparatus for frictional losses in pipes is primarily designed for conducting experiments on the frictional losses in pipes of different sizes. This unit has several advantages like, this does not require any foundation, trench work, etc, and so that you can conduct the experiments keeping the unit anywhere in the laboratory soon after receiving the equipment.



PIPE FRICTION

General Description:

The unit consists mainly of 1) Piping System 2) Measuring Tank 3) Differential Manometer 4) Supply pump set 5) Sump.

Major Losses:-

When water flows through a pipe, a certain amount of energy {or pressure energy} has to be spent to overcome the friction due to roughness of the pipe surface. This roughness effect or friction effect depends upon the material of pipe and scale formation if any when the surface is smooth the friction effect is less, for an old pipe due to scale formation or chemical deposits the roughness and hence the friction effect is higher.

CONSTRUCTIONAL SPECIFICATION

PIPING SYSTEM

Piping System of size 15 mm, 20 mm and 25 mm and 40mm diameter is provided with tapings at 02 meter distance and a flow control valve.

SUPPLY PUMP SET

The Supply Pump set is rigidly fixed on sump. The 0.5HP mono block pump with motor operates on single phase 220/240 volts 50 Hz AC supply.

MEASURING TANK

Measuring tank with gauge glass and scale arrangement for quick and easy measurement.

SUMP

Sump to store sufficient water for independent circulation through the unit for experimentation and arranged within the floor space of the main unit.

DIFFERENTIAL MANOMETER

Differential manometer with 1 mm scale graduations is used to measure the differential head produced by the flow meter.

BEFORE COMMISSIONING

- Check whether all the joints are leak proof and watertight.
- Close all the cocks on the pressure feed pipes and Manometer to prevent damage and overloading of the manometer.
- Check the gauge glass and meter scale assembly of the measuring tank and see that it is fixed water tight and vertical.
- Check proper electrical connections to the switch, which is internally connected to the motor.

Formulae:

1. Area of the collecting tank A = 0.4 x 0.4 sq.m
Rise of level R = 0.1 m (say)
Volume collected = AR cu.m
2. Manometer reading (Mercury filled)
Reading in the left limb = h_1 m
Reading in the right limb = h_2 m

Difference level = **$(h_1 – h_2)$ m of Hg**

Equivalent loss of water head = **$(13.6 - 1) \times (h_1 – h_2)$**

Major Losses

1. Pipe lines

Diameter of the pipe = **dm**

Area of the pipe **a** = **$3.14 \times D^2/4$ sq.m**

Velocity in the pipe **V** = **Q/a m/sec**

Test length of the pipe **l** = **1.25 m**

2. Darcy's Constant –f

Head loss **H** = **$(4.f.1V^2)/(2.g.d)$**

Substituting the values,

l = 1.25 m; g = 9.81 m/sq.sec

$f = 3.93\ Hd/V^2$

3. Chezy's Constant –C:

Chezy's formula **$V = C \sqrt{m\,i}$**

Where, m = hydraulic mean radius (d/4 for pipes)

And i = loss of head per unit length (per meter)

Substituting the values,

C = **$V / \sqrt{0.25d \times H \times 0.5}$**

C = **$2.236 \times V \sqrt{dH}$**

Model Calculations:

Head loss	**H**	**= 12.6 (h_1-h_2) m of water**
Discharge	**Q = AR/t**	**= 0.016/t cu.m/sec**
Pipe area	**$a = 3.14 \times d^2/4$**	**= sq.m 0.123×10^{-3}**
Velocity	**V = Q/a**	**= m/sec**

Friction factor

$F = 3.93\ Hd/V^2$

$C = 2.236\ V/\sqrt{dH}$

Procedure:

1. Select the required pipeline.
2. Connect the pressure tapping"s of the required line (or the pipe fitting for minor losses study) to the manometer by opening the appropriate pressure cocks and closing all other pressure cocks.
3. Open the flow control value in the pipe line and allow water to pass.
4. Vent the manometers at a reduced flow rate
5. By controlling the value required flow rate can be obtained to get a particular Reynolds number
6. Note the pressure difference from the manometer mercury columns.
7. Collect the water in the collecting tank for a particular rise of level and note the time taken

Repeat the experiments if required red at other flow rate

Observation Table:

S.NO.	Pipe diameter m	Manometer reading		Head loss „H" m of H_2O	Time for R cm rise „t" sec	Flow rate QX 10^{-3} cu.m/sec	Pipe rate aX10^{-3}sq.m	Flow velocity „V" m/sec	Friction factor	
		h_1 „m" of Hg	h_2 „m" of Hg						Darey"s „f"	Chezy „C"
1.										
2.										

Result:

1. Loss of head due to friction is proportional to length of pipe and square of velocity
2. Loss of head is inversely proportional to inside diameter of pipe.
3. Average value of coefficient of friction for

PRECAUTIONS:

1. Do not start the pump if the voltage is less than 180
2. Ensure the electrical neutral and earth connections are given correctly
3. Frequently (at least once in 3 months) grease or oil of the rotating parts
4. Ensure that the apparatus is operated at least some time every week to avoid clogging.
5. Ensure there are no leakages in the piping and measuring tank.

10. STUDY OF LOSSES IN PIPE FLOW- MINOR LOSSES

Aim: - To determine the minor losses due to sudden enlargement, sudden contraction and bend.

Apparatus: - A flow circuit of G. I. pipes of different pipe fittings viz. Large bend, Small bend, Elbow, Sudden enlargement from 25 mm diameter to 50 mm diameter, Sudden contraction from 50 mm dia to 25 mm dia, U-tube differential manometer, collecting tank.

Description:

The test rig consists of a piping circuit with three pipelines of nominal diameter 12.5mm made of materials aluminum, copper and stainless steel for major loss studies. A fourth pipe line of normal diameter 15mm (0.5") is provided with various pipe fittings [an elbow , a bend, sudden expansion, sudden contraction, ball value, globe value, gate valve] for minor losses studies. The pipes are connected in parallel and using the gate values provided in each pipeline, water is made to flow in one pipeline at a time.

A pair of quick-change cocks is fitted at the upstream and downstream of each pipe fitting under study and for the first three pipe line at 1.25m distance apart to measure the frictionless. The cocks are connected to two common chambers which in turn are connected to two common chambers which in turn are connected to the mercury manometer. The manometer is used to measure the pressure drop, which is the head loss.

The diameter of the sudden enlargement and contraction are as follows sudden enlargement

Inlet pipe diameter =0.5 X outlet pipe diameter sudden contraction:

Inlet pipe diameter = 2.0X outlet pipe diameter

The complete unit is supported on MS stands. Water flowing out from these pipes is collected in the collecting tank to determine the flow rate and hence the velocity in the pipe.

Theory:-

Minor Losses:-

Pipeline system in general include several auxiliary components in addition to pipes. Theses components include the following:

1. Transitions or sudden expansion and contraction for charging pipe size

2. Elbows and bends for charging in flow direction.

These components introduce disturbances in the flow that cause turbulence and hence mechanical energy loss in addition to that which occurs over a finite distance, when viewed from the perspective of an entire pipe system are localized near the component. Hence these losses are referred to as local losses or minor losses. It could be remembered that these losses sometimes are the dominate losses in a popping system and hence the term minor losses is a misnomer often.

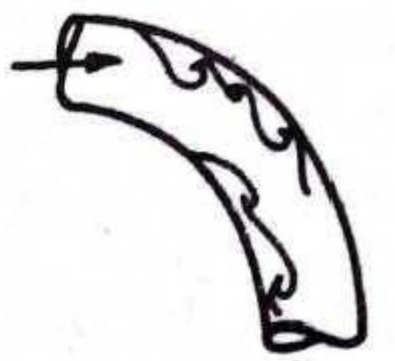


Figure: Loss due to bend

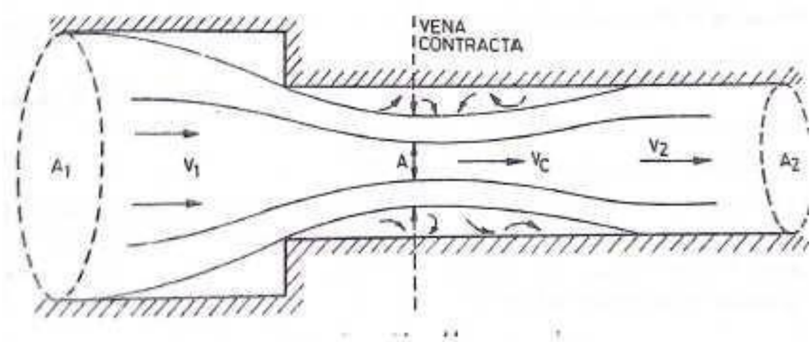


Figure: Loss due to sudden contraction

Sudden Contraction: - It represents a pipe line in which abrupt contraction occurs.
Inspection of the flow pattern reveals that it exists in two phases.
hcon = (Vc – V2)2/2g
Where
V_c = velocity at vena contracta
Losses at bends, elbows and other fittings:-
The flow pattern regarding separation and eddying in region of separations in bends, valves. The resulting head loss due to energy dissipation can be prescribed by the relation h = KV2/2g.
Where V is the average flow velocity and the resistance coefficient K depends on parameter defining the geometry of the section and flow. Resistances of large sizes elbows can be reduced appreciably by splitting the flow into a number of streams by a jet of guide vanes called cascades.

Formulae for Calculation:

Head loss	**H**	**= 12.6 (h_1-h_2)**
Discharge	**Q**	**= AR/t**
Velocity	**V**	**= Q/a = m/s**
Velocity head	**V/2g**	**= m of water**
Loss coefficient	**K**	**= H (V^2/2g)**

Calculations

1. Area of the collecting tank (A) = 0.4 x 0.4 sq.m

Rise of level (R) = 0.1 m (say)

Volume collected = AR cu.m

2. Manometer reading (Mercury filled)

Reading in the left limb = h_1 m

Reading in the right limb = h_2 m

Difference level = $(h_1 – h_2)$ m of Hg

Equivalent loss of water head = $(13.6 - 1) \times (h_1 – h_2)$

Minor Losses

1. Diameter of the pipe = d m

Area of the pipe (a) = $3.14 \times D^2/4$ sq.m

Velocity in the pipe (V) = Q/a m/sec

Velocity head (h_v) = $v^2/2g$ m of water

2. Loss coefficient for bend and elbow

Loss coefficient K = Loss/Velocity head

K = H/hy

3. Loss coefficient for bend sudden expansion

Let section 1 corresponds to uniform region upstream of the expansion and section 2 corresponds to the uniform region downstream of the expansion. Then from Bernoulli's theorem:

$$P_1 + V_1^2/2g+Z_1 = P_2 + v_2^2/2g+Z_2+\text{Losses}$$

Where, P, V, Z are the static pressure, velocity and elevation of the water particle and losses is the pressure loss due to the sudden expansion. Since elevation is constant, rearranging the equation.

$$\text{Loss} = (P_1-P_2) + V_1^2/2g\,(1-(V_2/V_1)^2)$$

But (P_1-P_2) is the static pressure difference, H in the manometer and $V_2/V_1 = a_1/a_2$,

The area ratio of the pipes (by continuity $a_1V_1 = a_2V_2$ = flow rate). Hence,

$$\text{Loss} = H+V_1^2/2g\,(1-(a_1/a_2)^2)$$

$$\text{Since } a_1/a_2 = (d_1/d_2) \times 2 = 0.25$$

$$\text{Loss} = H + 0.9375(V_1^2/2g)$$

$$K = \text{Loss}/ (V_1^2/2g)$$

Model Calculation:

Head loss	**H**	**= $12.6 (h_1-h_2)$ m of water**
Discharge	**Q = AR/t**	**= 0.016/t cu.m/sec**
Velocity	**V = Q/a**	**= m/sec**

Velocity **V/2g** **= m of water**

Loss coefficient **K** **= $H/(V^2/2g)$**

Procedure:

1. Select the required pipeline.
2. Connect the pressure tapping‟s of the required line (or the pipe fitting for minor losses study) to the manometer by opening the appropriate pressure cocks and closing all other pressure cocks.
3. Open the flow control value in the pipe line and allow water to pass.
4. Vent the manometers at a reduced flow rate
5. By controlling the value required flow rate can be obtained to get a particular Reynolds number
6. Note the pressure difference from the manometer mercury columns.
7. Collect the water in the collecting tank for a particular rise of level and note the time taken
8. Repeat the experiments if required red at other flow rate.

Observation

MINOR LOSSES:

S.No.	Manometer reading		Head loss „H‟ m of water	Time for R cm rise „t‟ seconds	Flow rate Q $x10^{-3}$ Cu – m/sec	Velocity v m/sec	Velocity coefficients $v^2/2g$ m of H_2O	Loss coefficient „k‟
	H_1 „m‟ of Hg	H_2 „m‟ of Hg						

Result:-

Hence minor losses are

Precautions:-

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

Viva Questions:

1. Define hydraulic gradient and total energy lines?
2. Define eddy loss?
3. Define sudden contraction?
4. Define sudden enlargement?

11. BERNOULLI'S EXPERIMENT

Aim: -To verify the validity of the Bernoulli's equation for an incompressible flow.

Apparatus: **-** Duct of variable cross section with supply and discharge chambers, collecting tank and stop watch etc.

Theory: -

$P/w + V^2/(2g) + Z=$ const. is called *Bernoulli's equation*. Each term in this equation represents the energy possessed by the fluid. Each term in the equation represents the energy per unit weight of the flowing fluid. The term *'P/w'* is known as *pressure head or static head*; *'$V^2/(2g)$'* is known as *velocity head or kinetic head* and *'Z'* is known as *potential head or datum head*. The *sum* of *P/w, $V^2/(2g)$ & Z* is known as *'Total head' or the total energy per unit weight of the fluid*. The *Bernoulli's equation thus states that in a steady, irrotational flow of an incompressible fluid the total energy at any point is constant*. In other words, if the Bernoulli‟s equation is applied between any two points in a steady irrotational flow of an incompressible fluid then, we get

$$P_1/w + V_1^2/(2g) + Z_1 = P_2/w + V_2^2/(2g) + Z_2$$

Where the different terms with subscripts 1 and 2 correspond to the two points considered.

The experimental setup consists of an upstream cylindrical chamber supplying water to a transparent and uniformly varying cross-sectional duct of converging-diverging section. The water from this duct flows into a downstream cylindrical section and then through a controlling gate valve into the collecting tank. 11 peizometric trappings are provided in the duct and these tapings are connected to glass tubes mounted vertically on a piezometer board.

Water is supplied to the upstream cylindrical chamber. By maintaining a head in the upstream chamber water flows in the transparent duct into the downstream duchy and finally into the collecting tank through the regulating gate valve and bend. The regulating gate valve is used maintain a water head in the downstream chamber. An overflow is provided for the upstream chamber.

Taking the datum line to be the center line of the conduct, the elevation head Z can be assumed to be zero. Hence for any point along the fluid in the convergent-divergent duct, the sum of the velocity head and the pressure head is constant by Bernoulli‟s there. The pressure head P is measured directly from the peizometric tube and the velocity calculated by measuring the actual flow rate. The scales are fixed on the piezometer and the inlet and outlet ducts such that the zero corresponds to the centerline of the duct.

The unit consist a sump of size 950 x 300 x 450 mm height and a monoblock pump, capacity is 0.5 HP, single phase 220 V, 2800 RPM and pump of size 25 mm to discharge about 15 LPM at 30 m total head.

Formulae for Calculations: -

For each set of readings:

Area of measuring tank A = Length x Breadth in (mm) ; time for (h) 10 cm rise in seconds. Rate of flow

Discharge (Q) = (Axh)/t m^3/s

Where,

A = Area of the measuring tank in meters= 0.3 m x 0.3 m

h = Rise of water level (say 10 cm) in meters.

t = Time in seconds for raise of water level

Volume collected = (A x h) cu.m

Since Z in the case of Horizontal flow $h_1 + V_1^2/2g = h_2 + V_2^2/2g$

Where,

h= Pressure head

V = Velocity = Q/a

Velocity head = $V^2_x/2g$ **m if water**

Q =Axh/t

a= Area of Duct at Pressure tapping

g = 9.81 Nm

From Peizometric readings static pressure at any section x (static head) = P_x **cm of water**

Measurement of the duct as follows:

1. **at pressure tapping 1 = 25 x 47mm = 0.001175 m at 0.02m**
2. **at pressure tapping 2 = 25 x 39mm = 0.00975 m at 0.06m**
3. **at pressure tapping 3 = 25 x 32mm = 0.0080 m at 0.10m**
4. **at pressure tapping 4 = 25 x 24mm = 0.0060 m at 0.14m**
5. **at pressure tapping 5 = 25 x 18mm = 0.00450 m at 0.17m**
6. **at pressure tapping 6 = 25 x 12.5mm = 0.00312 m at 0.20m**
7. **at pressure tapping 7 = 25 x 18mm = 0.00450 m at 0.23m**
8. **at pressure tapping 8 = 25 x 24mm = 0.00600 m at 0.26m**
9. **at pressure tapping 9 = 25 x 32mm = 0.00800 m at 0.30m**
10. **at pressure tapping 10 = 25 x 39mm = 0.00975 m at 0.34m**
11. **at pressure tapping 11 = 25 x 47mm = 0.001175 m at 0.38m**

Model calculation:

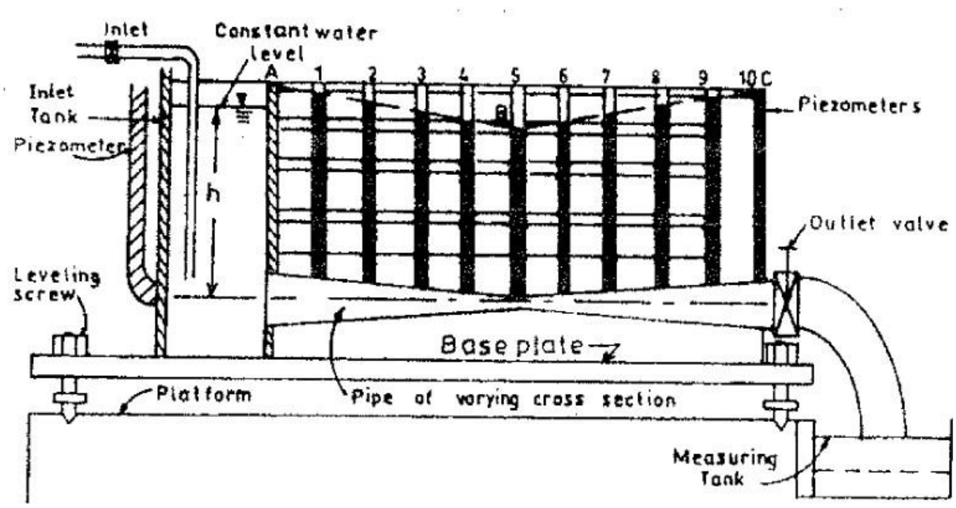
Section velocity (V_x)= Q/ax m/sec

Velocity head = 100(V^2_x/ 2g) cm of water

PROCEDURE:

1. Slowly open the supply gate and the outlet regulating gate valve and adjust both the valves both the valves such that for a particular head in the receiving cylinder, the inflow and the outflow are matched i.e., the head in the receiving cylinder should be maintained contestant. Observe the change of levels in the glass tubes. Since the cross sectional area of path is varying the velocity of fluid and hence the pressure head varies at each point
2. Note the height of water above the center of the conduit in each tube, this height corresponds to the static pressure head P at that point.
3. Determine the time taken for a certain rise in the water level in the collecting tank and calculate the flow rate.
4. Calculate the velocity of water at point"s where the pressure l=heads are measured.
5. Calculate the of pressure head and the velocity head at all eleven points and plot this valve against the x-direction (flow direction). It will be observed that the total head decrease gradually, especially in the diverging section due to the various losses friction, separation etc.

Diagram



Bernoulli's Apparatus

Observation table:

Run No.	Discharge (Q)	Cross sectional area	Piezometer Tube No.	1	2	3	4	5	6	7
1			h=Pressure Head							
			V=Q/a (Velocity)							
			$V^2/2g$ (Velocity Head)							
			Z =Datum Head							
			Total Head=h + $V^2/2g$ +Z							
2			h=Pressure Head							
			V=Q/a (Velocity)							
			$V^2/2g$ (Velocity Head)							
			Z =Datum Head							
			Total Head=h+ $V^2/2g$ +Z							
3			h=Pressure Head							
			V=Q/a (Velocity)							
			$V^2/2g$ (Velocity Head)							
			Z =Datum Head							
			Total Head=h + $V^2/2g$ +Z							

Table for calculations:

Table-2

S.NO	Actual discharge Q (m^3/s)	V=Q/A	Pressure Head (P/W)	Kinetic Head $V^2/2g$	Potential Head Z	Total enegy $H=P/W+V^2/2g+Z$
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						

Graphs*:* -Duct points on X-axis *Vs* Pressure head, velocity head, elevation head and Totalhead on Y-axis and on the same graph.

Result: - Bernoulli's equation is verified by conducting an experiment.

Precautions: -

1. Do not start the pump if the supply voltage is less than the rating voltage.
2. The water in the tank should be clean.

	le experiment schedule for the first 24 students (Batch- A1)				
	Batch1	Batch2	Batch3	Batch4	Batch5
	20/12/18	18/1/19	10/1/19	3/1/19	27/12/18
2	27/12/18	20/12/18	18/1/19	10/1/19	3/1/19
3	3/1/19	27/12/18	20/12/18	18/1/19	10/1/19
4	10/1/19	3/1/19	27/12/18	20/12/18	18/1/19
5	18/1/19	10/1/19	3/1/19	27/12/18	20/12/18

Sample experiment schedule for the remaining students (Batch-A2)					
Experiment	Batch6	Batch7	Batch8	Batch9	Batch10
1	21/12/18	24/1/19	11/1/19	4/1/19	28/12/18
2	28/12/18	21/12/18	24/1/19	11/1/19	4/1/19
3	4/1/19	28/12/18	21/12/18	24/1/19	11/1/19
4	11/1/19	4/1/19	28/12/18	21/12/18	24/1/19
5	24/1/19	11/1/19	4/1/19	28/12/18	21/12/18

MECH – A

Sample experiment schedule for the first 24 students (Batch- A1)					
Experiment	Batch1	Batch2	Batch3	Batch4	Batch5
6	21/1/19	22/3/19	14/3/19	7/3/19	28/1/19
7	28/1/19	21/1/19	22/3/19	14/3/19	7/3/19
8	7/3/19	28/1/19	21/1/19	22/3/19	14/3/19
9	14/3/19	7/3/19	28/1/19	21/1/19	22/3/19
10	22/3/19	14/3/19	7/3/19	28/1/19	21/1/19

Sample experiment schedule for the remaining students (Batch-A2)					
Experiment	Batch6	Batch7	Batch8	Batch9	Batch10
6	22/1/19	28/3/19	15/3/19	8/3/19	1/3/19
7	1/3/19	22/1/19	28/3/19	15/3/19	8/3/19
8	8/3/19	1/3/19	22/1/19	28/3/19	15/3/19
9	15/3/19	8/3/19	1/3/19	22/1/19	28/3/19
10	28/3/19	15/3/19	8/3/19	1/3/19	22/1/19

Vidya Jyothi Institute of Technology

(An Autonomous Institution)

(Accredited by NAAC, Approved by AICTE New Delhi & Permanently Affiliated to JNTUH)

Aziznagar Gate, C.B. Post, Hyderabad-500 075

DEPARTMENT OF MECHANICAL ENGINEERING

MOFHM LAB

Experiment Schedule

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DEPARTMENT OF MECHANICAL ENGINEERING

MOFHM LAB

Day to Day Evaluation

	Exp 1		Exp 2		Exp 3		Exp 4		Exp 5		

Roll No:	A	B	C	Exp1	A	B	C	Exp2	A	B	C	Exp3	A	B	C	Exp4	A	B	C	Exp5	Mid1
17911A0301	4	4	5	13	4	4	5	13	5	5	5	15	4	3	4	11	4	4	5	13	13
17911A0302	3	3	5	11	3	3	4	10	3	3	5	11	3	5	4	12	3	4	4	11	11
17911A0303	4	4	5	13	4	3	5	12	4	3	4	11	4	3	5	12	4	4	4	12	12
17911A0304	5	4	5	14	5	5	5	15	5	4	5	14	4	4	5	13	5	4	5	14	14
17911A0305	4	4	5	13	4	4	5	13	5	5	5	15	4	3	4	11	4	4	5	13	13
17911A0306	3	4	4	11	3	5	5	13	3	5	5	13	3	5	5	13	5	5	5	15	13
17911A0308	4	4	5	13	4	4	4	12	4	3	4	11	4	4	4	12	4	3	5	12	12
17911A0309	3	3	5	11	3	5	5	13	3	5	5	13	3	5	5	13	5	5	5	15	13
17911A0311	4	4	5	13	4	4	4	12	4	2	5	11	4	3	5	12	4	4	4	12	12
17911A0312	3	3	5	11	3	5	5	13	3	5	5	13	3	5	5	13	5	5	5	15	13
17911A0313	4	4	5	13	4	4	5	13	5	5	5	15	4	3	4	11	4	4	5	13	13
17911A0314	3	4	4	11	3	3	4	10	3	4	4	11	3	4	5	12	3	4	4	11	11
17911A0315	4	4	5	13	4	4	5	13	5	5	5	15	4	2	5	11	4	4	5	13	13
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17911A0319	3	4	4	11	3	5	5	13	3	5	5	13	3	5	5	13	5	5	5	15	13
17911A0320	4	4	5	13	4	5	5	14	5	5	5	15	4	5	5	14	5	4	5	14	14
17911A0321	4	5	5	14	5	5	5	15	4	5	5	14	4	4	5	13	4	5	5	14	14
17911A0322	4	4	5	13	4	4	5	13	5	5	5	15	4	2	5	11	4	4	5	13	13
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	Exp 6				Exp 7				Exp 8				Exp 9				Exp 10				
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DEPARTMENT OF MECHANICAL ENGINEERING

MOFHM LAB

RUBRICS FOR LABORATORY EVALUATION

CRITERIA OF EVALUATION	POOR (1)	AVERAGE (2)	GOOD (3)	EXCELLENT (4)
Experimental procedure	Missing several important experimental details.	Missing some important experimental details	Important experimental details are covered, some minor details missing.	All experimental details are covered and well written in proper format.
Results: data, figures, graphs, tables, etc.	Figures, graphs, tables contain errors or are poorly constructed, have missing titles, captions or numbers, units missing or incorrect, etc.	Most figures, graphs, tables are fine. Some important or required features are missing.	All figures, graphs, tables are correctly drawn except for some minor issues in presentation.	All figures, graphs, tables are correctly drawn, are numbered and contain titles/captions.
Safety Measures/ Conclusions	Missing the important points of Safety Measures/ Conclusions	Conclusions regarding major points are drawn, but many are misstated, indicating a lack of understanding. Also the safety measures are vague.	All important conclusions have been drawn, could be better stated. Safety measures are stated.	All important conclusions have been clearly made and student shows good understanding. Safety measures are mentioned in proper format and followed.
Spelling, grammar, sentence structure	Frequent grammar and/or spelling errors, writing style is rough and immature	Occasional grammar/ spelling errors, generally readable with some rough spots in writing style	Less than 3 grammar/ spelling errors, mature, readable style	All grammar/ spelling correct and very well-written.

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Vidya Jyothi Institute of Technology

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Aziz nagar Gate, C.B. Post, Hyderabad-500 075

DEPARTMENT OF MECHANICAL ENGINEERING

BATCH: 2017-21	Course: MFHM LAB			
A.Y.: 2018-19	LABORATORY I INTERNAL EXAMINATION AWARD LIST (25M)			
II B.Tech II Sem				
Sl. No.	**HT NO.**	**DTD (15M)**	**Exam (10M)**	**Total**
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A.Y.: 2018-19	**LABORATORY II INTERNAL EXAMINATION AWARD LIST (25M)**			
II B.Tech II Sem				
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BATCH: 2017-21	Course:MFHM LAB		
A.Y.: 2018-19	LABORATORY INTERNAL & EXTERNAL EXAMINATION AWARD LIST		
II B.Tech II Sem			
Sl. No.	**HT NO.**	**Internal Total (25M)**	**External Total (50M)**
1	17911A0301	24	43
2	17911A0302	20	46
3	17911A0303	20	48
4	17911A0304	24	44
5	17911A0305	24	45
6	17911A0306	23	47
7	17911A0308	22	44
8	17911A0309	23	46
9	17911A0311	20	46
10	17911A0312	24	43
11	17911A0313	22	46
12	17911A0314	20	46
13	17911A0315	23	45
14	17911A0316	18	46
15	17911A0317	24	48
16	17911A0319	22	44
17	17911A0320	24	45
18	17911A0321	24	44
19	17911A0322	22	44
20	17911A0323	23	49
21	17911A0324	20	43
22	17911A0325	23	45
23	17911A0327	22	47
24	17911A0328	22	47
25	17911A0329	23	48
26	17911A0330	24	49
27	17911A0331	24	45
28	17911A0332	24	49
29	17911A0333	24	47
30	17911A0334	16	48
31	17911A0335	20	43
32	17911A0336	24	48
33	17911A0337	24	45
34	17911A0338	23	43
35	17911A0339	24	44
36	17911A0340	22	49
37	17911A0341	22	43
38	17911A0342	22	44
39	17911A0343	23	43
40	17911A0344	22	43
41	17911A0345	22	43
42	17911A0346	22	46
43	17911A0347	24	48
44	17911A0349	21	49
45	17911A0350	24	45
46	17911A0351	24	46
47	17911A0352	23	46
48	17911A0354	23	47

49	17911A0355	24	47
50	17911A0356	24	45
51	17911A0358	25	47
52	17911A0359	22	47
53	17911A0360	17	43
54	17911A0361	22	47
55	17911A0362	23	45
56	17911A0363	22	47
57	17911A0364	18	46
58	17911A0365	20	43
59	17911A0367	23	45
60	17911A0368	22	45
61	17911A0369	22	46
62	17911A0371	24	45
63	17911A0372	24	45
64	17911A0373	23	44
65	17911A0374	24	46
66	17911A0375	23	43
67	17911A0376	23	49
68	17911A0377	22	46
69	17911A0379	22	46
70	17911A0380	21	43
71	17911A0381	22	46
72	17911A0382	22	45
73	17911A0383	19	45
74	17911A0384	22	48
75	17911A0385	24	48
76	17911A0386	24	49
77	17911A0387	24	44
78	17911A0388	23	47
79	17911A0389	20	47
80	17911A0390	22	47
81	17911A0391	22	47
82	17911A0392	20	44
83	17911A0393	24	46
84	17911A0394	21	43
85	17911A0395	22	47
86	17911A0396	22	47
87	17911A0397	24	45
88	17911A0398	21	44
89	17911A0399	20	45
90	17911A03A0	24	48
91	17911A03A1	23	45
92	17911A03A2	22	45
93	17911A03A3	21	43
94	17911A03A4	23	48
95	17911A03A5	23	49
96	17911A03A6	22	46
97	17911A03A7	20	49
98	17911A03A8	21	43
99	17911A03A9	25	43
100	17911A03B0	19	44
101	17911A03B1	22	48
102	17911A03B2	25	45
103	17911A03B3	24	47
104	17911A03B4	24	48
105	17911A03B5	22	47
106	17911A03B6	18	43
107	17911A03B7	24	45

108	17911A03B8	22	49
109	17911A03B9	23	47
110	17911A03C1	22	47
111	17911A03C2	23	44
112	17911A03C3	19	43
113	17911A03C4	17	45
114	17911A03C5	15	47
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145	17911A03F8	25	46
146	17911A03F9	22	44
147	17911A03G0	18	45
148	17911A03G1	20	47
149	17911A03G2	21	44
150	17911A03G3	20	47
151	17911A03G4	20	47
152	17911A03G5	20	45
153	17911A03G6	20	48
154	17911A03G7	22	48
155	17911A03G8	18	49
156	17911A03G9	18	46
157	17911A03H0	21	43
158	17911A03H1	21	47
159	17911A03H2	20	43
160	17911A03H3	25	47
161	17911A03H4	24	47
162	17911A03H5	16	43
163	17911A03H6	24	44
164	17911A03H7	21	45
165	17911A03H8	21	49
166	17911A03H9	22	46

167	17911A03J1	24	49
168	17911A03J2	13	49
169	17911A03J3	19	45
170	17911A03J4	25	45
171	17911A03J5	20	43
172	17911A03J6	19	49
173	17911A03J7	22	47
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175	17911A03K0	22	47
176	17911A03K1	20	48
177	17911A03K2	20	44
178	17911A03K3	25	49
179	17911A03K5	20	48
180	17911A03K6	23	47
181	17911A03K7	21	47
182	17911A03K8	21	48
183	17911A03K9	21	43
184	17911A03L0	25	45
185	17911A03L1	20	47
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187	17911A03L3	18	43
188	17911A03L4	23	48
189	17911A03L5	20	44
190	17911A03L6	20	49
191	17911A03L7	20	43
192	17911A03L8	20	43
193	17911A03L9	18	45
194	17911A03M0	21	49
195	17911A03M1	21	43
196	17911A03M2	16	46
197	17911A03M3	20	45
198	17915A0342	19	47
199	18915A0301	24	45
200	18915A0302	24	46
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205	18915A0307	24	46
206	18915A0308	24	45
207	18915A0310	23	46
208	18915A0311	23	46
209	18915A0312	22	48
210	18915A0313	23	46
211	18915A0314	22	43
212	18915A0315	22	49
213	18915A0316	22	46
214	18915A0317	22	45
215	18915A0318	25	43
216	18915A0319	25	43
217	18915A0320	23	47
218	18915A0321	21	46
219	18915A0322	22	43
220	18915A0323	22	46
221	18915A0324	20	47
222	18915A0325	21	48
223	18915A0326	18	43
224	18915A0327	24	49
225	18915A0328	24	47

226	18915A0329	22	43
227	18915A0330	23	46
228	18915A0331	22	49
229	18915A0332	23	45
230	18915A0333	23	43
231	18915A0334	23	44
232	18915A0335	24	49
233	18915A0336	21	44
234	18915A0337	22	44
235	18915A0338	22	48
236	18915A0339	25	46
237	18915A0340	23	48
238	18915A0341	23	45
239	18915A0342	16	45
240	18915A0343	18	45
241	18915A0344	24	48
242	18915A0345	19	46
243	18915A0346	20	44
244	18915A0347	23	48
245	18915A0348	22	48
246	18915A0349	23	49
247	18915A0350	23	45
248	18915A0351	23	47
249	18915A0352	22	43
250	18915A0353	22	43
No of students attempted		**250**	**250**
No of students scored >= 60% Marks		**246**	**250**
% of students scored >= 60% Marks		**98**	**100**
ATTAINMENT LEVEL		**3.0**	**3.0**
Course Attainment (80% Direct + 20% Indirect)			
Direct Attainment		**3.00**	
Indirect Attainment		**2.55**	
Course Attainment		**2.91**	

Indirect Attainment Report

Not secure | 172.18.0.172/ReportResults.aspx

VIDYA JYOTHI INSTITUTE OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

Logout

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COURSE INDIRECT ATTAINMENT REPORT

Batch: 2017-21
Year-Sem: II-II
Course: MOFHM LAB (C216)

Back

Course Indirect Attainment: 2.55

Students Participated: 205 **Total Students:** 256 **Survey Date:** 20-04-2019

Roll Number	CO1	CO2	CO3	CO4	CO5
Anonymous	2	3	3	3	3
Anonymous	3	3	2	2	3
Anonymous	3	2	2	3	3
Anonymous	2	2	2	2	3
Anonymous	2	2	2	2	3
Anonymous	2	3	2	2	3
Anonymous	2	2	2	2	3
Anonymous	2	3	2	2	3
Anonymous	2	2	3	2	3
Anonymous	2	3	3	2	3
Anonymous	2	3	2	2	3

Vidya Jyothi Institute of Technology

(An Autonomous Institution)

(Accredited by NAAC & NBA, Approved by AICTE New Delhi & Permanently Affiliated to JNTUH)

Aziz nagar Gate, C.B. Post, Hyderabad-500 075

DEPARTMENT OF MECHANICAL ENGINEERING

BATCH: 2016-2020	**Course: Tech Seminar, Comprehensive Viva & Major Project**				
A.Y.: 2019-20	**EXTERNAL EXAMINATION AWARD LIST**				
IV B.Tech II Sem					
Sl. No.	**HT NO.**	**TS (50M)**	**CVV (100M)**	**Major Project**	
				Internal Total (50M)	**External Total (150M)**
1	16911A0301	42	92	42	140
2	16911A0303	43	94	39	142
3	16911A0304	44	88	41	135
4	16911A0305	41	86	37	137
5	16911A0306	40	85	40	141
6	16911A0307	43	84	38	139
7	16911A0308	42	82	38	136
8	16911A0310	43	87	37	140
9	16911A0312	42	88	39	134
10	16911A0313	43	89	38	135
11	16911A0314	43	90	38	142
12	16911A0315	42	92	39	143
13	16911A0317	43	88	39	140
14	16911A0318	42	86	40	143
15	16911A0319	43	85	36	140
16	16911A0321	42	85	39	144
17	16911A0322	42	84	37	140
18	16911A0323	41	83	36	142
19	16911A0324	44	89	38	138
20	16911A0325	42	88	34	140
21	16911A0326	42	87	38	135
22	16911A0328	41	88	37	140
23	16911A0329	43	85	41	138
24	16911A0330	41	89	39	142
25	16911A0331	40	93	38	144
26	16911A0332	41	84	36	146
27	16911A0333	41	80	37	140
28	16911A0334	41	81	36	140
29	16911A0335	42	85	37	140
30	16911A0336	43	86	40	143
31	16911A0337	44	88	38	140
32	16911A0338	42	85	42	142
33	16911A0339	43	89	41	144
34	16911A0340	42	85	37	140
35	16911A0341	41	90	39	140
36	16911A0342	43	87	40	141
37	16911A0343	41	88	39	140
38	16911A0345	42	89	39	136
39	16911A0346	42	90	35	140
40	16911A0347	44	89	38	138
41	16911A0348	41	92	39	134
42	16911A0349	41	88	38	135
43	16911A0351	40	86	39	142
44	16911A0352	41	85	37	144
45	16911A0354	41	85	41	140

46	16911A0355	43	84	39	143
47	16911A0356	44	89	38	138
48	16911A0357	41	83	40	140
49	16911A0358	40	88	39	144
50	16911A0359	41	87	36	140
51	16911A0360	42	88	35	144
52	16911A0361	42	85	39	140
53	16911A0362	43	84	38	142
54	16911A0364	43	87	39	143
55	16911A0365	43	88	38	138
56	16911A0366	42	89	37	144
57	16911A0367	43	90	37	139
58	16911A0368	42	92	35	142
59	16911A0370	42	86	38	135
60	16911A0371	42	85	38	139
61	16911A0372	41	85	37	140
62	16911A0374	42	84	39	142
63	16911A0375	42	83	39	145
64	16911A0376	41	88	41	139
65	16911A0377	41	87	39	138
66	16911A0378	40	88	39	140
67	16911A0379	41	89	37	143
68	16911A0380	41	93	37	138
69	16911A0381	41	84	38	140
70	16911A0382	41	88	39	130
71	16911A0383	42	80	39	144
72	16911A0384	43	81	39	139
73	16911A0385	44	85	43	139
74	16911A0386	42	86	40	140
75	16911A0387	43	88	41	142
76	16911A0388	41	85	38	145
77	16911A0389	43	89	39	139
78	16911A0390	AB	AB	AB	AB
79	16911A0391	42	89	37	138
80	16911A0392	41	88	39	130
81	16911A0393	42	93	37	140
82	16911A0394	41	84	37	143
83	16911A0395	41	80	38	138
84	16911A0396	40	84	38	141
85	16911A0397	41	83	38	139
86	16911A0399	41	88	36	136
87	16911A03A0	43	87	36	138
88	16911A03A1	42	88	38	134
89	16911A03A2	43	89	38	135
90	16911A03A3	44	93	37	140
91	16911A03A5	41	84	37	142
92	16911A03A6	40	80	34	139
93	16911A03A7	43	81	37	143
94	16911A03A8	42	85	39	138
95	16911A03A9	43	86	41	144
96	16911A03B0	42	87	39	139
97	16911A03B1	42	85	39	138
98	16911A03B2	43	88	38	142
99	16911A03B3	43	89	38	138
100	16911A03B4	42	90	36	135
101	16911A03B5	43	92	38	139
102	16911A03B6	42	88	37	140
103	16911A03B7	41	88	39	128
104	16911A03B8	41	86	39	141

105	16911A03B9	43	85	41	138
106	16911A03C0	41	85	40	139
107	16911A03C1	42	85	39	136
108	16911A03C2	43	84	37	138
109	16911A03C3	44	83	37	134
110	16911A03C4	42	88	36	135
111	16911A03C5	43	87	38	140
112	16911A03C6	41	88	40	142
113	16911A03C7	43	89	41	139
114	16911A03C8	41	93	41	143
115	16911A03C9	42	84	40	138
116	16911A03D0	42	80	39	144
117	16911A03D1	41	81	41	139
118	16911A03D2	41	85	36	142
119	16911A03D3	40	86	39	138
120	16911A03D4	41	88	39	135
121	16911A03D6	41	85	40	139
122	16911A03D7	43	89	38	140
123	16911A03D8	42	88	40	142
124	16911A03E0	40	86	39	142
125	16911A03E1	43	88	41	145
126	16911A03E2	44	87	41	130
127	16911A03E3	41	88	38	138
128	16911A03E4	40	89	40	140
129	16911A03E5	40	86	39	142
130	16911A03E6	43	93	37	143
131	16911A03E7	42	84	36	138
132	16911A03E8	43	80	38	140
133	16911A03E9	42	81	36	142
134	16911A03F0	43	85	37	145
135	16911A03F1	43	86	38	139
136	16911A03F2	42	87	40	138
137	16911A03F3	43	88	38	140
138	16911A03F5	42	88	40	138
139	16911A03F6	43	87	39	134
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142	16911A03G0	41	93	40	142
143	16911A03G1	41	84	38	139
144	16911A03G2	43	80	41	143
145	16911A03G3	41	81	40	138
146	16911A03G4	40	85	40	144
147	16911A03G5	41	86	40	139
148	16911A03G6	43	88	38	142
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151	16911A03G9	41	86	40	139
152	16911A03H0	42	88	40	139
153	16911A03H1	40	86	39	142
154	16911A03H2	43	89	40	140
155	16911A03H3	42	85	38	142
156	16911A03H4	42	84	36	138
157	16911A03H6	40	86	39	142
158	16911A03H7	41	83	37	135
159	16911A03H8	42	88	38	139
160	16911A03H9	42	87	38	140
161	16911A03J0	41	88	36	142
162	16911A03J1	41	89	36	145
163	16911A03J2	40	93	37	139

164	16911A03J3	41	84	38	138
165	16911A03J4	41	80	38	140
166	16911A03J5	41	81	41	143
167	16911A03J6	42	85	39	138
168	16911A03J7	43	86	39	140
169	16911A03J8	44	88	39	144
170	16911A03J9	42	85	40	139
171	16911A03K0	43	89	38	139
172	16911A03K1	41	88	37	140
173	16911A03K2	43	89	39	142
174	16911A03K3	41	93	39	145
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181	16911A03L2	40	81	40	143
182	16911A03L3	41	85	38	138
183	16911A03L4	41	86	40	139
184	16911A03L5	43	88	36	142
185	16911A03L6	42	85	39	138
186	16911A03L7	43	87	36	135
187	16911A03L8	41	88	39	134
188	16911A03L9	44	88	38	139
189	16911A03M1	41	89	36	140
190	16911A03M3	41	88	39	130
191	16911A03M4	40	93	36	142
192	16911A03M5	43	84	36	142
193	16911A03M6	42	80	39	139
194	16911A03M7	43	81	38	143
195	16911A03M8	42	85	37	138
196	16911A03M9	43	86	36	144
197	16911A03N0	43	88	36	139
198	16911A03N1	42	85	36	142
199	16911A03N2	43	89	35	138
200	16911A03N3	42	88	39	135
201	16911A03N4	40	89	37	137
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203	17915A0302	41	88	39	125
204	17915A0303	42	84	37	135
205	17915A0304	43	83	33	140
206	17915A0305	44	88	38	142
207	17915A0306	42	87	37	144
208	17915A0307	40	88	39	146
209	17915A0308	41	89	39	140
210	17915A0309	41	93	37	140
211	17915A0310	40	84	39	144
212	17915A0311	43	80	37	143
213	17915A0312	41	81	35	146
214	17915A0313	40	86	35	140
215	17915A0314	43	86	40	142
216	17915A0316	42	88	42	145
217	17915A0317	42	85	38	139
218	17915A0318	41	82	40	138
219	17915A0320	41	83	39	140
220	17915A0321	43	89	38	143
221	17915A0322	41	84	37	138
222	17915A0323	40	92	37	142

223	17915A0324	41	88	37	144
224	17915A0325	42	86	37	139
225	17915A0327	43	93	39	142
226	17915A0328	42	84	38	145
227	17915A0329	43	80	38	139
228	17915A0330	42	81	38	138
229	17915A0331	43	85	38	140
230	17911A0332	41	83	39	140
231	17915A0333	42	86	39	139
232	17915A0334	42	88	40	143
233	17915A0335	41	85	39	138
234	17915A0336	42	87	39	144
235	17915A0337	42	88	38	139
236	17915A0338	43	89	35	143
237	17915A0339	42	93	35	142
238	17915A0340	43	88	39	139
239	17915A0341	42	87	40	140
240	17915A0343	42	88	38	142
241	17915A0344	41	89	40	145
242	17915A0345	41	93	38	139
243	17915A0346	43	84	36	138
244	17915A0347	41	80	38	140
245	17915A0348	42	81	38	143
246	17915A0349	43	85	39	138
247	17915A0350	41	85	40	140
248	17915A0351	43	86	38	142
249	17915A0352	41	88	39	145
250	17915A0353	43	85	39	139
No of students attempted		**249**	**249**	**249**	**249**
No of students scored >= 60% Marks		**249**	**249**	**249**	**249**
% of students scored >= 60% Marks		**100**	**100**	**100**	**100**
ATTAINMENT LEVEL		**3.0**	**3.0**	**3.0**	**3.0**
Course Attainment (80% Direct + 20% Indirect)					
Direct Attainment		**3.00**	**3.00**	**3.00**	
Indirect Attainment		**NA**	**NA**	**NA**	
Course Attainment		**3.00**	**3.00**	**3.00**	

COURSE END SURVEY FORM

Regulation: R15
Academic Year: 2018-2019
Program: B.Tech (Mechanical Engineering)
Year/Sem: II/ II
Course Name: MOFHM Lab
Course Code: A14385
Contact Hours: 3Lectures/1 Credit
No. of Students: 250

No. of lecture classes taken	**30**
No. of tutorial classes taken	
Course delivery modes	Experimentation,Demonstration
Technology utilization	Power Point
Assessment Tools	Internal Mid Examinations, and End Exam

OVERALL ATTAINMENT (80% DIRECT + 20% INDIRECT)	
DIRECT	3.00
INDIRECT	2.55
OVERALL ATTAINMENT	2.91