Practical Manual

Course Title

Fluid Mechanics

Course No. FE 112
B.Tech. - I Semester

• Compiled by •

Dr. R.B. Kshirsagar
Dr. A.R. Sawate
Prof. B.M. Patil

College of Food Technology
Vasantrao Naik Marathwada Krishi Vidyapeeth
Parbhani

DEPARTMENT OF FOOD ENGINEERING

COLLEGE OF FOOD TECHNOLOGY

VASANTRAO NAIK MARATHWADA KRISHI VIDYAPEETH, PARBHANI

Certificate

This is to certify that Shri/ku.____ Reg. No.____________ has completed the practical read book of Course No. FE-112 (Fluid Mechanics) as per the syllabus for B. Tech. (Food Tech.) first year I semester as prescribed by MCAER, Pune and his attendance is ________________ percent.

Date:

Course Teacher

Experiment No. 1

Study of different properties of fluid with numerical

Definitions:-

1. **Density (ℓ):-** The mass per unity volume of a fluid is called density or mass density
2. **Specific Weight:-** (w) The weight per unit volume of a fluid is called specific weight
3. **Specific Volume:-** The volume per unit mass of a fluid is called specific volume.
4. **Specific gravity :(S)** Specific gravity is defined as the ratio of the weight density (or density) of a fluid to the weight density (or density) of standard fluid
5. **Viscosity:-** Viscosity is defined as the property of fluid which offers resistance to the movement of one layer of fluid over another adjacent layer of the fluid
6. **Kinematic viscosity:-** (λ) The ratio of dynamic viscosity and density of fluid is called kinematic viscosity.
7. **Surface tension of liquid droplet:-** Surface tension is defined as the tensile force acting on the surface of a liquid in contact with a gas or an the surface between two immiscible liquids such that the contact surface behaves like a membrance under tension.
8. **Capillary rise:** The rise of liquid surface in a capillary tube is known as capillary rise.
9. **Capillary fall:** The fall of liquid surface in a capillary tube is known as capillary fall

Formulae:-

1] Density:- (e) Density = $\frac{\text{mass}}{\text{Volume}}$

$e = m/v$ Unit: gm/cm^3 or $1000\ kg/m^3$

2] Specific weight (W):- Specific Weight $= \frac{\text{weight}}{\text{volume}} = \frac{Mg}{V}$

$W = e \times g$ Unit: N/m^3

3] Specific Volume:

Specific Volume = $\frac{\text{volume of fluid}}{\text{Mass of fluid}}$

Specific Volume = $\frac{1}{m/v} = \frac{1}{e}$

Unit: m^3/kg

4] Specific gravity :(S) Specific gravity $= \frac{\text{Weight density of fluid}}{\text{Weight density of standard fluid}}$

OR

$= \frac{\text{density of fluid}}{\text{Density of standards}}$

5] Density of mercury: $= \frac{\text{Specific gravity of mercury}}{\text{Density of water}}$

6] Viscosity (μ): $\mu \frac{d\mu}{Dy} = \lambda$

$$\mu = \frac{\lambda}{d\mu / dy}$$

Unit :- NS/m^2

7] Kinematic Viscosity: Kinematic Viscosity (ϋ) $= \frac{\text{Dynamic Viscosity}}{\text{Density}}$

$$\ddot{\upsilon} = \frac{\mu}{\ell}$$

Unit:- m^2/sec

8] Surface tension of liquid droplet:

$$P = \frac{46}{D}$$

Unit : N/m^2

9] Surface tension of hollow bubble:

$$P = \frac{86}{D}$$

10] Capillary rise

$$h = \frac{46}{egd}$$

11] Capillary fall:

$$h = \frac{46 \cos\Theta}{egd}$$

Numerical on Properties of Fluids

Numerical.1 Calculate the density, specific weight and weight of one liter of petrol of specific gravity 0.7

Solve:

Numerical.2 A plate 0.025mm distant from fixed plate moves at 60 cm/s and require force of 2 N/m^2 to maintain this determine the fluid viscosity between the plates.

Solve:

Numerical.3 A flat plate of are $1.5m^2$ is pulled with speed of 0.4m/s relative to the another plate located at distance of 0.15mm from it. find force of the fluid whose viscosity is 1poise

Solve:

Numerical.4 The two horizontal plates are placed 1.25cm apart the space between then being filled with oil of viscosity 14 poise. Calculate the shear stress in oil. If upper plate is moved with velocity 2.5m/s

Solve:

Numerical.5 Find kinematic viscosity of an oil having density 981 kg/m^3. The share stress at point in oil is 0.2452 N/m^2 and velocity gradient at that point is 0.2m/s.

Solve:

Numerical.6 The surface tension of water in contact with air at 20°C is 0.0725 N/m the pressure inside the droplet of water is to be 0.02N/m^2 greater than outside pressure. Calculate the diameter of droplet of water.

Solve:

Numerical.7 Find the surface tension of soap bubble of 40mm diameter when the inside pressure is 2.5N/m^2 above the atmospheric pressure.

Solve:

Numerical.8 The pressure outside the droplet of water of diameter 0.04mm is 1032N/cm^2 (atmp) Calculate the pressure within the droplet. Its surface tension is given as 0.0725 N/m of water.

Solve:

Numerical .9 Calculate the capillary rise & fall in glass tube of 2.5mm diameter when immersed vertically in a) water b) mercury

Take surface tension for water 0.0725N/m surface tension for mercury 0.52 N/m in contact with air. [The specific gravity of mercury is 13.6 and angle of contact = 130°C glass tube]

Solve:

Numerical .10 Find out the minimum size of glass tube that can be used to measure water level if the capillary rise in tube is to be restricted to 2mm consider the surface tension of water in contact with air 0.73575

Solve:

Study of Fluid Pressure Measuring Devices (Manometers)

Principle:

The principle on which all the pressure measuring devices are based are of two types:-

i) By balancing the liquid column whose pressure is to be found out by same or another column. Also called as the tube gauges/ Manometers to measure the pressure.

I] Tube gauges/Manometers to measure fluid pressure.

A] Piezometer tube B] Manometer

A] Piezometer Tube:-

1) It is the simplest form of manometer tube used to measure gauge pressure
2) One end of this is connected to point where pressure is to be measured and other end is open to atmosphere.
3) The rise of liquid gives pressure head at that point
4) If at a point A, the height of liquid (water) is in Piezometer tube then pressure at A.

   =e x g x h x N/m^2
5) A Piezometer tube is not suitable for measuring negative pressure.

Figure of Piezometer:

B] Manometers

Types of Manometer.

1. Simple Manometer
2. Micro manometer
3. Differential manometer
4. Inverted differential manometer

1. Simple manometer

- It is slightly improved form of piezometer tube for measuring high as well as negative pressure.
- It consists of U tube. One end of which is attached to guage point & other is open to atmosphere as shown in fig.

(i) Positive pressure:-

1. The liquid used in simple manometer is generally mercury which is 13.6 times heavier than water.
2. Consider a simple manometer connected to a pipe containing a light liquid under high pressure
3. The high pressure in pipe will force the heavy liquid in left limb of U tube to move downward.
4. This downward movement of heavy liquid in left limb will cause a corresponding rise of heavy liquid in right limb.
5. The horizontal surface at which the heavy and light liquid meet in the left limb is known as a common surface or datum line.

Let Z-Z be datum line as shown in fig.

Let, h_1= Height of light liquid in left limb Above the datum line (incm)

h_2= Height of heavy liquid in right limb above the datum line (incm)

h= Pressure in the pipe

s_1= Specific gravity of light liquid

s_2= Specific gravity of heavy liquid

A little consideration will show that pressure in left limb and right limb above datum line are equal.

Pressure in left limb above datum line

= $h + S_1h_1$ cm of water-------------------------(1)

Similarly,

Pressure in right limb above datum line

= S_2h_2 cm of water----------------------------- (2)

Equating (1) and (2) we get

$$h+s_1n_1= s_2n_2$$

h= (s_2h_2-s_1h_1)cm.

h= (s_2h_2-s_1h_1)cm.

Figure of Positive pressure simple manometer:

b] Negative Pressure

1) In this case negative pressure in pipe will suck the light liquid which will pull up the heavy liquid in left limb of U-tube.
2) This upward movement of heavy liquid in left limb will cause a corresponding fall of liquid in right limb as shown in fig.

Now pressure in left limb above datum line

$= h + s_1h_2 = s_2h_2$ cm----------------------------(1)

Pressure in the right limb =0 ---------------------(2)

Equating (1) and (2) we get

$h+ s_1h_1 + s_2h_2 =0$

$h = -s_1h_1 - s_2h_2$ cm

$h = -(s_2h_2+ s_1h_1)$ cm

Figure of Negative Pressure Manometer:

2] Micromanometer :-

It is a modified form of manometer in which cross sectional area of the (left limb) is made much larger (about 100 times) than that of other limb as shown in figure.

A micromanometer is used for measuring low pressure.

There are two types of micromanometer as follows

a] Vertical tube micromanometer

b] Inclined tube micromanometer

a] Vertical tube micromanometer:-

Consider a vertical tube micromanometer connected to a pipe containing light liquid under a very high pressure

The pressure in pipe will force light liquid to push heavy liquid in the basin downward:-
This downward movement of heavy liquid in basin will cause a considerable rise of heavy liquid in the right limb.
Let z-z be the datum line

sh = falt of heavy liquid level in basin
h_1 = Height of light liquid above datum line
h_2 = Hight of heavey liquid (after except) in right limb above datum line
h = pressure in the pipe.

a = Area of basin
a = Cross section area of tube
s_1 = Specific gravity of light liquid
s_2 = Specific gravity of heavy liquid

As fall of heavy liquid level in basin will case a corresponding rise of heavy liquid level.

: $A\ sh = ah_2$ or $sh = a/A \times h_2$----------(1)

We know, pressures in left & right limb above datum line are equal.

Pressure in the left limb above datum line

$= h + s_1h_1 + s_1sh$ -----------(2)

Pressure in the right limb above datum line

$= s_2h_2 + s_2sh$ -----------------(3)

Equating (2) & (3) we get

$h + s_1 h_1 + s_1sh = s_2h_2 + s_2sh$

$h = s_2h_2 + s_2sh - s_1h_1 - s_1sh$

$= s_2 h_2 - s_1h_1 + sh (s_2 - s_1)$

Substituting value of sh from equation we get

$h = s_2h_2 - s_1h_1 + \frac{ah_2}{A}(s_2 - s_1)$----------------------------------(4)

Sometimes ration a/A is neglected. The above equation becomes

$h = s_2h_2 - s_1h_1$

Figure of Vertical tube Micro Manometer:

b] Inclined tube micrometer:

(1) Inclined tube micrometer is more sensitive than vertical tube micrometer.

(2) Due to inclined tube, distance moved by heavy liquid in the narrow tube will be comparatively more & thus it can give a higher reading for given pressure.

(3) From geometery of figure we find.

$$\frac{h_2}{\text{length}} = \sin\Theta$$

$$H2 = l \sin\Theta$$

Hence equation for pressure at given point is

$h = s_2h_2 - s_1h_1 + ah_2\ (s_2 - s_1)$

Using value of h_2

$$H = s_2\ l \sin\Theta - s_1h_1 + \frac{a}{A} l \sin\Theta\ (s_2 - s_1)$$

Figure of Inclined Tube Micro manometer:

To study the Differential Manometer

It is a device for measuring the difference of pressure between two points in a pipe or in two different pipes.

A differential manometer consists of a U tube containing heavy liquid whose two end are connected to points, whose difference of pressure is to be found out.

A] A and B at same level:-

Consider a differential manometer whose two ends are connected with two different points A &B at same level as shown in fig.

Let us assume that pressure at point A is more than that at point B

The greater pressure at a Will force the light liquid in the U tube to move downwards

This downward movement of liquid in left limb will cause a corresponding of liquid in right limb as shown in fig rise heavy

Let Z-Z be the datum line.

Let, h = Difference of levels of heavy liquids in right & left limb.

S_1 = Specific gravity of light liquid in pipe

S_2 = specific gravity of heavy liquid.

We know pressure in left limb and right limb above datum line are equal.

Differece of pressure in two points A & B.

hA- hB = hx (sp.Gravity of heavy liquids minus sp. gravity of light liquid)

$hA - hB = h(s_2 - s_1)$

B] A & B at different levels

Consider a differential manometer whose two ends are connected to two different points A & B at different levels and containing different liquids as shown in fig.

Let us assume that pressure at point A. is more than that at point B.

The greater pressure at A will force heavy liquid to move downwards.

This downward movement of liquid in left limb will cause a corresponding rise of heavy liquid in the right limb as shown in fig.

Let Z-Z be datum line

Let, h_1 = height of liquid in left limb above datum line

h_2 = difference of levels of heavy liquid in left and right limb

h_3= height of liquid level in right limb above datum lilne
hA= Pressure in pipe A
hB= Pressure in pipe B
s_1= Specific gravity of liquid in left pipe (A)
s_2 = Specific gravity of heavy liquid
s_3= Specific gravity of liquid in right pipe (B)
We know pressure in left limb& right limb above the datum line are equal
Pressure in left limb above datum line
$= hA+s_1h_1$-----------------(1) and
Pressure in right limb above datum line
$= hB+ s_2h_2+s_3h_3$---------------(2)
Equating these two equations.
$hA+ s_1h_1= s_2 h_2 + s_3h_3 + hB$
$hA-hB= s_2h_2+ s_3h_3 - s_1h_1$

Figure of differential manometers having liquid at same level and different level:

I] Inverted differential Manometer:-

1) It is a type of differential Manometer in which inverted U tube is used.
2) An inverted differential Manometer is used for to measure difference of low pressure
3) It consists of an inverted U-tub containing a light liquid whose two ends are connected to the points whose difference of pressure is to be found out

Explanation:-

Consider an inverted differential manometer whose two ends are connected to two different points A&B as shown in fig.

Let us assume that pressure at A is more than that atB

The areater pressure at A will force the light liquid in the inverted U tube to move upwards

This upward movement of liquid inleft limb will cause a corresponding fall of light liquid in right limb as shown in fig.

Let Z-Z be the datum line

Let. h_1 = height of liquid in left limb below datum line.

h_2 = Difference of levels of right liquid right & list limbs.

h_3 = height of liquid in right limb below datum line.

hA = Pressure in Pipe A

hB = Pressure in Pipe B

s_1 = Specific gravity of liquid in left limb

s_2 = Specific gravity of liquid in right limb

we Know pressures in left limb & right limb below datum line are equal.

Pressure in left limb below datum line

$= hA - s_1h_1$ -----------------(1)

Pressure in right limb below datum line

$= hB - s_2h_2 - s3h_3$ ---------------(2)

Equating these two pressures.

$hA - S_1h_1 = hB - s_2h_2 - s_3h_3$

$hA - hB = -(s_2h_2 + s_3h_3 - s_1h_1)$

Figure of Inverted differential manometer:

Studies of Mechanical Gauges

Principle:

By balancing the liquid column whose pressure is to be found out by spring or dead weight also called as mechanical gauges to measure pressure.

Mechanical gauges are used to measure a very high fluid pressure. It is also used for measurement of pressure in boilers or other pipes

Three types of mechanical gauges

1. Bourdons tube pressure gauge
2. Diaphragm gauge
3. Dead weight pressure gauge.

1. Bourdon's tube pressure gauge

- The pressure above & below atmospheric pressure easily measured with the help of a bourdons tube pressure guage.
- It consist of an elliptical tube ABC bent into an arc of a circle as shown in figure.
- This bent up tube is called bourdens tube
- When guage is connected to fluid (Whose pressure is to be found out) at C at the fluid under pressure flows into tube.
- Due to increased temperature of Bourdans tube, tends to straighten itself'
- Since the tube is encased in a Circular cover therefore it tends to become circular instead of straight.
- With the help of simple pinion & sector arrangement, the elastic deformation of Bourdoris tube rotates the pointer.
- This pointer moves over a calibrated scale which directly gives pressure as in fig.
- A Bourdon's tube pressure guage can be used for high pressure also.

Figure:

2. Diaphagram pressure gauge:-

- It is used to found the pressure above or below the atmospheric pressure .
- It consist of a corrugated diaphragm
- When the gauge is connected to the fluid (Whose pressure is to be found out) At C the fluid under pressure causes same deformation of diaphagram
- With the help of pinion arrangement the elastic deformation of diaphagram rotates the pointer
- This pointer moves over a calibrated scale which directly gives the pressure as shown in fig.
- A diaphragm pressure is generally used to measuring relatively low pressure .

Figure:

3. Dead weight pressure gauge

- It is most accurate pressure gauge.
- It is generally used for cal liberation of the other pressure gauges in a laboratory
- It consists of piston & cylinder of known area and connected to a fluid by a tube as shown in fig.
- The pressure on fluid in the pipe is calculated by relation $P = \frac{\text{Weight}}{\text{Area of piston}}$
- A pressure gauge to be calibrated is fitted on their end of tube as shown in fig.
- By changing the weight on piston the pressure on fluid is calculated and marked by pointer

Figure:

Numerical on fluid pressure by manometers

Definitions and formulae:-

1] Pressure:-

Force per unit area is called as pressure:

Formula:- P = F/A **P= w x h**

Where w = sp. weight

P= egh

Unit:- N/m^2

2] Simple manometer:- Positive pressure:-

Formula:- $h= (s_2h_2-s_1h_1)$ Unit: cm/mm

$P_A= e_2gh_2-e_1gh_1$ Unit: N/m_2

Negative pressure:-

Formula:- $h= -(s_2h_2+ s_1h_1)$

$P_A= -(e_2gh_2+e1gh_1)$

3] Vertical tube manometer:

Formula:-

$$Pa = e_2gh_2-e_1gh_1 + \frac{ah_2}{A} (e_2g-e_1g)$$

$$h = s_2h_2-s_1h_1 = \frac{ah_2}{A} (s_2-s_1)$$

4] Inclined tube manometer:-

Formulae:-

$h_2 = L\sin\Theta$

So $P_A = L\sin\Theta e_2g_2-h_1e_1g$

$h= L\sin\Theta\, s_2-h_1s_1$

5] Differential Manometer

It is a device used for measuring the difference of pressure between two points in a pipe of in two different pipes.

A] Pipes of fluid at same level

Formulae:-

$P_A - P_B = gh(e_2 - e_1)$

$h_A - h_B = h(s_2 - s_1)$

B] Two different points at different levels having same or different liquid.

Formulae:-

$P_A - P_B = e_2gh_2 + e_3gh_3 - e_1gh_1$

$h_A - h_B = s_2h_2 + s_3 h_3 - s_1h_1$

6] Specific weight of water:

CGS:- 1gm/cm^2

MKS:- 0.001kg /cm^2

Numerical .1 An open tank contains a water upto a depth of 2m and above it an oil of specific gravity 0.9 for a depth of 1m find the pressure intensity

1) At the interface of 2 liquids

2) at The bottom of the tank.

Given data:-

Height of water = 2m

Height of oil=1m

Specific gravity of oil =0.9

Formula and solution

1) Interface of 2 liquids:-

P_A = egh= 0.9 x 1000 x9.81 x1

P_A= 8829 N/m^2

P_A= 8829 N/m^2

2) Pressure intensity at bottom

P_B = egh

= 1000 x 9.81 x2

19.62 x1000

P_B= 19620 N/m^2

P= P_A + P_B = 8829+19620

P=28449 N/m^2

Numerical 2: What are the guage pressure and absolute pressure at a point 3m below the free surface of a liquid having a density of 1.53 x 103 kg/m^3. If the atmospheric pressure is equivalent to 750 mm of Hg? The specific gravity of Hg is 13.6 & density of water is 1000 kg/m^3

Solve:

Numerical :3 A simple manometer is used to measure the pressure of oil whose specific gravity is 0.8 flowing in a pipe line. Its height limb open to the atmosphere and left limb connected to pipe the centre of pipe is 9 cm below the level of Hg. Specific gravity of Hg is 13.6 If the difference of mercury level in the right limb is 15 cm above the datum. Determine the absolute pressure of the oil in the pipe in kg/ cm^2

Solve:

Numerical :4 The right limb of simple U tube manometer containing Hg is open to a pipe in which a fluid of specific gravity 0.9 is flowing. The centre of the pipe is 12 cm below the level of fig in the right limb. Find the pressure of fluid in the pipe. If the difference of Hg level in the two limb is 20 cm above the datum.

Solve:

Numerical :5 A Simple U tube manometer containing Hg is connected to a pipe in which a fluid of specific gravity 0.8 having vacuum pressure is flowing the other end of manometer is open to atmosphere. Find the vacuum pressure or negative pressure in a pipe If difference of Hg level in the two limb or left limb is 40 cm and the height of fluid in left from the centre of pipe is 15 cm.

Solve:

Numerical :6 To determine the pressure in the pipe containing of specific gravity 0.8 a micromanometer was used to as shown in fig. the ratio of area of reservoir to that of limb is 50.

Figure:

Solve:

Numerical :7 A single column manometer is connected to a pipe containing a liquid of specific gravity 0.9 as shown in fig. Find the pressure in pipe if the are of the reservoir is 100 times the area of tube the specific gravity of fig is 13.6

Figure:

Solve:

Study of the Reynolds no. Apparatus and predict the type of flow

Aim:- To predict the type of flow of a water

Procedure:-

1. It consist of cylindrical vertical tank which is ¾ filled with water.
2. At bottom outlet of tank there is attachment of transparent glass pipe and also there is an arrangement of hypodermic needle with capillary tubings is fixed centrally in the inlet end of glass pipe.
3. Glass pipe is attached with valve to control flow rate of water.
4. At the top of tank colored die solution is kept in bottle which is transferred to capillary tube at a specific rate of flow into a glass pipe along with water.
5. If the flow rate is less then we will observed the color die solution is in strait layer this is called as laminar flow.
6. At this stage collect the water in a measuring cylinder for a specific time i.e. 30 sec.
7. Now if you increase the flow rate by opening valve the laminar flow will suddenly change in form of eddies and afterwards there is a bulk mixing of colour die solution with water in glass pipe is called as turbulent flow.
8. At this stage collect the water in measuring cylinder for 30 sec.

Data:-

Diameter of glass pipe= 2.1 cm

$\grave{e}/\mu = 10^2$ sec/cm^2

Sr. No	Volume collected in cm^2/ml	Time in sec	Volumetric Flow rate Volume/time	Velocity CMIS Volumatric Flow rate/ Area of glass pipe	Reynolds No. DV è/µ	Type of Flow
1	540	30	18	5.196	1091.16	Laminar Flow
2						
3						
4						

Calculation

Velocity = $\frac{\text{Volumetric Flow rate}}{\text{Area of glass pipe}}$

Volumatric flow rate = $\frac{\text{Volume time}}{\text{Time}} = \frac{540}{30} = 18\ cm^3/sec$

Area of glass pipe (A) $= \frac{\pi d^2}{4} = \frac{3.142x(2.1)^2}{4} = \frac{13.856}{4} = 3.46$ cm^2

Velocity $= \frac{\text{Volumetric flow rate}}{\text{Area of glass pipe}} = \frac{18}{3.464} = 5.196$ cm/ sec

Reynolds No. $= \frac{DV e}{\mu}$

Reynolds No.1 $= \frac{DV \dot{e}}{\mu} = 2.1x100x5.196 = 1091.16$

Calculations : Calculate the Reynolds number for other observations as per above calculations

Numerical on time for emptying tank through orifice

Formulae

Time for emptying a tank through orifice at its bottom= T =

$$T = \frac{2A\sqrt{H_1}-\sqrt{H_2}}{Cd\text{-} a\sqrt{2g}}$$

for complete emptying tank

$$T = \frac{2A\sqrt{H_1}}{Cd.\ a\sqrt{2g}}$$

Numerical :1 A swimming pool 10 mm long and 6m wide holds water to a depth of 1.25m if the water is discharged through an opening at the bottom of at pool of an area $0.23m^2$. Find the time taken to completely emptying it . cd = 0.6

Solve

Numerical :2 A reservoir of cross sectional area $1m^2$ contains water 4m deep and orfice of 60mm diameter is provided at its bottom. Find the fall of water level upto 2 min. cd = 0.6

Solve

Numerical :3 Circular tank of diameter 4m contains water up to a height of 5m the tank is provided with an orifice of diameter 0.5m at bottom. Find the time taken by water i) to fall form 5m to 2m ii) for completely emptying tank. where cd = 0.6

Solve

Verification of Bernoullis Theorem

OBJECTIVE:- To verify Bernoullis Theorem experimentally.

TEST SET UP:- It comprises following-

1. Set up of 'Bernoullis Theorem' experiment.
2. Stop watch.
3. Accessories.

INTRODUCTION & THEORY:-

Bernoulli's Daniell was a swiss engineer, who belonged to a renowned mathematical family, & he gave this equation in 1738.

For any mass of flowing liquid, when there is a continuous connection between all the particles of the flowing liquid, the total energy remains the same at every section provided there is no addition or subtraction of energy.

ENERGY OF LIQUID IN MOTION:-

The energy in general may be defined as the capacity to do work. Though the energy exists in many forms, yet the following are important from the subject point of view.

1) Potential energy
2) Kinetic energy.
3) Pressure energy.

1) Potential energy:-

It is energy possessed by a liquid particle, by virtue of it's position. If liquid particle is Z meter above the horizontal datum, the potential energy of the particle will be Z meter- kg/kg of liquid. Potential head of liquid, at that point, will be Z meter of liquid.

2) Kinetic energy:-

It is energy of liquid particle by virtue of it's motion or velocity. If liquid particle is flowing with a mean velocity of V m/s, the kinetic energy of the particle will be

$$\frac{V^2}{2g} = \text{Kinetic Energy per unit weight or kinetic head. \{'m'\}}$$

3) Pressure energy:-

It is the energy possessed by a liquid particle, by virtue of it's pressure. If the liquid particle is under a pressure of P kg/m^2, the pressure energy of the particle will be P/w of the liquid, where w is specific weight of liquid. The pressure head of the liquid under this pressure will be P/w meter of the

liquid. Total energy of a liquid particle in motion is the sum of it's potential energy kinetic energy, pressure energy.
P/w = pressure Energy per unit weight of fluid or pressure head. {'m'}

4) Total energy:-

$$E = Z + \frac{v2}{2g} + \frac{P}{w} \text{ m.}$$

LIMITATIONS OF BERNOULLIS THEOREM:-

The Bernoullis theorem is the basic equation which has the widest application in hydraulics. Since this equation is applied for the derivation of many formulae, so its clear understanding is very essential.

Through the Bernoullis equation has number practical applications, yet we shall discuss its application on the following Hydraulic devices.

1. Venturimeter.
2. Orifice.
3. Pitot tube.

EXPERIMENTAL SET UP:-

1. Flow channel 700 m.m. long, transparent acrylic.
2. Supply with flow control valve.
3. Manometric tubes (11No.) fixed over flow channel with separate scale.
4. Sump tank – 1210 x 450 x 450mm
5. Measuring tank- 450 x 330 x 410 mm
6. Inlet, outlet tank- Of suitable size.

PROCEDURE:-

1. Start the motor.
2. Open the by pass valve fully.
3. Control the gate valve for steady flow.
4. Allow some time to raise the water level in manometric tubes.
5. Take the height level in manometric tubes
6. Take the time required for 100 mm rise in water level of measuring tank.

OBSERVATIONS:-

1. Width of channel = 0.05 m
2. Area of Measuring tank = (0.45 x 0.33) m^2
3. Time required for 100 mm rise in measuring tank = ---------------- sec.

Sr. No.	TUBES NO.	HEAD H in cm	HEAD (H) In (m.)	HIGHT OF CHANNEL in m	C/S AREA OF CHANNEL (A) (m^2)
1	1			0.039	0.00195
2	2			0.034	0.00170
3	3			0.029	0.00145
4	4			0.024	0.00120
5	5			0.019	0.00095
6	6			0.015	0.00075
7	7			0.019	0.00095
8	8			0.024	0.00120
9	9			0.029	0.00145
10	10			0.034	0.00170
11	11			0.039	0.00195

CALCULATIONS:-

1.Discharge (Q) = $\dfrac{\text{Area of measuring tank x 0.1}}{\text{Time required in sec.}}$ =

Q=-------------m^3/sec.

2. Velocity (V) = $\dfrac{\text{Discharge (Q) in m3/sec.}}{\text{Cross sectional area (A) of tube in } m^2}$ (m/s)

=--------------------------

3. Pressure (P) = eg.H N/m2

Where,

density = 1000 kg/m3

g = 9.81 m/sec2

H = Head in m.

4. Pressure head = P/w meter

Where,

W= Specific weight of water = 9.81 x 1000 N/m^3

RESULT TABLE :---

Sr.	TUBE NO	P/W	$V^2/2g$	$P/w + v^2/2g$
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

The total Head varies from------------ meter to ----------- meter.
Here the loss due to friction in the flow channel which is not taken in account.

Losses In Pipe Friction Apparatus

OBJECTIVE:- 1. To determine coefficient of friction for pipes
2. To determine head lost in pipe friction.

TEST SET UP:- It comprises of following
1) Set up of pipe friction apparatus.
2) Stop Watch.
3) Accessories.

INTRODUCTION & THEORY

A pipe is a closed conduit, generally of circular cross- section, used to carry water or any other fluid, when the pipe is running full, the flow is under pressure. But if the pipe is not running full, the flow is not under pressure. In such a case the atmospheric pressure exits inside the pipe.

While designing any pipe line system (It may be a water supply scheme or pipes in hydraulic circuits) the designer has to take into account the losses in the pipe & fitting. This is necessary to estimate total loss of head which will occur when the liquid will reach to the desire destination.

LOSS OF HEAD IN PIPES:-

When the water is flowing in a pipe it experience some resistance to it's motion whose effect is to reduce the velocity & ultimately the head of water available. Though there are many types of losses, yet the major loss is due to frictional resistance of the pipe only. The frictional resistance of the pipe depends upon the roughness of the inside pipe. It has been experimentally found that more the roughness of the inside surface of the pipe, greater will be the resistance. This is friction is known as fluid friction & the resistance is known as frictional resistance.

The losses are primarily of two types-

A) Major losses.
B) Minor losses.

A) Major losses :-

There losses are due to friction. In the case of pipes longer than 1000 tunes the diameter.

B) Minor losses:-

1) Loss due to entry.
2) Loss due to changes in cross- section of the pipe such as-
   a) Sudden contraction.
   b) Sudden expansion.
3) Los due to change of direction. (Elbow, Bends)
4) Loss due to obstruction. (Valve, Diaphragm)
5) Loss due to exit.

In a long pipe the major loss of head is due to friction in the pipe only. The minor losses are so small, as compared to friction loss, that they may be neglected. But in the case of a short pipe, the minor losses, as compared to the friction loss, are of appreciable amount & thus can not be neglected.

The earlier experiments, on the fluid friction were conducted by Froude who conducted that-

1. The frictional resistance varies approximately with the square of the velocity of liquid, &
2. The frictional resistance varies with the nature of the surface. (Froude Willian Was an English scientist & engineer, who first performed his experiments on ship models in tanks. He gave the basic theory for the liquid flow through the pipes)

Darcy's Formula For loss of Head In Pipes: -

Consider a uniform long pipe through which the water is flowing at Uniform rate.

l- Length of the pipe.

d- Diameter of the pipe.

v- Velocity of water in the pipe.

f- Frictional resistance per unit area (of wetted surface) per unit velocity

hf- loss of head due to friction.

Let us consider sections (1-1) & (2-2) of the pipe.

Now,

P_1- Intensity of pressure sat section at 1-1

P_2- Intensity of pressure at section 2-2

A little consideration will show, P_1 & P_2 would have been equal if there would have been no frictional resistance.

Now,

Considering horizontal forces on water between section (1-1) & (2-2) and equating the same, we get,

$P_1A = P_2A +$ Frictional resistance.

Or frictional resistance $= P_1A - P_2A$,

Dividing both the side by w

We get,

$$\frac{\text{Frictional resistance}}{W} = \frac{P_1A - P_2A}{W}$$

We know that,

Force due to frictional resistance = Product of coefficient of frictional resistance, wetted area and square of velocity.

$$\frac{F' \times \pi DL \times V^2}{W} = \frac{P_1A - P_2A}{W}$$

$$\frac{F' \times \pi DL \times V^2}{A \times W} = \frac{P_1 - P_2}{w}$$

But $\frac{\quad}{W}$ = hf = loss of pressure head due to friction.

$$\frac{F' \times \pi DL \times V^2}{A \times W} = hf$$

$$\frac{F' \times \pi DL \times V^2}{\pi/4 \times d^2 \times W} = hf$$

$$\frac{4f' \times L \times V^2}{d \times W} = hf$$

But $f' = \frac{fw}{2g}$ (f= Darcy's factor)

$$h_f = \frac{4f \times w \times L \times v^2}{2gwd}$$ (f= Darcy's factor)

$$h_f = \frac{4f \times L \times v^2}{2gd} \qquad 1$$

We know that the discharge, (Q)
Q= a x v

$$v = \frac{Q}{a}$$

Put $v = \frac{Q}{A}$

We get,

$$h\,f = \frac{4f \times L \times (Q/a)^2}{2gd}$$

$$h\,f = \frac{4f \times L \times Q^2}{2gda^2}$$

Put a = π/4 d²

We get

$$h_f = \frac{4f \times L \times Q^2}{2gd(\pi/4 \times d^2)^2}$$

$$h_f = \frac{f \times L \times Q^2}{3d^5} \qquad 2$$

$$h_f = \frac{h_f \times 3 d^5}{L \times Q^2}$$

The equation 1 & 2 give us the value of loss of head in pipes due to friction. The following points should be taken into consideration at the time of using above equations.

a) The equation 1 should be used when velocity of water in the pipe is known.

b) The equation 2 should be used when discharge in the pipe is known.

In addition to the major losses of head due to friction following Minor losses of head also take place.

(a) Loss of head at entrance

$$= \frac{0.5 V^2}{g}$$

(b) Loss of head due to velocity of water at outlet

$$= \frac{V^2}{2g}$$

Thus, if all losses are considered, then,

$$hf = \frac{0.5 V^2}{2g} + \frac{4 f L V^2}{2gd} + \frac{V^2}{2g}$$

But, if minor losses (being very small as compared to the frictional loss) are neglected.

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

In actual practice, the minor losses are neglected, Until and unless mentioned in the example.

HYDRAULIC GRADIENT LINE:-

If pressure heads (i.e. p/w) of a liquid flowing in a pipe, be plotted as vertical ordinates on the centre line of the pipe, then the line joining the tops of such ordinates is known as hydraulic gradient line as shown in fig.

TOTAL ENERGY LINE

If the sum of pressure heads and velocity heads (π/w+v2/2g) of a liquid flowing in a pipe, be plotted as vertical ordinates on the centre line of the pipe, then the line joining the top of such ordinates is known as total energy line as shown in fig. Or in other words, the total energy line lies, over the hydraulic gradient, by an mount equal to the velocity heads as shown in fig.

EXPERIMENTAL SET UP:-

1. Sump tank :- 1210mm x 410mm x 410 mm
2. Measuring tank: - 410 mm x 330 mm x 410 mm
3. Two pipes:-
   a. Dia of pipe -22mm
   b. Dia of pipe – 12.5 mm
4. Flow control valve.
5. Differential manometer- To measure pressure differences.
6. Stand- sump tank is fitted on a strong stand.

PROCEDURE:-

1. Before starting flow through pipes the initials manometer reading is taken.
2. Then the fluid is allowed to flow through pipes.
3. Then the manometer readings on the pipe is taken down.
4. Take the time required for 100 mm rise in water level in measuring tank.
5. Above procedure is repeated for different discharges.
6. Take at least 2/3 readings.

OBSERVATIONS:-

1. Length of pipe :- 1.5 m
2. Diameter of pipe A :- 22 mm
3. Diameter of Pipe B :- 12.5mm
4. Area of Measuring tank :- (0.41 x 0.33) m^2
5. Height of water to be measured in measuring tank :- 0.1 m

OBSERVATION TABLE:-

Sr No.	Manometer Reading		Difference H in mm	Difference H in m OF water	Time required for 100 mm Rise in water level
	H1 mm	H2 mm			

CALCULATIONS:-

1. Head lost in friction in m of water (hf) = (h1+h2/100) x 13.6
1m of Hg= 13.6 m of water.

2. Velocity (V) in m/s
V = Q/A
Where,
Q= Discharge in m^3/s

$$Q = \frac{\text{Area of measuring tank x 0.1}}{\text{Time required (Sec)}}$$

A= Area of the pipe in m^2

3. Coefficient of friction –(f)
We have,

$$h_f = \frac{F \times L \times V^2}{2\,gd}$$

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

Where,

h_f	=	Head lost in friction in meters of water.
g	=	$9.81\ m/s^2$
d	=	Dia. Of the pipe in meter.
L	=	Length of the pipe in meter.
v	=	Velocity of flow through pipe in m/s

RESULT TABLE:-

Sr. No.	Discharge M3/s	Head lost in friction (hf) in m of water	Coefficient of friction (f)	Average (f)
1				
2				
3				
4				
5				
6				

NOTE:-- As frictional head loss is inversely proportional to diameter of pipe, the head loss in 22 mm dia. Pipe is very less with compared to 12.5 mm dia. Pipe.

Metacentric Height Apparatus

AIM:- To determine Metacentric Height of Given ship Model.

THEORY:-

A) BUOYANCY:-

When a body is immersed in fluid either wholly or partially it is subjected to an up ward force which tends to lift (or buoy) it Up. This tendency due to an upward force opposite to action of gravity, is known as BUOYANCY.

B) BUOYANT FORCE & CENTRE OF BUOYANCY:-

The force tending to lift up the body under such condition is known as BUOYANT FORCE (up thrust). The point of application of the force of buoyancy on the body is known as CENTRE OF BUOYANCY.

The magnitude of the buoyant force can be determined by the well- known *Archimedis' principle,* which states that when a body is immersed in a fluid it is buoyad or lifted up by a force which is equal to the weight of the fluid displaced by the body. For a body immersed in a fluid, the self- weight of the body always acts in vertical downward direction. As such if a body floating in fluid is to be in equilibrium the buoyant force must be equal to the weight of the body

i.e.

$$F_B = W$$

Further the lines of action of both, the buoyant force and the weight of the body must lie along the same vertical line, so that their moments about any axis is zero.

METACENTRE AND METACENTRIC HEIGHT

Consider a body floating in a liquid. If it is statically in equilibrium, it is acted upon by two forces, viz. the weight of body W acting at centre of gravity G of the body and the buoyant force F_B acting at centre of buoyancy B. The forces F_B & W are equal and opposite as shown in fig. points G & B lie along same vertical line which is vertical axis of body .

Let this body be tilted slightly to angle of hill (Θ) .It is assumed that the position of the centre of gravity G remains unchanged relative to the body. This is so because as the body is tilted the portion of the body immersed on the right hand side increased while that on the left hand side decreases and hence centre of buoyancy moves to new position B_1 In tilted position of the body the buoyant force acts in a vertical upward direction at B_1 now if vertical line is drawn through the new centre of buoyancy B_1 it intersects the axis of the body BG at point M Which is known as metacentre. Thus metacentre may be defined as the point of intersection between the axis of floating body passing through the points B and GT and a vertical line passing through the new centre of buoyancy Ba. For small values of the angle of hill the position of metacentre M is practically constant.

The distance GM is given by the formula,

$$G.M = \frac{w.X}{W.\tan\Theta} \quad (W = Ws + w)$$

Where, w is the weight provided on ship model
X = distance at which weight is provided,
Ws = weight of ship model

USE:- This phenomenon of metacentre is very much useful for the branch of ship building so as to avoid dangerous accidents like tilting of ship due to uneven loading of ship.

SPECIFICATION:-

The arrangement in which a ship model is made to float in small tank
- Set weight are provided
- Graduated are & pointer arrangement is provided to measure angle of tilt.
- A crossbar is provided in a ship model to place the load at desired distance (x).

PROCEDURE:-

1) Weight the ship model and note down its value say Ws gms
2) Put the ship model in water tank and adjust the pointer to zero position with the help of adjustable weight.
3) Place the weight at desired distance (X_1) On longitudianal cross bar.
4) Note down angle (T) which gives angle Θ
5) Repeat the step (3) & (4) for different loads and different distances.

OBSERVATIONS:-

1) Weight of ship model (Ws) = 8500 gms.
2) Angle of tilt Θ =
3) X1 = 50mm
4) X2 = 100 mm
5) X3 = 140 mm
6) X = 210 mm

OBSERVATION TABLE:-

Sr. No	Load $_{LH}$	Θ	Distance X (cm)	Load $_{RH}$ (Kg)	

CALCULATIONS:-

$$G.M = \frac{w.X}{W.\tan\Theta}$$

Where, G.M. = Meta- centric Height in 'm'.
'w' is the weight provided on ship model
'X' = distance at which weight is provided,
'Ws' = weight of ship model
(W = Ws +w)

Determination of Coefficient of Discharge For Triangular Notch

OBJECTIVE :-

A) Determination of coefficient of discharge for triangular notch.

B) Determination of coefficient of discharge for rectangular notch.

A) **Determination of coefficient of discharge for triangular notch.**

TEST SET UP :- It comprises following-

1 Set up of triangular notch experiment

2 Stop watch.

3 Accessories.

INTRODUCTION & THEORY:-

A notch may be defined as an opening in one side of tank or reservoir, like a large orifice, with the upstream liquid level below the top edge of the opening. Since the top edge of the notch above the liquid level, serves no purpose, therefore a notch may have only the bottom edge & sides. The bottom edge over which the liquid flows is known as sill or crest of the notch and the sheet of liquid flowing over a notch is known as vein. A notch is usually made of a metallic plate & us used to measure the discharge of liquids.

DIFFERENCE BETWEEN AN ORIFICE & NOTCH.

1. An orifice has a closed perimeter but a notch has an open perimeter.

2. Flow through an orifice is under pressure where as flow through a notch is atmospheric.

3. An orifice is used to draw water from a vessel and to measure the discharge of outflow form a vessel. A notch is used to measure the discharge through an open channedl & to regulate the fall in a channel.

CLASSIFICATION :-

Notch are generally classified based on their shapes. The following are important from the subject point of view.

1. Rectangular notch.
2. Triangular notch or V notch

USES OF NOTCHES:-

1. Notches are used in channels to measure the discharge for the purpose of regulation & research work.
2. Another practical use of notch is its employment in the canal drop. When a canal drop is constructed in a canal, it is designed with a suitable number of notches openings. The notches are

designed to provide full supply discharge & half supply discharge at full supply level & half supply level. Because of this arrangement, the water level in the canal is not affected by the increased velocity at the drop point. Otherwise if a drop is constructed without notch openings there will be a fall in the supply level up to a considerable distance on the up stream side, which will affect the discharge through the outlets.

EXSPERIMENTAL SET UP:-

SUPPLY TANK - 1210 X 450 X 410 MM
MEASURING TANK - 450MM X 330 MM X 410 MM
FLOW CHANNEL - 1500 X 290 X 290 MM
With triangular notch
STAND - Supply tank is fitted on heavy stand
Necessary Piping and Valves.
Notch Interchange Arrangement.

PROCEDURE:-

1. First take initial reading of water level
2. The fluid flow is observed & started.
3. Take final reading of water level.
4. Time required for 100 mm rise of water level in measuring tank is noted down
5. The above procedure is repeated for different discharges.

OBSERVATIONS:-

1. Angle of notch $\Theta = 60^0$
2. Area of measuring tank = (0.45 x 0.33) m^2

OBSERVATION TABLE:-

Sr. No	INITIAL READING mm	FINAL READING mm	DIFFERENCE mm	DIFFERENCE (H) (m)	$H^{5/2}$ (m)	TIME REQD. FOR 100 mm RISE IN WATER LEVEL (SEC)
1						
2						
3						
4						
5						
6						
7						
8						

CALCULATIONS:-

1. $Q_{theoretical} = 8/15.\sqrt{2g}.\tan\Theta/2.\ H^{5/2}$ (m^3/sec)

2. $Q_{Actual} = \dfrac{\text{Area of measuring tank } (m^2) \times 0.1m}{\text{Time require (sec.)}}$

3. Coefficient of discharge $(C_d) = \dfrac{Q_{Actual}}{Q_{theoretical}}$

RESULT TABLE:-

Sr. No.	H m	Q Actual m^3/sec.	Q Theoretical m^3/sec	C_d	Average C_d
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Determination of Coefficient of Discharge For Rectangular Notch

TEST SET UP:-

It comprises following

1. Set up of rectangular notch experiment.
2. Stop watch.
3. Accessories.

EXSPERIMENTAL SET UP:-

SUPPLY TANK - 1210mm X 450mm X 410 mm
MEASURING TANK - 450mm X 330 mm X 410 mm
FLOW CHANNEL - 1500mm X 290mm X 290mm
With triangular notch
STAND - Supply tank is fitted on strong stand
Notch Interchange Arrangement.
Necessary Piping and Valves.

PROCEDURE:-

1. First take initial reading of water level
2. The fluid flow is observed & started.
3. Take final reading of water level.
4. Time required for 100 mm rise of water level in measuring tank is noted down
5. The above procedure is repeated for different discharges.

OBSERVATIONS:-

1. Angle of rectangular notch (b) = 80mm
2. Area of measuring tank = (0.45 x 0.33) m^2

Sr. No	INITIAL READING cm	FINAL READING cm	DIFFERENCE cm	DIFFERENCE (H) (m)	$H^{3/2}$ (m)	TIME REQD. FOR 100 mm RISE IN WATER LEVEL (SEC)
1						
2						
3						
4						
5						
6						
7						
8						

CALCULATIONS:-

1. $Q_{theoretical} = 2/3 \sqrt{2g} . b. H^{3/2}$ (m^3/sec)

2. $Q_{Actual} = \dfrac{\text{Area of measuring tank } (m^2) \times 0.1m}{\text{Time require (sec.)}}$

3. Coefficient of discharge (C_d) = $\dfrac{Q_{Actual}}{Q_{theoretical}}$

RESULT TABLE:-

Sr. No.	H m	Q Actual m^3/sec.	Q Theoretical m^3/sec	Cd	Average Cd
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Numerical on determination of coefficient of discharge (Cd) through rectangular and triangular notches

Numerical.1 Rectangular notch 0.5m wide has a constant head of 40 cm find the discharge over the notch in mls If coefficient of diameter for the notch Is 0.6

Solve:

Numerical.2 A rectangular notch has a discharge of 21.5 m^3/min when the head of water is halt of the notch find the breadth of notch. cd= 0.6

Solve:

Numerical.3 Determine the height of rectangular notch (Weir) of length 6m to be built across a rectangular channel. The maximum depth of water on the stream side of weir is 1.8 m & Θ is 2000 l/sec cd= 0.6

Solve:

Numerical.4 The head of water over rectangular notch is 900mm. the Θ is 300 l/sec find the length of notch when cd = 0.6

Solve:

Numerical.5 A right angled V notch was used to measure the discharge of centrifugal pump if the depth of water at V notch is 200mm calculate the discharge over the notch in l/min.

Solve:

Numerical.6 During an experiment in a lab 50 lit of water flowing over a right angle V notch was collected in 9 min. If the head of sill is 50mm calculate Cd.

Solve:

Numerical.7 A water flows over a rectangular notch 1m length over a depth of 15 cm then the same quantity of water passes through a triangular right angled notch. find the depth of water through this notch take cd for rectangular notch.0.62 for triangular notch. 0.59

Solve:

Venturimeter, Orificemeter Apparatus

AIM: To determine the coefficient of discharge for an Orifice. And Venturi Meter

EQUIPMENT:

1. Supply tank connected to a centrifugal pump. Connected further to the pipe fitted with orfice & venture through a supply valve.
2. A long pipe line fitted with a shape edged concentric circular with pressure taps on the v/s an d/s side of the plate
3. A differential mercury u tube manometer
4. Discharge measurement tank fitted with a Piezometer tube.

THEORY:

Orifice & venture meter

Orifice & Ventiri meter is a flow measuring devie it is used extensively to measure flow through pipes. In its simplest form it consists of merely one hole circular in shape in a plate both thin and flat which being champed between the flanges at a joint in the pipe line so that its palne is perpendicular to the axis of the pipe.

Pressure tapings for being connected to a differential guage are made in the pipe wall on both sides of the plate.

PROCEDURE:

1. Record the inlet pipe diameter (d_1) & venture diameter (d_2) and the densities of manometer fluid P_m and hat of flowing fluid P_f
2. Open the regulation valve and under steady state condition note the readings h1 and h2 in the two limbs of the mercury differential manometer.
3. Note the initial level of water in measuring tank. Collect the water in the measuring tank for certain time and note the final level of water in measuring tank. Calculate the actual discharge.
4. Calculate the theoretical discharge Q_{th} and $C_d = \dfrac{Q_{act}}{Q_{th}}$
5. Very the flow rate through the system with the regulating valve and take different readings.

FORMULA USED:

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

$$Q_{act} = \frac{A(h_2 - h_1)}{t}$$

OBERVATIONS FOR VENTURIMETER & ORIFICE METER:

A = Area of measuring tank (cm ^{2})
h_1 = height of measuring tank initial reading level
h_2 = height of measuring tank final level reading second
h = $(h_2 - h_1)$

$$H = R\left(\frac{e_m}{e_f} - 1\right)$$

Where, R = mercury Difference
e_m = Density of Mercury
e_f = Density of fluid

H = Difference in Manometer in the Cm of water.
a_1 = Area of pipe cm^2

$$Qth = \frac{\sqrt{2\,gH}\,(a_1 \times a_2)}{\sqrt{a_1^2 - a_2^2}}$$

a = Area of Measuring tank (cm^2)
h = height of water collected in tank for 't' sec (cm)
h = Difference in Manometer in the cm of water.
a_1 = Area of pipe cm^2
a_2 = Area of throat cm^2

Density of Manometer fluid mercury (pm)	=	13.6 kg / cm3
Density of water (pf)	=	1 kg/ cm3
Sump Tank	=	30 x 30 x 90 cm
Area of measuring tank (A)	=	30 cm x 30 cm
	=	900 cm^2
Diameter of pipe d_1	=	2.5 cm
Diameter of Orifice d_2	=	1.5 cm

Area of pipe a_1 $= \frac{\pi}{4} d_1^2 = 4.90$ cm^2

Area of Orifice a_2 $= \frac{\pi}{4} d_2^2 = 1.77$ cm^2

EXAMPLE READING 1ST CALCULATION (VENTURIMETER)

Area of measuring tank (A)	=	30 cm x 30 cm = 900 cm^2
Density of manometer fluid mercury (pm)	=	13.6 kg/ cm^3
Density of water (pf)	=	1 kg/ cm^3
Diameter of pipe d^1	=	2.5 cm
Diameter of throat d_2	=	1.5 cm
Area of pipe $a_1 = \pi d_1^2/4$	=	4.90 cm^2
Area of throat $a_2 = \pi d_2^2/4$	=	1.77 cm
g	=	981

FORMULA USED:

$$Q_{act} = \frac{A(h2 - h1)}{t} = \frac{900 \times (20.4 - 5)}{30} = 462$$

$$Q_{th} = \frac{\sqrt{2gh}\,(a_1 \times a_2)}{\sqrt{a_1^2 - a_2^2}} = \frac{\sqrt{2 \times 981 \times (13.1-10) \times 12.6} \times (4.90 \times 1.77)}{\sqrt{(4.90)^2 - (1.77)^2}}$$

$$= 539.82$$

$$Q_{cd} = \frac{Q_{act}}{Q_{th}} = \frac{462}{539.82} = 0.86$$

EXAMPLE READING 1ST CALCULATION (ORIFICMETER)

Area of measuring tank (A)	=	30 cm x 30 cm = 900 cm^2
Density of manometer fluid mercury (pm)	=	13.6 kg/ cm^3
Density of water (pf)	=	1 kg/ cm^3
Diameter of pipe d^1	=	2.5 cm
Diameter of throat d_2	=	1.5 cm
Area of pipe $a_1 = \pi d_1^2/4$	=	4.90 cm^2
Area of throat $a_2 = \pi d_2^2/4$	=	1.77 cm^2
g	=	981

FORMULA USED:

$$Q_{act} = \frac{A(h_2 - h_1)}{t} = \frac{900 \times (20.2 - 5)}{30} = 456$$

$$Q_{th} = \frac{\sqrt{2gh}\,(a_1 \times a_2)}{\sqrt{a_1^2 - a_2^2}} = \frac{\sqrt{2 \times 981 \times (16.6-113.4)} \times 12.6 \times (4.90 \times 1.77)}{\sqrt{(4.90)^2 - (1.77)^2}}$$

$$= 533.79$$

$$Q_{cd} = \frac{Q_{act}}{Q_{th}} = \frac{456}{533.79} = 0.85$$

Numerical on determination of coefficient of discharge (Cd) through orifice, venturimeter and Pitot tube

Numerical.1 A reservoir of cross sectional area $1m^2$ contains water 4m deep and orifice of 60mm diameter is provided at its bottom find the fall of water level up to 2min. cd=0.6

Solve:

Numerical.2 Circular tank of diameter 4m contains water upto a height of 5m the tank is provided with an orifice of diameter 0.5m at bottom find the time taken by water (i) to fall from 5m to 2m (ii) for completely emptying tank. Wherer cd= 0.6

Solve:

Numerical.3 Circular tank of diameter 1.25m contains water upto at height of 5m and orifice of 50mm diameter is provided at its bottom cd= 0.02 find the height of water above the orifice after 1.5min

Solve:

Studies of Centrifugal Pumps

Introduction:

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. The different types of pumps that exist to impel liquids through pipes can be divided into three main groups: positive-displacement, rotary, and centrifugal pumps.

A) Centrifugal Pumps

The use of centrifugal force to increase liquid pressure is the basic concept associated with operation of a centrifugal pump. As illustrated in figure, the pump consists of a motor-driven impeller enclosed in a case. The product enters the pump at the centre of impeller rotation and, due to centrifugal force, moves to the impeller periphery. At this point, the liquid experiences maximum pressure and moves through the exit to the pipeline.

Most sanitary centrifugal pumps used in the food industry use two vane impellers. Impellers with three and four vanes are available and may be used in some applications. Centrifugal pumps are most efficient with low-viscosity liquids such as milk and fruit juices, where flow rates are high and pressure requirements are moderate. The discharge flow from centrifugal pumps is steady. These pumps are suitable for either clean and clear or dirty and abrasive liquids. They are also used for pumping liquids containing solid particles (such as peas in water). Liquids with high viscosities, such as honey, are difficult to transport with centrifugal pumps, because they are prevented from attaining the required velocities by high viscous forces within the product.

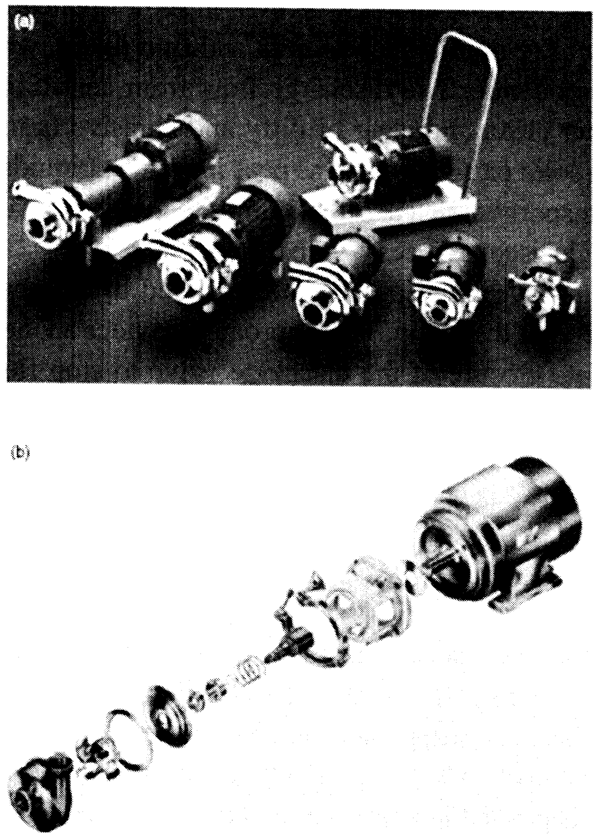
Flow rates through a centrifugal pump are controlled by a valve installed in the pipe and connected to the discharge end of the pump. This approach provides an inexpensive means to regulate flow rate, including complete closure of the discharge valve to stop flow. Since this step will not damage the pump, it is used frequently in liquid food processing operations. However, blocking flow from a centrifugal pump for long periods of time is not recommended, because of the possibility of damage to the pump. The simple design of the centrifugal pump makes it easily adaptable to cleaning-in-place functions.

Principle:-

The process liquid enters the suction nozzle and then into eye (center) of a revolving device known as an impeller. When the impeller rotates, it spins the liquid sitting in the cavities between the vanes outward and provides centrifugal acceleration. As liquid leaves the eye of the impeller a low-pressure area is created causing more liquid to flow toward the inlet. Because the impeller blades are curved, the fluid is pushed in a tangential and radial direction by the centrifugal force.

Working:-

- Centrifugal Pump consists of a rotating impeller inside a stationary volute (casing).
- Liquid enters the pump through the suction inlet into the eye of the impeller.
- The speed of the rotating impeller then forces the liquid out through the discharge nozzle.
- The liquid enters the inlet of the centrifugal pump underatmospheric pressure, and flows into the eye of the impeller.
- The Centrifugal force exerted on the liquid by the rotating impeller, moves the liquid away from the impeller eye and out along the impeller vanes to their extreme tip where the liquid is then forced against the inside walls of the volute and out through the discharge of the pump.
- Due to the reduction of pressure occurring at pump inlet and impeller eye, liquid is drawn into the pump in continuous flow as it moves through the pump.



Study of Positive Displacement Pump

By application of direct force to a confined liquid, a positive displacement pump produces the pressure required to move the liquid product. Product movement is related directly to the speed of the moving parts within the pump. Thus, flow rates are accurately controlled by the drive speed to the pump. The mechanism of operation also allows a positive displacement pump to transport liquids with high viscosities.

Principle:-

A positive displacement pump makes a fluid move by trapping a fixed amount of the fluid and forcing (displacing) that trapped volume into a discharge pipe or discharge system.

Working:-

All positive displacement pumps operate on the same basic principle. This principle can be most easily demonstrated by considering a reciprocating positive displacement pump consisting of a single reciprocating piston in a cylinder with a single suction port and a single discharge port as shown in Figure. Check valves in the suction and discharge ports allow flow in only one direction.
During the suction stroke, the piston moves to the left, causing the check valve in the suction Figure. Reciprocating Positive Displacement Pump Operation line between the reservoir and the pump cylinder to open and admit water from the reservoir. During the discharge stroke, the piston moves to the right, seating the check valve in the suction line and opening the check valve in the discharge line. The volume of liquid moved by the pump in one cycle (one suction stroke and one discharge stroke) is equal to the change in the liquid volume of the cylinder as the piston moves from its farthest left position to its farthest right position.

(C) A **rotary pump**, illustrated in figure, is one type of positive displacement pump. Although there are several types of rotary pumps, the general operating concept involves enclosure of a pocket of liquid between the rotating portion of the pump and the pump housing. The pump delivers a set volume of liquid from the inlet to the pump outlet. Rotary pumps include sliding vane, lobe type, internal gear, and gear type pumps. In most cases, at least one moving part of the rotary pump must be made of a material that will withstand rubbing action occurring within the pump. This is an important feature of the pump design that ensures tight seals. The rotary pump has the capability to reverse flow direction by reversing the direction of rotor rotation. Rotary pumps deliver a steady discharge flow.
Piston or plunger pumps are the most representative of the **positive-displacement pumps**, also called alternative pumps. In these pumps, a piston draws the liquid through an inlet check valve and then forces it out through a discharge check valve. Because the discharge flow rate is not continuous with time, double action pumps are used in many cases. The volumetric efficiency concept, defined as the quotient between the volume of the discharged fluid and the volume swiped by the piston, is usually employed in these pumps.

Rotary pumps do not need retention valves to intake and discharge liquids; the spinning parts confined within a shell accomplish this, creating an empty volume space that causes the liquid to penetrate. This volume is then reduced and the liquid expelled. Gear, screw, and vane pumps can be cited among the different types of rotary pumps. Rotary pumps are frequently used to transport food powders such as dehydrated milk and soluble coffee.

Difference between Centrifugal Pump and Positive Displacement Pump

Centrifugal Pump	Positive Displacement Pump
It is one of the rotary pumps which used kinetic energy of impeller.	It is a positive displacement type pump which is forced by piston.
It continuously discharges the fluid.	It does not discharge the fluid continuously.
In centrifugal pump the flow rate decreases which increasing the pressure.	The pressure does not affect flow rate in reciprocating pumps.
It is used for pumping high viscous fluid.	It is used for pump low viscous fluid.
In this pumps discharge is inversely promotional to the viscosity of fluid.	In reciprocating pump viscosity of fluid does not affect the discharge rate.
Efficiency of these pumps are low compare to reciprocating pump.	Efficiency is high.
Centrifugal pump have problem of priming.	It does not have any problem of priming.
It uses impellers to transfer energy to fluid.	It uses piston cylinder device to transfer energy to fluid.
They are lighter than reciprocating pumps.	These are heavier compare to centrifugal pump.
It gives higher discharge at low heads.	These gives higher heads at low discharge.
It is less costly.	These are costly.
These pumps required less maintenance.	These required higher maintenance.
Centrifugal pumps are easy to install.	These pumps are difficult to install.
These required less floor space.	These required more floor area.