METHODIST
COLLEGE OF ENGINEERING & TECHNOLOGY
Accredited by NAAC with A+ and NBA
Estd : 2008
Affliated to Osmania University & Approved by AICTE

LABORATORY MANUAL

FLUID MECHANICS & HYDRAULIC ENGINEERING LABORATORY (2PC556CE)

BE V Semester (Autonomous)

NAME: ______________________________

ROLL NO: ______________________________

BRANCH: ______________ **SEM:** ______________

DEPARTMENT OF CIVIL ENGINEERING

Empower youth- Architects of Future World

VISION

To produce ethical, socially conscious and innovative professionals who would contribute to sustainable technological development of the society.

MISSION

- To impart quality engineering education with latest technological developments and interdisciplinary skills to make students succeed in professional practice.
- To encourage research culture among faculty and students by establishing state of art laboratories and exposing them to modern industrial and organizational practices.
- To inculcate humane qualities like environmental consciousness, leadership, social values, professional ethics and engage in independent and lifelong learning for sustainable contribution to the society.

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DEPARTMENT OF CIVIL ENGINEERING

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Prepared
By
Ms. Shiphali Preeti Aind
Assistant Professor

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DEPARTMENT OF CIVIL ENGINEERING

VISION

To evolve into a centre of excellence for imparting holistic civil engineering education contributing towards sustainable development of the society.

MISSION

- To impart quality civil engineering education blended with contemporary and interdisciplinary skills.

- To provide enhanced learning facilities and professional collaborations to impart a culture of continuous learning.

- To involve in training and activities on communication skills, teamwork, professional ethics, environmental protection and sustainable development.

DEPARTMENT OF CIVIL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES

The Graduates of the programme shall be able to:

PEO 1: Engage in planning, analysis, design, construction, operation and maintenance of built environment.

PEO 2: Apply the knowledge of civil engineering to pursue research or to engage in professional practice.

PEO 3: Work effectively as individuals and as team members in multidisciplinary projects with organizational and communication skills.

PEO 4: Demonstrate the spirit of lifelong learning and career enhancement aligned to professional and societal needs.

DEPARTMENT OF CIVIL ENGINEERING

PROGRAM OUTCOMES

Engineering Graduates will be able to:

- **PO1. Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and civil engineering specialization to the solution of complex civil engineering problems.
- **PO2. Problem analysis:** Identify, formulate, review research literature, and analyze complex civil engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **PO3. Design/development of solutions:** Design solutions for complex civil engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **PO4. Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **PO5. Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex civil engineering activities with an understanding of the limitations.
- **PO6. The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional civil engineering practice.
- **PO7. Environment and sustainability:** Understand the impact of the professional civil engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **PO8. Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the civil engineering practice.
- **PO9. Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **PO10. Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

Civil Engineering Graduates will be able to:

PSO 1. Investigate properties of traditional and latest construction materials using standard testing methods.

PSO 2. Use AutoCAD, STAAD Pro, ETABS, Revit Architecture and ANSYS software for computer aided structural analysis and design.

PSO 3. Describe the principles of sustainable development and green buildings for environmental preservation.

Laboratory Code of Conduct

1. Students should report to the concerned labs as per the time table schedule.
2. Studentswhoturnuplatetothelabswillinnocasebepermittedtoperformtheexperiment scheduled for the day.
3. Students should bring a note book of about 100 pages and should enter the readings/observations into the note book while performing the experiment.
4. After completion of the experiment, certification of the concerned staff in-charge in the observation book is necessary.
5. Staff member in-charge shall award 25 marks for each experiment based on continuous evaluation and will be entered in the continuous internal evaluation sheet.
6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate last session should be submitted and certified by the staff member in-charge.
7. Not more than three students in a group are permitted to perform the experiment on a set-up for equipment-based labs. Only one student is permitted per computer system for computer-based labs.
8. The group-wise division made in the beginning should be adhered to, and no student is allowed to mix up with different groups later.
9. The components required pertaining to the experiment should be collected from the stores in-charge, only after duly filling in the requisition form/log register.
10. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
11. Any damage of the equipment or burn-out of components will be viewed seriously by either charging penalty or dismissing the total group of students from the lab for the semester/year.
12. Students should be present in the labs for the total scheduled duration.

13. Students are required to prepare thoroughly to perform the experiment before coming to Laboratory.
14. Procedure sheets/data sheets provided to the students, if any, should be maintained neatly and returned after the completion of the experiment.

DEPARTMENT OF CIVIL ENGINEERING

FLUID MECHANICS & HYDRAULIC ENGINEERING LABORATORY

DO'S & DON'Ts

DO'S

- Learn Aim, objective & significance of the practical/ Experiment.
- Keep silence in the lab.
- Always perform the experiment or work precisely as directed by the teacher/Faculty
- Don't forget to bring calculator, graph sheet and other accessories when you come to lab.
- Before performing practical, read instrument manual carefully.
- Wear Shoes and apron while working in the laboratory
- Maintain clean and orderly laboratories and work area.
- Be aware of the various experiment controls (start button, stop button, speed control) for each lab.
- Be aware of the experiment harness when conducting experiments.
- Do not leave experiments running gunattended.
- Any injuries should be reported immediately for proper care.

DON'Ts

- Don't use mobile phones during lab hours.
- Don't try to repair any faulty instrument.
- Don't use apparatus without permission

FLUID MECHANICS & HYDRAULIC ENGINEERINGLABORATORY (2PC556CE)

COURSE OUTCOMES

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

CO1. Compute discharge flowing through streams and canals.

CO2. Determination the type of flow in pipe, and discharge through pipes and losses in pipes.

CO3. Competence in understanding flow phenomenon in open channels.

CO4. Analyze the force acting due to jets concept and its application in hydraulic machines.

CO5. Demonstrate working principles of hydraulic pumps and turbines.

B. E. V Semester

FLUID MECHANICS & HYDRAULIC ENGINEERINGLABORATORY (2 PC 556 CE)

S.No	Name of the Experiment	CO'S Mapped	PO'S PSO'S
1	Determination of Coefficient of discharge of a Rectangular notch with end contractions	CO1	PO1, PO2
2	Determination of coefficient of discharge of V- Notch.	CO1	PO1, PO2
3	Determination of coefficient of discharge of a Venturimeter.	CO1	PO1, PO2
4	Determination of coefficient of discharge of an Orifice meter.	CO1	PO1,PO2
5	Determination of coefficient of discharge of a Circular Orifice.	CO1	PO1, PO2
6	Determination of coefficient of discharge of a Mouth piece	CO1	PO1, PO2
7	Classification of flow by Reynold's Experiment.	CO2	PO1, PO6, PO8, PO9, PO10
8	Determination of Darcy's friction factor.	CO2	PO1,PO2, PO6, PO8, PO9, PO10
9	Determination of roughness coefficient in an open channel.	CO3	PO1,PO2, Po6, PO8, PO9,PO10
10	Determination of a vane coefficient.	CO4	PO1,PO2, PO6,PO8, PO9,PO10
11	Determination of basic characteristics of a hydraulic jump.	CO3	PO1,PO2
12	Study of main characteristic curve of a centrifugal pump.	CO5	PO1, PO2
13	Study of universal characteristic curve of a Francis Turbine.	CO5	PO1, PO2

B.E. V Semester2020-21
FLUID MECHANICS LAB (PC 351 CE)
CO- PO Mapping

PO / CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS0 1	PSO 2	PSO 3
PC 556.1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
PC 556.2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
PC 556.3	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
PC 556.4	3	-	-	-	-	1		1	1	1	-	-	-	-	-
PC 556.5	3	2	-	-	-	1		1	1	1	-	-	-	-	-
PC556 Avg.	**3**	**2.2**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**1**	**-**	**-**	**-**	**-**	**-**

<table>
<tr><th>Course code</th><th>Course Title</th><th colspan="6">Core/ Elective</th></tr>
<tr><td rowspan="3">2PC556CE</td><td rowspan="3">Fluid Mechanics & Hydraulic Engineering Laboratory</td><td colspan="6">Core</td></tr>
<tr><td>L</td><td>T</td><td>P/D</td><td>Credits</td><td>CIE</td><td>SEE</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>1</td><td>40</td><td>60</td></tr>
</table>

Prerequisite: Fluid Mechanics & Hydraulic Engineering

Course Objectives:

The objective of this course is to impart knowledge to

- Verify the principles studies in fluid mechanics.
- Calibrating various flow measuring device by determining coefficient of discharge.
- Provide understanding of practical application of open channels.
- Application of force concepts on jets and hydraulic machines.
- Determination of characteristics curve of turbine and pumps.

Course Outcomes:

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

CO1. Compute discharge flowing through streams and canals.

CO2. Determination the type of flow in pipe, and discharge through pipes and losses in pipes.

CO3. Competence in understanding flow phenomenon in open channels.

CO4. Analyze the force acting due to jets concept and its application in hydraulic machines.

CO5. Demonstrate working principles of hydraulic pumps and turbines.

List of Experiments:

1. a) Determination of coefficient of discharge of a Rectangular Notch with end contractions.
   b) Determination of coefficient of discharge of V- Notch.
2. a) Determination of coefficient of discharge of a Venturimeter.
   b) Determination of coefficient of discharge of an Orifice meter.
3. a)Determination of coefficient of discharge of a Circular Orifice.
   b) Determination of coefficient of discharge of a Mouth piece.
4. Classification of flow by Reynold's Experiment.
5. Determination of Darcy's friction factor.
6. Determination of roughness coefficient in an open channel.
7. Determination of a vane coefficient.
8. Determination of basic characteristics of a hydraulic jump.
9. Study of main characteristic curve of a centrifugal pump.
10. Study of universal characteristic curve of a Francis Turbine.

Text Books

T1. *S.K.Som and Biswas, G, 'Fluid Mechanics and Fluid Machines', Tata McGraw- Hill Publishing Co., New Delhi, 1998.*

T2. *P.N. Modi 'Hydraulic and Fluid Mechanics Including Hydraulic Machines', Standard Book House, New Delhi,2013.*

Reference Books:

R1. *Yuan, S.W., 'Foundation of Fluid Mechanics' Prentice-Hall India Pvt. Ltd., New Delhi, 1976.*

R2. *A.K.Mohanty, 'Fluid Mechanics', Prentice- Hall India Pvt. Ltd., New Delhi, 1994.*

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INDEX

EXPERIMENT – 1

DETERMINATION OF COEFFICIENT OF DISCHARGE OF A RECTANGULAR NOTCH WITH END CONTRACTION

Aim: To determine the Coefficient of Discharge (C_d) of a rectangular notch with end contraction

Apparatus Required:

1.Scale
2.Stopwatch,
3.Piezometer tube
4.Collecting tube
5.Open channel with rectangular notch
6.Pointer gauge

Theory:

Notches are used to measure the rate of flow or discharge in canals and streams. When a liquid flows over a notch the height of the liquid above the top of the sharp edge (crest) bears a relationship with the discharge across it. The conditions of flow in the case of weirs are practically the same as those of a rectangular notch and hence often a notch is called a weir and vice versa.

Coefficient of discharge $Cd=Q_A/Q_T$

Actual discharge $Q_A=AR/T$ cm^3/sec

Where

A=Area of collecting tank

R=Rise in collecting tank

T=Time for collection of water in collecting tank

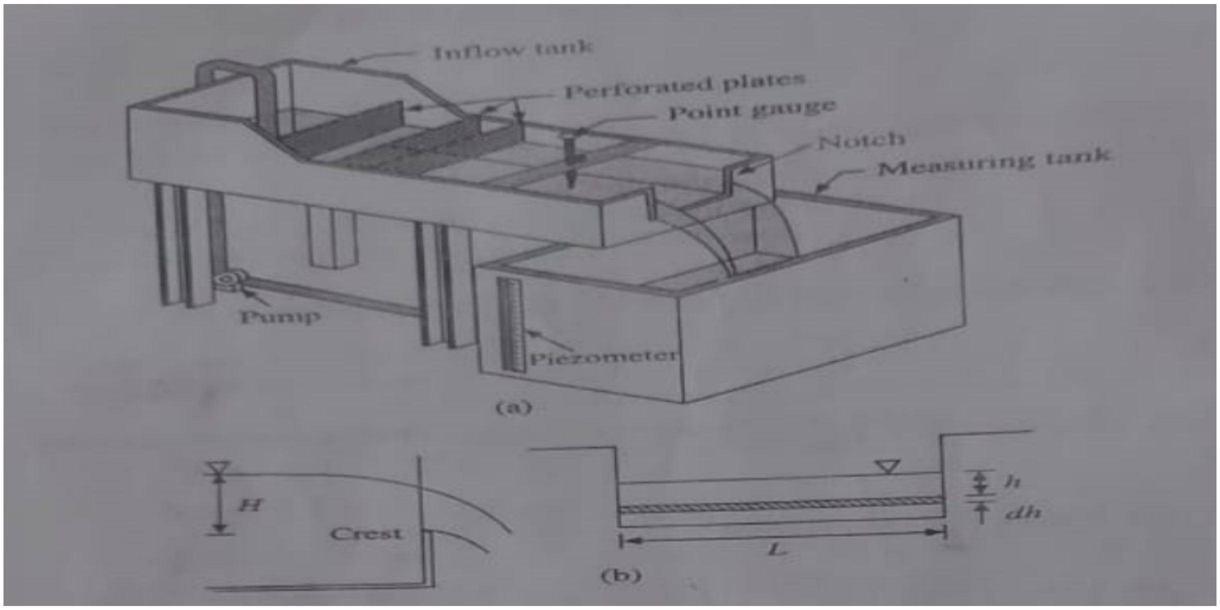
Theoretical discharge $Q_T=2/3\sqrt{2g}(L-0.1nH)H^{3/2}$

Where

L=Length of the notch

n= No of end contraction

H=Head above sill of notch



Procedure

1.The rectangular notch fitted to the channel and length of the notch is measured

2.water is allowed to flow in the channel by opening the regulating valve in the supply pipe up to the crest level

3.The pointer gauge reading is noted corresponding to the crest level i.e. reading at zero head (H_1).

4.Water is allowed to flow over the notch by opening the regulating valve in the supply pipe.

5.After the flow stabilizes and becomes steady time is noted for, by 10cmrise of water in the collecting tank and discharge is calculated

6.The pointer gauge reading is noted for corresponding steady flow i.e. reading for steady flow

over notch(H_2)

7.The theoretical discharge is calculated

8.By substituting values of Q_A and Q_T obtained above, Cd is calculated,min 8 times.

9.The experiment is repeated for min 8 times for different discharges in the channel and calculated by obtaining values of Q_A and Q_T above.

Observation and Calculation:

Data to be noted

1.Size of collecting Tank

2.Area of collecting Tank

3.Length of rectangular notch

4.No of end contractions

S.No.	Pointer gauge readings		Steady Head over notch H=(H – H_1) cms	Rise in collecting tank (R) cms	Time for collection of water (T) sec	Discharge cm^3/Sec		Co-efficient of discharge (C_d)	Remarks
	Reading at zero head (H_1) cms	Reading at steady flow over notch (H_2) cms				Actual discharge (Q_A)	Theoretical discharge (Q_T)		

Detailed Specimen Calculation (Reading No)

Length of sill notch L=…………..cms

Zero Head Reading H_1=…………..cms

Reading at steady flow over notch H_2=…………cms

Head above sill of notch $H=H_2-H_1$=………….cms

Theoretical Discharge $Q_T=2/3(L-0.nH)\sqrt{2g}H^{3/2}$=………….$cm^3$/sec

Collecting tank dimensions L × B=……………cms

Rise in collecting tank R=…………..cms

Time for collection of water in collecting tank T=…………sec

Actual discharge Q_T=AR/T cm^3/sec

Coefficient of discharge $C_d=Q_A/Q_T$

Result

(a) Average C_d value from experiment=………….

(b) Average Cd value from graph=………..

Comments

The value for C_d for a rectangular notch is approximately 0.6.The value of C_d depends on the Head(H).If the head is small, the value of C_d is also affected by viscosity and surface tension

Precautions

1.Care is to be taken that there is no flow over the crest before taking the initial pointer gauge reading

2.Ascertain the steady state of flow for a specific regulating value opening before taking the final pointer gauge reading

3.Measure the accurate specific rise in the collecting tank after the tank is approximately 1/4th full.

4.The pointer gauge reading are noted where there are no curvature effects

Graphs

1.Graph between Q vs $H^{3/2}$

2.Graph between Log Q vs Log H

Viva- Questions

1.state advantages of rectangular notch?

2.Mention some practical applications of notches

3.If the error is measurement of head is 10.What is the error in measurement of discharge of a rectangular notch.

EXPERIMENT – 2

DETERMINATION OF COEFFICIENT OF DISCHARGE OF A V OR TRIANGULAR NOTCH.

Aim : To determine the coefficient of discharge of a V or Triangular notch.

Apparatus Required: Triangular notch, Stopwatch and Scale.

Theory :

A notch is a device used for measuring the rate of flow of liquid through a small channel or a tank or streams. It may be defined as an opening in the side of a tank or vessel such as liquid surface in the tank if below the level of opening. The bottom of the notch over which the water flows is known as crest or sill and a thin sheet of water flowing through the notch is known as nappe or vein,Classification of Notches

1. According to the shape of the opening

(a) Rectangular notches (b) Triangular notches

(c) Trapezoidal notches (d) Stepped notches

2. According to the effect of the sides on the nappe

(a) Notch with end contraction (b) Notch without end contraction or suppressed notch.

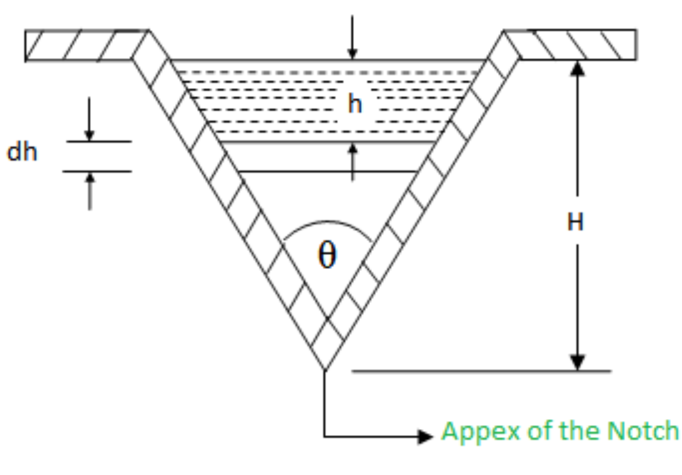
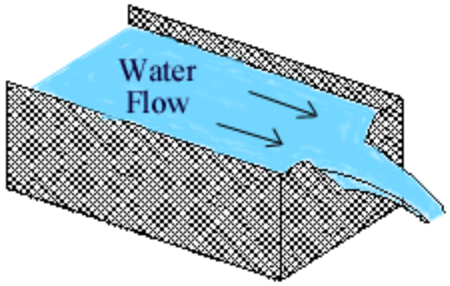
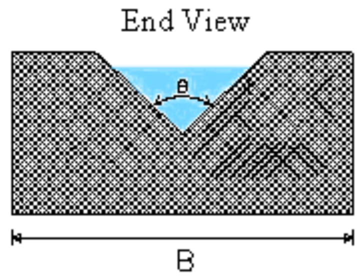


Fig : Triangular Notch

Let,

- H = Height of the liquid above the apex of the notch
- θ = Angle of the notch
- C_d = Coefficient of discharge





The discharge over notch is measured by measuring the head acting over the notch. As water approaches the notch, its surface becomes curved. Therefore, the head over the notch is to be measured at the upstream of the notch where the effect of curvature is minimum. Also it should be close to the notch so that the loss of energy between head measuring section and notch is negligible.

In practical, the head over notch is measured at a distance of 3 to 4 times the maximum height from the notch.

TRIANGULAR NOTCH

Dimensions of a Triangular notch are

Height (H)= Head above the sill of the notch or apex of the notch

$\theta = Angle\ of\ the\ notch$

Theoretical discharge of Triangular notch, $Q_{th} = \frac{8}{15} C_d \tan\theta/2 \sqrt{2g}\, H^{5/2}$

Procedure :

1 Fix the triangular notch.

2. Allow water in a channel.

3.Regulate the gate valve so that the water just flows over the sill.

4.Take the reading in the point gauge. The pointer just touches the water surface. The reading is Sill level reading.

5. Allow more water and maintains the discharge at a constant value by regulating the gate valve.

6. Adjust the pointer gauge and take the water level reading.

7. Collect the water in the collecting tank for a rise of 10 cm and note the time taken in seconds.

8. Repeat the experiment for different heads.

Calculations :

1. Area of the tank, A = m^2
   Rise of water level, R m = m
   Volume collected = A* R= m^3
   Time taken, t Sec = sec

   Actual discharge, Q_a = $\frac{A*R}{t}$ m^3/sec

2. Initial sill level reading, h_1 m = m
   Final water level reading, h_2 m = m
   Head of water, H = (Initial sill level reading - Final water level reading)

3.Calculate the Theoretical Discharge, $Q_{th} = \frac{8}{15} C_d \tan\theta/2 \sqrt{2g}\, H^{5/2}$

4.Coefficient of Discharge, $C_d = \frac{Q_a}{Q_{th}}$

Observations :

S.No.	Hook Gauge reading		Head above sill H 'm' of water	Time for R cm rise t seconds	Actual flow rate Q_a, m^3/sec	Theoretical flow rate Q_{th}, m^3/sec	Coeff. of Discharge, $C_d = \frac{Q_a}{Q_{th}}$
	h_1 m of water	h_2 m of water					
1							
2							

3							
4							

Result :The Coefficient of Discharge of V or Triangular notch , C_d = ---------

Graphs :

1.Q_a Vs $H^{5/2}$

2.log Q_a Vs log H

3.Q_a Vs Q_{th}

Viva-Questions :

1.Define a notch ?

2.How notches are classified ?

3.Where notches are used in real time ?

EXPERIMENT – 3

DETERMINATION OF COEFFICIENT OF DISCHARGE OF A VENTURI METER

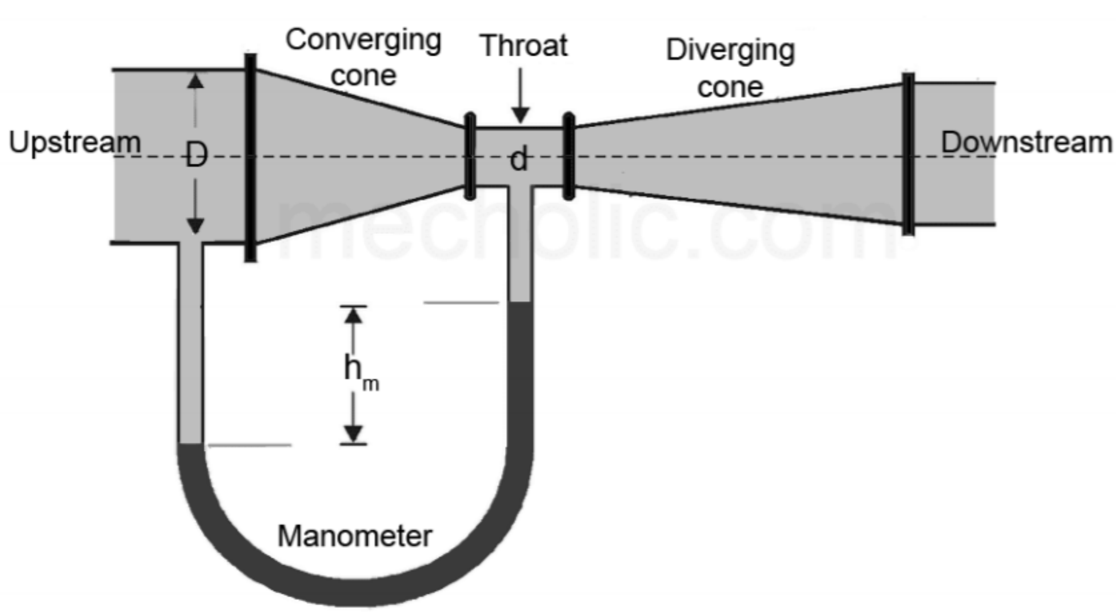
Aim: To determine coefficient of discharge of a venturi meter.

Apparatus: Stopwatch, Scale.

Theory:
Venturi meters are flow meters used to measure the flow rate of fluid in a pipe. It consists of Short length of pipe tapering to narrow throat in the middle hey and then diverging gradually to the original diameter of the pipe. As the water flows hey 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 calculated by applying Bernoulli's equation.

The experimental setup consists of 3 gunmetal venturi meters of d/D ratio = 0.6 of sizes.

1. 50 mm inlet diameter and 30 mm throat diameter,
2. 40 mm inlet diameter and 24 mm throat diameter,
3. 25 mm inlet diameter and 15 mm throat diameter.



The meters are fitted in the piping system with sufficiently long pipe lengths (greater than 10 dia) both upstream and downstream of the meters. Each pipe has the respective eventually venturi meter with quick action Cocks for pressure tapping. These pressure tapping are connected to a common middle chamber, which in turn is connected to a differential manometer. Each pipe is provided with a flow control valve. The water from the piping system is collected by a M.S. collecting tank of size 0.8 m x 0.8 m x 1 m with gauge glass scale fitting and a drain valve. The complete unit is supported by a strong iron stand. A differential manometer of 1 m length is provided to measure the pressure drops.

Procedure :

1. Select the required venturi metre.
2. Open its cocks and close the other cocks so that only pressure for the metre in use is communicated to the manometer.
3. Open the flow control valve and allow a certain flow rate.
4. Vent the manometer if required.
5. Observe the readings in the manometer.
6. Collect the water in the collecting tank. Close the drain valve and find the time taken for 10 cm rise in the tank.
7. Repeat the experiment for six different discharges.

Calculations:

1. i)Area of collecting tank, A = m^2

   ii)Rise in water level = R = 0.1 m

   iii)Volume collected,V= A*R = 0.064 m^3 =

   iv)Time taken t, sec =

   v)Actual flow rate, $Q_a = \frac{A*R}{t}$ m^3/sec =

2. Manometer readings (Mercury filled)

   i)Reading in the left limb=h_1 m =

   ii)Reading in the right limb=h_2 m =

   iii)Difference in mercury levels = $(h_1 - h_2)$ m of Hg =

   iv)Pressure drop = dH = (13.6-1) * $(h_1 - h_2)$ =

   Or H= 12.6 $(h_1 - h_2)$ m of water =

3. For a venturi meter,

Theoretical Discharge, $Q_t = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$ =

Where, a_1 = Area of inlet = $\frac{\pi D^2}{4}$

a_2 =Area of Throat = $\frac{\pi d^2}{4}$

D = Diameter of inlet

d = Diameter of throat = 0.6 D

4. Coefficient of venturi meter, c = $\frac{Q_a}{Q_t}$

Observations :

1. Area of collecting tank, A = m^2
2. Pressure drop, H = 0.126 (h_1- h_2) m of water =
3. Actual Discharge, $Q_a = \frac{A*R}{t}$ m^3/sec = m^3/sec
4. Theoretical Discharge, $Q_t = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$ = m^3/sec
5. Coefficient of venturi meter, = $c_d = \frac{Q_a}{Q_{th}}$

S.No	Manometer reading		Pressure drop, H m of water	Time in sec for rise R cm	Actual Discharge Q_a, m^3/sec	Theoretical Discharge, Q_{th} m^3/sec	Coefficient of venturi meter, C_d
	h_1 m of Hg	h_2 m of Hg					

Result : Coefficient of Venturi meter is

Graphs :

a) Q_a Vs Q_t

b) Q_a Vs $\sqrt{H}$

c) log Q_a Vs log H

Viva-Questions :

1. Why the divergent cone is longer than convergent cone in venturi meter?
2. Explain why the length of diverging cone is greater than converging cone in venturi meter?
3. Compare the merits and demerits of venturi meter with orifice meter.
4. Why C_d value is high in venturi meter than orifice meter?

Experiment – 4

DETERMINATION OF COEFFICIENT OF DISCHARGE OF AN ORIFICE METER

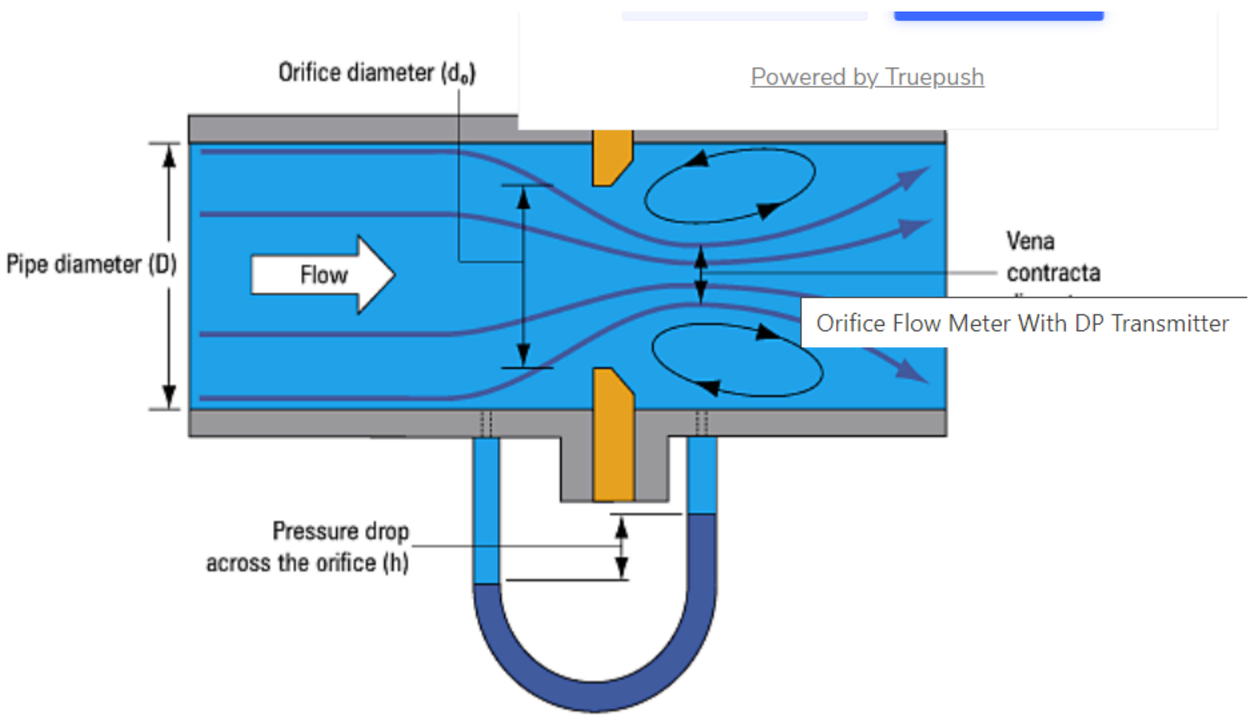
Aim: To determine coefficient of discharge of an Orifice meter.

Apparatus: Orifice meter set, Stopwatch, Scale.

Theory : Orifice meters are flow meters used to measure the flow rate of fluid in a pipe.It consists of an orifice plate housed between two flanges. As the water flows hey through these meters, 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 calculated by applying Bernoulli's equation.

The experimental setup consists of 3 gunmetal orifice meters of d/D ratio = 0.6 of sizes.

1. 50 mm inlet diameter and 30 mm throat diameter,
2. 40 mm inlet diameter and 24 mm throat diameter,
3. 25 mm inlet diameter and 15 mm throat diameter.



The meters are fitted in the piping system with sufficiently long pipe lengths (greater than 10 dia) both upstream and downstream of the meters. Each pipe has the respective orifice meter with quick action Cocks for pressure tapping. These pressure tapping are connected to a common middle chamber, which in turn is connected to a differential manometer. Each pipe is provided with a flow control valve. The water from the piping system is collected by a M.S. collecting tank of size 0.8 m x 0.8 m x 1 m with gauge glass scale fitting and a drain valve. The complete unit is supported by a strong iron stand. A differential manometer of 1 m length is provided to measure , the pressure drops.

Procedure :

1. Select the required orifice metre.
2. Open its cocks and close the other cocks so that only pressure for the metre in use is communicated to the manometer.
3. Open the flow control valve and allow a certain flow rate.
4. Vent the manometer if required.
5. Observe the readings in the manometer.
6. Collect the water in the collecting tank. Close the drain valve and find the time taken for 10 cm rise in the tank.
7. Repeat the experiment and take about six sets of readings.

Calculations:

1. i)Area of collecting tank, A = m^2

   ii)Rise in water level = R = 0.1 m

   iii)Volume collected ,V= A*R = m^3

   iv)Time taken t, sec =

   v)Actual flow rate, $Q_a = \frac{A*R}{t}$ m^3/sec = m^3/sec

2. Manometer readings (Mercury filled)

   i)Reading in the left limb=h_1 m =

   ii)Reading in the right limb=h_2 m =

   iii)Difference in mercury levels = $(h_1 - h_2)$ m of Hg =

   iv)Pressure drop = dH = (13.6-1) * $(h_1 - h_2)$ =

   Or H= 12.6 $(h_1 - h_2)$ m of water =

3. For a orifice meter,

Theoretical Discharge, $Q_t = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$ =

Where, a_1 = Area of pipe cross-section = $\frac{\pi D^2}{4}$

a_2 =Area of Orifice = $\frac{\pi d^2}{4}$

H = Pressure drop

4. Coefficient of discharge of orifice meter, c = $\frac{Q_a}{Q_t}$

Observations :

1. Area of collecting tank, A = m^2
2. Pressure drop, H = 0.126 (h_1- h_2) m of water =
3. Actual Discharge, $Q_a = \frac{A*R}{t}$ m^3/sec = m^3/sec
4. Theoretical Discharge, $Q_t = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}$ = m^3/sec
5. Coefficient of discharge of orifice meter, = $c_d = \frac{Q_a}{Q_{th}}$

S.No	**Manometer reading**		**Pressure drop, H m of water**	**Time in sec for rise R cm**	**Actual Discharge Q_a, m^3/sec**	**Theoretical Discharge, Q_{th} m^3/sec**	**Coefficient of discharge, C_d**
	h_1 m of Hg	**h_2 m of Hg**					

Result : Coefficient of discharge of an orifice meter is

Graphs :

a) Q_a Vs Q_t
b) Q_a Vs $\sqrt{H}$
c) log Q_a Vs log H

Viva-Questions :

1.Why Vena contracta is at a distance of half the diameter of the orifice?
2. Why principle of orifice meter is different from that of the venturi meter ?
3. What is the approximate distance of vena contracta from the centre of orifice ?
4. What is the standard values of C_d ranges ?

EXPERIMENT – 5

DETERMINATION OF COEFFICIENT OF DISCHARGE OF A CIRCULAR ORIFICE

Aim: To determine the Coefficient of Discharge (C_d)of a Circular orifice.

Apparatus Required :

1. Orifice and an orifice tank with piezometer.
2. Collecting tank with piezometer tube.
3. Stop watch

Theory:

An orifice is an opening having a closed perimeter, made in the walls or the bottom of a tank or a vessel containing fluid through which the fluid may be discharged.

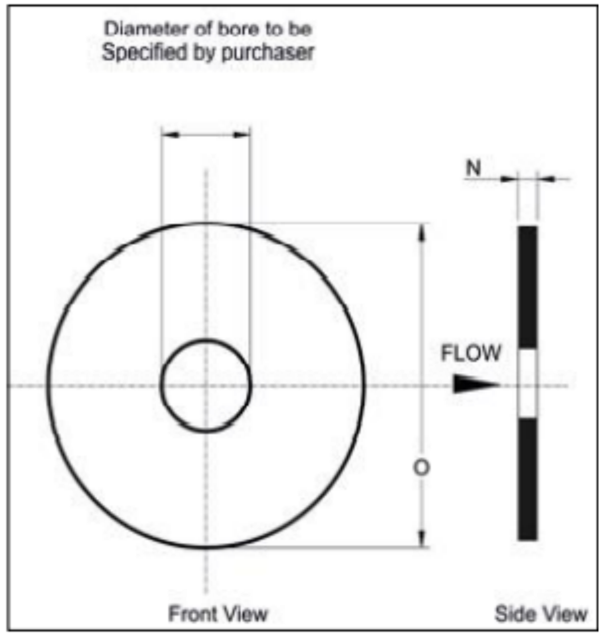
Types of Orifices: Orifices may be classified based on their size, shape, shape of the upstream edge and the discharged conditions.

1. According to the size
(a) Large orifice
(b) Small orifice

2. According to the Shape
(a) Circular orifice (b) Rectangular orifice
(c) Triangular orifice, (d) Square orifice

3. According to the shape of the upstream edges
(a) Sharp edged orifice (b) Bell-mouthed orifice

4. According to the discharge condition
(a) Orifice discharged free (b) Submerged orifices



Velocity of the jet = $\sqrt{2gh}$

Discharge $Q = a \cdot \sqrt{2gh}$

where a = area of c.s of orifice

h = head over the orifice

Water enters the supply tank through a perforated diffuser placed below the water surface.The flow passes into the tank and leaves through a sharp edged orifice Set at the side of the tank. Water comes of the supply tank in the form of a jet which is directed to the collecting tank. The flow rate is measured by recording the time taken to collect a known volume of water in the tank.Co- efficient of discharge is the ratio between actual and theoretical discharge of water flowing through the orifice. $C_d$of standard orifices varies from 0.61 to 0.65.For general purpose the value of C_d is taken as 0.62.

Actual Discharge $Q_a = \frac{AR}{t}$ m^3/sec

Where, A = area of the measuring tank in m^2,

R =rise in water level in the measuring tank in m,

t = time taken for the rise in water level.

Theoretical Discharge, $Q_{th} = a\sqrt{2gh}$ m^3/sec,

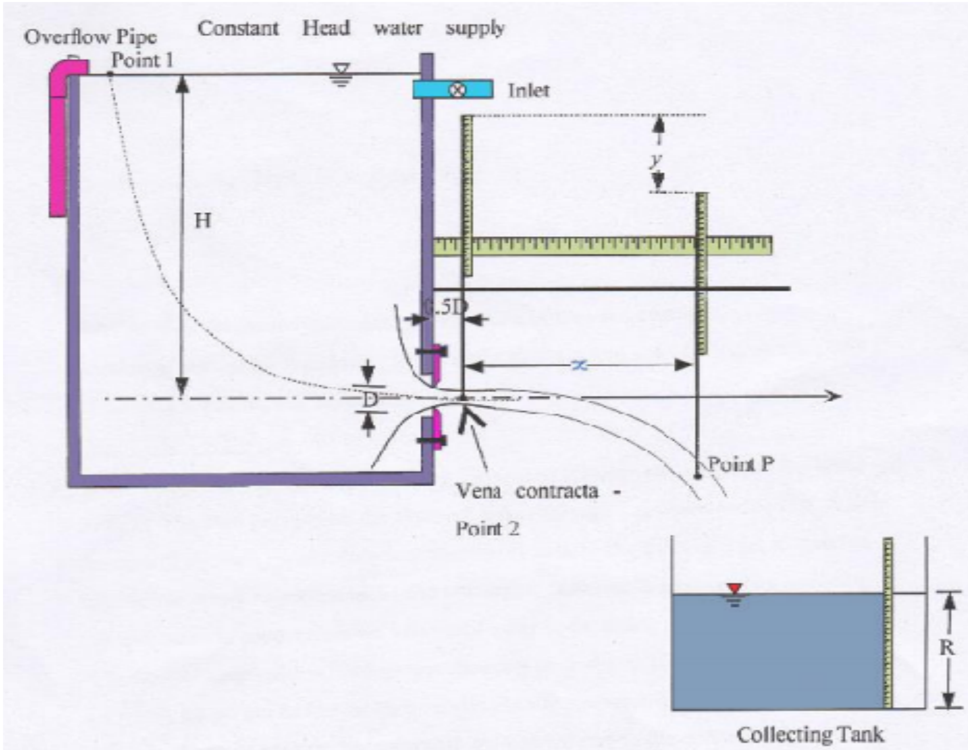
Where, a = area of the orifice in m^2, g = acceleration due to gravity m/s^2

h = head over the orifice in m

Coefficient of Discharge, $c_d = \frac{Q_a}{Q_{th}}$

Procedure:

1. Note the diameter of the orifice and dimensions of the collecting tank.
2. Open the supply valve and maintain a steady head over the orifice.
3. Note the head over the orifice (h) from the piezometer.
4. Close the outlet valve of the measuring tank firmly and note the time required for the rise in water level(R) by using a stopwatch.
5. After observing the time, open the outlet valve.
6. Open the supply valve little more and repeat the steps 2 to 5 for different values of "h".
7. Tabulate the readings (h and t) and calculate co-efficient of discharge.



Observations and Calculations

Specimen calculations:

Dia of the orifice (d) =

Area of the orifice (a) =

Head over the orifice (h) =

Taking g = 9.81m/s^2

Theoretical Discharge, "Qth" = a×√2gh =

Dimensions of the measuring tank,

L= ,B=

Area of the measuring tank (A) = L×B =

Rise in water level in the measuring tank (R) =

Time taken for the water rise (t) =

Actual Discharge $Q_a = \frac{A*R}{T}$ **m³/sec**

Co-efficient of discharge $c_d = \frac{Q_a}{Q_{th}}$

S.No	**Head (h) (m)**	**Time (t) (s)**	**Q_a**	**$Q_{th}=a\sqrt{2gh}$**	**$C_d=Q_a/Q_{th}$**	**Average C_d**
1						
2						
3						
4						

Result: The Coefficient of Discharge (C_d) of a Circular Orifice =

Graphs: 1. Graph Between Qa Vs Log H
2. Log Qa Vs LogH

Viva Questions:

1. What is an Orifice ?
2. What is meant by coefficient of discharge?
3. How the orifices are classified ?
4. What is vena contracta ?

EXPERIMENT – 6

DETERMINATION OF COEFFICIENT OF DISCHARGE OF A MOUTHPIECE

Aim: Determination of Coefficient of Discharge (C_d) of a mouthpiece.

Apparatus Required: Balancing tank fitted with mouth piece, collecting tank , stopwatch and scale.

Theory: A short piece of pipe fitted into the side of tank for discharging water is known as "Mouthpiece".The coefficient of discharge of a mouthpiece is greater than the orifice of the same diameter.There are various types of mouthpieces such as internal mouthpiece, External cylindrical mouthpiece and converging diverging mouth piece.

The Coefficient of discharge by falling head method is given by

$$C_d = 2A\frac{\sqrt{H1}-\sqrt{H2}}{aT\sqrt{2g}}$$

Where,

A= Area of supply tank (Balancing Tank)
d= Diameter of mouthpiece = 0.03
a= Area of C/S of mouthpiece = πr^2
H_1= Initial Head
H_2= Final Head
T = Time taken for the head to fall from H_1 to H_2.

Description of the Equipment: The unit consists of M.S supply tank of size 0.5 m x 0.5 m x1 meter.With inlet diffuser supply for damping water level oscillations, overflow outlet, gauge glass tube and scale fitting, drain cock and provision for fixing interchangeable mouthpieces. The tank is connected to the main supply line. The whole unit is supported on a strong iron stand. The water from the mouthpiece is collected by M.S. collecting tank of size 0.5 m x 0.5 m x 0.6 m gauge glass and scale fitting and drain valve.

Procedure:

1 . Fit the given cylindrical mouthpiece externally to the tank and note the dimension of the mouthpiece accurately using an inside caliper.

2. Note the dimensions of the supply tank.

3.Open the inlet valve and fill the supply tank with water and close the gate valve quickly.

4. Find the time taken for the fall from a head of H_1meter above the center of the mouthpiece to a head of H_2meters about the center

5. Again fill the tank and repeat the experiment for the different ranges of fall and take about six sets of readings.

Calculations:

Initial head = H_1 = m

Final head = H_2= m

Time taken = t = seconds

Area of supply tank =A= m^2

Area of mouthpiece = a= m^2

Then , $$C_d = 2A\frac{\sqrt{H1}-\sqrt{H2}}{aT\sqrt{2g}}$$

Observations:

Area of supply tank =A= m^2

S.No.	H_1 (m)	H_2 (m)	Time for fall (T) (sec)	$\sqrt{H1}-\sqrt{H2})$	C_d
1					
2					
3					
4					
5					
6					

Result : The Coefficient of Discharge (C_d) of a mouthpiece is

Graph: Time Vs($\sqrt{H1}-\sqrt{H2}$)

Viva Questions:

1. What is a Mouthpiece?

EXPERIMENT – 7

DETERMINATION OF TYPES OF FLOW (REYNOLD'S NUMBER)

Aim : To find the Reynolds number range to distinguish Laminar and Turbulent flow of water.

Apparatus : Reynolds apparatus, Dye and Stop watch.

Theory: There are two types of flow conditions, where fluid passes through a conduit,

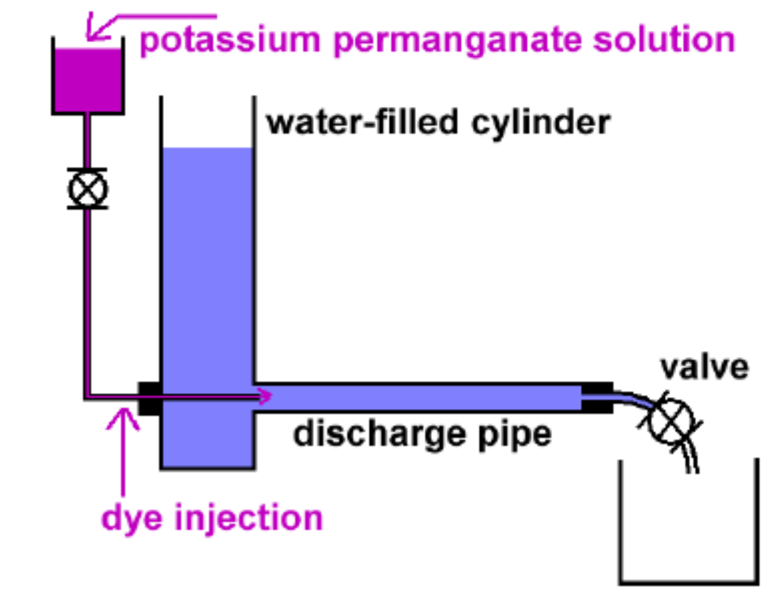
1. Laminar Flow,
2. Turbulent Flow.

Generally for pipe flow , a) when Reynolds number is below 2000 the flow is LAMINAR and

b) when the number is more than 4000 the flow will is TURBULENT.

c) The change of flow from laminar to turbulent in between is called TRANSITION and Reynolds number to this flow will be 2000 to 4000.

Description of the Apparatus :The apparatus consists of supply tank with overflow arrangement. A supply pipe is provided with gate valve supplying water to the supply tank. A glass tube is connected into the supplying tank. The tube has a bell mouthed entrance. A nozzle with a dye container is provided at the entry point of glass tube. As the flow occurs in the glass tube a fine jet or ray of dye is injected into the glass tube through the nozzle. A collecting tank is provided to measure discharge flowing through the glass tube.



Procedure:

1.Dye filled into the container in the apparatus. Dye liquid valve is closed.

2. Water is supplied to the apparatus tank. The valve controls the flow through a transparent pipe is closed.

3. Flow control valve is opened slightly. The constant column is obtained.

4.The valve is opened and the flow of dye is controlled so that the colors appear as straight lines.

5.Flow rates is measured.

6.Velocity increased slightly until the dye began to appear wavy/square. This flow rates is measured.

7. Flow velocity increased again until the dye began to appear dispersed in water and flow is measured.

8.At different discharge reading are taken.

Observations & Calculations :

For a particular gate valve opening,

Discharge, Q = $\frac{A*h}{t}$ m^3/sec,

Where, A = Area of collecting tank,

t= Time in sec

a = Area of tube

V= Velocity =$\frac{Q}{a}$m/sec

Re= Reynolds Number = $\frac{V*d}{v}$

d=Diameter of glass tube.

v=Kinetic velocity of water flowing in the glass tube.

S.No.	Time for 10 cm rise "h"	Q = $\frac{A*h}{t}$ m^3/sec	V= $\frac{Q}{a}$m/sec	Re=$\frac{V*d}{v}$	Type of flow

Result: The flow is :

Viva - Question:

1. What is Reynolds Number?
2. Explain what is the meaning if one say "The flow has low Reynold Number"?

EXPERIMENT – 8

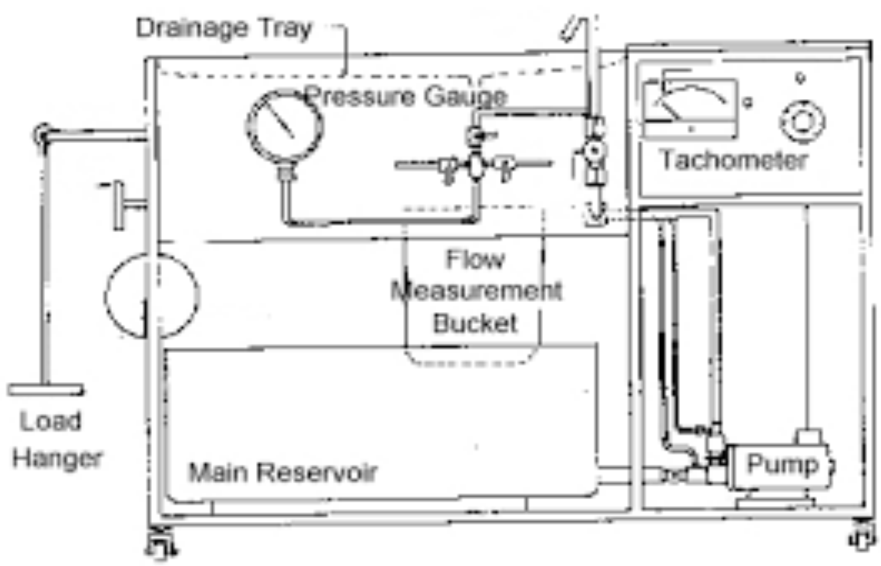
DETERMINATION OF DARCY'S FRICTION FACTOR

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

Apparatus : Experimental setup,Stopwatch and Scale**.**

Theory : When water flows through a pipe, a certain amount of energy has to be spent to overcome the friction due to the roughness of the pipe surface. This roughness effect or friction effect depends upon the material of the pipe and scale information if any. Where the surface is smooth the friction effective is less. For an old pipe due to scale formation or chemical deposits the roughness and hence the friction effect is higher.

Experimental Setup :The test rig consists of a piping circuit with three horizontal GI pipe lines of nominal diameters 25mm, 20 mm and 15 mm. The pipes are connected in parallel and using the gate valve provided in each pipeline, water is made to flow in one pipeline at a time.
A pair of quick-change cocks is fitted at 2 m distances apart in each pipe to measure the frictional losses. The Cocks are connected to two common chambers which in turn are connected to the differential mercury manometer. The manometer is used to measure the pressure drop, which is the head loss in a horizontal pipe.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.



Procedure :

1. Select the required pipeline.

2. Connect the pressure tapping of the required pipeline to the manometer by opening the appropriate pressure Cocks and closing all other pressure cocks.

3. Open the flow control valve in the pipeline and allow water to pass.

4. Vent the Manometer at a reduced flow rate. (**Warning**: Care should be taken to avoid spillover of mercury into the header pipes while venting). Experiment should always be started by slowly opening the control valve and simultaneously observing the mercury columns in the manometer. For accidental spillovers, stop the experiment and recover the mercury from the bottom of the header.

5. By controlling the valve, 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 experiment and take about 6 sets of readings at other flow rates.

Calculations :

1. Area of collecting tank, A = m^2

Rise of level, R = m,

Volume collected, = A * R m^3 = m^3

Time for 10cm rise, t = sec

Discharge, $Q = \frac{A*R}{t}$ m^3/sec

2. Manometer readings (Mercury filled) :

Reading in the left limb= h_1 m=

Reading in the right limb= h_2 m=

Difference in level = $(h_1 - h_2)$ m of Hg

Equivalent loss of water head = $h_f = (13.6-1) * (h_1 - h_2)$

$= 12.6 (h_1 - h_2)$ m of water

3. Pipeline

Diameter of pipe, d =

Area of pipe, a =

Velocity in the pipe, V = $\frac{Q}{a}$ m/sec

Length of pipe between the cocks, L = 2 m

4. Darcy's coefficient of friction (f)

Head loss, $h_f = \frac{4fLv^2}{2gd}$,

Friction factor, $f = \frac{2h_f gd}{4Lv^2}$

Observations :

1. Length of pipe , L = 2 m
2. Area of collecting tank, A = 0.6 m x 0.6 m = 0.36 m^2
3. Head loss, h_f = 12.6 (h_1- h_2) m of water
4. Discharge , Q = $\frac{A*R}{t}$ m^3/sec
5. Area of pipe, a =
6. Velocity in the pipe, V = $\frac{Q}{a}$ m/sec
7. Friction factor, f = = $\frac{2h_f gd}{4Lv^2}$

S.No.	Pipe dia	Manometer reading		Head loss h_f m of water	Time in sec for rise R cm	Flow rate Q, m^3/sec	Pipe area, a m^2	Flow velocity, V, m/sec	Coefficient of friction
		h_1 m of Hg	h_2 m of Hg						

Result : The coefficient friction of a given pipe is

Graphs :

a) h_f Vs $\frac{v^2}{2g}$

b) Log h_f Vs Log V.

Viva-Questions :

1. Define major loss in pipe?
2. Define friction factor in the pipe?

EXPERIMENT – 9

DETERMINATION OF ROUGHNESS COEFFICIENT IN AN OPEN CHANNEL

Aim: To determine the Manning's rugosity (roughness) coefficient (n) and Chezy's coefficient © of thegiven open channel.

Apparatus: MS rectangular flume with glass sides, scale, stop watch, collecting tank.

Theory: A conduit in which the flowing stream is not completely enclosed by solid boundaries but has a free surface exposed to atmospheric pressure is known as an open channel. Flow in rivers, canals and sewers are some of the familiar examples of open channel flow. When water flows through such a channel the flow encounters resistance from the bed and sides of the channel.The equations for mean velocity in open channel such as Manning's and Chezy's involve certain Rugosity or roughness coefficients as noted below.

Manning's formula :$V = R^{2/3}S^{1/2}/N$

Chezy'sformula :$V = C\sqrt{RS}$

Where V = Mean velocity of flow in m/s
S = Slope of energy line
N= Manning's rugosity coefficient

C = Chezy's Coefficient
R= Hydraulic radius = (A/P) (m)

B = Bed width of channel
Y= depth of flow

Procedure :

1. The bottom width of the channel is measured
2. The longitudinal slope of bed is noted
3. Water is allowed to flow in the channel by opening the regulating valve in the supply pipe.
4. After the flow stabilizes and becomes steady time is noted for, say, 10 cm rise of water in the collectingtank and discharge is calculated.
5. The point gauge is kept approximately at mid length of the channel and the depth, of water over the bedof channel is measured with it by noting the readings of the bed level and water level.
6. The hydraulic radius R is calculated
7. The mean velocity of flow in the channel is found by dividing the discharge with area of flow.
8. By substituting the values of V, R and S obtained above in the Manning's and Chezy's formulas. N andC are determined.
9. The experiment is repeated for different discharges in the channel.

Observation:

Sl.No.	Depthof flow (Cms) (y)	Area of flow (Cm^2)A	Wetted Perimeter (Cms)P	Hydraulic Radius (Cms)R	Discharge (Cm^3/S)Q	Mean Velocity (cm/s)V	Manning's (n)$n=R^{2/3}S^{1/2}/V$	Chezy's C C=V/□RS

SPECIMEN CALCULATIONS :

Bed width of the channel,	B	=	m	
Longitudinal bed slope,	S	=		
Dimensions of collecting tank		=	m x	m
Rise of water in collecting tank		=	m	
Time of collection		=		
Discharge		=		
Bed Level reading,	h_1	=	cm	
Water level reading,	h_2	=	cm	
Depth of flow,	y	$= h_1 - h_2 =$	m	
Hydraulic radius,				
Mean velocity of flow	V	=		
Manning's rugosity coefficient,	n	=		
Chezy's coefficient,	C	=		

GRAPHS :

1. V Vs $R^{2/3} / n$
2. V Vs $CR^{1/2}$

RESULT :

Average n =

Average c =

QUESTIONS :

1. What is the relation between n and c?
2. What is the relation between Darcy's f and c?
3. What is effect of Reynold's number on n?

EXPERIMENT – 10

DETERMINATION OF A VANE COEFFICIENT

Aim : To determine the coefficient of impact of the jet striking the vanes.

Apparatus: Jet on vane apparatus, different types of vanes, stop watch.

Theory:
The objective of this experiment is to investigate the reaction forces produced by the change in momentum of a fluid flow when a jet of water strikes a flat plate or a curved surface, and to compare the results from this experiment with the computed forces by applying the momentum equation. Engineers and designers use the momentum equation to accurately calculate the force that moving fluid may exert on a solid body. For example, in hydro power plants, turbines are utilized to generate electricity. Turbines rotate due to force exerted by one or more water jets that are directed tangentially onto the turbine's vanes or buckets. The impact of the water on the vanes generates a torque on the wheel, causing it to rotate and to generate electricity.

Procedure:

1. Fix the nozzle and the vane of required shape in position and set the force indicator to show zero
2. Close the front transparent cover tightly.
3. Keep the delivery valve closed and switch ON the pump.
4. Open the delivery valve and adjust the flow rate of water as read on the Rota meter.
5. Observe the force as indicated on force indicator.
6. Note down the diameter of jet, shape of vane, flow rate, force and tabulate the results.
7. Switch OFF the pump after the experiment is over and closes the delivery valve.
8. Repeat the experiment at different flow rates with same jet and vane.
9. Change the vane and carryout the experiment with different flow rates.

Calculation :

Data:

- Diameter of the Jets 'd' = 4,5 & 7 mm
- Acceleration due to Gravity 'g' = 9.81 m/sec^2
- Density of water 'ρ_w' = 1000 kg/m^3

1. Discharge (Q):

$$Q_D = \frac{Q}{60*1000} \text{ m}^3/\text{sec}$$

Where,
60 &1000 are conversion factors to m^3/sec
Q = Rota meter reading in LPM

2. Velocity (V) :

$$V=\frac{QD}{A} \text{ m/sec}$$

Where, A= area of jet considered = $A = \pi r^2$

3. Theoretical Force (F_T) :

a) For Flat Vane $F_{T1} = \frac{\rho A V^2}{g}$ Kg

b) For Inclined Vane $F_{T2} = \frac{\rho A V^2}{g}$ Sinθ Kg

c) For Hemi-Circular Vane $F_{T3} = \frac{2\rho A V^2}{g}$ Kg

4. Coefficient of Impact:

$$C_D = \frac{F_A}{F_T}$$

Obseravtion:

Type of Plate	Jet Dia.	Rotamete rreading inLPM	Actual Force(F_A)in kg	Discharg ein m^3/sec	Velocity V=Q/A cm/sec	Theoretical force in kg			Co efficient of Impact, Cd
						Flat	Inclined	Curved	

Result: Coefficient of discharge C_D =

Average Flat vane:

Average Inclined vane:

Average Hemi- Circular vane:

Graph:

F_A Vs F_T

Viva- Questions:

1. Define vane?
2. What is the practical application of jet of vanes?
3. Which Vane is having more impact?

EXPERIMENT – 11

DETERMINATION OF BASIC CHARACTERISTICS OF A HYDRAULIC JUMP

Aim: To determine the sequent depth theoretically and experimentally of a hydraulic jump in a rectangular channel and also the loss of energy in the jump.

Apparatus: Rectangular flume with head gates, scale, stopwatch, point gauge, collecting tank.

Theory : Hydraulic jump is defined as the sudden and turbulent passage of water from super critical to sub critical state in an open channel. It is one of the most frequent encounter cases of rapidly varied flow. There is a sudden rise in the water surface accompanied by the formation of a strong surface roller and turbulent eddies of large size at the beginning of the jump. These eddies extract energy from the mean flow, break up into smaller ones as they move down stream. Thus there is a considerable dissipation of energy due to the formation of jump.

The situation of super critical flow changing to sub-critical flow frequently occurs below spillways and lace gates.Whether the flow in open channel is sub-critical, critical or super critical depends upon the Froude number ofthe flow F_r which is defined as the ratio of inertial force to gravity force and for a rectangular channel it is expressed as the supercritical flow depth before the jump is called the initial depth or pre jump depth as, and the depth y_2 in the sub-critical flow after the jump is termed the sequent depth or post jump depth.

The depths $y_1$and y_2 are called conjugate depths as one depth is conjugate to the other.

For a given discharge the specific force will have the same value at these two depths of flow.

i) In a rectangular channel the sequent depth y_2 is given by

ii) The energy Lost or dissipated in the jump is given by

iii) Height of jump

iv) Length of jump

Jump can be classified as

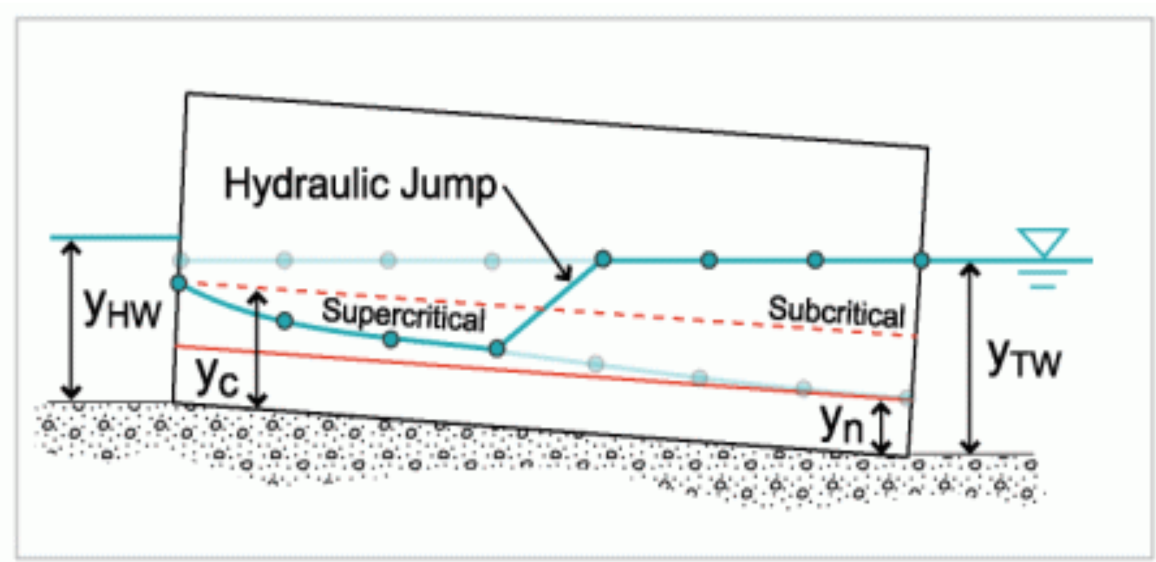
1. F_1 = 1.0 to 1.7 - undular jump
2. F_1 = 1.7 to 2.5 – weak jump
3. F_1 = 2.5 to 4.5 – oscillating jump
4. F_1 = 4.5 to 9.0 – Steady jump
5. F_1= above 9.0 strong or choppy jump

PROCEDURE:

1. Water is admitted into the flume (channel) by opening the regulating valve in the supply pipe.
2. A steady flow is established in the channel, keeping the head gate in the channel much above the flowof water.
3. The head gate is lowered slowly with the help of hand wheel thus decreasing the opening below the up stream gate.
4. Once the gate is lowered below the water surface water shoots up with high velocity below the gate witha smaller depth of flow indicating supercritical flow condition.
5. The depth of flow near the head gate in the position is the initial depth which is measured with a point gauge.
6. The sequent depth y_2 after the formation of jump is measured with the point gauge.
7. The water flowing in the channel is calculated by using the venturi meter for measurement of discharge.
8. The velocity v_1 before the jump is found and the theoretical sequent depth is calculated from the jump equation.
9. The above steps are repeated for different value of y, for the same discharge and also for differentdischarges.
10. The measured and theoretical sequent depths are compared with each other and energy lost is calculated.

Observation:

Sl. No.	P1 Pressure gauge	P2 Vacuum gauge	H= (P_1-P_2) x 0.76 X 12.6	Q (m^3/s)	y1	V1	Fr1	y2	V2	Fr2	H= y2-y1	ΔE	Type of jump
1													
2													
3													
4													
5													
6													



Calculation :

Bed width of the channel (width of flame) B = m
Venturimeter Inlet Dia,'D' = mm
Throat Dia,'d' = mm

Discharge

$$Q = C_D \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{(a_1^2 - a_2^2}} \quad m^3/sec$$

Where, C_D= Co-efficiency of discharge
a_1= Area of Inlet Section= $\pi D^2/4$ m^2
a_2= Area of Throat Section = $\pi d^2/4$ m^2
Loss of Head'h'= 12.6 x ($P_i - P_t$) x 0.760 m
($P_i - P_t$)= Differential head across Venturimeter in kg/ m^2
760 mm of Hg= 1 kg/Cm^2

Point gauge readings:
Bed level reading before jump h1 = cm
Water level reading before jump h2= cm
Initial depth, y_1 = h1 ~ h2 = cm = m
Bed level reading after jump h3 = cm
Water level reading after jump h4= cm
Measured Sequent depth,(y2)M = h3 ~ h4 = cm = m
Initial Velocity $\mathbf{V_1 = Q/ By_1}$ = m/s
Initial Froude No., $\mathbf{Fr_1= V_1/\sqrt{gy_1}}$ =
Theoretical sequent depth,(y_2) **T**= $\mathbf{y_1/2 (\sqrt{8 Fr1^2 +1} - 1)}$ = m
Energy Lost in the jump, $\mathbf{\Delta E = (y2-y1)^3/4 y1y2}$ = m
Height of jump, $\mathbf{h_j = y_2 - y_1}$ = m
Length of jump, Lj= **4 to 7 times its height** = m

Result:
Types of hydraulic jump are:

Viva- Questions :

1. What is the difference between conjugate depths and alternate depths?
2. Give the classification of hydraulic jumps based on initial Froude number.
3. What is the reason for formation of hydraulic jump when the flow changes from supercritical flow to Sub critical flow?
4. What happens when flow changes from sub critical to supercritical state?

EXPERIMENT – 12

STUDY OF MAIN CHARACTERISTIC CURVES OF A CENTRIFUGAL PUMP

Aim: To conduct a performance test on the Centrifugal pump to study the characteristic curves of pump.

Apparatus :Centrifugal pump test rig, stop watch, scale.

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.

Specifications:

- ✧ Electrical Services : 230V, 15A, 1ph, 50Hz, AC with Neutral & Earth connection.
- ✧ Pump : Centrifugal pump (kirloskar make), 1HP. Maximum Speed-3000 rpm.
- ✧ Pressure Gauges : 0-2 kg/cm^2 range connected before Delivery valve.
- ✧ Vacuum Gauge : 0-760mm of Hg, connected after suction valve
- ✧ Energy Meter : Single Phase, Energy meter constant: 3200 Rev/ KW-Hr.
- ✧ Speed Indicator : 0-9999 RPM (Digital Type).
- ✧ Control Valves : Suction and Delivery.
- ✧ Total Head : 8-12 m.
- ✧ Collecting Tank : 0.12 m^2 with Butterfly valve.

Procedure:

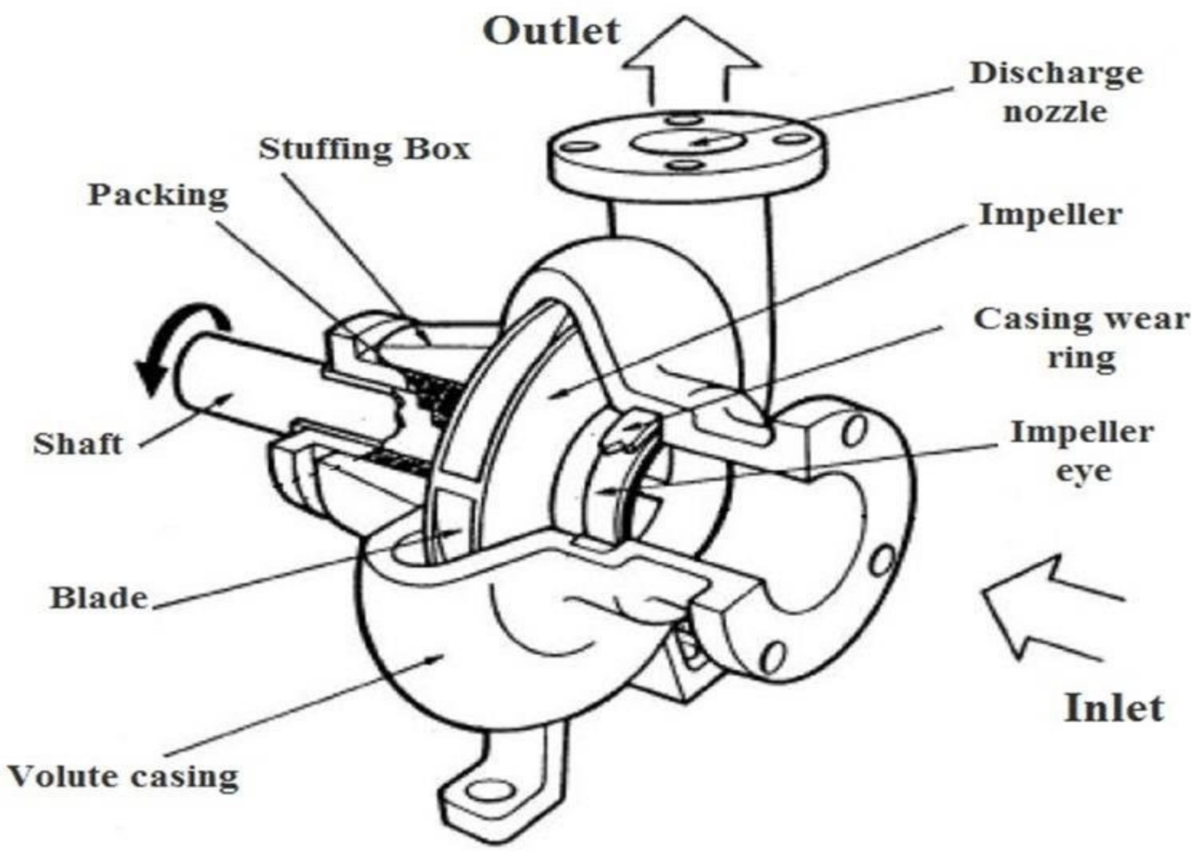
All the necessary instrumentation along with its accessories is readily connected. It is just enough to follow the instructions below:

1. Fill the sump tank with clean water.
2. Keep the delivery and suction valves open.
3. Connect the power cable to1 ph, 220V, 15 Amps.
4. Select the required speed using step cone pulley arrangement.
5. Keep the delivery valve fully open after priming.
6. Switch-ON the Mains so that the Mains-ON indicator glows. Now switch-ON the motor.
7. Note down the speed using digital RPM indicator.
8. Note down the pressure Gauge, Vacuum Gauge and time for number of blinks of Energy meter disc.
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. Repeat the experiment for different openings of the delivery valve (Pressure and Flow rate), note down the readings as indicated in the tabular column.
11. Repeat the experiment for different speeds so that the pressure gauge readings are shown and repeat the steps (4&9).
12. After the experiment is over, keep the delivery valve open and switch OFF the mains.
13. Calculate the results using formulae given and tabulate it.

14. Draw the graphs of Head Vs Discharge.

Observation:

Speed/ valve position	Delivery Pressure "P"in kg/cm^2	Suction Pressure "Pv"in mm of Hg	Time for "n" blinks of energy meter, "t"	Rise in water level R in mm	Time taken "t"sec	Total Head "H"in m	Discharge Qa in m^3/sec	Power output, Ppump in KW	Hp elec in KW	Hp shaft in KW	Efficiency



Calculation:

1. Basic data / constants:
1 HP=745watts
1 kg/cm2=760mm of Hg (10m of water)
Density of water, "ρ_w"=9810N/m3
Energy meter constant=3200rev/kw-h
Area of collecting tank=0.12m

2.Electrical Power as indicated by Energy Meter:

$$\mathbf{Hp_{elec}} = \frac{n*1000*60*60}{3200*t*1000} \text{ kw}$$

$$\mathbf{Hp_{shaft}} = Hp_{elec} * 0.70 \text{ kw}$$

Where,
n = Number of blinks of energy meter = 3.
t = is the time taken by the Energy meter for n blinks, in seconds.
0.70 = Transmission Efficiency.

3. Discharge Rate "Q" in m-3 /sec:

$$\mathbf{Q} = \frac{A*R}{1000*T} = \frac{0.12*R}{1000*T} \text{ m}^3\text{/sec}$$

Where,
"A" =0.12 m^2 is the area of Collecting Tank.
"R" =the Rise of level water collected in mm.
"T" =time taken in seconds for 'R' mm rise of water.

4. Total Head 'H' in m:
H = (10(Delivery Pressure + Vacuum Head)) + x
= 10(P + P_V / 760) m

Where,
'P' is the pressure in kg/cm^2.
'P_V' is the vacuum in mm of Hg.
Correction Head, x = 0.7 m

5. Hydraulic Power (Delivered by the Pump):

$$Hp_{pump} = \frac{WQH}{1000} \text{ kw}$$

Where,

‘W’=9810 N/m^3.

‘Q’=From Formulae-3.

‘H’=From Formulae-4.

6. Pump Efficiency :

$$\eta_{pump} = \frac{p_{pump}}{p_{shaft}} * 100 \%$$

Result:

Efficiency of centrifugal pump is

Graph:

1. Total Head Vs Discharge
2. Efficiency Vs Discharge

Viva- Questions:

1. Define pump?

2. What are the various parts of centrifugal pump?

3. Define pump casing?

EXPERIMENT – 13

STUDY OF UNIVERSAL CHARACTERISTIC CURVES OF A FRANCIS TURBINE

Aim: To conduct a performance test on the Francis turbine to study the characteristic curves of turbine.

Apparatus: Francis turbine, Stop watch.

Theory: Hydraulic (or water) turbines are the machines which use the energy of water (Hydro- power) and convert it into mechanical energy. Thus the turbine becomes the prime mover to run the electrical generators to produce the electricity, Viz., Hydro Electric power.

Specifications:

- ***Supply pump/ Motor Capacity*** **:** 10HP, 3 ph, 440V, 50 Hz, AC.
- ***Turbine*** **:**150mm Dia Impeller. Guide Vane Angles Adjustable from maximum and minimum
  Run away Speed – 2000 rpm (approx.)
- ***Loading*** **:** AC Alternator.
- ***Provisions*** **:** a) Flow rate by Venturimeter
  C_d= 0.88
  Inlet Dia=100mm
  Throat Dia=60mm
  Pressure gauges for inlet & throat pressure measurement.
  b) Head on Turbine by pressure gauge of range : 0-2 kg/cm^2 and
  Vacuum gauge : 760mm of Hg.
  c) Electrical Load change by Switches (Maximum connected Load: 2000 watts).
  d) Turbine Speed by digital RPM Indicator.
  e) Supply water control by Butterfly Valve.
- ***Electrical supply*** **:** 3ph, 440V, AC, 30A, with Neutral & Earth.

Procedure:

1. Connect the supply pump – motor unit to 3 ph, 440V, 30A, Electrical supply, with neutral and earth connections and ensure the correct direction of pump – motor unit.
2. Keep the Gate closed.
3. Keep the Electrical load at minimum, by keeping all the switches at OFF- position.
4. Set the Guide vane position for a particular opening (Ex. ¼, 1/2, or ¾ open) and set the crest level for zero on the point gauge.
5. Press the green button of the supply pump starter & then release.
6. Slowly, open the gate so that the Turbine Rotor picks up the speed and attains maximum at full opening of the gate.

a) Note down the Voltage and Current, Speed, Pressure, Vacuum on the control panel, and flow rate of water using Venturimeter Inlet and Throat Pressure Gauge and tabulate the results.

b) Change the position of guide vane angles and repeat the readings. If necessary, the gate valve (butterfly valve) also can be used for speed control.

7. Close the gate and then switch OFF the supply water pump set.
8. Follow the procedure described below for taking down the reading for evaluating the performance characteristics of the Francis Turbine.

Observation:

TABLE OF READINGS- I

Constant Speed Characteristics
METHOD : By keeping the gate constant &
By changing the guide vane position

Turbine speed in RPM	Head on Turbine		Energy meter reading		Voltmeter reading 'V' volts	Ammeter reading 'I'amps	Venturimeter		Diff. Head across Venturi meter (Pi-Pt) in kg/cm^2	No.of bulbs on action
	Pressure "P" in kg/cm^2	Vacuum "Pv" in mm of Hg.	No.revolution of disk "n"	Time taken insec "t"			Inlet pressure "Pi" in kg/cm^2	Throat pressure"Pt" in kg/cm^2		

TABLE OF CALCULATIONS- I

Constant Speed Characteristics

Turbin espeed inRPM	Net Head on Turbine 'H' in mtrs	Discharge (Flow Rate) 'Q' in m^3/sec	IP_{elec} in kW	BP_{tur} in kW	% η_{tur}	% of Full Load

TABLE OF READINGS- II

Constant Head Characteristics

METHOD : By keeping the guide vane constant &

By changing the gate valve position

Turbine speed in RPM	Head on Turbine		Energy meter reading		Voltmeter reading 'V' volts	Ammeter reading 'I' amps	Venturimeter		Diff. Head across Venturi meter (Pi - Pt) in kg/cm^2	No.of bulbs on action
	Pressure "P" in kg/cm^2	Vacuum "Pv" in mm of Hg.	No. revolution of disk "n"	Time taken insec "t"			Inlet pressure "Pi" in kg/cm^2	Throat pressure "Pt" in kg/cm^2		

TABLE OF CALCULATIONS- II

Constant Head Characteristics

Turbine speed in RPM	Net Head on Turbine 'H' in mtrs	Discharge (Flow Rate) 'Q' in m^3/sec	IPelec in kW	BPtur in kW	% ηtur	% of Full Load

Calculation:

Data:
Venturimeter

Inlet Dia,'D'= 100mm
Throat Dia,'d' = 60mm
Density of water= 1000kg / m^3
Energy Meter Constant= Rev. / sec.

1.Head on the Turbine
'H' in meters of water = $10\,(P_i+P_v/760)$
Where, 'P' is the pressure gauge reading in kg/cm^2 and 'Pv' is the Vacuum gauge reading.

2.Discharge (Flow Rater) of
Water through the Turbine=Flow rate by Venturimeter

$$Q = C_D \frac{a_1 a_2\sqrt{2gh}}{\sqrt{(a_1^2 - a_2^2}} \quad m^3/sec$$

Where, C_D= Co-efficiency of discharge= 0.88
a_1= Area of Inlet Section = $\pi d^2/4\ m^2$
a_2= Area of Throat Section = $\pi d^2/4\ m^2$
Loss of Head'h'= 12.6 x ($P_i - P_t$) x 0.760 mtrs
($P_i - P_t$)= Differential head across Venturimeter in kg/ m^2
760 mm of Hg= 1 kg/Cm

3.Hydraulic Input to the Turbine :

$$IP_{Hyd} = \frac{QH\,W_g}{1000}\ kw$$

Where, W_g = 9810 N
Q= Flow Rate of Water in m^3 /sec.
H= Head on Turbine in m

4. Brake power of the Turbine:

$$BP = \frac{n}{E.M.Constant} * \frac{3600}{t} * \frac{1}{0.75}$$

Where, 0.75 is the efficiency of Transmission & Generator and
E.M Constant = 1200 Revs. / KWH (Energy meter constant) and
't' = is the time in seconds for energy meter disc to rotate by 5 revolutions.
n = Number of Revolution of energy meter

5.Turbine Efficiency, η_{tur} = BP / IP_{hyd} x 100 %

Result:
Efficiency of Francis Turbine is :

Graph:
Discharge Vs Efficiency

Viva - Questions:

1. How does a hydraulic turbine work?

2. What is the difference between an axial and a radial flow turbine?
3. What are the main components of a hydraulic turbine system?