|| Jai Sri Gurudev ||

S J C Institute of Technology, Chickballapur
Department of Civil Engineering

CO-PO and CO-PSO Mapping

Name of the Faculty: Mr. Ravindranath.C and Ms. Ankitha. V
Subject: Fluid Mechanics Sub code: 17CV33 **Semester: III**

Course Objectives:

The objectives of this course are to make students learn:

1. The Fundamental properties of fluids and its applications.
2. Hydrostatic laws and application to practical problem solving
3. Principles of Kinematics and Hydro-Dynamics for practical applications
4. Basic design of pipes and pipe networks considering flow, pressure and its losses.
5. The basic flow rate measurements.

Course Outcomes:

After studying this course, students will be able to:

CO1	Apply a sound knowledge of fundamental properties of fluids and fluid Continuum
CO2	Analyzing solve problems on hydrostatics, including practical applications
CO3	Analyze principles of mathematics to represent kinematic concepts related to fluid flow
CO4	Apply fundamental laws of fluid mechanics and the Bernoulli's principle for practical applications
CO5	Evaluating the discharge through pipes and over notches and weirs

Programme Specific Outcomes (PSO's)

After Successful completion of B.E programme in Civil Engineering, the students will be able to:

PSO1: Apply Civil Engineering knowledge in analysis, design, laboratory investigations and construction aspects.

PSO2: Solve problems in various fields of Civil Engineering with appropriate construction materials and technology.

	CO-PO Mapping												CO-PSO Mapping	
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	-	-	-	-	1	-	-	-	-	2	1
CO2	2	2	2	-	-	-	2	1	-	-	-	1	2	1
CO3	2	2	1	-	-	-	-	1	-	-	-	-	2	1
CO4	1	1	2	-	-	-	2	1	-	-	-	-	2	1
CO5	1	1	3	-	-	-	-	1	-	-	--	1	3	1
Avg	1.6	1.4	1.8	-	-	-	2	1	-	-	[illegible]	[illegible]	[illegible]	[illegible]

1: Slightly 2: Moderately 3: Substantially

Justification:

CO1: Apply the knowledge of engineering science in properties of fluid, graduates will able to identify, formulate and analyse the problems in fluid flow and develop appropriate solution.
CO2: Applying the engineering knowledge of Hydrostatic fluids, analyse the problems and design the solution for complex engineering problems with appropriate solutions in lifelong learning.
CO3: Apply the knowledge of mathematics, engineering fundamentals in the concept of kinematic fluid flow, analyse the problems and develop the solutions with ethical principles in velocity and total acceleration of fluid particles.
CO4: Apply the basic engineering knowledge in fundamental laws of fluid mechanics, analyse the problems to develop the solutions and demonstrate the knowledge of Bernoulli's principle for practical applications
CO5: Apply the basic engineering knowledge, identify and analyse the problems to design and development the appropriate solutions in discharge through pipes, notches and weirs for the need of lifelong learning with ethical principles.

20/7/2018

Signature of Committee members **Signature of the HOD**

1. **Mr. Ravindranath. C**
2. **Mrs. Ankitha. V**
3. **Mrs. Chandrakala. S**

2022/3/14 15:01

SJCIT/NBA/ CO-PO-PSO REPT/ 2018-19	S J C INSTITUTE OF TECHNOLOGY Chickballapur - 562 101 Department of Civil Engineering

Course Title	FLUID MECHANICS					Course Code	C203
Subject Code	17CV33	Semester	3	Section	A & B	Emp.ID	2025
Faculty Name	Mrs. ANKITHA V					No.students	114

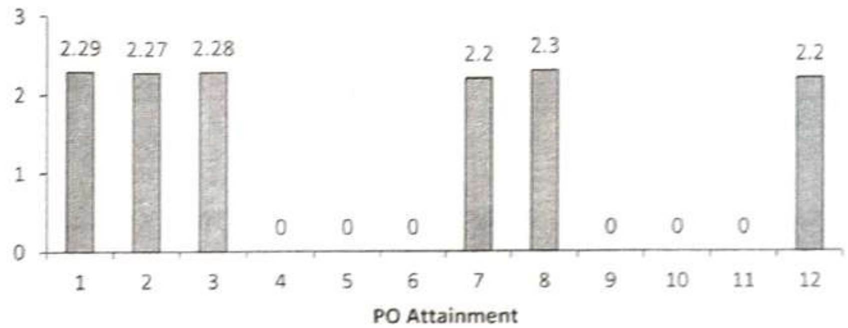
Summary of CO attainments of Sub: 17CV33 Based on (AVERAGE-TYPE-1) Academic Year:2018-19

CO	CID_CO	CIE			SEE			CES			TOT_Attainment		
		S_AT	T_ST	ATN	S_AT	T_ST	ATN	S_AT	T_ST	ATN	ATN	%	Status
CO1	C203.1	340	114	3	218	114	1.9	252	105	2.4	2.4	80	YES
CO2	C203.2	191	101	1.9	218	114	1.9	237	105	2.3	2	65	YES
CO3	C203.3	342	114	3	218	114	1.9	250	105	2.4	2.4	80	YES
CO4	C203.4	336	114	3	218	114	1.9	258	105	2.5	2.4	80	YES
CO5	C203.5	305	114	2.7	218	114	1.9	251	105	2.4	2.3	76	YES

All CO's Attained

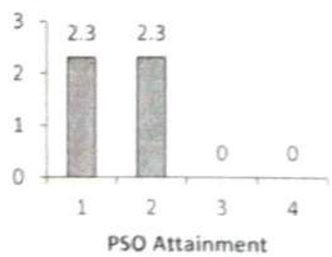
Summary of PO attainments of Sub: 17CV33 Based on (AVERAGE-TYPE-1) Academic Year:2018-19

PO Number	1	2	3	4	5	6	7	8	9	10	11	12
Direct ATNT(D)	2.25	2.23	2.24				2.15	2.27				2.15
Indirect ATNT(ID)	2.39	2.39	2.4				2.4	2.4				2.4
Total-ATNT	2.29	2.27	2.28				2.2	2.3				2.2
ATNT TO SCALE	1.22	1.06	1.37				1.47	1.47				0.77



Summary of PSO attainments in Year:2018-19

PSO Number	1	2	3	4
Direct ATNT(D)	2.26	2.27		
Indirect ATNT(ID)	2.4	2.4		
Total-ATNT	2.3	2.3		
ATNT TO SCALE	1.69	0.77		



Ankitha
09/05/2019

09/05/2019

Department : CIVIL ENGINEERING

LESSON PLAN

CLASS: III SECTION: A	FACULTY: ANKITHA V	SUBJECT: **FLUID MECHANICS**	SUB CODE: **17CV33**

OBJECTIVE: The objectives of this course is to make students to learn:

1. The Fundamental properties of fluids and its applications.
2. Hydrostatic laws and application to practical problem solving.
3. Principles of Kinematics and Hydro-Dynamics for practical applications.
4. Basic design of pipes and pipe networks considering flow, pressure and its losses.
5. The basic flow rate measurements.

PREREQUISITE(s): Trigonometry and Elements of civil engineering.

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

1. Possess a sound knowledge of fundamental properties of fluids and fluid continuum.
2. Compute and solve problems on hydrostatics, including practical applications.
3. Apply principles of mathematics to represent kinematic concepts related to fluid flow.
4. Apply fundamental laws of fluid mechanics and the Bernoulli's principle for practical applications.
5. Compute the discharge through pipes and over notches and weirs.

IT IS BASIC SUBJECT FOR: Applied Hydraulics and Fluid Mechanics Laboratory

SUBJECT APPLICATIONS: Pipe network, discharge measurements

MODULE	TOPIC	PLANNED		ACTUAL		REMARKS
		No of Hours	Date	No of Hours	Date	
1	**Fluids & Their Properties**: Concept of fluid, Systems of units. Properties of fluid; Mass density, Specific weight, Specific gravity, Specific volume, Viscosity, Cohesion, Adhesion	01	1-8-18	01	02/18	Site visiting
	Surface tension& Capillarity, Fluid as a continuum, Newton's law of viscosity	01	2-8-18	01	03/18	
	Numerical Problems on Viscosity	01	3-8-18	01	06/18	
	Capillary rise in a vertical tube and between two plane surfaces	01	4-8-18	01	08/18	
	Numerical Problems on Capillary	01	6-8-18	01	08/18	
	Vapour pressure of liquid, compressibility and bulk modulus	01	8-8-18	01	09/18	
	Capillarity, surface tension, pressure inside a water droplet, pressure inside a soap bubble and liquid jet	01	9-8-18	01	09/18	
	Numerical problems	01	10-8-18	01	10/18	

	Fluid Pressure and Its Measurements: Definition of pressure, Pressure at a point, Pascal's law	01	13-8-18	01	13/8	
	Variation of pressure with depth. Types of pressure.	01	16-8-18	01	16/8	
	Measurement of pressure using simple manometers, Numerical problems	01	17-8-18	01	18/8	
	Measurement of pressure using inclined manometers, Numerical problems	01	20-8-18	01	20/8	
	Measurement of pressure using differential manometers, Numerical problems	01	23-8-18	01	23/8	
	Introduction to Mechanical and electronic pressure measuring devices.	01	24-8-18	01	27/8	Varamahalakshmi festival
	Flip class, Module- 1 Test	01	25-8-18	01	30/8	Link Holiday
2	**Hydrostatic forces on Surfaces :** Definition, Total pressure, centre of pressure,	01	27-8-18	01	31/8	
	Total pressure on horizontal, vertical and inclined plane surface.	01	29-8-18	01	03/9	
	Total pressure on curved surfaces, water pressure on gravity dams, Lock gates.	01	30-8-18	01	05/9	
	Numerical problems	01	31-8-18	01	05/9	
	Fundamentals of fluid flow (Kinematics): Introduction. Methods of describing fluid motion.	01	1-9-18	01	06/9	
	Velocity and Total acceleration of a fluid particle.	01	3-9-18	01	06/9	
	Tutorial -1	01	5-9-18	01	15/9	
	Types of fluid flow, Description of flow pattern.	01	6-9-18	01	7/9	
	Basic principles of fluid flow, three-dimensional continuity equation in Cartesian coordinate system.	01	7-9-18	02	12/9 14/9	Repetition [1 hr]
	1st INTERNALS 8-9-18 , 10-9-18, 11-9-18 [19/9/18 to 20/9/18]					
	Derivation for Rotational and irrotational motion.	01	12-9-18	01	14/9	
	Potential function, stream function, orthogonality of streamlines and equipotential lines.	01	14-9-18	01	15/9	
	Numerical problems on Stream function and velocity potential.	01	17-9-18	01	17/9	
	Introduction to flow net.	01	19-9-18	01	24/9	
	Flip class, Module 2 Test	01	20-9-18	01	25/9	
3	**Fluid Dynamics:** Introduction. Forces acting on fluid in motion.	01	22-9-18	01	26/9	

	Euler's equation of motion along a streamline and Bernoulli's equation	01	24-9-18	01	27/9	
	Assumptions and limitations of Bernoulli's equation. Modified Bernoulli's equation.	01	26-9-18	01	01/10	
	Problems on applications of Bernoulli's equation (with and without losses)	01	27-9-18	01	03/10	
	Vortex motion; forced vortex, free vortex, problems	01	28-9-18	01	04/10	
	Momentum equation problems on pipe bends.	01	29-9-18	01	05/10	
	Applications: Introduction. Venturimeter, Orificemeter, Pitot tube.	01	1-10-18	01	06/10	
	Numerical Problems	01	3-10-18	01	06/10	
	Tutorial - 2	01	4-10-18	01	10/10	
	Flip class, Module- 3 Test	01	5-10-18	01	11/10	
4	**Orifice and Mouthpiece:** Introduction, classification, flow through orifice	01	6-10-18	01	12/10	
	2nd INTERNALS 9-10-18 , 10-10-18, 11-10-18 [15, 16 & 17 / 10 / 18]					
	Hydraulic coefficients, Numerical problems.	01	12-10-18	01	22/10	
	Mouthpiece, classification	01	15-10-18	01	25/10	
	Borda's Mouthpiece (No problems).	01	17-10-18	01	31/10	
	Notches and Weirs: Introduction. Classification, discharge over rectangular,	01	22-10-18	01	02/11	
	Triangular, Trapezoidal notches	01	29-10-18	01	03/11	
	Cippoletti notch, broad crested weirs	01	31-10-18	01	03/11	
	Numerical problems.	01	2-11-18	01	05/11	
	Ventilation of weirs, submerged weirs.	01	3-11-18	01	07/11	
	Tutorial- 3, Module 4 Test	01	5-11-18	01	14/11	
5	**Flow through Pipes:** Introduction. Major and minor losses in pipe flow.	01	7-11-18	01	09/11	
	Darcy-Weisbach equation for head loss due to friction in a pipe.	01	9-11-18	01	10/11	
	3rd INTERNALS 12-11-18, 13-11-18, 14-11-18 [22, 23 & 24 / 11 / 18]					
	Pipes in series, pipes in parallel, equivalent pipe-problems.	01	15-11-18	01	14/11	
	Minor losses in pipe flow, equation for head loss due to sudden expansion.	01	16-11-18	01	19/11	
	Numerical problems.	01	19-11-18	01	16/11	
	Hydraulic gradient line, energy gradient line.	01	22-11-18	01	17/11	
	Pipe Networks, Hardy Cross method	01	23-11-18	01	26/11	
	Numerical problems.	01	24-11-18	01	27/11	
	Surge Analysis in Pipes: Water hammer in pipes	01	26-11-18	01	28/11	

	Equations for pressure rise due to gradual valve closure and sudden closure for rigid and elastic pipes.	01	28-11-18	01	29/11	
	Numerical problems.	01	29-11-18	01	29/11	
	Flip class, Module 5 Test	01	30-11-18	01	30/11	

Assignments and Mini Project

Assignment – I **Submitted on:**	24/9/2018
Assignment – II **Submitted on:**	22/10/2018
Assignment – III **Submitted on:**	22/11/2018

Assignment-IV [Group Assignment] - 28/11/2018

Literature to be Referred for the Course:

Book Type	Code	Title & Author	Publication Information		
			Edition	Publisher	Year
Text Books	T1	"Hydraulics and Fluid Mechanics", P N Modi and S M Seth.	20th	Standard Book House, New Delhi	2015
	T2	"A Text book of Fluid Mechanics and Hydraulic Machines", R K Bansal.	9th	Laxmi Publications, New Delhi	2005
Reference Books	R1	"Fluid Mechanics", J F Douglas	5th	Pearson	2009

Comments by Faculty:

Completed as per plan.

Comments by HOD:

Satisfactory.

Note: Plan and execution is for 5 Modules.

Prepared by	Mrs. ANKITHA V	Reviewed by	Mr. RAVINDRA M.V	Approved by	Dr. G. NARAYANA
Date & sign	Ankitha V 30/07/18	Date & sign	30/7/18	Date & sign	30/07/18

Module - 3

Fluid Dynamics

Introduction:

Fluid dynamics is a branch of fluid mechanics which deals with the study of fluids under motion along with the forces which induces the motion.

The forces acting on the fluids are known as Hydro-dynamic force. The dynamic eqn of the fluid motion is obtained by Newton's second law of motion

ie, Force = Mass x Acceleration

$$F = m \times a$$

Types of forces acting on fluid flow:-

For the fluid flow problems the forces acting on the fluid mass may be any one (or) combination of several of the following forces:-

1) Inertia force, (F_i) ; & 6) Elastic force (F_e)
2) Viscous force (F_v)
3) Gravity force (F_g)
4) Pressure force (F_p)
5) Surface tension force (F_s)

1) Inertia force (F_i):- It is equal to the product of mass & acceleration of the flowing fluid & acts in the direction opposite to the direction of acceleration. It is always existing in fluid flow problem.

ie, $F_i = m \times a$

2) Viscous force (F_v):- It is equal to the product of shear stress (τ) due to viscosity & surface area of the flow. It is present in the fluid flow problems where viscosity is having an important role to play.

ie: $F_v = \tau \times A$

3) Gravity force (F_g):- It is equal to the product of mass & acceleration due to gravity of the flowing fluid. It is present in the case of open surface flow.

ie. $F_g = m \times g$

4) Pressure force (F_p):- It is equal to the product of pressure intensity & C/s^n area of the following fluid. It is present in the case of pipe flow.

ie. $F_p = P \times A$.

5) Surface tension force (Fs):- ②

It is equal to the product of surface tension & length of the surface of the flowing fluid.

ie; $F_s = \sigma \times l$

6) Elastic force (Fe):- It is equal to the product of Elastic stress & area of the flowing fluid.

ie, $F_e \times K \times A$

For a flowing fluid, the above mentioned forces may not always be present. And also the forces, which are present in a fluid flow problem are not of equal magnitude. There are always one or 2 forces which dominate the other forces. These dominating forces govern the flow of fluid.

The problems of fluid mechanics can be solved with the help of the following 3 eqn or laws:-

1) Continuity eqn (law of conservation of mass)
2) Energy eqn (law of conservation of energy).
3) Momentum eqn (law of conservation of momentum or impulse momentum theory).

Energy & its forms:-

Energy is defined as the capacity to do work or the capacity to produce the change in existing state. Energy cannot be seen but its effect can be seen & hence it can be computed. Energy is recongnized in various forms like potential energy, kinematic energy, datum energy, chemical energy, electrical energy & so on. All these forms are interchangable.

Potential Energy:-

It is the energy possessed by the virtue of its position or location w.r.t certain airbitrary datum. Hence, the potential energy represents the work required to move the fluid mass against gravity from the respective position.

P.E = mass × acceleration due to gravity × height

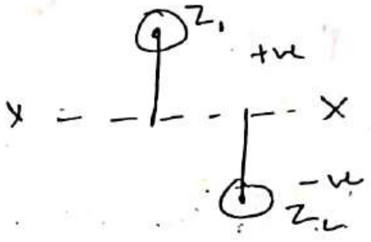
$= mg \times z$

{ ∵ wt of mass × fluid = accel }

Potential Energy per unit wt $= \frac{m \times g \times z}{m \times g} = z$

then - z datum

∴ where Z is known as datum head. The datum head may be +ve (or) −ve depending upon the position of the fluid above or below the reference axis



The datum head is also termed as potential head.

Kinematic Energy (or) kinetic head or velocity head (or) velocity Energy

The energy possessed by virtue of its motion is termed as kinetic Energy or velocity head.

According to Newton's second law of motion we have,

$$F = ma$$

diff w.r.t a

$$\frac{dF}{da} = m$$

$$\text{ie} \quad dF = m\,da$$

$$dF = m.\frac{dv}{dt}$$

X'y on b.s by ds

{ force × distance = work done
Distance/time = velocity

$$\therefore dF \times ds = m \times \frac{dv}{dt} \times ds$$

The various forces acting on the fluid Element are:

1) The pressure force $(p \times dA)$ acting at section ①-①.

2) The pressure force $[(p+dp)\,dA]$ acting at section ②-②.

3) The weight component $W \cos\theta$ or $\rho g\, dA\, ds \cos\theta$

Let 'θ' is the angle b/w the direction of flow & the line of action of the weight of Element.

A/c to newton's second law of motion we have,

$$F = ma$$

~~Selecting~~ substituting the values of 'F' in Newton's law, we get.

$$(p \times dA) - [(p+dp)\,dA] - (\rho g\, dA\, ds \cos\theta) = ma$$

$$p\,dA - p\,dA - dp\,dA - \rho g\, dA\, ds \cos\theta = \rho\, dA\, ds \times a$$

$$dp\,dA = -\rho\, dA\, ds\, \frac{dv}{dt} - \rho g\, dA\, ds \cos\theta \quad \left(\because a = \frac{dv}{dt}\right)$$

$\div$ by $(\rho \times dA \times ds)$ on b.s

$$\frac{dp}{\rho\, dA} = -\frac{dv}{dt} - g \cos\theta$$

$$\frac{dp}{\rho\, dA} = -\frac{dv}{ds} \times \frac{ds}{dt} - g \times \cos\theta$$

$$\therefore V.\frac{dv}{ds} + g\cos\theta + \frac{dp}{\rho\, ds} = 0 \quad (5)$$ $\left(\because \frac{ds}{dt} = V\right)$

From the fig, $\cos\theta = \frac{dz}{ds}$

$$\therefore V.\frac{dv}{ds} + g\frac{dz}{ds} + \frac{dp}{\rho ds} = 0$$

X^{ly} on b.s ds

$$\therefore \boxed{V\,dv + g\,dz + \frac{dp}{\rho} = 0} \rightarrow (A)$$

This eqn is known as Euler's eqn

Bernoulli's Equation from Euler's eqn

W.K.T Euler's eqn ; $v\,dv + g\,dz + \frac{dp}{\rho} = 0$

$\div$ by g on b.s

$$\frac{v.dv}{g} + dz + \frac{dp}{\rho g} = 0.$$

Integrating above eqn:

$$\frac{1}{g}\int v.dv + \int dz + \frac{1}{\rho g}\int dp = \text{constant}$$

$$\boxed{\frac{V^2}{2g} + z + \frac{P}{\rho g} = \text{Constant}} \rightarrow (B)$$

This eqn is known as Bernoulli's eqn. or it represents the total energy per unit weight of the fluid.

where; $\frac{P}{\rho g}$ → Pressure energy per unit weight (
or pressure head of fluid.

$V^2/2g$ → kinetic energy per unit
weight or kinetic head.

z → potential energy per unit weight
or potential head

X'y 'g' by eqn (B)

ie, $\boxed{\frac{V^2}{2} + zg + \frac{P}{\rho} = \text{constant}}$ → (C) this eqn
represents total weight per unit mass.

~~Determ.~~

Derivative of Bernoulli's eqn from energy principle:-

Statement:- Bernoulli's theorem based on the principle of Conservation of energy states that, "In a steady Continuous incompressible non-viscos fluid. the sum of the potential head (datum head), velocity head & pressure head is same at all points" or in other words "the total energy remains constant for a ideal steady incompressible fluid flowi continuously" or for a perfect incompressible fluid flowing continuously the sum of the total energy at any point is the same".

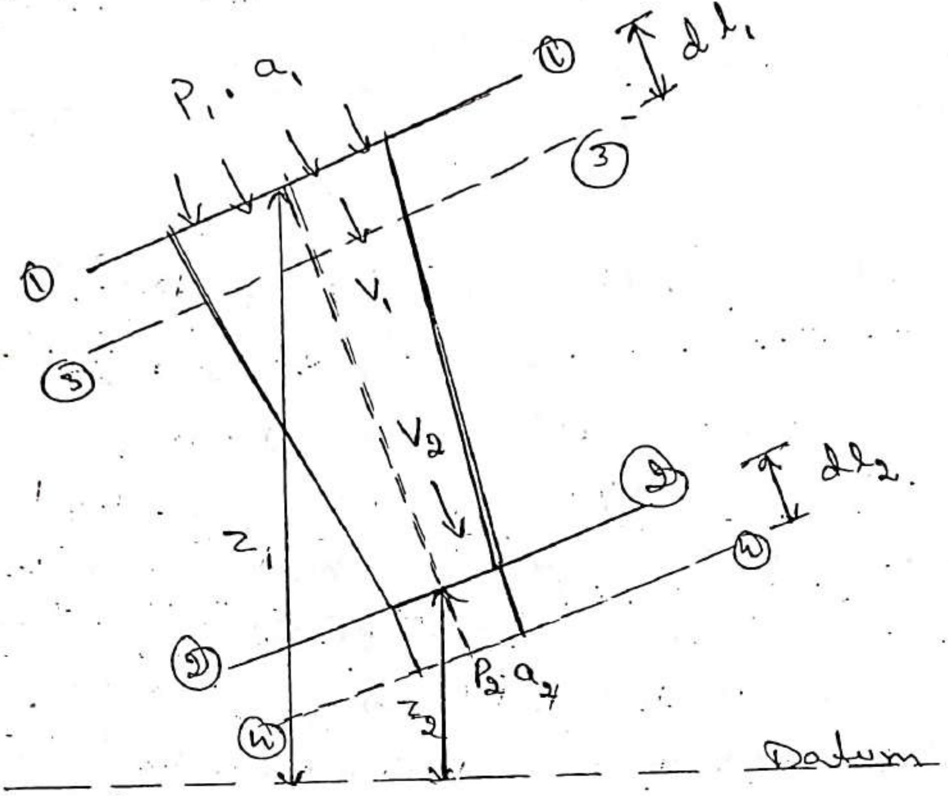
Mathematically, we have $\frac{V^2}{2g} + \frac{P}{\rho g} + Z = \text{Constant}$

(or) $$\frac{V_1^2}{2g} + Z_1 + \frac{P_1}{w} = \frac{V_2^2}{2g} + \frac{P_2}{w} + Z_2$$

Assumptions:-

1) Fluid is ideal
2) Fluid is Continuous
3) Fluid is Steady
4) Fluid is incompressible
5) Fluid is irrotational

Proof:-



Consider a liquid which is incompressible, frictionless with steady condition flowing continuously through a pipe as shown in the fig. The fluid filled in the pipe be under pressure.

Let, Z_1, P_1, V_1 & a_1 represents datum height pressure, velocity & C/s^n area of section ①-①. Similarly Z_2, P_2, V_2 & a_2 represents corresponding values at section ②-②.

Let the quantity of liquid b/w the section ①-① & ②-② moves to ③-③ & ④-④ by a small distance dl_1 & dl_2 as shown in fig. So that the movement of the liquid b/w ①-① & ②-② is equivalent to the movement of liquid b/w ③-③ & ④-④.

Let W be the total weight of the fluid & w Specific weight of the fluid.

∴ Weight of the fluid b/w (1)-(1) & (3)-(3) } = Sp. wt × volume

i.e; $W = w \times a_1 dl_1$

Similarly wt of the fluid b/w (2)-(2) & (4)-(4) (W) } $= w a_2 dl_2$

Since the flow is continuous,

$$W = w a_1 dl_1 = w a_2 dl_2$$

(or) $$\frac{W}{w} = a_1 dl_1 = a_2 dl_2 \longrightarrow (1)$$

The workdone by the pressure at the section (1)-(1) in moving the liquid to the section (3)-(3) is

= Force × distance

$= P_1 a_1 \times dl_1$ (∵ Force $= Pa$)

$||^{ly}$, the work done by the pressure at the section (2)-(2) in moving the liquid to the section (4)-(4) is

$= P_2 a_2 \times dl_2$

∴ Total work done $= P_1 a_1 dl_1 - P_2 a_2 dl_2 \rightarrow (2)$

But, from eqn (1) we have $\frac{W}{w} = a_1 dl_1 = a_2 dl_2$

∴ Eqn (2) becomes i.e,

∴ Total work done $= P_1 \frac{W}{w} - P_2 \frac{W}{w}$

$= (P_1 - P_2)\frac{W}{w} \longrightarrow (3)$

Since the fluid has been moved from ① to ①-② & ②-② to ③-③ there will be limitation of datum energy which will be given by.

Loss of datum energy (DE) = $W[z_1 - z_2]$

Then, the gain of ~~kinematic~~ kinetic energy is given by,

$$\text{gain of K.E} = W\left[\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right]$$

{ ∵ $Q = a_1 V_1 = a_2 V_2$; here a_2 is less, hence V_2 is more. }

For the above system, we have

Total workdone + loss of DE = gain of KE

$$\frac{W}{w}(P_1 - P_2) + W(z_1 - z_2) = W\left[\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right]$$

$$\frac{P_1}{w} - \frac{P_2}{w} + z_1 - z_2 = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

(or)

$$\boxed{\frac{P_1}{w} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{w} + z_2 + \frac{V_2^2}{2g}} \rightarrow (A)$$

From this eqn it is very clear that the sum of pressure energy, datum energy & kinetic energy remains constant for a continuous flowing incompressible fluid

$$\boxed{\frac{V^2}{2g} + z + \frac{P}{w} = \text{constant}}$$

Limitations:-

1) It has been taken into account the veloci is constant through the c/s^n, but in actual practice it is not true since the velocity is maximum at the centre & it slowly decreases at the walls due to the friction hence average velocity must be taken into account.
2) Flow is not steady in actual practice.
3) All the external forces must be taken into account.
4) Liquid is not always incompressible.
5) The concept of ideal fluid does not holds good in real practice.
6) When the fluid is flowing along a curved path the energy due to centrifugal force must be taken into account.
7) It has been assumed that there is los of energy during the flow. But in case of turbulent flow some amount of energy is converted into heat energy & incase of viscous flow some amount of energy is lost due to shear force. Hence these losses must be taken in account in real practice

Modified Bernoulli's equation or Bernoulli's equation for real fluids:-

By deriving Bernoulli's eqn, it was assumed that the fluid is ideal & non-viscous or frictionless. However, in actual practice the fluids are real having viscosity & hence during the flow of liquids it offers resistance. Due to this resistance their exists certain losses which are not taken into account during the derivation of Bernoulli's eqn. Hence, the Bernoulli's eqn for real fluids is given by the correlation.

$$\frac{P_1}{w} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{w} + z_2 + \frac{v_2^2}{2g} + h_L$$

where, h_L ⟹ head loss or energy loss.

Applications of Bernoulli's eqn:-

Bernoulli's eqn is applied for all problems of incompressible fluid flows where energy is involved. It is used for flow measuring devices which inturn based on the principle ie, as the flow accelerate (velocity increases) corresponding the pressure decreases. The drop or decrease of pressure can be measured conviniently & corelated to the discharge. The various flow measuring devices based on Bernoulli's eqn are

1) venturimeter, 2) orifice meter, 3) Pitot tube.

problems

(9)

Water is flowing through a pipe of 5cm dia under a pressure of 29.43 N/cm² (gauge) & with mean velocity of 2.0 m/sec. Find the total head or total energy per unit weight of the water at a c/s, which is 5m above the datum line.

Soln:- Given

Dia of pipe = 5cm = 0.5m

Pressure (P) = $29.43\ N/cm^2 = 29.43 \times 10^4\ N/m^2$

velocity (V) = 2.0 m/sec

$z = 5\ m$

Total head = pressure head + kinetic head + datum head

$\therefore$ Pressure head $= \frac{P}{\rho g} = \frac{29.43 \times 10^4}{1000 \times 9.81} = 30\ m$

Kinetic head $= \frac{V^2}{2g} = \frac{2 \times 2}{2 \times 9.81} = 0.204\ m$

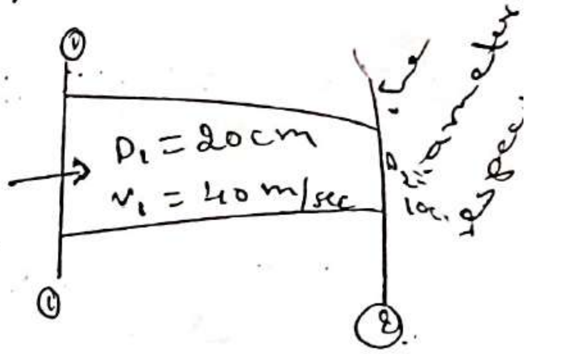
$\therefore$ Total head $= \frac{P}{\rho g} + \frac{V^2}{2g} + z = 30 + 0.204 + 5$

$= 35.204\ m$

2) A pipe, through which water is flowing, is having diameters, 20cm & 10cm at the c/s ① & ② respectively. The velocity of water at section ① is given 4.0 m/sec. Find the velocity head at section ① & ②, & also rate of discharge

Soln: Given:

$D_1 = 20\,cm = 0.2\,m$



$A_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4}(0.2)^2 = 0.0314\,m^2$

$V_1 = 4.0\,m/sec$

$D_2 = 0.1\,m$

$A_2 = \frac{\pi}{4}(D_2)^2 = 0.00785\,m^2$

(i) Velocity head at section ①

$= \frac{V_1^2}{2g} = \frac{4 \times 4}{2 \times 9.81} = 0.815\,m$

(ii) Velocity head at section ② $= \frac{V_2^2}{2g}$

To find V_2, apply continuity eqn at ① & ②

$\therefore A_1 V_1 = A_2 V_2$

(or) $V_2 = \frac{A_1 V_1}{A_2}$ = ~~0.00785 × 4~~

$= \frac{0.0314 \times 4}{0.00785} = 16\,m/sec$

$\therefore$ Velocity head at section ② $= \frac{V_2^2}{2g}$

$= \frac{16 \times 16}{2 \times 9.81} = 83.047\,m$

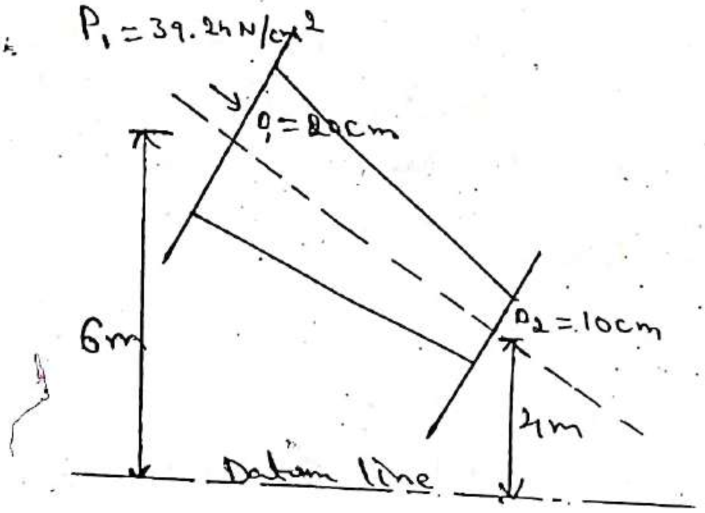
(iii) Rate of discharge $= A_1 V_1$ (or) $A_2 V_2$

$= 0.0314 \times 4 = 0.1256\,m^3/sec$

$= 125.6$ litres/sec

(10) The water is flowing through a pipe having diameters 20cm & 10cm at section ① & ② respectively. The rate of flow through pipe is 35 litre/sec. The section-① is 6m above datum & section-② is 4m above datum. If the pressure at section ① is 39.24 N/cm², find the intensity of pressure at section-②.

Solution:- Given:-



At section-①

$D_1 = 20cm = 0.2m$

$A_1 = \frac{\pi}{4}(D_1)^2 = \frac{\pi}{4}(0.2)^2$

$A_1 = 0.0314 m^2$

$P_1 = 39.24 N/cm^2$

$= 39.24 \times 10^4 N/m^2$

$z_1 = 6.0 m$

At section-②

$D_2 = 10cm = 0.1m$

$A_2 = \frac{\pi}{4}(D_2)^2 = \frac{\pi}{4} \times (0.1)^2$

$A_2 = 0.00785 m^2$

$z_2 = 4m$

$P_2 = ?$

∴ Rate of flow, $Q = 35$ lit/sec

∴ $Q = A_1V_1 = A_2V_2$

$V_1 = \frac{Q}{A_1}$ & $V_2 = \frac{Q}{A_2}$

∴ $V_1 = \frac{35 \times 10^{-3}}{0.0314} = 1.114$ m/sec

$V_2 = \frac{35 \times 10^{-3}}{0.00785} = 4.456$ m/sec

Applying Bernoulli's eqn at section ① & ② we get

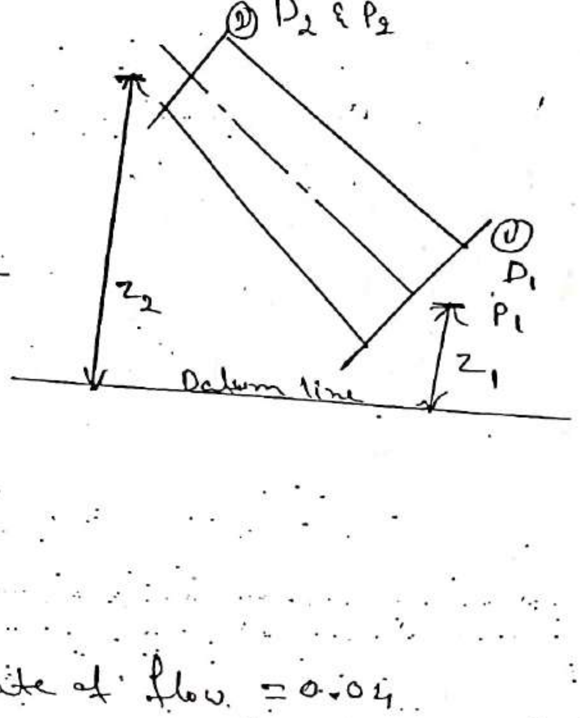
$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + z_2$$

$$\therefore \frac{39.24\times10^4}{1000\times9.81} + \frac{(1.114)^2}{2\times9.81} + 6 = \frac{P_2}{1000\times9.81} + \frac{(4.456)^2}{2\times9.81} + \frac{24.525}{1000}$$

$$\therefore \boxed{P_2 = 40.27\ N/cm^2}$$

4) Water is flowing through a pipe having diameter 300mm & 200mm at the bottom & upper end respectively. The intensity of pressure at the bottom end is 24.525 N/cm² & the pressure at the upper end is 9.81 N/cm². Determine the difference in datum head if the rate of flow through pipe is 40 lit/sec

Soln:- Given



At section - ①

$D_1 = 300mm = 0.3m$

$P_1 = 24.525\ N/cm^2 = 24.525\times10^4\ N/m^2$

At section - ②

$D_2 = 200mm = 0.2m$

$P_2 = 9.81\ N/cm^2 = 9.81\times10^4\ N/m^2$

$Q = 40\ lit/sec = 40\times10^{-3}\ m^3/sec$

Now; $A_1V_1 = A_2V_2 = \text{rate of flow} = 0.04$

$$\therefore V_1 = \frac{Q}{A_1} = \frac{0.04}{\frac{\pi}{4}\times D_1^2} = \frac{0.04}{\frac{\pi}{4}\times(0.3)^2} = 0.5658\ m/sec$$

$$\& \quad V_2 = \frac{Q}{A_2} = \frac{0.04}{\frac{\pi}{4}D_2^2} = \frac{0.04}{\frac{\pi}{4}\times(0.2)^2} = 1.274\ m/sec$$

Apply Bernoulli's eqn at section - ① & ②

$$\therefore \frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$$

$$\frac{24.525\times10^{4}}{1000\times9.81}+\frac{(0.5658)^2}{2\times9.81}+z_1=\frac{9.81\times10^{3}}{1000\times9.81}+\frac{(1.274)^2}{2\times9.81}+z_2$$

$$\therefore (z_2-z_1) = 25 + 0.0163 - 10 - 0.0827$$

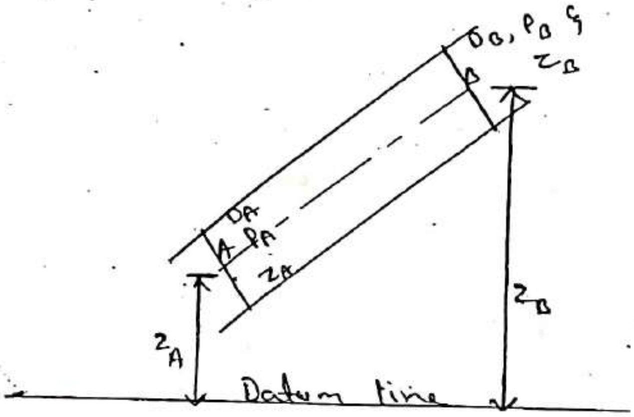
$$z_2 - z_1 = 14.933 \text{ m}$$

5) A pipe of dia 400 mm carries water at a velocity of 25 m/sec. The pressures at the points A & B are given as 29.43 N/cm² & 22.563 N/cm² respectively while the datum head at A & B are 28 m & 30 m. Find the loss of head b/w A & B.

Solu^n:- Given:-

Dia of pipe (D) = 400 mm = 0.4 m

velocity (V) = 25 m/sec



At point (A);

$P_A = 29.43 \text{ N/cm}^2$

$= 29.43\times10^4 \text{ N/m}^2$

$Z_A = 28 \text{ m}$

$V_A = V = 25 \text{ m/sec}$

$\therefore$ Total energy at 'A', $E_A = \frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A$

$$= \frac{29.43\times10^4}{1000\times9.81} + \frac{(25)^2}{2\times9.81} + 28$$

$$= 89.855 \text{ m}$$

At point (B):-

$P_B = 22.563 \text{ N/cm}^2$

$Z_B = 30 \text{ m}$

$V_B = V = 25 \text{ m/sec}$

$\therefore$ Total energy at B; $(E_B) = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B$

$$= \frac{22.563\times10^4}{1000\times9.81} + \frac{(25)^2}{2\times9.81} + 30$$

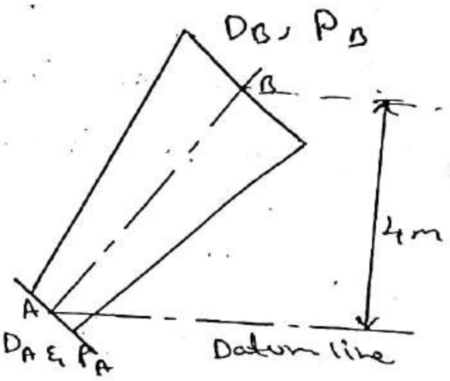
$E_B = 84.855$ m

$\therefore$ Loss of energy $= E_A - E_B = 89.855 - 84.855$

$= 5.0$ m

6) A pipeline carrying oil of specific gravity 0.8 changes in diameter from 200mm diameter at a position 'A' to 500mm diameter at a position 'B' which is 4m at a higher level. If the pressures at A & B are 9.81 N/cm² & 5.886 N/cm² respectively & the discharge is 200 litre/sec determine the loss of head & direction of flow

Soln:- Given



Discharge (Q) = 200 lit/sec

$= 0.2\ m^3/sec$

Sp. gr of oil $= 0.87$

$\therefore \rho$ of oil $= 0.87 \times 1000$

$= 870\ kg/m^3$

At section (A):-

$D_A = 200mm = 0.2m$

$A_A = \frac{\pi}{4}(D_A)^2 = \frac{\pi}{4}(0.2)^2$

$A_A = 0.0314 m^2$

$P_A = 9.81\ N/cm^2$

~~9.81 N/~~

$P_A = 9.81 \times 10^4\ N/m^2$

$Z_A = 0$

At section (B):-

$D_B = 500mm = 0.5m$

$A_B = \frac{\pi}{4}(D_B)^2 = \frac{\pi}{4}(0.5)^2 = 0.1963\ m^2$

$P_B = 5.886\ N/cm^2$

$= 5.886 \times 10^4\ N/m^2$

$Z_B = 4m$

$\therefore V_A = \frac{Q}{A_A} = \frac{0.2}{0.0314} = 6.369$ m/sec

& $V_B = \frac{Q}{A_B} = \frac{0.2}{0.1963} = 1.018$ m/sec

Total energy (A) $= E_A = \frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A$

$= \frac{9.81 \times 10^4}{0.87 \times 1000 \times 9.81} + \frac{(6.369)^2}{2 \times 9.81} + 0$

$= 13.56$ m

Total energy (B) $= E_B = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B$

$= \frac{5.886 \times 10^4}{870 \times 9.81} + \frac{(1.018)^2}{2 \times 9.81} + 4$

$= 10.949$ m.

(i) Direction of flow: As E_A is more than E_B & hence flow is taking place from A to B.

(ii) Loss of head $(h_L) = E_A - E_B$

$= 13.56 - 10.95 = 2.61$ m

Venturimeter :-

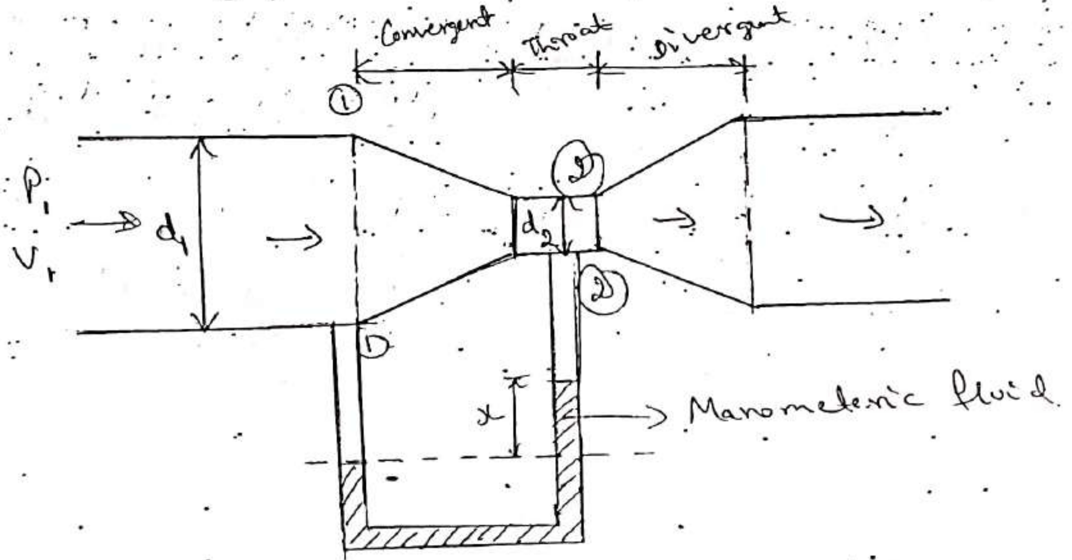
Venturimeter is a device works on the principle of Bernoulli's equation & used for the measurement of discharge through a pipe.

The Bernoulli's principle was first demonstrated by G.B. Venturi, an Italian physicist in 1797. But the principle was first applied & the Instrument was invented by an American Engineer CLEMENS HERSWEL in 1887.

Venturimeter is convenient for large size & for large discharges. Efficiency is high & pressure recovery is greater. But it is not flexible & initial cost is high.

The venturimeter consists of 3-parts namely;

a) convergent b) Throat c) Divergent



Differential manometer

Consider a venturimeter as shown in fig. Let d_1 be the dia at the inlet, P_1 → pressure at ①-①
V_1 → velocity at ①-①.
a_1 → C/s area at ①-①.

Similarly d_2, P_2, V_2, a_2 corresponding values at section ②-②. As the fluid flows through the convergent position the velocity increases corresponding pressure decreases. Applying the Bernoulli's eqn. b/w the section ①-① & ②-②
we have,

$$\frac{P_1}{w} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{w} + z_2 + \frac{V_2^2}{2g}$$

Taking the centre line of the venturimeter as datum.
then, $z_1 = z_2$ (pipe is horizontal)

$$\therefore \frac{P_1}{w} + \frac{V_1^2}{2g} = \frac{P_2}{w} + \frac{V_2^2}{2g}$$

(or) $$\frac{P_1}{w} - \frac{P_2}{w} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

(or) $$h = \frac{V_2^2 - V_1^2}{2g}$$

$$V_2^2 - V_1^2 = 2gh \rightarrow ①$$

W.K.T by continuity eqn, $Q = a_1 V_1 = a_2 V_2$

$$V_1 = \frac{a_2 V_2}{a_1}$$

Sub in eqn ①, we get; ~~$V_2^2 = 2gh$~~

$$V_2^2 - \frac{a_2^2 V_2^2}{a_1^2} = 2gh$$

$$V_2^2 \left[1 - \frac{a_2^2}{a_1^2}\right] = 2gh$$

(or) $$V_2^2 \left[\frac{a_1^2 - a_2^2}{a_1^2}\right] = 2gh$$

Also, W.K.T $\frac{Q}{a_2} = V_2$

$$\therefore \frac{Q^2}{a_2^2} = \frac{a_1^2 \times 2gh}{a_1^2 - a_2^2}$$

$$\therefore Q^2 = \frac{a_1^2 \times a_2^2 \times 2gh}{a_1^2 - a_2^2}$$

(or) $$\boxed{Q = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}}$$

Note:- 1) The above eqn gives the theoretical discharge through the venturimeter. But in actual practice the actual discharge is less than the theoretical discharge.

W.K.T Actual discharge is given by,

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

(C_d = Co-efficient of venturimeter & its value is less than 1)

$$\therefore Q_{act} = C_d \times Q_{theo}$$

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

2) The value of h has to be determined by using a differential manometer.

Case (1):- Let $S_m \rightarrow$ Sp. gravity of manometric liquid (heavy fluid)

$S \rightarrow$ Sp. gravity of metering fluid

$x \rightarrow$ manometer reading.

The pressure head is given by.

$$h = x\left[\frac{S_m}{S} - 1\right]$$

Case (2):- If the differential manometer contains fluid lighter than the fluid flowing in the pipe. Then the differential head is given by:

$$h = x\left[1 - \frac{S_m}{S}\right]$$

Problems

1) A horizontal venturimeter with inlet & throat diameter 30cm & 15cm respectively is used to measure the flow of water. The reading of differential manometer connected to the inlet & the throat is 20cm of mercury. Determine the rate of flow. Take $C_d = 0.98$.

Soln:- Given,

$d_1 = 30cm = 0.3m$

$d_2 = 15cm = 0.15m$

$x = 20m$

$C_d = 0.98$

$\therefore$ Area of inlet; $a_1 = \frac{\pi d_1^2}{4} = 0.07\ m^2$

Area of throat; $a_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times (0.15)^2}{4} = 0.0176\ m^2$

The pressure head is given by:

$$h = x\left[\frac{S_m}{S} - 1\right] = 0.2\left[\frac{13.6}{1} - 1\right] = 2.52\ m\ of\ H_2O$$

$\therefore$ Discharge, $$Q_{act} = \frac{C_d \times a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

$$= \frac{0.98 \times 0.07 \times 0.0176 \times \sqrt{2 \times 9.81 \times 2.52}}{\sqrt{0.07^2 - 0.0176^2}}$$

$Q_{act} = 0.125\ m^3/sec$

(15)

2) An oil of sp. gravity 0.8 is flowing through a venturimeter having inlet diameter 20cm & throat diameter 10cm. The oil-mercury differential manometer shows a reading of 25cm. Calculate the discharge of oil through the horizontal venturimeter. Take $C_d = 0.98$.

Soln:- Given: $S_o = 0.8$, $S_m = 13.6$, $d_1 = 20cm = 0.2m$

$d_2 = 10cm = 0.1m$, $x = 25cm = 0.25m$

$C_d = 0.98$; $Q = ?$

$$h = x\left[\frac{S_m}{S_o} - 1\right] = 0.25\left[\frac{13.6}{0.8} - 1\right] = 4m$$

$$a_1 = \frac{\pi}{4} d_1^2 = \frac{\pi}{4}(0.2)^2 = 0.03 m^2$$

$$a_2 = \frac{\pi}{4} d_2^2 = \frac{\pi}{4}(0.1)^2 = 0.00785 m^2$$

$$\therefore Q_{act} = \frac{C_d \times a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} = \frac{0.98 \times 0.03 \times 0.00785 \times \sqrt{2 \times 9.81 \times 4}}{\sqrt{0.03^2 - 0.00785^2}}$$

$$C_d = 0.0706 \, m^3/sec = 70.61 \, lit/sec$$

3) A horizontal venturimeter with inlet dia 20cm & throat dia 10cm is used to measure the flow of oil of sp. gravity 0.8. The discharge of oil through venturimeter is 60 lit/sec. Find the reading of the oil mercury differential manometer. Take $C_d = 0.98$.

$\therefore$ Head Lost (h_L) = 4 % of h

$$= \frac{4}{100} \times 19.032 = 0.761 \text{ m}$$

$$\therefore C_d = \sqrt{\frac{h - h_L}{h}} = \sqrt{\frac{19.032 - 0.761}{19.032}} = 0.979 \approx 0.98$$

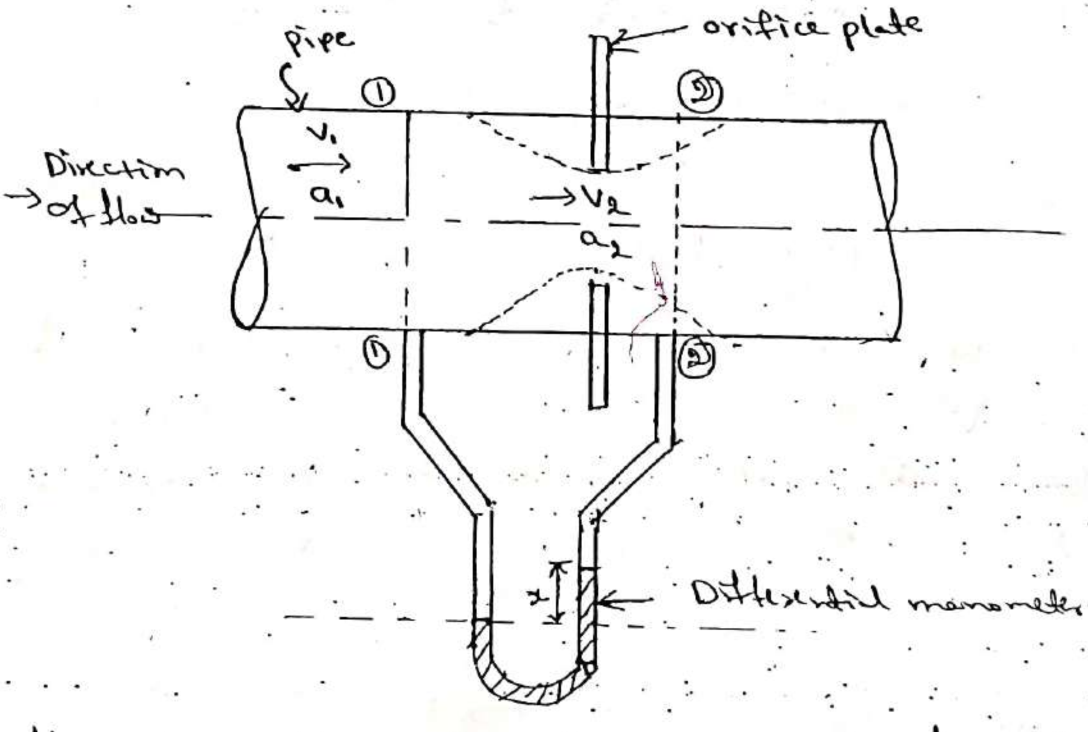
$$\therefore q = \frac{C_d * a_1 a_2 * \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}} = \frac{0.98 * 0.0706 \times 0.00785 \times \sqrt{2 \times 9.81 \times 19.03}}{\sqrt{0.0706^2 - 0.00785^2}}$$

$$Q = 0.1495 \text{ m}^3/\text{sec} \approx 0.15 \text{ m}^3/\text{sec} = 150 \text{ lit}/\text{sec}$$

3

Orifice meter:

Orifice meter works on the principle of Bernoulli's eqn & used for the measurement of discharge through the pipe similar to that of venturimeter. It consists of a flat circular plate which has a circular sharp edged hole called orifice, which is concentric with the pipe. The orifice diameter is kept generally 0.5 time the diameter of the pipe, through it may vary from 0.4 to 0.8 times the pipe diameter.



At the orifice the c/s area of flow decreases & velocity increases which inturn reduces the pressure compare to that of the inlet. However, according to Bernoulli's eqn the total energy remains constant. Hence according to Bernoulli's eqn: the discharge through the orifice meter can be obtained similar to that of venturimeter.

$$\therefore Q_{theo} = \frac{a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

But, the actual discharge is given by,

$$Q_{act} = C_d * Q_{theo}$$

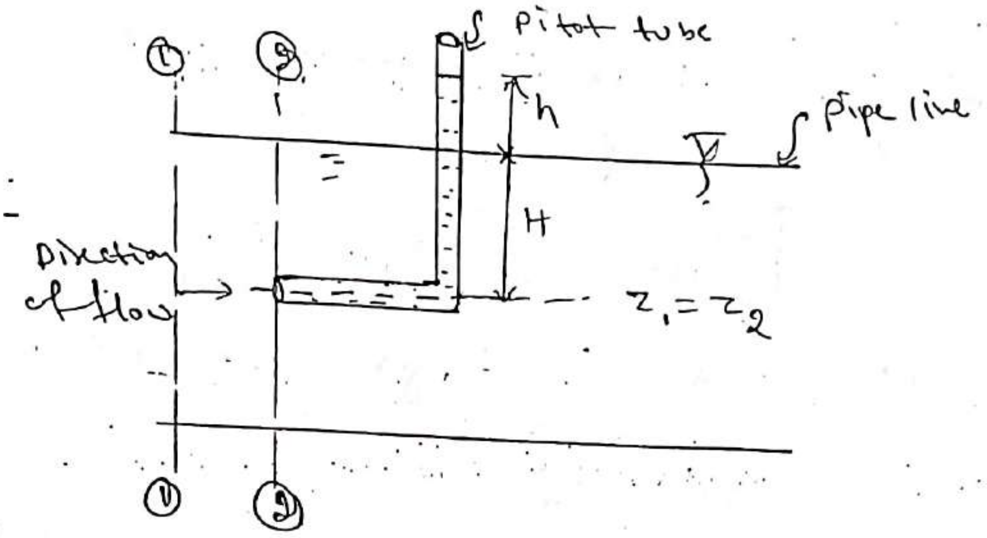
$$\therefore Q_{act} = \frac{C_d * a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

Where, $a_1 \rightarrow$ C/s^n area of the pipe,
$a_2 \rightarrow$ c/s^n area of the orifice.
$C_d \rightarrow$ co-efficient of discharge
[varies 0.6 — 0.66]

Pitot tube:-

A pitot tube is a simple glass tube bent through 90° or L-shape, works on the principle of Bernoulli's eqn. & used for the measurement of velocity of flow in a continuous flowing fluid.

A pitot tube having the pointed & short length is kept usually facing the direction of flow as shown in fig.



As the fluid enters the pitot tube the velocity get reduced to zero & the pressure at that point is termed as stagnation pressure. Applying Bernoulli's eqn b/w the stagnation point & the upstream of the flowing liquid.

$$\frac{P_1}{w} + z_1 + \frac{v_1^2}{2g} = \frac{P_2}{w} + z_2 + \frac{v_2^2}{2g}$$

Taking the centre line of the pitot tube as the datum we have, $z_1 = z_2$ & at stagnation point, $v_2 = 0$.

$$\therefore \frac{P_1}{w} + \frac{v_1^2}{2g} = \frac{P_2}{w}$$

$$\therefore \frac{v_1^2}{2g} = \frac{P_1 - P_2}{w}$$

ie $\frac{v_1^2}{2g} = h$

$$v_1 = \sqrt{2gh} \quad (or) \quad \boxed{V = \sqrt{2gh}}$$

The velocity so obtained is known as theoretical velocity. However the actual velocity is given by $V_{act} = V_{theo} \times C_v$

where; $C_v \longrightarrow$ Co-efficient of velocity of pitot tube

$$\therefore \boxed{V_{act} = C_v \times \sqrt{2gh}}$$

The value of C_v ranges b/w 0.95 to 0.98

Problem

1) In a vertical pipe conveying oil of sp. gr. 0.8, two pressure gauges have been installed at A & B where the diameters are 16cm & 8cm respectively. A is 2m above B. The pressure gauge readings have shown that the pressure at B is greater than at A by 0.981 N/cm². Neglecting all losses, calculate the flow rate. If the gauges at A & B are replaced by tubes filled with the same liquid & connected to a U-tube containing mercury. Calculate the difference of level of mercury in the 2 limbs of the U-tube.

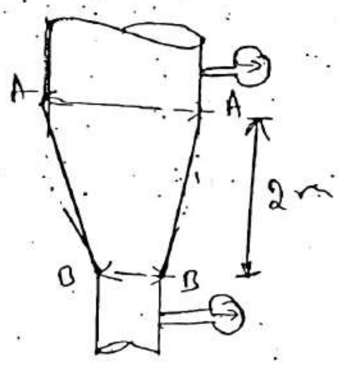
Soln:- Given

$S_o = 0.8$

$d_A = 16\text{ cm} = 0.16\text{ m}$

$d_B = 8\text{ cm} = 0.08\text{ m}$

$Z_A = 2\text{m}$



Difference of pressure, $P_B - P_A = 0.981\text{ N/cm}^2$

$= 0.981 \times 10^4\text{ N/m}^2$

Area at A $(a_A) = \frac{\pi d_A^2}{4} = \frac{\pi (0.16)^2}{4} = 0.02\text{ m}^2$

(19)

$$a_o = \frac{\pi d_o^2}{4} = \frac{\pi \times (0.08)^2}{4} = 0.00502\ m^2$$

∴ Difference of Pressure head,

$$\frac{P_B - P_A}{w} = \frac{0.981 \times 10^{+4}}{0.8 \times 1000 \times 9.81}$$

$$= 1.25$$

Taking datum at 'B', & applying Bernoulli's eqn, we have

$$\therefore \frac{P_A}{w} + z_A + \frac{V_A^2}{2g} = \frac{P_B}{w} + z_B + \frac{V_B^2}{2g}$$

(or)

$$\frac{P_B}{w} - \frac{P_A}{w} = + z_A - z_B + \frac{V_A^2}{2g} - \frac{V_B^2}{2g}$$

$$\therefore 1.25 = 2 - 0 + \frac{V_A^2}{2g} - \frac{V_B^2}{2g}$$

(or)

$$\frac{V_B^2}{2g} - \frac{V_A^2}{2g} = 0.75$$

Applying continuity eqn, ie, $Q = a_A V_A = a_B V_B$

$$\therefore V_B = \frac{a_A V_A}{a_B}$$

Sub.

$$\frac{a_A^2 V_A^2}{a_o^2\, 2g} - \frac{V_A^2}{2g} = 0.75$$

ie,

$$\frac{(0.02)^2 V_A^2}{(0.00502)^2 (2 \times 9.81)} - \frac{V_A^2}{(2 \times 9.81)} = 0.75$$

$$0.809 V_A^2 - 0.0509 V_A^2 = 0.75$$

$$V_A^2 = \frac{0.75}{0.758}$$

$$V_A^2 = 0.989$$

$$\therefore \boxed{V_A = 0.995 \, m/sec}$$

$\therefore$ Rate of flow, $Q = a_A V_A = 0.02 \times 0.995$

$$Q = 0.0199 \, m^3/sec$$

(ii) Difference of level of mercury in the U-tube

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

where, $h = \left[\frac{P_A}{w} + Z_A\right] - \left[\frac{P_B}{w} + Z_B\right]$

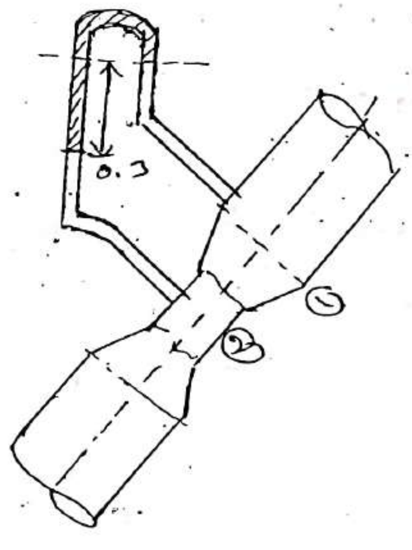
$$h = \frac{P_A}{w} - \frac{P_B}{w} + Z_A - Z_B$$

$$h = -1.25 + 2 = 0.75 \, m$$

$$\therefore 0.75 = x\left[\frac{13.6}{0.8} - 1\right] = x \, 16$$

$$\therefore x = 0.046 \approx 0.05 \, m \text{ (or) } 5 \, cm$$

Q. Find the discharge of water flowing through a pipe of 30cm diameter placed in an inclined position where a venturimeter is inserted, having a throat diameter of 15cm. The difference of pressure b/w the main & throat is measured by a liquid of sp. gravity 0.6 in an inverted U-tube which gives a reading of 30cm. The loss of head b/w the main & throat is 0.2 times the kinetic head of the pipe. (20)



Soln: Given:

$Q = ?$

$d_1 = 30cm = 0.3m$

$d_2 = 15cm = 0.15m$

$S_o = 0.6$

$x = 30cm = 0.3m$

$h_L = 0.2 \times \frac{V_1^2}{2g}$

$a_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.3)^2}{4} = 0.0706\ m^2$

$a_2 = \frac{\pi d_2^2}{4} = \frac{\pi (0.15)^2}{4} = 0.0176\ m^2$

W.K.T; $h = x\left[1 - \frac{S_m}{S}\right] = 0.3\left[1 - \frac{0.6}{1}\right] = 0.12m$ of H_2O

Applying Bernoulli's eqn:

$$\frac{P_1}{w} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{w} + z_2 + \frac{V_2^2}{2g} + h_L$$

4) An orifice meter with orifice diameter 15cm inserted in a pipe of 30cm ϕ. The pressure difference measured by a mercury oil differential manometer on the 2 sides of the orifice meter gives a reading of 50cm of mercury. Find the rate of flow of oil of sp. gravity 0.9 when the co-efficient of discharge of the meter = 0.64.

Soln: Given:- $d_2 = 15cm$, $d_1 = 30cm$, $x = 50cm$ of Hg.

$S_o = 0.9$. $C_d = 0.64$

$$\therefore a_1 = \frac{\pi \times d_1^2}{4} = \frac{\pi \times (0.3)^2}{4} = 0.07 \, m^2$$

$$a_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times (0.15)^2}{4} = 0.02 \, m^2$$

Differential head, $h = x\left[\frac{S_m}{S} - 1\right]$

$$= 0.5\left[\frac{13.6}{0.9} - 1\right] = 7.05 \text{ m of oil}$$

$$\therefore Q = \frac{C_d \times a_1 a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

$$= \frac{0.64 \times 0.07 \times 0.02 \sqrt{2 \times 9.81 \times 7.06}}{\sqrt{(0.07)^2 - (0.02)^2}}$$

$$\boxed{Q = 0.15 \, m^3/sec}$$

8

(5) A pitot static tube placed in the centre of 300 mm pipe line has one orifice pointing upstream and other perpendicular to it. The mean velocity in the pipe is 0.8 of the central velocity. Find the discharge through the pipe if the pressure difference b/w the 2 orifices is 60 mm of H_2O. Take co-efficient of pitot tube 0.98.

Soln. Given:- $d = 300\ mm = 0.3\ m$

$V_{mean} = 0.8V$

$Q = ?$

$h = 60\ mm$ of $H_2O = 0.06\ m$ of H_2O

$C_v = 0.98$

W.K.T $V_{central} = C_v \times \sqrt{2gh} = 0.98 \times \sqrt{2 \times 9.81 \times 0.06}$

$= 1.06\ m/sec$

$\therefore V_{mean} = 0.8 \times V_{centre} = 0.8 \times 1.06$

$= 0.85\ m/sec$

$\therefore Q =$ area of pipe $\times V_{mean}$

$= \frac{\pi}{4} \times (0.3)^2 \times 0.85$

$= 0.060\ m^3/sec$

6) Find the velocity of flow of an oil through a pipe when the difference of mercury level in a differential U-tube manometer connected to the tappings of the pitot tube is 100mm. Take co-efficient of pitot tube 0.98 & Sp. gravity of oil is 0.8.

Solu^n Given

$x = 100mm$

$C_v = 0.98$

$S_o = 0.8$

$V = ?$

W.K.T; $h = x\left[\frac{S_m}{S_o} - 1\right]$

$= 0.1\left[\frac{13.6}{0.8} - 1\right]$

$h = 1.6m$ of oil

$\therefore V = C_v\sqrt{2gh} = 0.98\sqrt{2\times9.81\times1.6}$

$V = 5.49$ m/sec

7) A pitot tube is inserted in a pipe of 300mm ϕ. The static pressure in pipe is 100mm of mercury (vacuum). The stagnation pressure at the centre of pipe, recorded by the pitot tube is 0.981 N/cm². Calculate the rate of flow of water through pipe, if the mean velocity of flow is 0.85 times the central velocity. take $C_v = 0.98$.

Solu^n:- Given, d = 300mm

Static pressure head $= -100mm$ of Hg

$= -\frac{100}{1000} = -0.1m\times13.6$

$= -1.36m$ of H_2O

Stagnation pressure head $= 0.981\ N/cm^2 = 0.981\times10^4\ N/m^2$

$\therefore$ Stagnation pressure head $= \frac{p}{w} = \frac{0.981 \times 10^4}{9810}$

$= 1\ m$

$\therefore h =$ Stagnation pressure head $-$ Static pressure head

$= 1 - (-1.36)$

$= 2.36\ m$

$\therefore$ Velocity at centre, $V = C_v \sqrt{2gh}$

$= 0.98 \sqrt{2 \times 9.81 \times 2.36}$

$= 6.668\ m/sec$

$\therefore V_{mean} = 0.85 * V = 0.85 \times 6.668$

$= 5.667\ m/sec$

$\therefore Q = a * V_{mean} = \frac{\pi \times (0.3)^2}{4} \times 5.667$

$= 0.4\ m^3/sec$

The momentum Equation

It is based on the law of conservation of momentum or on the momentum principle which states that the net force acting on a fluid mass is equal to the change in momentum of flow per unit time in that direction. The force acting on a fluid mass 'm' is given by Newton's 2nd law of motion.

$$F = m \times a$$

But, $a = \frac{dv}{dt}$

$$\therefore F = m * \frac{dv}{dt}$$

$$\boxed{F = \frac{d(mv)}{dt}}$$ ($\because$ m is constant known as the momentum principle)

It can also be written as $\boxed{F * dt = d(mv)}$ known as impulse - momentum equation & states that the impulse of a force F acting on a fluid mass m in a short interval of time dt is equal to the change of momentum d(mv) in the direction of force.

II JAI SRI GURUDEV II

SRI ADICHUNCHANAGIRI SHIKSHANA TRUST (R.)

S.J.C. INSTITUTE OF TECHNOLOGY

CHICKBALLAPUR - 562 101.

Assignment Book

Name ADNAN BAIG

Class 3rd SEM CIVIL ENGG Roll/Reg. No Diploma

Subject FLUID MECHANICS

Assignment No.	Date	REMARKS	Sig. of the Student	Sig. of the Staff Member
I				
II				
III	11/2/2022	ASSIGNMENT - III 10/10	[signature]	[signature] 12/2/2022
IV	3/3/2022	ASSIGNMENT - IV 10/10	[signature]	[signature] 07/03/2022

Staff in-Charge

Head of Department

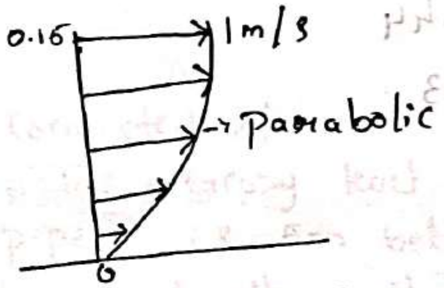
SJCIT CONSUMERS CO-OPERATIVE SOCIETY LTD.

CHICKBALLAPUR - 562 101.

Assignment - 03

1. Calculate the velocity gradiant of distance 0, 100, 150 mm from the boundary if the velocity profile is a parabola with verfex 150mm from the boundary where the velocity is 1m/s. also Calculate the shear stresses of these points if the fluid is a viscosity of 0.804 N-s/m².

Solⁿ :. $\mu = 0.804$ N-s/m²



$y = 0, 100, 150$

$u = 1$ m/s

$y = 0, 0.1$ m, 0.15 m

- The velocity profile is given parabolic and equation velocity profile is

$$u = ay^2 + by + c \rightarrow ①$$

B.C

a) $y = 0$, $u = 0$

b) $y = 0.15$, $u = 1$

c) $y = 0.15$ $\frac{du}{dy} = 0$

a) $y = 0$, $u = 0$

$u = a(0)^2 + b(0) + c$

$c = 0$

b) $y = 0.15$ $u = 1$

$0.10 = a(0.15)^2 + b(0.15) + 0$

$0.0225a + 0.15b - 1 = 0 \rightarrow ⓐ$

c) $y = 0.15 \quad \frac{du}{dy} = 0$

$$\frac{du}{dy} = 2ay + b$$

$$0 = 2a(0.15) + b$$

$$\boxed{0.3a + b = 0} \rightarrow (b)$$

equation a & b

$a = -44.44$

$b = 13.33$

$c = 0$

eqn ① =>

$$u = -44.44y^2 + 13.33y \rightarrow ②$$

diff w r to y

$$\frac{du}{dy} = -44.44y + 13.33$$

i) velocity gradiant

$$\left(\frac{du}{dy}\right)_{y=0} = -44.44(0) + 13.33$$
$$= 13.33/s$$

$$\left(\frac{du}{dy}\right)_{y=0.1} = -44.44(0.1) + 13.33$$
$$= 8.89/s$$

$$\left(\frac{du}{dy}\right)_{y=0.15} = -44.44(0.15) + 13.33$$
$$= -6.666 + 13.33$$
$$= 6.66/s$$

ii) Shear Stress

$$\tau = \mu \frac{du}{dy}$$

$(\tau)_{y=0} = (0.804)\ (13.33)$

$= 10.71\ N/m^2$

$(\tau)_{y=0.1} = \upsilon \frac{du}{dy}$

$= 0.804\ (8.89)$

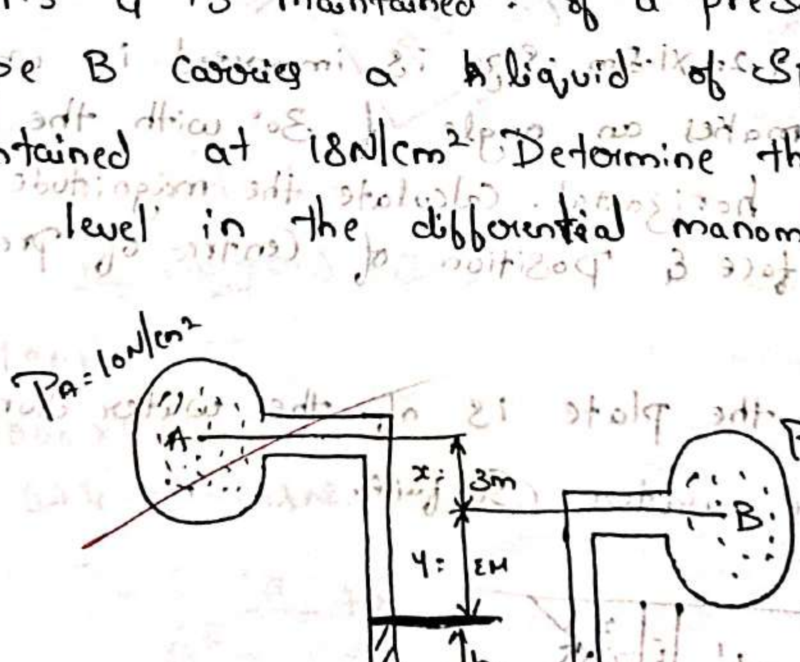
$= 7.147\ N/m^2$

$(\tau)_{y=0.15} = \upsilon \frac{dy}{dy}$

$= 0.804\ (6.66)\ N/m^2$

2) a differential manometer is connected b/w two pipes A & B. Pipe A is 3m above the pipe B. The mercury level in the manometer limb connected to the pipe A is 5m below the centre of the pipe A & is of a higher level than that of the limb connected to pipe B. The pipe A carries a liquid of specific gravity 1.3 & is maintained of a pressure of 10N/cm² while the pipe B carries a liquid of specific gravity 0.9 & is maintained at 18N/cm². Determine the difference in mercury level in the differential manometer.

Sol^n



$P_A = 10 N/cm^2$

$= \frac{10}{10^{-4}} N/m^2$

$P_B = 18 N/cm^2$

$= 18 \times 10^4 N/m^2$

$\gamma_A = 1.5 \times 1000$
$= 1500$

$\gamma_B = 0.9 \times 1000$
$= 900$

$x = 3m$

$y = 2m$

$\gamma_2 = 13.6 \times 1000$
$= 13600$

$P_A + (\gamma_A g x) + (\gamma_2 g h) = P_B + (\gamma_B g (y+h))$

$10 \times 10^4 + (1500 \times 9.81 \times 5) + (13600 \times 9.81 h)$

$= 18 \times 10^4 + (900 \times 9.81 (2+h))$

$10^5 + 73575 + 133416h = 18 \times 10^4 + 17658 + 8829h$

$124527h = 24083$

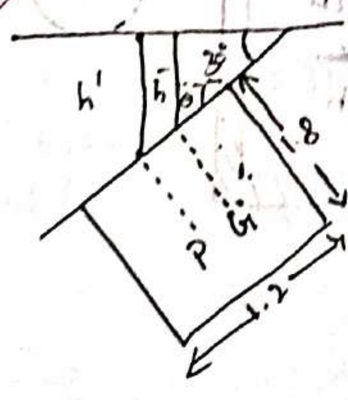
$h = 0.1933m$

3) A rectangular plate 1.2m×1.8m size is immersed in water in an inclined position & makes an angle of 30° with the horizontal the 1.2m side being horizontal. Calculate the magnitude of the net force on one face & position of centre of pressure when.

a. The top edge of the plate is of the water surface &

b. 3m below the water surface.

(a)



$\bar{h} = 0.6 \sin 30^\circ$

$\bar{h} = 0.3$

$F = \rho g A \bar{h}$

$F = 1000 \times 9.81 \times 2.16 \times 0.3$

$F = 6356.88 N$

$I_G = \frac{bd^3}{12}$

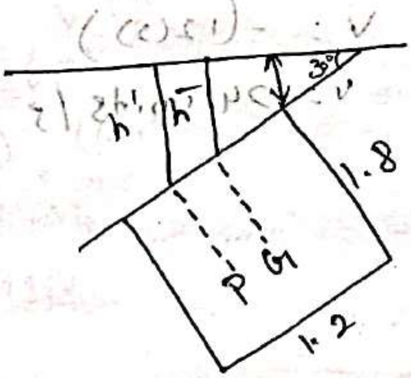
$= \frac{12 \times (1.8)^3}{12}$

$= 0.5832 m^{2}$

$h' = \frac{0.5832 \times \sin^2(30)}{2.16 \times 0.3} + 0.3$

$h' = 0.525 m$

b) below 30 m



$\bar{h} = 30 + 0.6 \sin 30^\circ$

$\bar{h} = 30 + 0.3 = 30.3$

$F = \rho g A \bar{h}$

$= 1000 \times 9.81 \times 2.16 \times 30.3$

$= 642044.88 N$

$h' = \frac{I_G \sin^2\theta}{A \bar{h}} + \bar{h}$

$= \frac{0.5832 \times 0.15}{2.16 \times 30.3} + 30.3$

$h' = 30.3022 m$

4. If for a two-dimensional potential flow, the velocity potential is given by $\phi = 4x(3y-4)$, determine the velocity of the point (2,3). Determine also the value of stream function ψ at the point (2,3).

Solⁿ:-

$\phi = 4x(3y-4)$

$u = -\frac{\partial \phi}{\partial x}$ $\qquad$ $v = -\frac{\partial \phi}{\partial y}$

$u = -\frac{\partial}{\partial x}(12xy-16)$ $\qquad$ $v = -\frac{\partial}{\partial y}(12xy-16)$

$u = -(12y-16)$ $\qquad$ $v = -(12-0)$

$u = -(12(3)-16)$ $\qquad$ $v = -(12(2))$

$u = -20$ units/s $\qquad$ $v = -24$ units/s

$V = -20i - 24j$

$V = \sqrt{(20)^2 + (24)^2}$

$V = 31.2$ units/s

Stream function ψ

$u = -\frac{\partial \psi}{\partial y}$ $\qquad$ $v = \frac{\partial \psi}{\partial x}$

$\frac{\partial \psi}{\partial y} = -u$ $\qquad$ $\frac{\partial \psi}{\partial x} = v$

$\frac{\partial \psi}{\partial y} = 2y - 16 \rightarrow (1)$ $\qquad$ $\frac{\partial \psi}{\partial x} = -12x \rightarrow (2)$

Integrate with r.t.o y.

$\psi = \frac{12y^2}{2} - 16y + C$

$\psi = 6y^2 - 16y + c \rightarrow$ (3)

diff w r to 'x'

$\frac{\partial \psi}{\partial x} = 0 - 0 + \frac{\partial c}{\partial x}$

$\frac{\partial c}{\partial x} = -12x$

Integrate w r to 'x'

$c = -\frac{12x^2}{2} + c$

c is neglected

$c = -6x^2$

Substitute in eqn (3)

$\psi = 6y^2 - 16y - 6x^2$

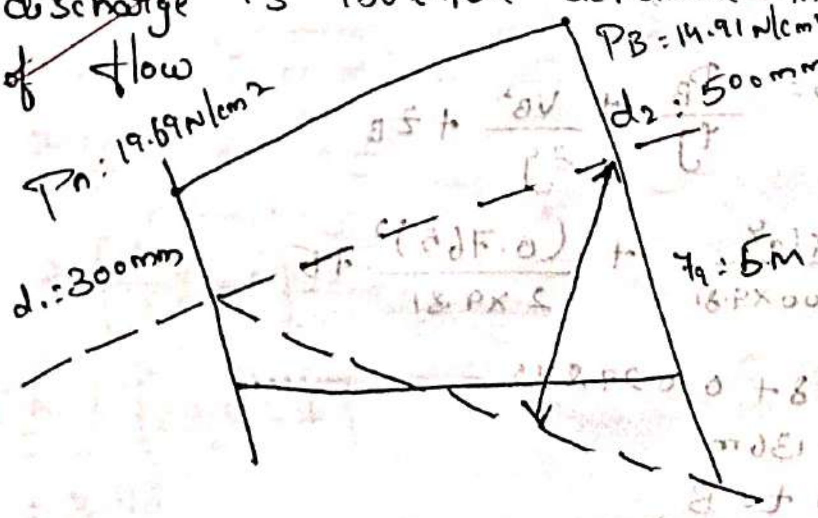
$\psi = 6(3)^2 - 16(3) - 6(2)^2$

$= 162 - 48 - 24$

$\psi = 90$ units/s

5) A pipe line carrying oil of specific gravity 0.8 changes in diameter from 300mm to position A to 500mm diameter to position B which is 5m at a higher level. If the pressure of A & B are 19.62 N/cm² & 14.91 N/cm² respectively & the discharge is 150 lit/sec determine the loss of head & direction of flow

Sol:



$Q = 150$ lit/sec

$Q = \frac{150}{1000}$

$Q = 0.15 m/s$

$S_{oil} = 0.8$

$P_A = 19.62 N/cm^2$

$P_A = 19.62 \times 10^4 N/m^2$

$P_B = 14.91 N/cm^2$

$= 14.91 \times 10^4 N/m^2$

$Q = a_1 v_1 = a_2 v_2$

$a_1 = \frac{\pi d_1^2}{4} = \frac{\pi (0.3)^2}{4}$

$= 0.07 m^2$

$a_1 = \frac{\pi d_2^2}{4} = \frac{\pi (0.5)^2}{4}$

$= 0.196 m^2$

$Q = a_1 v_1$

$v_1 = \frac{Q}{a_1} = \frac{0.15}{0.07} = 1.142 m/s$

$v_1 = \frac{Q}{a_2} = \frac{0.15}{0.196} = 0.765 m/s$

Total head of A $= \frac{P_A}{\rho g} + \frac{v_1^2}{2g} + Z_A$

$= \frac{19.62 \times 10^4}{1000 \times 0.8 \times 9.81} + \frac{(2.142)^2}{2 \times 9.81} + 0$

$= 19.97 + 0.233$

$= 25.229 m$

Total head of B $= \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B$

$= \frac{14.91 \times 10^4}{0.8 \times 1000 \times 9.81} + \frac{(0.765)^2}{2 \times 9.81} + 5$

$= 18.998 + 0.029873$

$= 23.136 m$

Flow from A to B

loss of Head $= T_A - T_B \Rightarrow 2.093 m$

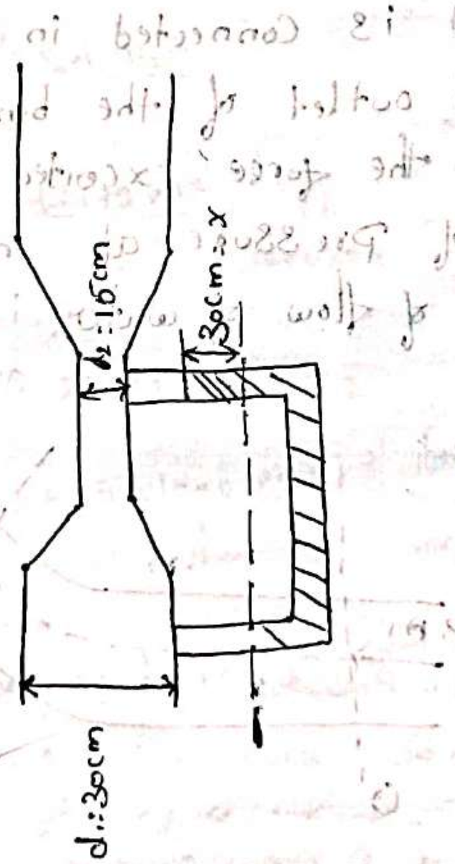
6> A 30 X 15cm ~~fee~~ venturimeter is inserted in a vertical pipe carrying water, flowing in the upward direction. A differential mercury monometer connected to the inlet & throat gives a reading of 30cm. Find the discharge. Take Cd = 0.98

Soln: $d_1 = 30cm = 0.3m$

$d_2 = 15cm = 0.15m$

$x = 30cm = 0.2m$

$Cd = 0.98$



$$a_1 = \frac{\pi (0.3)^2}{4} = 0.0706m^2$$

$$a_2 = \frac{\pi (0.15)^2}{4} = 0.0176m^2$$

$$h = x\left[\frac{h_m}{h_s} - 1\right]$$

$$= 0.3\left[\frac{13.6}{1} - 1\right]$$

$$= 3.78$$

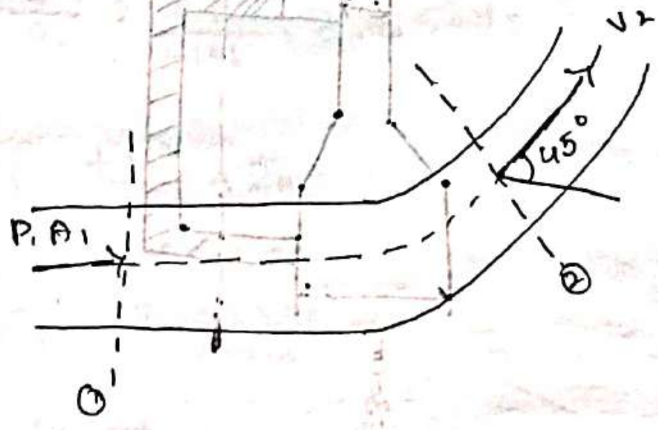
$$Q = \frac{a_1 \, a_2 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}$$

$$= \frac{0.98 \times 0.07 \times 0.017 \sqrt{2 \times 9.81 \times 3.78}}{\sqrt{(0.0049)^2 - (0.000284)^2}}$$

$= 0.1509 m^3/sec$.

7) A 45^0 reducing bend is connected in a pipe line the diameter at the inlet & outlet of the bend being 600mm & 300mm respectively. find the force exerted by water on the bend if the intensity of pressure at inlet to bend is $8.829\ N/cm^2$ & rate of flow of water is 600 lit/sec

Sol^n:



$\theta = 45^0$

$D_1 = 600mm$
$= 0.6 m$

$D_2 = 300mm$
$= 0.30 m$

$P_1 = 8.829\ N/cm^2$
$= 8.829 \times 10^4\ N/m^2$

$Q = 600\ lit/s = 0.6 m^3/s$

$a_1 = \frac{\pi}{4} D_1^2 = \frac{\pi}{4}(0.6)^2$
$= 0.1827 m^2$

$a_2 = \frac{\pi}{4} D_2^2 = \frac{\pi}{4}(0.3)^2$
$= 0.07068 m^2$

$V_1 = \frac{Q}{a_1} = \frac{0.6}{0.2827} = 2.122\ m/s$

$V_2 = \frac{Q}{a_2} = \frac{0.6}{0.07068} = 8.488\ m/s$

Applying Bernoulli's eqn of ~~Ee~~ section ① & ② we get

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2$$

$$Z_1 = Z_2$$

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} = \frac{P_2}{\rho g} + \frac{v_2^2}{2g}$$

$$\frac{8.829 \times 10^4}{1000 \times 9.81} + \frac{(2.122)^2}{2 \times 9.81} = \frac{P_2}{1000 \times 9.81} + \frac{(8.488)^2}{2 \times 9.81}$$

$$\frac{P_2}{1000 \times 9.81} = 9.2293 - 3.672$$

$$P_2 = 5.5575 \times 1000 \times 9.81$$

$$P_2 = 5.45 \times 10^4\ N/m^2$$

Force on the bend in x- & y direction are given by equations

$$F_x = \rho Q (v_1 - V_2 \cos\theta) + P_1 A_1 - P_2 A_2 \cos\theta$$

$$= 1000 \times 0.6 [2.122 - 8.488 \cos 45^\circ] + 8.829 \times 10^4 \times 0.2827 - 5.45 \times 10^4 \times 0.07068 \times \cos 45^\circ$$

$$= -2327.9 + 24959.6 - 2720.3$$

$$= 24959.6 - 5048.2$$

$$= 19911.4\ N$$

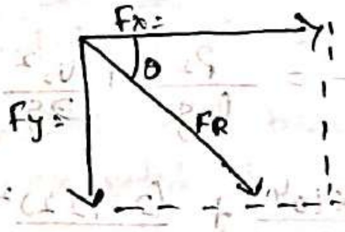
$F_y = \rho Q [-V_2 \sin\theta] - P_2 A_2 \sin\theta$

$= 1000 \times 0.6 [-8.488 \sin 45^\circ] - 5.45 \times 10^4 \times 0.07068 \times \sin 45^\circ$

$= -3601.1 - 2721.1$

$= -6322.2 N$.

-ve sign means F_y is acting in the downward direction



Resultant force $F_R = \sqrt{F_x^2 + F_y^2}$

$= \sqrt{(19911.4)^2 + (-6322.2)^2}$

$= 20890.9 N$

The angle made by the resultant force with x-axis

$\tan\theta = \frac{F_y}{F_x} = \frac{6322.2}{19911.4}$

$= 0.3175$

$\theta = \tan^{-1}(0.3175)$

$\boxed{\theta = 17^\circ 36'}$

8) The head of water over an orifice of 100mm diameter is 10mm. The discharge through the orifice is 70lps. If the coordinate of a point on the jet measured from vena contracta are 4.3m horizontal & 0.5m vertical determine Cd, Cv & Cc.

Sol^n :- $d = 0.1m$ $H = 10m$

$a = \frac{\pi d^2}{4} = \frac{\pi \times 0.1^2}{4} = 7.853 \times 10^{-3}$ mm²

$x = 4.3m$

$y = 0.5m$

$Q_{act} = 70 l/sec = 0.07 m^3/sec$

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

$Q_{the} = a\sqrt{2gh} \Rightarrow 7.853 \times 10^{-3} \times \sqrt{2 \times 9.81 \times 10}$

$Q_{the} = 0.1099 m^3/s$

$C_d = \frac{Q_{act}}{Q_{the}} = \frac{0.07}{0.1099} = 0.64$

~~$C_v = \frac{V_{act}}{V_{the}}$~~

$C_v = \frac{x}{2\sqrt{yH}} \Rightarrow \frac{4.3}{2\sqrt{0.5 \times 10}} = 0.961$

$C_c = \frac{C_d}{C_v} = \frac{0.64}{0.961} = 0.66$

9. water flow over a rectangular weir 1m wide of a depth of 150mm & afterwards passes through a triangular right angled weir. Taking Cd for the rectangular & triangular weir as 0.62 & 0.59 respectively Determine the depth over the triangular weir

Soln:-

$l = 1m$

$H_1 = 150mm = 0.15m$

$\theta = 90^\circ$

$Cd = 0.59$

$Cd_{rectn} = 0.62$

$$Q = \frac{2}{3} Cd \times L \sqrt{2g} [H^{3/2}]$$

$$Q_R = \frac{2}{3} \times 0.62 \times \sqrt{2 \times 9.81} (0.15)^{3/2}$$

$$= 0.1063 m^3/sec$$

$$Q = \frac{8}{15} Cd \sqrt{2g} \tan \theta/2 [H^{5/2}]$$

$$0.1063 = \frac{8}{15} (0.59) \sqrt{2 \times 9.81} . (1) . [H^{5/2}]$$

$$1.5945 = 7.84 (H^{5/2})$$

$$H = 0.3576 m$$

10. The rate of flow of water through a horizontal pipe is $0.25 m^3/s$. The diameter of the pipe which is 200mm is suddenly enlarge to 400mm. The pressure intensity in the smaller pipe is $4.77 N/cm^2$ Determine

i) loss of head due to sudden enlargement

ii) Pressure intensity in the large pipe

iii) Power lost due to enlargement

Sol^n: $Q = 0.25\ m^3/s$

$d_1 = 200mm = 0.2m$

$d_2 = 400mm = 0.4m$

$p_1 = 11.77\ N/cm^2$

$p_2 = ?$

$$a_1 = \frac{\pi d_1^2}{4} = \frac{\pi(0.2)^2}{4} = 0.031 m^2$$

$$a_2 = \frac{\pi d_2^2}{4} = 0.125 m^2$$

$$Q = a_1 v_1 = a_2 v_2$$

$$V_1 = \frac{Q}{a_1} = \frac{0.25}{0.031} = 8.06 m/s$$

$$V_2 = \frac{Q}{a_2} = \frac{0.25}{0.125} = 2 m/s$$

i) loss of head due to sudden enlargement

$$h_e = \frac{(V_1 - V_2)^2}{2g} = \frac{(8.06-2)^2}{2\times 9.81}$$

$$h_e = 1.817m$$

ii) pressure intensity in large pipe

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + h_e$$

$$\frac{P_2}{\rho g} + \frac{P_1}{\rho g} + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} - h_e$$

$$\frac{P_2}{1000\times 9.81} = \frac{11.7\times 10^4}{1000\times 9.81} + \frac{(8.06)^2}{2\times 9.81} - \frac{(2)}{2\times 9.81} - 1.817$$

$$\frac{P_2}{1000 \times 9.81} = 11.9973.311 - 0.203 - 1.817$$

$$P_2 = 13.281 \times 1000 \times 9.81$$

$$P_2 = 13.02 \times 10^4 \ N/m^2$$

12/11/22

10/10

Internal Test Question paper format- CBCS Scheme

Name of the staff/s: Ankitha V, Ravindranath. C

Date: 09/10/2018

Signature:

Reviewer's Signature:

NOTE: Only the following information's to be given to the students:

S.J.C. Institute of Technology

Department: Civil Engineering

Test: **II**

Subject Name: **Fluid Mechanics**
Semester: 3rd
Duration: 90 minutes

Subject Code: **17CV33**
Section: A & B
Max Marks: 30

INSTRUCTIONS: Answer ***any one*** full question from each part.

Q.No.	Part-A	Marks	CO	Levels
1.	a) Comparison between i) steady & unsteady flow ii) Uniform & non-uniform flow.	05	CO3	L2
	b) The velocity potential function is given by $\Phi = 5(x^2-y^2)$. Determine the velocity component at the point (4, 5).	05	CO4	L3
	OR			
2.	a) Comparison between i) Laminar & turbulent flow ii) Path line & stream line.	05	CO3	L2
	b) A pipe line carrying oil of specific gravity 0.8 changes in diameter from 300mm diameter at position A to 500mm diameter at B which is 5m higher than A. If the pressure at A and B are respectively 20 N/cm^2 and 15 N/cm^2 and discharge is 150 lps, determine the loss of head.	05	CO4	L3
	Part-B			
3.	Derive an expression for Bernoulli's equation under energy principle.	10	CO4	L3
	OR			
4.	Derive an expression for of continuity equation in Cartesian coordinates.	10	CO4	L3
	Part-C			
5.	A horizontal venturimeter with inlet and throat diameter 20cm and 10 cm respectively is used to measure the flow of water. The reading of differential manometer the inlet and throat is 20cm of mercury. Determine the rate of flow. Take $C_d = 0.98$	10	CO5	L3
	OR			

6.	An orifice meter with orifice diameter 10cm is inserted in a pipe of 20cm diameter. The pressure gauges fitted upstream and downstream of the orifice meter gives readings of 19.62 N/cm^2 and 9.81N/cm^2 respectively. Co-efficient of discharge for the meter is given as 0.6. Determine the discharge of water through pipe.	10	CO5	L3

CO3=05M	CO4=15M	CO5=10M	L2=05M	L3=25M	L4=0M

Internal Test Question paper format- CBCS Scheme

Name of the staff/s: Raviondranath. C and Ankitha. V

Date: 12/09/2018 Signature: Rdg Ankitha 12/9/18

Reviewer's Signature: 12/9/18 12/9/18

NOTE: Only the following information's to be given to the students.

S.J.C. Institute of Technology

Department: Civil Engineering

Test: **I**

Subject Name: **Fluid Mechanics**
Semester: 3rd
Duration: 90 minutes

Subject Code: **17CV33**
Section: A & B
Max Marks: 30

INSTRUCTIONS: Answer ***any one*** full question from each part.

Question Number		Marks	CO	Levels
1	**a.** Define the following fluid properties with units: i. Specific weight ii. Kinematic viscosity iii. Surface tension iv. Capillarity v. Dynamic viscosity.	5	CO1	L1
	b. A plate having an area of 0.6 m^2 is sliding down the inclined plane at 300 to the horizontal with a velocity of 0.36m/s. There is a cushion of fluid 1.8mm thick between the plane and the plate. Determine the viscosity of the fluid, if the weight of the plate is 280N.	5	CO1	L3
	OR			
	a. Distinguish between i. Cohesion and adhesion ii. Real and ideal fluid.	5	CO1	L1
	b. Determine the minimum size of a glass tube for the capillary rise in it not to exceed 0.2mm of water. The surface tension of water in contact with air is 0.0725 N/m and contact angle 60^0	5	CO1	L3
2	Calculate the velocity gradient at distances 0, 100, 150 mm from the boundary if the velocity profile is a parabola with vertex 150mm from the boundary where the velocity is 1m/s. Also calculate the shear stresses at these points if the fluid as a viscosity of 0.804 N-s/m^2.	10	CO2	L3
	OR			
	a.Explain the different types of pressure. Give the relationship between them. Indicate these pressures by means of a sketch.	5	CO2	L3
	b. A hydraulic press has a ram o 300mm diameter and plunger of 45mm diameter. Determine the weight lifted by the hydraulic press when the force applied at the plunger is 500N.	5		

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3	A U – tube differential manometer containing mercury is connected on one side to a pipe A containing carbon tetrachloride of specific gravity 1.6 under a pressure of 120 kPa and on the other side of a pipe B containing oil of specific gravity 0.8 under a pressure of 200kPa. The pipe A lies 2.5m above pipe B and the mercury level in the limb connecting with pipe A lies 4m below the pipe A. Determine the difference in the levels of mercury in the two limbs of manometer.	10	CO2	L3
	OR			
	Derive the expression for the vertical plane surface submerged in liquid	10	CO2	L3

CO1=10M	CO2=20M	L1=05M	L2=00M	L3=25M

Internal Test Question paper format- CBCS Scheme

Name of the staff/s: Ravindranath.C and Ankitha

Date: 15/11/2018 Signature: Ravindranath 15/11/18 Ankitha 15/11/18

Reviewer's Signature: 19/11/18 22/11/18

S.J.C. Institute of Technology

Department: Civil Engineering
Test : III
Semester:III Section: A & B
Subject Name & Code: **FLUID MECHANICS** **17CV33**

Instructions

Duration: 90 minutes Max Marks: 30

Q.No.	Questions	Marks	CO	Levels
1.	a).Derive an expression for Darcy Wishbech equation for frictional losses	10	CO4	L4
	OR			
	b) A closed cylindrical tank is 3.5m high and contains an oil of relative density 0.85 to a height of 3m above the bottom. The space above the oil surface contains air under a pressure of 50kN/m2. If an orifice of diameter 8 cm is provided on the side of the tank with its centre 25 cm above the bottom, estimate the weight of fluid discharge in one minute. Take Cd = 0.60	10	CO4	L4
2.	a) Determine theoretical discharge for Triangular notch	10	CO5	L5
	OR			
	b) A flow from a channel is controlled by a trapezoidal notch so that the full supply discharge of 2m3/s flows over the notch at a head of 1.2m measured over the crest. At half this head, a discharge of 0.6m3/s passes over the notch. Assuming Cd = 0.62, Determine the base width and side slope of notch.	10	CO5	L5
3.	a) Determine an expression for the discharge through a Venturimeter.	10	CO5	L5
	OR			
	b) A pipe line of 0.6m diameter is 1.5km long. To increase the discharge, another line of the same diameter is introduced parallel to the first in the second half of the length. Neglecting minor losses, find the increase in discharge if 4f = 0.04. The head at inlet is 300mm	10	CO5	L5

CO1=00	CO2=0	CO3=0	CO4=10	CO5=20	L1=0	L2=0	L3=	L4=10	L5=20

CBCS SCHEME

USN 1SJ17CV004 **17CV33**

Third Semester B.E. Degree Examination, Dec.2018/Jan.2019
Fluid Mechanics

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Define the term 'fluid'. Distinguish between liquid and gases. **(06 Marks)**

b. Derive the expression for surface tension on a liquid droplet. **(06 Marks)**

c. The dynamic viscosity of an oil, used for lubrication between a shaft and sleeve is $0.6 Ns/m^2$. The shaft diameter is 0.4m and rotates at 190rpm. Calculate the power lost in the bearing a sleeve length of 90mm. Take the thickness of the oil film as 1.5mm. **(08 Marks)**

OR

2 a. Explain the working of a Bourdon's pressure gauge with a diagram. **(06 Marks)**

b. State and prove Pascal's law. **(08 Marks)**

c. A differential manometer is connected at the two points A and B of two pipes as shown in Fig.Q.2(c). The pipe A contains a liquid of sp.gr = 1.5 while pipe B contains a liquid of sp.gr = 0.9. The pressures at A and B are $9.81 \times 10^4 N/m^2$ and $17.65 N/m^2$ respectively. Find the difference in mercury level in the differential manometer. **(06 Marks)**

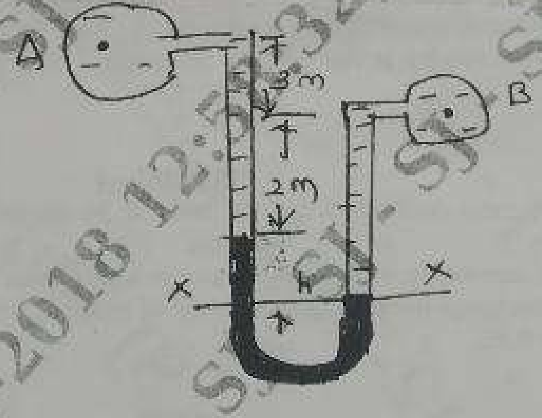

Fig.Q.2(c)

Module-2

3 a. Define: i) Total pressure ii) Centre of pressure. **(04 Marks)**

b. Derive the expression for the total pressure and center of pressure on a vertically immersed plane surface. **(08 Marks)**

c. The velocity potential function $\phi = \frac{-xy^3}{3} - x^2 + x^3y + y^2$.

i) Find the velocity component in x and y directions.

ii) Show that ϕ represents a possible case of fluid flow. **(08 Marks)**

OR

4 a. Derive continuity equation in Cartesian coordinates for 3 dimensional flow. (08 Marks)

b. A rectangular plane surface 1m wide and 3m deep lies in water in such a way that its plane makes an angle of 30° with the free surface of water. Determine the total pressure and the depth of center of pressure when the upper edge of the plate is 2m below the free surface. (06 Marks)

c. What is flownet? The stream function for a two dimensional flow is given by $\psi = 2xy$. Find the velocity potential function 'ϕ'. (06 Marks)

Module-3

5 a. State the assumptions made in deriving the Euler's equation of motion. Hence obtain Bernoulli's equation from Euler's equation with a neat sketch. (10 Marks)

b. A pipe of diameter 400mm carries water at a velocity of 25m/s. The pressure at the points A and B are given as 29.43 N/cm^2 and 22.563 N/cm^2 respectively, while the datum head at A and B are 28m and 30m. Find the loss of head between A and B. (05 Marks)

c. Show that for a pitot tube actual velocity $V = C_v\sqrt{2gh}$ with usual notations. (05 Marks)

OR

6 a. Derive the equation for discharge through a venturimeter. (08 Marks)

b. Water flow at the rate of 0.147m^3/s through a 150mm diameter orifice inserted in a 300mm diameter pipe. If the pressure gauges fitted upstream and down stream of the orifice plate have shown readings of 176.58 kN/m^2 and 88.29 kN/m^2 respectively, find the coefficient of discharge 'C' of the orifice meter. (05 Marks)

c. A 45° reducing bend is connected in a pipe line, the diameters at the inlet and outlet of the bend being 600mm and 300mm respectively. Find the force exerted by water on the bend if the pressure intensity at the inlet to the bend is 8.829 N/cm^2 and rate of flow of water is 600 lit/sec. (07 Marks)

Module-4

7 a. Define hydraulic coefficient Cc, Cv and Cd for an orifice and obtain the relation between them. (08 Marks)

b. Derive the expression of discharge through a triangular notch. (08 Marks)

c. Find the discharge over a Cipolletti weir of length 2.0m when the head over the weir is 1m. Take $C_d = 0.62$. (04 Marks)

OR

8 a. What are the advantages of triangular notch over rectangular notch? How do you classify mouth pieces? (06 Marks)

b. A jet of water, issuing from a sharp-edged vertical orifice under a constant head of 10.0cm at a certain point, has the horizontal and vertical coordinates measured from the Vena-Contracta as 20.0cm and 10.5cm respectively. Find the value of C_v. Also find the value of C_c if $C_d = 0.60$. (06 Marks)

c. What is broad crested weir? Show that under maximum discharge conditions $h = 2/3\ H$ with usual notations for a broad crested weir. (08 Marks)

Module-5

9 a. Derive Darcy's equation for head loss through pipes. **(08 Marks)**

b. Explain: i) Pipes in parallel ii) Pipes in series. **(04 Marks)**

c. The rate of water flow of water through a horizontal pipe is 0.025 m^3/s. The diameter of the pipe which is 200mm is suddenly enlarged to 4000mm. The pressure intensity in the smaller pipe is 11.772 N/cm^2. Compute:

i) Loss of head due to sudden enlargement

ii) Pressure intensity in the large pipe. **(08 Marks)**

OR

10 a. Explain the terms:

i) Hydraulic gradient and

ii) Total energy line. **(04 Marks)**

b. Derive the expression for pressure loss due to sudden closure of the valve when the pile is elastic. **(08 Marks)**

c. For a pipe network shown in Fig.Q.10(c) find the flow in each pipe. The valve of 'n' mg/c assumed as 2.0. **(08 Marks)**

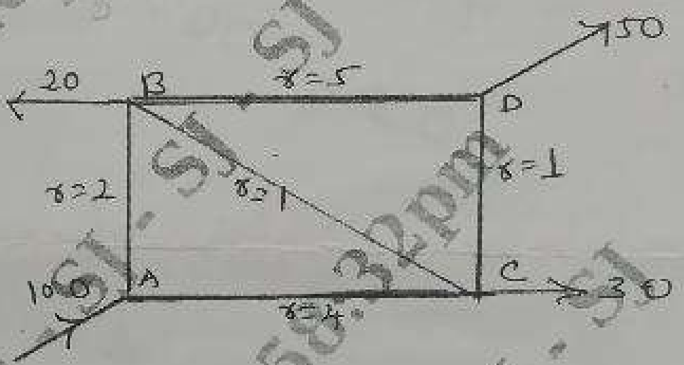

Fig.Q.10(c)

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