Maharashtra Institute of Technology, Aurangabad

Department of Plastics and Polymer Engineering

LABORATORY MANUAL

ACADEMIC YEAR: **PART: II**
COURSE: FLUID MECHANICS **COURSE COORDINATOR: MS. P. N. SHINDIKAR**

Experiment No. - 01

1. **Aim:** a) To study different flow conditions.
   b) To obtain the Reynolds number in different flow conditions
2. **Theory:**

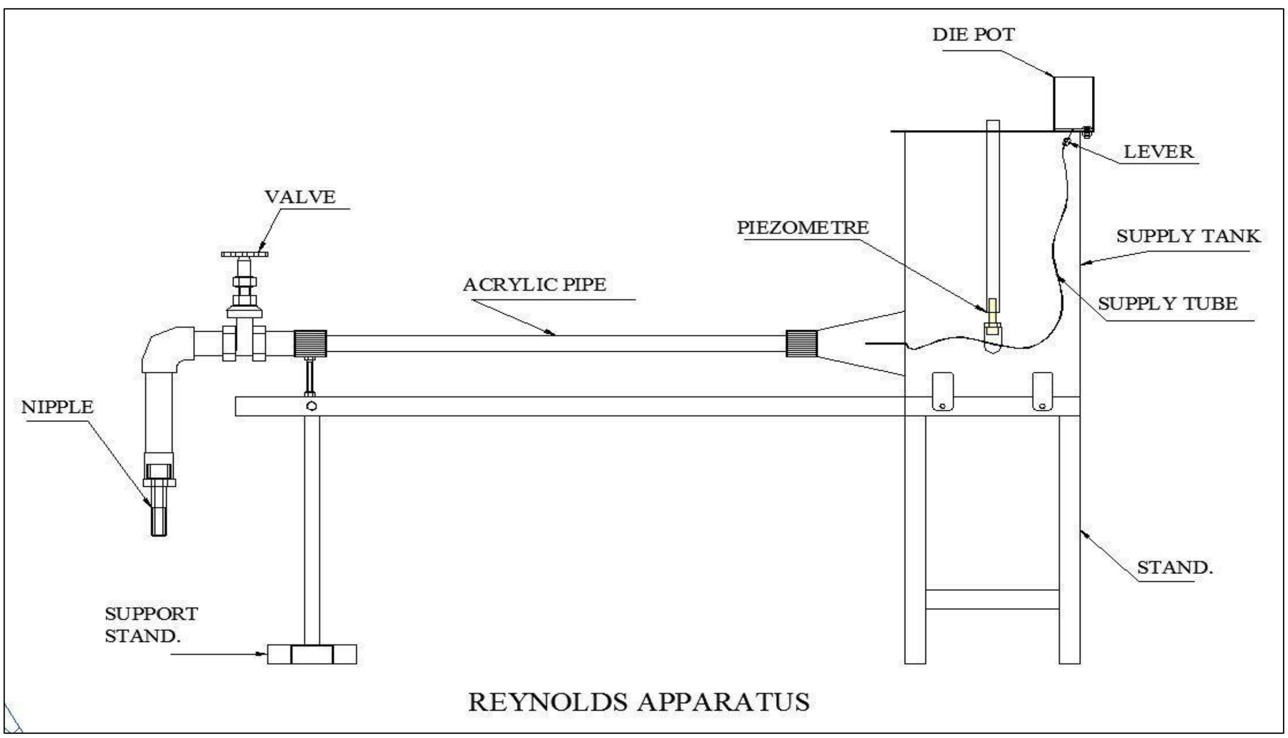
3. **Apparatus:** Apparatus consist of storage cum supply tank, which has the provision for supplying colored dye through jet. A Perspex tube is provided to visualize the different flow condition. The entry of water in

Perspex tube is through elliptical bell mouth to have smooth flow at the entry. A regulating valve is provided on the downstream side of the tube to regulate the flow. The discharge must be varied very gradually from a smaller to larger value. A collecting tank is used to find the actual discharge through the Perspex tube.

4. Observation:

- Diameter of Acrylic tube (ID) = ***25mm***
- Kinematic viscosity of water = ***1 x 10^{-6} m^2/sec***
- Supply tank = ***400X 400 X 600 mm***
- Sump tank- ***900 X 350 X 350 mm***

5. **Diagram:**



6. Procedure:

1. Note down the relevant dimensions of the Perspex tube, area of collecting tank.

2. By maintaining suitable mount of steady flow in Perspex tube, open inlet of the dye tank so that the dye stream moves as a straight line in the tube.
3. The discharge flowing in the Perspex tube is recorded.
4. This procedure is repeated for other values of discharge.
5. By increasing the velocity of flow in the Perspex tube, again open the inlet of the dye tank so that the dye stream begins to break up in the tube, which shows the fluid is no more in the laminar conditions. Hence transition stage occurs.
6. The discharge flowing in the Perspex tube is recorded.
7. This procedure is repeated for other values of discharge.
8. On further increase in the velocity of flow in the Perspex tube, again open the inlet of dye tank so that the dye mixes completely in the tube which shows fluid is no more in the transition stage. Hence turbulent flow occurs in the tube.
9. The discharge flowing in the Perspex tube is recorded.
10. This procedure is repeated for other values of discharge

7. Observation Table:

Sr. No.	Type of Flow	Discharge *(Lit/ sec)*	Discharge Q *(m^3/sec)*	$Re = \frac{4Q}{\pi d v}$
1.	Laminar			
2.	Turbulent			
3.	Transition			

8. Result:

9. Conclusion:

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Experiment No. - 02

1. **Aim:** To validate Bernoulli's assumptions and theorem by experimentally proving that the sum of the terms in the Bernoulli equation along a streamline always remains a constant.

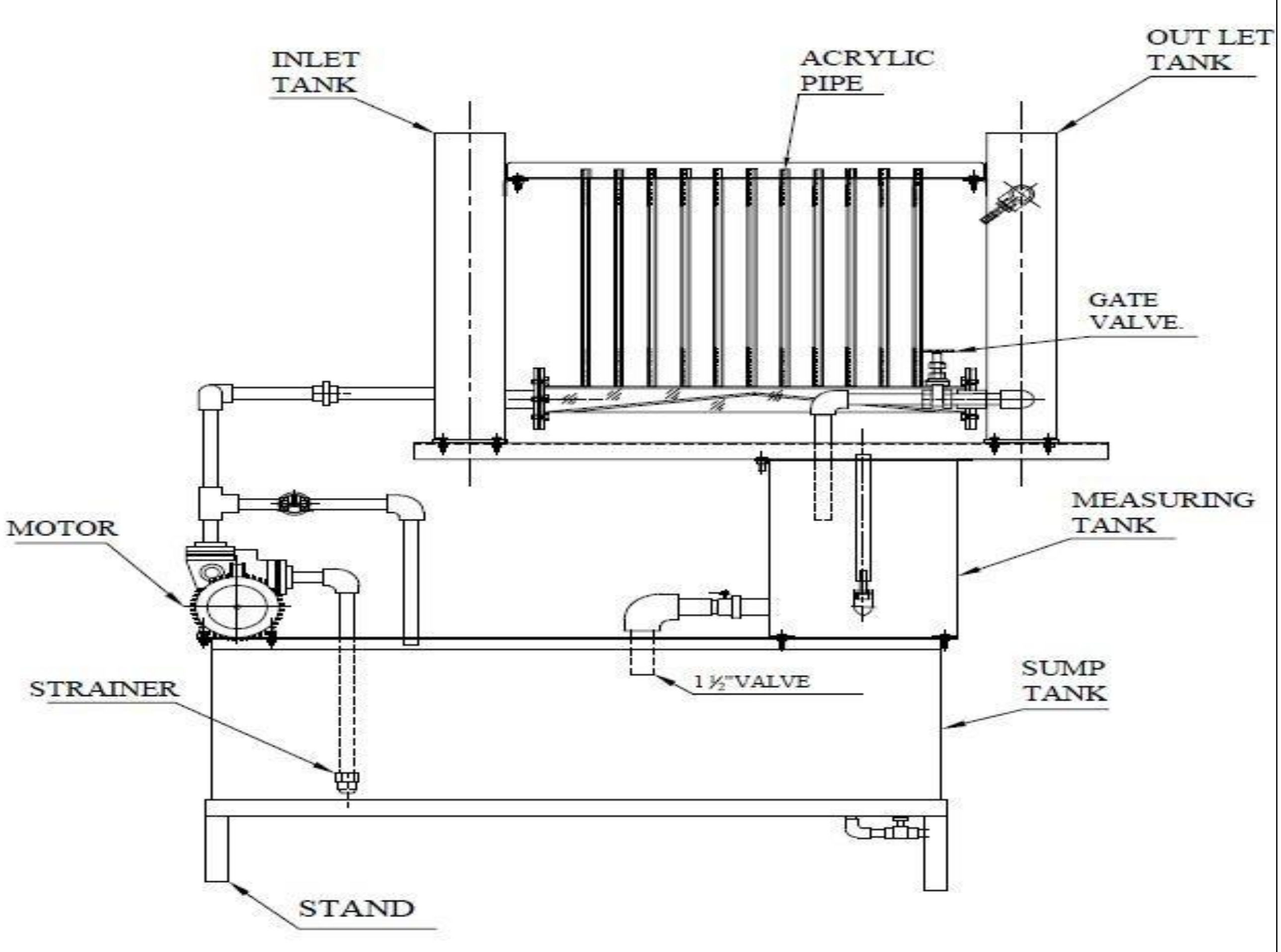
2. **Theory:**

3. **Description:**
   Apparatus for the verification of Bernoulli's theorem and measuring tank with stop watch setup for measuring the actual flow rate
4. **Specifications:**
   - Transparent Acrylic Flow channel ***700 mm*** long.
   - Monoset Pump with bypass valve.
   - Piezometeric Tubes (11 No.) fixed over Transparent Acrylic flow Channel with separate scale.
   - Sump tank- ***900 X 350 X 350 mm***
   - Measuring tank - ***295 X 345 X 345 mm***
   - Piezometeric Tube fixed to measuring Tank to note the time to collect water for a specific rise in the measuring tank

5. **Procedure:**
   1. Observe the dimensions of the convergent divergent duct of the apparatus. Note it down.
   2. Measure the collecting tank cross sectional area.
   3. First fully open the bypass valve.
   4. Start the Monoset Pump.
   5. Control the gate valve for steady flow of water & Proper Graph.
   6. Allow some time to raise the water level in Piezometeric Tubes for proper Graph
   7. Note down the all the piezometer readings at different locations A1, A2, ..Up-to A11.
   a. Note the time to collect water for a specific rise in the measuring tank and thus find the discharge through the duct.
   8. Repeat the experiment for a medium and low head levels in the supply Tank..
6. **Observation:**
   1. Width of Channel = 0.05 m
   2. Length of Chanel = 0.7 m
   3. Area of Measuring tank = (0.295 x 0.345) m^2

4. Time to Collect Water for a Specific rise in the Measuring tank (100 mm) = *sec*

7. Diagram:



FRONT VIEW
BERNOULLI'S THEOREM APPARATUS.

8. Observation Table:

SR. No.	Piezometeric Tubes No.	Head H in (cm)	Head H in (m)	Height of Chanel in (m)	C/S Area of Chanel (A)(m^2)
				0.039	0.00195
				0.034	0.00170
				0.029	0.00145
				0.024	0.00120
				0.019	0.00095
				0.015	0.00075
				0.019	0.00095
				0.024	0.00120
				0.029	0.00145
				0.034	0.00170
				0.039	0.00195

9. Calculation:

1. Actual discharge:

Qact	= (a * R) / (t)
	= --------- m^3/s

- a = Area of Measuring tank(m^2)
- R= Specific rise in the Measuring Tank, (0.1m)
- t = Time taken to rise R meters, (sec)

2. Velocity :

V= (Discharge) / (c/s area)
= ------- m/s

3. Pressure:

   P = ρ * g * H

   = ------ (N/m^2)

- P = Density of the fluid *(kg/m^3) =1000 (kg/m^3)*
- g = Acceleration due to gravity *(m/s^2) = 9.81(m/s^2)*
- H = Head in (*m*) =.............................*(m)*

4. Pressure head = (P) / (ρ * g)

   =

5. Elevation = Z = Constant

6. E = (V^2/2g) + (P / ρ * g) + Z

   = ------- (m)

10. Result:

11. Conclusion:

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Experiment No. - 03

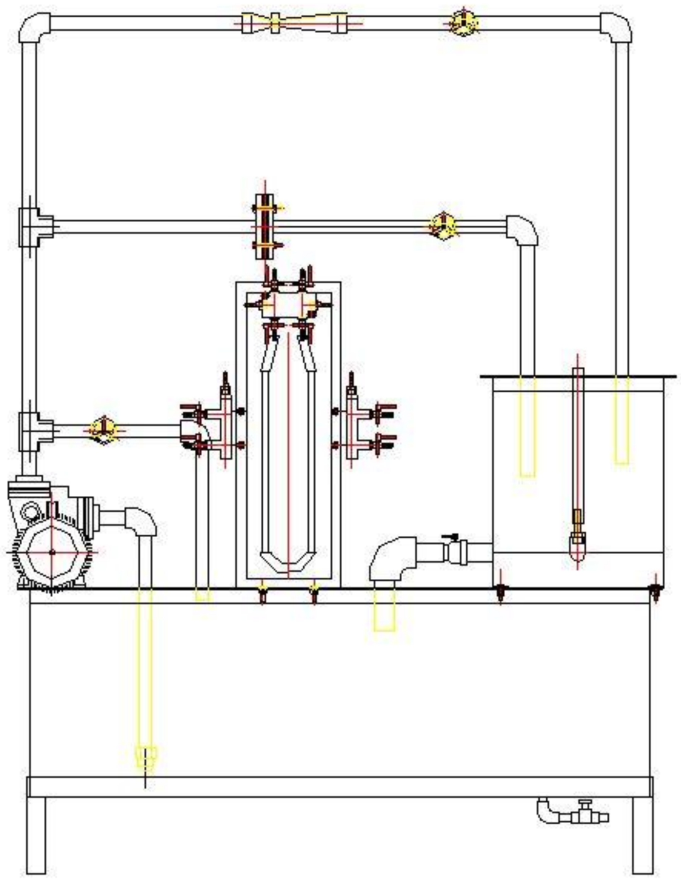
1. **Aim:** T o Calibrate the given obstruction flow meters, like Orifice-meter and venturi-meter.

2. **Theory:**

3. Description:

Supply pipe connected with the venturi-meter and orifice-meter, a differential manometer to measure the pressure difference across the obstruction and a collecting tank with stop watch to measure the actual rate of flow.

4. Diagram:



VENTURIMETER & ORIFICEMETER APPARATUS

5. Specifications:

- Sump Tank - *900 X 350 X 350 mm*
- Measuring Tank - *295 X 345 X 345 mm*
- Orifice meter & Venturi meter.
- Differential manometer.
- Flow control valve.
- Necessary piping & valves
  - Stand - Sump tank is fitted on a strong stand

6. Procedure:

1. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
2. Open by-pass valve.
3. Now switch ON the main power supply.
4. Switch ON the moonset pump.
5. By closing the bypass valve first take the discharge through the venturimeter.
6. Open the pressure taps of manometer of related test section, very slowly to avoid the blow of water on manometer fluid.
7. Open the air release valve provided on the manometer, slowly to release the air from manometer.
8. When there is no air in the manometer, close the air release valves.
9. Adjust water flow rate in desired section with the help of control valve
10. Record the manometer reading.
11. Measure the flow of water, discharged through desired test section, using stop watch and measuring tank.
12. Repeat steps for different flow rates of water, operating control valve
13. Above all procedure repeats to the orifice meter to calibrate the Orifice meter

7. A) Observations for Venturi meter:

- Diameter of the Throat = 13*mm*
- Diameter of Convergent Cone = 30*mm*
- Area of Measuring Tank = (0.295 x 0.345) m^2
- S_h= Specific gravity of manometer fluid (i.e. Mercury) (*Hg*) = 13.6 kg/m^3
- S_o = Sp. gravity of the liquid flowing through the pipe (i.e. Water) = 1 kg/m^3
- Sp. gravity of the light liquid (i.e. Water) = 1 kg/m^3

8. A) Observation Table:

Sr. No.	Manometer Difference in (x) mm of Hg	Time for Specific rise in the Measuring tank (100mm)

9. A) Calculations:

1. Pressure head (h) in m of water:

$$h = x\left[\frac{S_h}{S_o} - 1\right]$$

Where,

1. S_h= Specific gravity of manometer fluid (i.e. Mercury) (*Hg*) = 13.6
2. S_o = Sp. gravity of the liquid flowing through the pipe (i.e. Water) = 1
3. Sp. gravity of the light liquid (i.e. Water) = 1
4. x = Manometer Difference in (*m*)

2. Actual Discharge (Q_{act})

$$\text{Actual Discharge } Q_{act} = \frac{a \times R}{t} \; (m^3/s)$$

Where,

1. a = Area of Measuring tank *(m^2)*
2. R= Specific rise in the Measuring tank, *(0.1m)*
3. t = Time taken to rise R meters, *(sec)*

3. Theoretical Discharge (Q_{th})

$$Q_{th} = C_d \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \times \sqrt{2gh}$$

Where,

1. C_d= Coefficient of venturi meter = 0.98
2. a_1 = Area of venturi meter at convergent cone = 7.06 X 10^{-4} (m^2)
3. a_2= Area of venturi meter at Throat = 1.32 X 10^{-4} (m^2)
4. h = Pressure Head in (m)
5. g = Acceleration due to gravity =9.81 (m/s^2)

3. Coefficient of Discharge (Cd)

$$Cd = \frac{Q_{act}}{Q_{th}}$$

7 B) Observations for (Orifice meter)

1. Diameter of the Orifice meter = 13*mm*
2. Area of Measuring Tank = (0.295 x 0.345) m^2
4. S_h= Specific gravity of manometer fluid (i.e. Mercury) (*Hg*) = 13.6 kg/m^3
5. S_o = Sp. gravity of the liquid flowing through the pipe (i.e. Water) = 1 kg/m^3
6. Sp. gravity of the light liquid (i.e. Water) = 1 kg/m^3

8 B) Tabular Column

Sr. No.	Manometer Difference in (*x*) *mm* of *Hg*	*Time for Specific rise in the Measuring tank (100mm)*

9 B) Calculations

1. Pressure Head (*h*) in *m* of water

$$h = x\left[\frac{S_h}{S_o} - 1\right]$$

Where,

1. S_h= Specific gravity of manometer fluid (i.e. Mercury) (*Hg*) = 13.6
2. S_o = Sp. gravity of the liquid flowing through the pipe (i.e. Water) = 1
3. Sp. gravity of the light liquid (i.e. Water) = 1
4. x = Manometer Difference in (*m*)

2. Actual Discharge (Q_{act})

$$\text{Actual Discharge } Q_{act} = \frac{a \times R}{t} \; (m^3/s)$$

Where,

1. a = Area of Measuring tank *(m^2)*
2. R= Specific rise in the Measuring tank, *(0.1m)*
3. t = Time taken to rise R meters, *(sec)*

3. Theoretical Discharge (Q_{th})

$$Q_{th} = cd * a * \sqrt{(2gh)}$$

Where,

1. a_2= Area of Orifice meter = 1.32 X 10^{-4} (m^2)
2. h = Pressure Head in (m)
3. g = Acceleration due to gravity =9.81*(m/s^2)*
4. cd = Coefficient of Orifice meter = 0.6

4. Coefficient of Discharge (Cd)

$$Cd = \frac{Q_{act}}{Q_{th}}$$

10. Result:

a) Coefficient of discharge for Venturi meter:

b) Coefficient of discharge for Orifice meter:

11. Conclusion:

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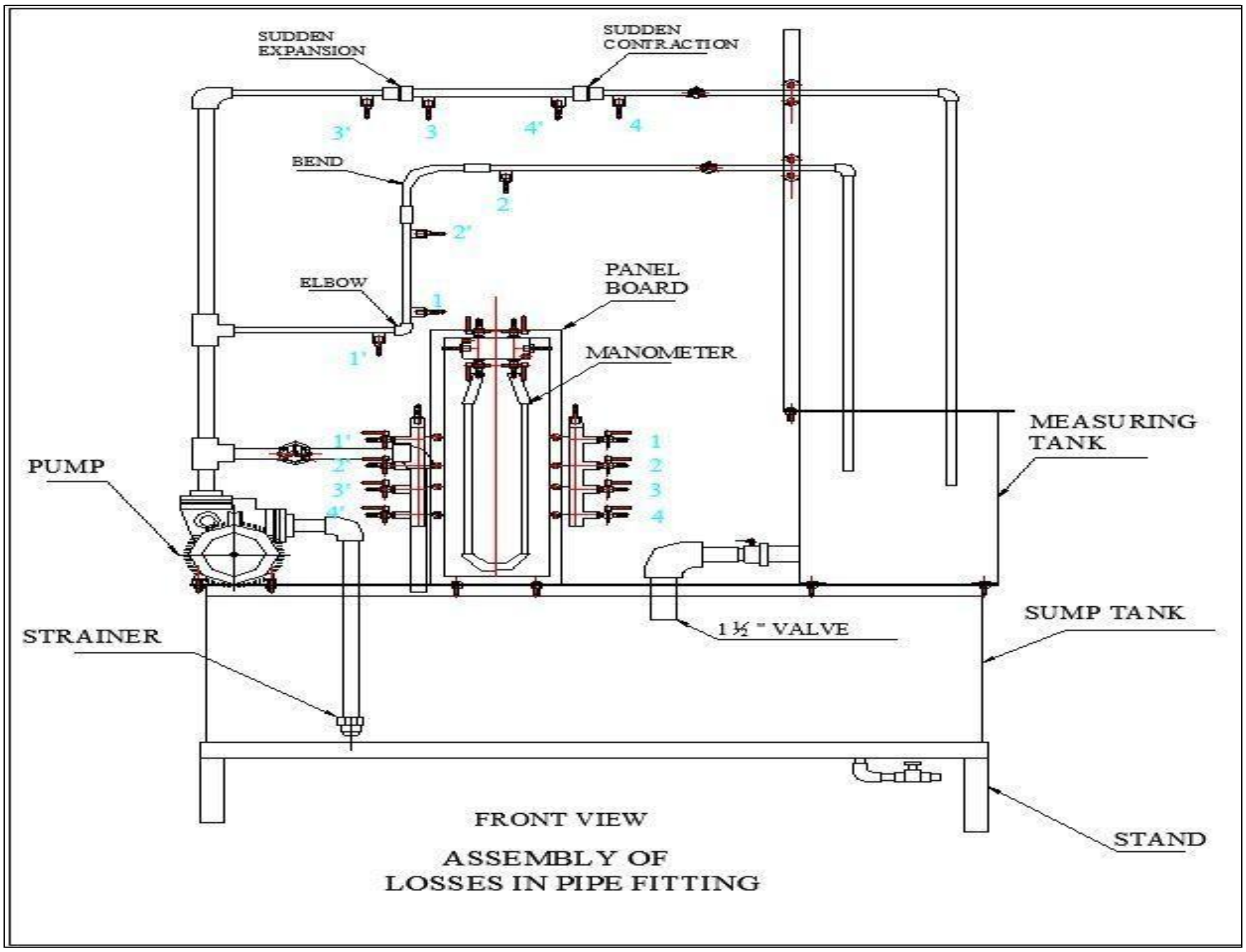
Experiment No. - 04

1. **Aim:** To study the losses of head due to various fittings in pipelines.
   To determine the loss of head in the fittings at the various water flow rates.
   To determine the loss co-efficient for the pipe fittings

2. **Theory:**

3. **Description:** The apparatus consist of two pipes with different fittings. Bend, sudden expansion, sudden contraction and elbow are provided at pipes. Pressure tapings are provided at inlet and outlet of these fittings at suitable distance. A differential manometer fitted in the line gives head loss due to fittings. Supply to the pipe line is made through centrifugal pump, which deliver water from sump tank. The flow of water in pipes can be regulated by the valve provided at the end for pipe 1 and gate valve fitting for pipe 2. Discharge is measured with the help of measuring tank and stop watch.

4. **Diagram:**



5. Observation:

1. Sump Tank - 900 X 350 X 350 mm
2. Measuring Tank - 295 X 345 X 345 mm
3. Pipe Fittings: - Bend, Elbow, Sudden Expansion, Sudden Contraction
4. Differential manometer.
5. Flow control valve.
6. Necessary piping & valves.
7. Stand - Sump tank is fitted on a strong stand.

6. Procedure:

1. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
2. Open by-pass valve.
3. Now switch ON the main power supply.
4. Switch ON the moonset pump.
5. By closing the bypass valve first take the discharge through the chosen fitting.
6. Open the pressure taps of manometer of related test section, very slowly to avoid the blow of water on manometer fluid.
7. Open the air release valve provided on the manometer, slowly to release the air from manometer.
8. When there is no air in the manometer, close the air release valves.
9. Adjust water flow rate in desired section with the help of control valve
10. Record the manometer reading.
11. Measure the flow of water, discharged through desired test section, using stop watch and measuring tank.
12. Repeat steps for different flow rates of water, operating control valve

7. Observations for Enlargement

- Diameter of the small pipe (d_1) :- 16mm = 0.016m
- Diameter of the Enlargement (d_2) :- 27mm = 0.027m
- Area of Measuring Thank : - (0.295 x 0.345) m^2

8. Observation table:

Sr. No.	Manometer Difference in (x) mm of Hg	Time for Specific rise in the Measuring tank (100mm)

9. Calculation:

1. Head lost or Minor Loss *m* of water (h_L)

$$h = x\left[\frac{S_h}{S_o} - 1\right]$$

Where,

1. S_h= Specific gravity of manometer fluid (i.e. Mercury) (*Hg*) = 13.6
2. S_o = Sp. gravity of the liquid flowing through the pipe (i.e. Water) = 1
3. Sp. gravity of the light liquid (i.e. Water) = 1
4. x = Manometer Difference in (m)

2. Actual Discharge (Q_{act})

$$\text{Actual Discharge } Q_{act} = \frac{a \times R}{t} \; (m^3/s)$$

Where,

a = Area of Measuring tank *(m^2)*

R= Specific rise in the Measuring tank, *(0.1m)*

t = Time taken to rise R meters, *(sec)*

3. Velocity: V_1: (m/s)

$V_1 = Q_{act} / A_1$

Where

$$A_1 = \frac{\pi}{4} (d_1)^2 \quad (m^2)$$

4. Velocity: V_1: (m/s)

$V_1 = Q_{act} / A_1$

Where

$$A_1 = \frac{\pi}{4} (d_1)^2 \quad (m^2)$$

5. Velocity: V2: (m/s)

$V_1 = Q_{act} / A2$

Where

$$A2 = \frac{\pi}{4} (d2)^2 \quad (m^2)$$

6. Loss Coefficient (K_L) for Enlargement

$$K_L = 2\,g\,h_L / (V_1 - V_2)^2$$

Where,

g = Acceleration due to gravity = 9.81 (m/s^2)

10. Observations for Contraction, Bend, Elbow

- Diameter of the Contraction *(d)* :- *16 mm = 0.016m*
- Diameter of the Bend *(d)* :- *16 mm = 0.016m*
- Diameter of the Elbow *(d)* :- *16 mm = 0.016m*
- Area of Measuring Thank : - (*0.295 x 0.345*) m^2

11. Observation table: (For Contraction):

Sr. No.	Manometer Difference in (x) mm of Hg	Time for Specific rise in the Measuring tank (100mm)

12. Observation table: (For Bend):

Sr. No.	Manometer Difference in (x) mm of Hg	Time for Specific rise in the Measuring tank (100mm)

13. Observation table: (For Elbow):

Sr. No.	Manometer Difference in (x) mm of Hg	Time for Specific rise in the Measuring tank (100mm)

14. Calculations:

1. Head lost or Minor Loss *m* of water (h_L)

$$h = x\left[\frac{S_h}{S_o} - 1\right]$$

Where,

1. S_h= Specific gravity of manometer fluid (i.e. Mercury) (*Hg*) = 13.6
2. S_o = Sp. gravity of the liquid flowing through the pipe (i.e. Water) = 1
3. Sp. gravity of the light liquid (i.e. Water) = 1
4. *x* = Manometer Difference in (*m*)

2. Actual Discharge (Q_{act})

$$\text{Actual Discharge } Q_{act} = \frac{a \times R}{t} \ (m^3/s)$$

Where,
a = Area of Measuring tank *(m^2)*
R= Specific rise in the Measuring tank, *(0.1m)*
t = Time taken to rise R meters, *(sec)*

3. Velocity:

$$V = \frac{Q_{act}}{A}$$

Where,

$$A = \frac{\pi}{4} (d)^2 \quad (m^2)$$

4. Loss Coefficient (K_L) for Contraction, Bend and Elbow:

$$K_L = 2\, g\, h_l / (V)^2$$

Where,

g = Acceleration due to gravity = 9.81 (m/s^2)

15. Result:

K_L for Expansion:

K_L for Contraction:

K_L for Bend:

K_L for Elbow:

16. Conclusion:

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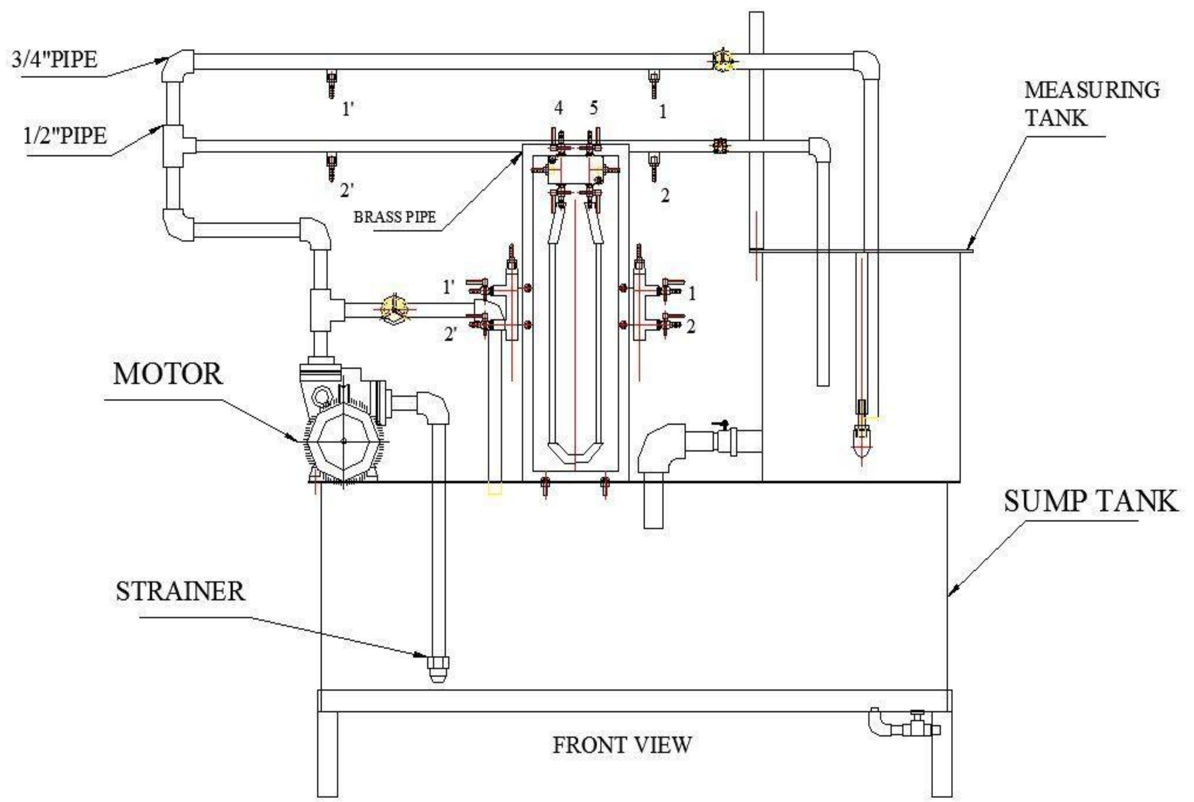
LABORATORY MANUAL

Experiment No. - 05

1. **Aim:** To determine the friction factor (major losses) for Darcy –Weisbach equation.

2. **Theory:**

3. **Description:** The pipe flow rig with pipes of different diameters, a collecting tank with stop watch to measure the discharge and a differential manometer to measure the pressure drop in the test section.
4. **Diagram:**



PIPE FRICTION PPARATUS.

5. **Observation:**
   a. Sump Tank - *900 X 350 X 350 mm*
   b. Measuring Tank - *295 X 345 X 345 mm*
   c. Two Pipes -
      i. Dia. of pipe - *0.022 m (For pipe ¾")*
      ii. Dia. of pipe - *0.016 m (For pipe ½")*
   d. Differential manometer.

e. Flow control valve.
f. Necessary piping & valves.
g. Stand - Sump tank is fitted on a strong stand.
h. Distance between pressure tapings : - *1m*
i. Diameter of pipe : - *0.022 m (For pipe ¾")*
j. Diameter of pipe : - *0.016 m (For pipe ½")*
k. Area of Measuring Thank : - (*0.295 x 0.345*) m^2

6. Procedure:

1. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.
2. Open by-pass valve.
3. Now switch ON the main power supply.
4. Switch ON the moonset pump.
5. By closing the bypass valve first take the discharge through the chosen pipe.
6. Open the pressure taps of manometer of related test section, very slowly to avoid the blow of water on manometer fluid.
7. Open the air release valve provided on the manometer, slowly to release the air from manometer.
8. When there is no air in the manometer, close the air release valves.
9. Adjust water flow rate in desired section with the help of control valve
10. Record the manometer reading.
11. Measure the flow of water, discharged through desired test section, using stop watch and measuring tank.
12. Repeat steps for different flow rates of water, operating control valve

7. Observation table:

Sr. No.	Manometer Difference in (x) *mm* of *Hg*	*Time for Specific rise in the Measuring tank (100mm)*

8. Calculation:

1. Head lost or Minor Loss *m* of water (h_L)

$$h = x\left[\frac{S_h}{S_o} - 1\right]$$

Where,

S_h= Specific gravity of manometer fluid (i.e. Mercury) (*Hg*) = 13.6

S_o = Sp. gravity of the liquid flowing through the pipe (i.e. Water) = 1

Sp. gravity of the light liquid (i.e. Water) = 1

x = Manometer Difference in (*m*)

2. Actual Discharge (Q_{act})

$$\text{Actual Discharge } Q_{act} = \frac{a \times R}{t} \; (m^3/s)$$

Where,

a = Area of Measuring tank *(m^2)*

R= Specific rise in the Measuring tank, *(0.1m)*

t = Time taken to rise R meters, *(sec)*

3. Velocity:

$$V = \frac{Q_{act}}{A}$$

Where,

$$A = \frac{\pi}{4} (d)^2 \qquad (m^2)$$

4. Coefficient of friction - *(f)*

$$h_f = \frac{4 \times f \times L \times V^2}{2gd}$$

$$f = \frac{h_f \times 2gd}{4 \times L \times V^2}$$

Where,

1. h_f = Head lost in friction in meter of water.*(m)*
2. g = Acceleration due to gravity = 9.81 (m/s^2)
3. d = Inside diameter of pipe, *(m)*
4. L = Distance between pressure tapings, *(m)*
5. V = Velocity of fluid flow through pipe in *(m/s)*

9. Result:

Coefficient of friction =

10. Conclusion:

Experiment No. - 06

1. **Aim:** To determine the effect of superficial mass velocity on pressure drop across the packed bed with liquid flow. Verify Erguns equation. Determine the effect of modified Reynolds number on modified friction factor. (Using Virtual lab)
2. **Theory:**

3. **Apparatus required:** CCl_4 manometer, Hg manometer.

4. **Procedure:**
   1. Keep the bypass valve completely open and the main valve completely closed. Switch on the pump.
   2. Connect a CCL_4 manometer across the packed bed. Open the main valve and allow the fluid to flow through the bed.
   3. Wait till steady state is attained
   4. Note down the manometer reading and the flow rate using the rotameter.
   5. Increase the flow rate by opening the main valve and throttling the bypass valve suitably and repeat steps (3) and (4).
   6. Use Hg manometer at higher flow rates.
   7. After completing the experiment, close the main valve. Switch off the pump. Determine the void volume by draining water from the column.

5. **Observation table:**

6. **Result:**

7. **Conclusion:**

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Experiment No. - 07

1. **Aim:** To conduct an experiment on the flow of water through fluidized bed and to obtain the effect of superficial velocity on bed porosity and pressure drop. Determine the minimum fluidization velocity from the experimental data (Using virtual lab)
2. **Theory:**

3. **Apparatus required:** CCl_4 Manometer, Hg Manometer, bucket, Stop watch.
4. **Procedure:**
    1. Keep the bypass valve open and the main valve closed. Switch on the pump.
    2. Connect CCl_4 manometer across the bed.
    3. Allow the fluid through flow through the bed by opening the main valve.
    4. Ensure for steady flow condition note down the flow rate using the rotameter.
    5. The corresponding height of the bed and the difference in levels in the manometer limbs to be noted down.
    6. The procedure is to be repeated for different flow rates, both for static and fluidized bed conditions.
    7. Use Hg manometer for higher flow rates.
    8. Collect the fluid present in the static bed after closing the main valve, to calculate the void volume.

5. **Observation table:**

6. **Result:**

7. **Conclusion:**

Experiment No. – 08

1. **Aim:** To determine friction in pipes. (Using virtual lab)
2. **Apparatus:** Pipes having different diameters connected to a differential manometer, collecting tank, stopwatch and scale
3. **Procedure:**
    1. Open Friction in Pipes experiment
    2. Select the required diameter of pipe, then click NEXT button
    3. Click on the selected pipe inlet valve to allow the flow through it
    4. Click on main inlet valve to allow the flow through it and then click on pipe valve to allow water flow to test for air bubbles.
    5. Click on knot to change from isolated position to air-vent position and again click to change it to read position.
    6. Now click on tank outlet valve to open and allow flow, note the manometer reading.
    7. Here click on tank outlet valve to close to measure the discharge.
    8. Repeat the same procedure for other trials.
4. **Observation table:**

5. Result:

6. Conclusion:

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Experiment No. – 09

1. **Aim:** To study different types of fittings used in industries

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Experiment No. – 10

1. **Aim:** To study different types of valves used in industry