NAWAB SHAH ALAM KHAN COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

OU CODE: PC403CE   SUBJECT: FLUID MECHANICS PROGRAMME: UG

BRANCH: CIVIL

YEAR: II nd   DOCUMENT No: NSAKCET/CE/01

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DESIGN:
DATE:

APPROVED BY (HOD):

1) NAME SYED FARRUKH ANWAR (ASSOC. PROF)
2) SIGN
3) DATE

1.1 Vision of Institute

To be a leading institute of world class quality technical education with strong ethical values, preparing students for leadership in their fields for the dynamic and global careers, developing breakthrough environment for professional education and research.

Mission of Institute

M1: To enable the students to develop into outstanding professionals with high ethical standards capable of creating developing and managing local and global engineering enterprises.

M2: To ensure quality assurance by fulfilling expectations of the society and industry with state of the art technology.

M3: To attract and retain knowledgeable, creative, motivated, and highly skilled individuals whose leadership and contributions uphold the college tenets of education through student–centric learning methodologies.

M4: To provide opportunities for deserving students of all communities.

M5: To promote all round personality development of the students through interactions with alumni and academia.

1.1 Availability of statements of the Department

Vision of the Civil Engineering Department

To develop technically strong civil engineers having ethics and human values by providing quality education, enabling them to be competent in facing any challenges that may arise during their service in particular to the society and in general to the nation.

Mission of the Civil Engineering Department

M1: To provide conceptually strong technical knowledge relating to all fields of civil engineering braced with professional ethics.

M2: To adopt the latest developments in civil engineering to provide conducive environment for better teaching learning process.

M3: To provide adequate soft skills and make the students prepare for industry ready to grab the opportunities in this field.

M4: To encourage students to participate in various technical events at research institutes, institutes of higher learning so that they develop the capabilities to serve the nation effectively

1.2 PEO's of Civil Engineering Department

PEO1: Graduates will be capable of handling the Civil Engineering projects independently in their future assignments

PEO2: Graduates will be able to apply technical skills in their chosen fields in an ethical manner.

PEO3: Graduates will be able to implement their core concept to obtain solution for real time problems.

FLUID MECHANICS

PC403 CE

Instruction: 3 periods per week
CIE: 30 marks
Credits: 3

Duration of SEE: 3 hours
SEE: 70 marks

Objectives:

The objectives of this course is to impart knowledge of:

- Concepts and principles of fluid mechanics–statics, kinematics and dynamics
- Properties of fluid pressure, pressure measurements and problems in fluid statics
- Fluid kinematics, including types of flows, fluid path lines and continuity equations

Outcomes:

After completing this course, the student will be able to:

- Classify the fluids based on their properties
- Solve problems on pressure calculations, hydrostatic forces on bodies and buoyancy
- Relate types of flows with the corresponding mathematical equations
- Apply Euler's, Bernoulli's and Momentum equation to solve fluid dynamic problems
- Apply principles of fluid dynamics to make flow measurement calculations

UNIT – I

Fluid Properties: Basic Concepts and Definitions: Distinction between a fluid and a solid; Density, Specific weight, Specific gravity, Kinematic and dynamic viscosity; variation of viscosity with temperature, Newton law of viscosity; vapour pressure, boiling point, cavitation; surface tension, capillarity, Bulk modulus of elasticity, compressibility.

Fluid Statics: Fluid Pressure: Pressure at a point, Pascal's law, Piezometer, Manometer, Differential Manometer, Micromanometers. Pressure gauges, transducers.

UNIT – II

Fluid Kinematics: Classification of fluid flow-steady and unsteady flow, uniform and non-uniform flow, laminar and turbulent flow, rotational and irrotational flow, compressible and incompressible flow, ideal and real fluid flow,one,two-andthree-dimensionalflows.Streamline,pathline,streakline and stream tube.

Law of mass conservation: Continuity equation from control volume and system analysis. Definition and properties of Stream function, velocity potential function and uses of flownets.

UNIT – III

Fluid Dynamics: Convective and local acceleration. Surface and body forces. Euler's equations of motion.

Law of energy Conservation: Bernoulli's equation from Euler's equation. Application of Bernoulli's equation.

UNIT – III

Shear Stress in Beams: Derivation of equation of shear stresses, distribution across rectangular, circular, T and I section.

***Direct and Bending Stresses*:** Direct loading, Eccentric loading, limit of eccentricity, Core of sections, rectangular and circular, solid and hollow sections

UNIT – IV

***Compound Stresses*:** Stresses on oblique planes, principal stresses and planes. Mohr's circle of stress.

***Application to pressure vessels*:** Thin cylinders subjected to internal fluid pressure, volumetric change. Thick Cylinders: Lame's equations, stresses under internal and external fluid pressures, Compound cylinders, Shrink fit pressure.

UNIT – V

***Torsion*:** Theory of pure torsion in solid and hollow circular shafts, shear stress, angle of twist, strength and stiffness of shafts, Transmission of Power. Combined torsion and bending for determination of principal stresses and maximum shear stress. Equivalent bending moment and equivalent twisting moment.

***Springs*:** Close and open coiled helical springs under axial load and axial twist, Carriage springs.

Suggested Reading:

1. D.S. Prakash Rao, *Strength of Materials- A Practical Approach*, Universities Press, Hyderabad, 1999.
2. R. K. Bansal, *A Textbook of Strength of Materials (Mechanics of Solids – S.I. Units)*, Laxmi Publications Pvt. Ltd., 6th Edition, 2015
3. R.K. Rajput, *A Textbook of Strength of Materials*, S. Chand Publications, New Delhi, 2007.
4. R. Subramanian, *Strength of Materials*, Oxford University Press, New Delhi, 2016.
5. S. S. Bhavikatti, Strength of materials, Vikas Publishing House, Delhi, 2002.
6. Ferdinand P Beer, Johnston and De Wolf., *Mechanics of Materials*, Tata McGraw-Hill, Delhi, 2004.

Department of civil Engineering

Course Outcomes & CO-PO

Mapping

Course Name: Fluid Mechanics AY: 2020-21

Course Code: PC403CE Semester: III

Name of the faculty: Mohd Azheruddin

Course Outcomes

After completing this course the student will be able to:

CO No.	Course Outcome	Taxonomy Level
223.1	Understand the physical properties of fluid, concept of viscosity for kinematics and dynamics flow with effect of temperature, vapor pressure, surface tension, capillary rise and fall derivation of Pascal's law, Manometers (U-tube, differential, single column),	IV-Understanding
223.2	Remembering the classification of fluid flow, stream-streak line concept properties of it, continuity equation for 3-D flow, uses of flow nets.	I-Remembering
223.3	Remember the concept of Convective and local accelerations, applications of Bernoulli's equation ,concept of vortex flow.	III-Applications
223.4	Remember in Venturi meter, orifice meter and pitot tube, hot wire anemometer, discharge through notches and wiers, spillways, discharge through mouthpiece.	I-Remembering

Fluid Mechanics (PC403CE) A.Y:2020-21CO-PO/PSO mapping

Justification

CO1: Understand the physical properties of fluid, concept of viscosity for kinematics and dynamics flow with effect of temperature, vapor pressure, surface tension, capillary rise and fall derivation of Pascal's law, Manometers (U-tube, differential, single column),

	Mapping Level	Justification
P01	2	To derive an equation, it requires the basic knowledge and to solve the problems requires the same.
P02	1	Least relates with designing part of the fluid problems.
P03	1	Least relates with designing part of the fluid problems
P04	3	The basic knowledge of the fluid behavior will help to overcome the complex problems related with it.
P012	2	Principles of fluid flow is helping very much to understand the latest topics in Geotechnical, Ground water, waste water etc.

CO2: Remembering the classification of fluid flow, stream- streak line concept properties of it, continuity equation for 3-D flow, uses of flow nets.

	Mapping Level	Justificatio n
PO1	2	Gathering the information related to fluid flowing in three different directions will help in measuring the forces with it.
PO2	2	Moderately deals with the calculations which will leads to design of the various complex problems in a very simple way.
PO3	1	Least relates with the different engineering fields in Civil Engineering.
PO4	2	Fairly relates the solutions to the complex problems with different dimensional flow.
PO12	2	Principles of fluid flow is helping very much to understand the latest topics in Geotechnical, Ground water, waste water etc.

CO3: Remember the concept of Convective and local accelerations, applications of Bernoulli's equation ,concept of vortex flow..

	Mapping Level	Justification
PO1	3	Strongly co-relates with the mathematics involvement to solve problems for fluids.
PO3	1	Least related with designing problems.
PO4	2	The equations derived by Bernoulli's provides the base for the solutions for complex problems.
PO12	2	Derivations will always open the gates for future learning with different parameters with various conditions.
PSO1	1	Least relates with design process, executing the problems having complexity in solutions with very much ease.

CO4: Remember in Venturi meter, orifice meter and pitot tube, hot wire anemometer, discharge through notches and wiers, spillways, discharge through mouthpiece.

	Mapping Level	Justification
PO1	3	Strongly relates with applying the basic knowledge to carry out an experiment on different types of flow for knowing the Reynold's number, knowledge is the only way to visualize the Magnus effect and understanding the concept of important topics such as Boundary layer.
PO2	2	Moderately relates with the analysis problems for Venturi meter, orifice meter and pitot tube designing the pipe flow through Notches and Wiers of different shapes
PO3	2	Except solving the problems related with different types of flow and conducting an experiment on the behavior of fluids, it is least related with the public safety and environmental concerns.
PSO 1	2	Co-efficient will help in designing the problems for different types of flows.

Faculty sign

HoD

CO-PO Mapping before gaps:

PO / CO	P O1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS0 1	PSO 2	PSO 3
CO 1	2	1	1	3	-	-	-	-	-	-	-	2	-		-
C02	2	2	1	2	-	-	-	-	-	-	-	2	-	-	-
C03	3	1	2	2	-	-	-	-	-	-	-	2	1	2	-
C04	3	2	2	-	-	-	-	-	-	-	-	1	-	2	-
AVG	2.5	1.75	1.25	1.75	-	-	-	-	-	-	-	1.75	-	1	-

Signature of Faculty

Head of Department

PREREQUISITES: Things to be known prior to FLUID MECHANICS

Level	Credits	Periods/Week	**Pre requisites**
UG	3	3	Know where Fluid Mechanics is applied. This intrigues and drives you to know how is it applied.
			As FM includes a lot of physics, focus more on the equations and laws that govern the fluid flow. make a list of them. Understand the terms of the equations and be good at making proper rearrangements for the subjective of the formula.

1. Know where Fluid Mechanics is applied. This intrigues and drives you to know how is it applied.
2. Statics have a lot of formulas. Kinematics have many equations. Dynamics have complicated derivations. So, instead of worrying about memorizing it, be focused and try to know the point of its formulation. Keep yourself focused on Statics and Kinematics. Give a read and understand WHY does it happen?
3. Focus more on Boundary layer theory and Equations of continuity in different forms, Laminar - Turbulent flows and the equations associated, Velocity profiles on flat plates and conduit flows.
4. Solve a few simple numerical to feel confident enough.

NSAKCET, HYDERABAD

DEPARTMENT OF CIVIL ENGINEERING,

B.E-II year Name of Faculty: - MOHD AZHERUDDIN

SUB: - FLUID MECHANICS

Lesson schedule

SL.NO	TOPICS TO BE COVERED	NO. OF PERIODS	DATE
	UNIT-I		
1	Dimensions and units, physical properties of fluid.	2	15-03-2021
2	Newton's law of viscosity. problems on Newton's law of viscosity,	2	16-03-2021
3	Dynamic viscosity, Kinematic viscosity, velocity gradient, numerical.	2	22-03-2021
4	specific gravity, surface tension theory, Numerical	2	23-03-2021
5	Vapor pressure, Pascal's law	2	30-03-2021
6	Problems on Pascal's law, atmospheric gauge, vacuum pressure, pressure measurements.	2	05-04-2021
7	Problems on manometers, concept of manometers	2	06-04-2021
8	Differential u-tube manometer,	2	12-04-2021
9	Problems of differential manometer, inverted u-tube manometer.	2	13-04-2021
10	Problems on inverted u-tube manometer,	2	19-04-2021
11	Hydrostatics forces on submerged plane, horizontal	2	20-04-2021

12	Different types of numerical on it.	2	26-04-2021
13	vertical, inclined centre of pressure derivation and problems	2	27-04-2021
14	Pressure on curved surfaces,	2	03-05-2021
15	Numerical.	2	04-05-2021
	UNIT-II		
16	Introduction to buoyancy and floatation	2	10-05-2021
17	stability of bodies with different forces.	2	11-05-2021
18	meta centre liquids in relation equilibrium.	2	17-05-2021
19	Basic concept of fluid kinematics in brief.	2	18-05-2021
20	Numerical on fluid kinematic	2	24-05-2021
21	Solving previous year exam papers.	2	25-05-2021
22	Properties of stream function.	2	31-05-2021
23	stream line, path line, steam tube, numerical on properties of stream function	2	01-06-2021
24	Classification of flows, steady, unsteady, uniform, non-uniform	2	07-06-2021
25	turbulent, rotational and irrotational flow	2	08-06-2021
26	Equation of continuity for one two- and three-dimensional flows	2	14-06-2021
27	Problems on continuity equation	2	15-06-2021
28	Previous year question paper solution.	2	05-07-2021
29	Stream velocity potential functions	2	06-07-2021
30	Concept of circulation in fluid	2	12-07-2021

	mechanics.		
31	velocity flow net analysis	2	13-07-2021
	UNIT-III		
32	Fluid dynamics , convective and local acceleration	2	19-07-2021
	surface and body forces, Numerical on the body forces		20-07-2021
33	Euler's and Bernoulli's equation for flow along a stream line for 3-D flow	2	26-07-2021
34	Applications of Bernoulli's equation, Numerical on Bernoulli's equation. Vortex flow.	2	27-07-2021
	UNIT-IV		
35	Pitot tube, venturi meter, orifice meter, derivations and problems on the same	2	02-08-2021
36	Notches and weir derivation problems	2	03-08-2021
37	Mouth piece concept cylindrical and Borda's mouthpiece.	2	09-08-2021
	UNIT-V		
38	Compressibility of liquids and gases, energy equation for		10-08-2021
39	isothermal and adiabatic conditions,		16-08-2021
40	velocity of pressure wave, Mach number	2	17-08-2021
41	stagnation pressure, density and temperature.		19-08-2021

NAWAB SHAH ALAM KHAN COLLEGE OF ENGINEERING & TECHNOLOGY								
NEW MALAKPET, HYDERABAD - 500024.								
TIME TABLE FOR B.E II YEAR II SEMESTER 2020 - 2021 (ONLINE/OFFLINE MODE)								
DEPARTMENT OF CIVIL ENGINEERING								wef:31-8-2020
Branch	Civil II-B							
Days	9:30 TO 10:20	10:20 TO 11:10	11:10 TO 12:00	12:00 TO 12:50	12:50 TO 1:30	1:30 TO 2:20	2:20 TO 3:10	3:10 TO 4:00
MON	EOME		FM		L B	IC	MT&E	
TUE	MT&E		ETCE		U R	IC	FM	
WED	ETCE		MOM		N E	IC	M-III	
THUR	EOME		FA		C A	IC	M-III	
FRI	MOM		FA		H K	TUTORIALS		

THEORY:

ETCE : MS. SABIHA
FM : MR AZHER
M-III : IMRANA
MOM : MR IMTIYAZ
EOME : MR SHARJEEL
MT&E : MR HUZAIFA
FA : MS AZEEZA SHAHEEN
IC : MR HASEEB

HOD **PRINCIPAL**

NAWAB SHAH ALAM KHAN COLLEGE OF ENGINEERING & TECHNOLOGY								
NEW MALAKPET, HYDERABAD - 500024.								
TIME TABLE FOR B.E II YEAR II SEMESTER 2020 - 2021 (ONLINE/OFFLINE MODE)								
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MON			FM		L B	IC		
TUE					U R	IC	FM	
WED					N E	IC		
THUR					C A	IC		
FRI					H K	TUTORIALS		

THEORY:

ETCE : MS. SABIHA
FM : MR AZHER
M-III : IMRANA
MOM : MR IMTIYAZ
EOME : MR SHARJEEL
MT&E : MR HUZAIFA
FA : MS AZEEZA SHAHEEN
IC : MR HASEEB

HOD **PRINCIPAL**

For reference:

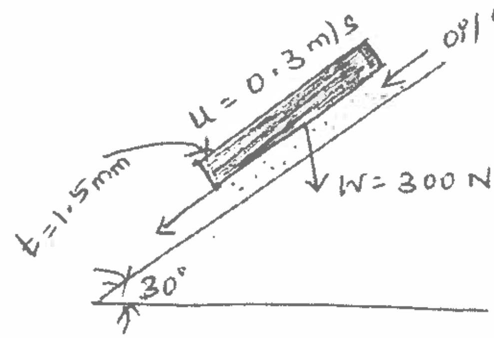
1) A textbook of Fluid Mechanics and Hydraulic Machines by R.K Bansal.
2) A textbook of Fluid Mechanics by R.K Rajput
3) Google for some topics.
4) B.N Moodi in Hydraulics Machines.

UNIT - I

FLUID PROPERTIES & FLUID STATISTICS

1. Calculate the dynamic viscosity of an oil, which is used for lubrication between a square plate of size 0.8m x 0.8m and an inclined plane with angle of inclination 30° as shown in fig. The weight of square plate is 300 N and it slides down the inclined plane with a uniform velocity of 0.3 m/s. The thickness of oil film is 1.5mm.

[NOV / Dec 2012]



Given:- Size of plate = 0.8m x 0.8m

Angle of plane = $\theta = 30°$

Wt. of plate = 300 N

Velocity of plate = $u = 0.3 m/s$

Thickness of oil film = $t = dy = 1.5 mm = 1.5 \times 10^{-3} m$

To find:- The dynamic viscosity of oil (μ)

Soln:- Component of weight 'W' along the plane =

$= W \cos 60°$

$= 300 \times \cos 60°$

$= 150 N$

∴ Shear force F, on the bottom surface of the

Shear stress $\tau = \frac{F}{Area}$

$= \frac{150}{0.8 \times 0.8}$

$\boxed{\tau = 234.375 \ N/m^2}$

$\tau = \mu \left[\frac{du}{dy}\right]$

du = change of velocity = u − 0

$du = u - 0$

$= \boxed{u = 0.3 \ m/s}$

$\boxed{dy = t = 1.5 \times 10^{-3} \ m}$

$\tau = \mu \left[\frac{du}{dy}\right]$

$234.375 = \mu \times \left[\frac{0.3}{1.5 \times 10^{-3}}\right]$

$\boxed{\mu = 1.17 \ NS/m^2}$

$\mu = 1.17 \times 10$

$\boxed{\mu = 11.7 \text{ poise}}$ $\quad \because \boxed{1 \text{ poise} = \frac{1}{10} \frac{NS}{m}}$

(2) A 400 mm diameter shaft is rotating at 200 rpm in a bearing length 120 mm. If the thickness of oil film is 1.5 mm and the dynamic viscosity of the oil film is 0.7 NS/m2, determine

(a) Torque required to overcome friction in bearing
(b) power utilized in overcoming viscous resistance
Assume a linear velocity profile [Nov/Dec - 2013]

Given:-

Diameter = D = 400 mm = 0.4 m

Speed of shaft = N = 200 rpm

Bearing length = L = 120 mm = 0.12 m

Thickness of oil film = t = 1.5 mm = 1.5×10^{-3} m

Viscosity of oil μ = 0.7 NS/m²

To find:- (a) Torque required

(b) power utilized.

Soln:-

Velocity of shaft $u = \frac{\pi D N}{60}$

$$u = \frac{3.14 \times 0.4 \times 200}{60}$$

$$\boxed{u = 4.187 \text{ m/s}}$$

$$\tau = \mu \cdot \left[\frac{du}{dy}\right]$$

$du = u - 0 = u = 4.187$ m/s

$dy = t = 1.5 \times 10^{-3}$ m

$$\tau = \mu \left[\frac{du}{dy}\right]$$

$$\tau = \frac{0.7 \times 4.187}{1.5 \times 10^{-3}} = 1953.9 \text{ N/m}^2$$

$$\boxed{\tau = 1953.9 \text{ N/m}^2}$$

Torque on shaft = Force × D/2

Force F = Stress × Area

$= \tau \times \pi D L$

$= 1953.9 \times 3.14 \times 0.4 \times 0.12$

$$F = 294.49 \text{ N}$$

$$T = F \times D/2$$

$$= \frac{294.49 \times 0.4}{2} = 58.89 \text{ Nm}$$

$$T = 58.89 \text{ Nm}$$

$$\text{Power lost} = \frac{2 \pi N T}{60}$$

$$= \frac{2 \times 3.14 \times 200 \times 58.89}{60}$$

$$\text{Power lost} = 1232.76 \text{ W}$$

---

(3) A trapezoidal channel 2m wide at the bottom and 1m deep has side slope 1:1, determine

(i) Total pressure

(ii) centre of pressure on the vertical gate closing the channel when it is full of water

[Nov/Dec 2013]

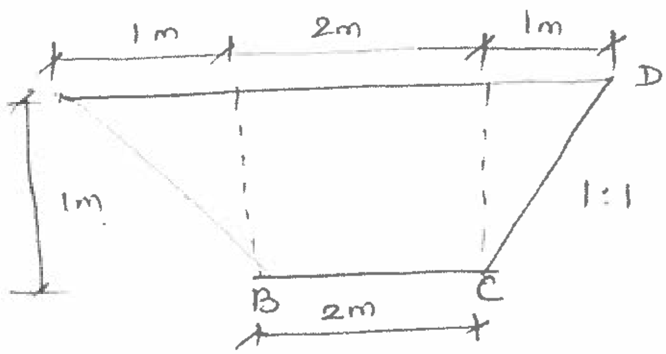
Given :- width at bottom = 2 m

Depth d = 1 m

Side slopes = 1:1

To find:-

(i) Total pressure
(ii) Centre of pressure



Soln.

The distance of the C.G of the trapezoidal channel from surface

$$x = \left[\frac{2a+b}{a+b}\right] \times \frac{h}{3}$$

$a = 2m$
$b = 4m$
$h = 1m$

$$x = \left[\frac{(2\times 2)+(4)}{(2+4)}\right] \times \frac{1}{3} = 0.444\ m$$

$$\boxed{\bar{h} = x = 0.444m}$$

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

$\rho = 1000\ kg/m^3$, $A = \left(\frac{a+b}{2}\right) \times h$

$F = 1000 \times 9.81 \times A \times 0.444$

$$A = \left[\frac{2+4}{2}\right] \times 1 = 3m^2$$

$$\boxed{A = 3m^2}$$

$$\boxed{F = 13079\ N}$$

Centre of Pressure $h^* = \frac{I_G}{A\bar{h}} + \bar{h}$

$$I_G = \left[\frac{a^2 + 4ab + b^2}{36(a+b)}\right] \times h^3$$

$$= \left[\frac{(2)^2 + (4 \times 2 \times 4) + (4)^2}{36(2+4)}\right] \times (1)^3$$

$$\boxed{I_G = 0.2407\ m^4}$$

$$h^* = \left[\frac{0.2407}{3 \times 0.444}\right] + 0.444$$

$$\boxed{h^* = 0.625\ m}$$

Ans:-

Total pressure $F = 13079\ N$

Centre of pressure $h^* = 0.625\ m$

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(4) A vertical gap 2.2 cm wide of infinite extent contains a fluid of viscosity 2.0 NS/m² and Sp. gravity 0.9. A metallic plate 1.2 m × 1.2 m × 0.2 cm is to be lifted up with a constant velocity of 0.15 m/sec through the gap. If the plate is in the middle of the gap. Find the force required. The weight of the plate is 40 N. [May / June 2014]

Given :-

Width of gap = 2.2 cm

Viscosity $\mu = 2.0 \, NS/m^2$

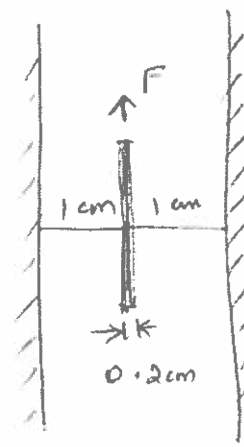
Sp. gravity of fluid = 0.9

Wt. density of fluid $\rho = 0.9 \times 1000$

$= 900 \, kg/m^3$ $\quad$ $\because 1 kg = 9.81 N$

$= 900 \times 9.81$

$$\rho = 8829 \, N/m^3$$



Vol. of plate = $1.2m \times 1.2m \times 0.2 cm$

$= 1.2 \times 1.2 \times 0.2 \times 10^{-2}$

$= 2.88 \times 10^{-3} \, m^3$

Velocity of plate = 0.15 m/s

Thickness of plate = 0.2 cm = 2×10^{-3} m

Wt. of plate = 40 N.

When the plate is in the middle of the gap, the distance of the plate from vertical surface of the gap =

$$= \frac{\text{Width of gap} - \text{thickness of plate}}{2}$$

$$= \frac{2.2 - 0.2}{2} = 1 \, cm = 0.01 \, m$$

S.F of the left side of the plate = F_1 = shear stress × area.

$$F_1 = \mu \left[\frac{du}{dy}\right] \times \text{Area}$$

$du = u = 0.15\ m/s$

$dy = t = 0.01\ m$

$F_1 = 2 \times \left[\frac{0.15}{0.01}\right] \times 1.2 \times 1.2$

$\boxed{F_1 = 43.2\ N}$

Similarly, the S.F on the right side of the metallic plate.

F_2 = Shear stress × Area

$= \mu \left[\frac{du}{dy}\right] \times$ Area

$= 2 \times \left[\frac{0.15}{0.01}\right] \times 1.2 \times 1.2$

$\boxed{F_2 = 43.2\ N}$

Total S.F $F = F_1 + F_2$

$\boxed{F = 86.4\ N}$

In this case the weight of plate (which is acting vertically downward) and upward thrust is also to be taken into account.

The upward thrust = wt. of fluid displaced.

= [wt. density of fluid] × [vol. of fluid displaced]

$= 8829 \times 0.00288$

The upward thrust = 25.43 N.

The net force acting in the downward direction due to wt. of the plate & upward thrust

= Wt. of plate − upward thrust

= 40 − 25.43

= 14.57 N.

∴ Total force reqd. to lift the plate up = Total shear force + 14.57

= 86.4 + 14.57

Total force reqd = 100.97 N

(5) Calculate the capillary rise in millimetres in a glass tube of 4 mm dia. when immersed in (i) water (ii) mercury. The temperature of the liquid is 20°c and the values of surface tension of water & mercury in contact with air are 0.735 N/m and 0.51 N/m respectively. The contact angle for water θ = 0° and for mercury θ = 130°. Take specific wt. of water at 20° c as equal to 9790 N/m³ [NOV/DEC 2012]

<u>Given:-</u> dia of tube = 4 mm = 4×10^{-3} m

Surface tension of water = 0.735 N/m

Surface tension of mercury = 0.51 N/m

Contact angle for water θ = 0°.

Contact angle for mercury θ = 130°.

Sp. wt. of water $= 9790\ N/m^3 = \rho_w$

Sp gravity of mercury $= \rho_g = 13.6$

$\therefore = 13.6 \times 1000 = 13600\ kg/m^3$

To find (i) capillary rise when immersed in water

$$h = \frac{4\sigma}{\rho g d} = \frac{4 \times 0.735}{9790 \times 9.81 \times 4 \times 10^{-3}}$$

$h = 7.653 \times 10^{-3}\ m$

$\because \cos\theta = \cos(0) = 1$

$$\boxed{h = 7.653\ mm}$$

(ii) Capillary Rise for mercury

$$h = \frac{4\sigma \cos\theta}{\rho g d}$$

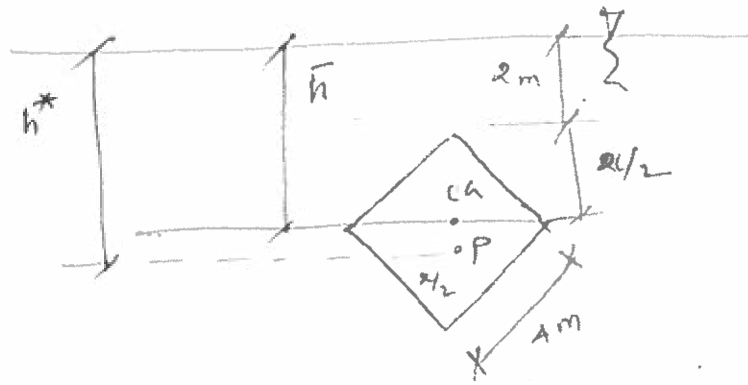
$$= \frac{4 \times 0.51 \times \cos(130°)}{13600 \times 9.81 \times 4 \times 10^{-3}}$$

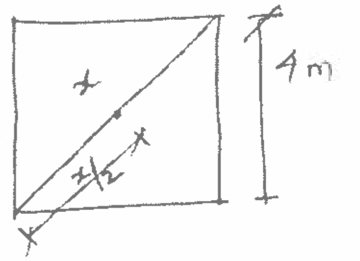
$= -2.45 \times 10^{-3}\ m$

$$\boxed{h = -2.45\ mm}$$

–ve sign indicates capillary depression.

(6) A square plate of 4 m sides is immersed vertically in water. One of its diagonal is vertical and the nearest corner from the surface of water is 2 m. Compute total pressure and centre of pressure.





$x = \sqrt{4^2 + 4^2}$

$x = 5.65\,m$

Given:- Size of plate $4m \times 4m$.

Note:- If one of its diagonal is vertical $\theta = 90°$

To find:- Total pressure & centre of pressure.

(i) Total Pressure $F = \rho g A \bar{h}$

$$\bar{h} = 2 + \frac{x}{2}$$

$$= 2 + \frac{5.65}{2} = 4.82\,m$$

$$\bar{h} = 4.82\,m$$

$$A = 4 \times 4 = 16\,m^2$$

$$F = 1000 \times 9.81 \times 16 \times 4.82$$

$$F = 757803\ N$$

(ii) centre of pressure $h^* = \frac{I_G \sin^2\theta}{A\bar{h}} + \bar{h}$

I_G = 2 x M.I about base of one triangle

$= 2 \times \left[\frac{bh^3}{12}\right]$

$= 2 \times \left[\frac{2.825 \times (2.825)^3}{12}\right]$

$b = \frac{5.65}{2}$

$b = 2.825$

$h = 2.825$

$I_G = 10.61\ m^4$

$h^* = \left[\frac{10.61 \times \sin^2(90^\circ)}{16 \times 4.82}\right] + 4.82$

$h^* = 4.95\ m$

(7) A simple U-tube manometer containing mercury is connected to a pipe in which a fluid of sp. gravity 0.8 & having vacuum pressure in pipe, if the difference of mercury level in the two limb is 40 cm and the height of fluid in the left limb from the center of pipe is 15 cm below.

Given:- Sp. gravity of fluid $S_1 = 0.8$

Sp. gravity of mercury $S_2 = 13.6$

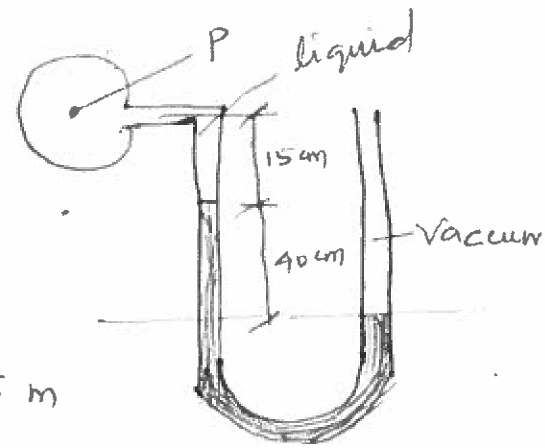
$\rho_1 = S_1 \times 1000 \Rightarrow 0.8 \times 1000$.

$\rho_1 = 800\ kg/m^3$

$\rho_2 = S_2 \times 1000$

$= 13.6 \times 1000$

$\boxed{\rho_2 = 13600 \text{ kg/m}^3}$



height of liquid $h_1 = 15\text{ cm} = 0.15\text{ m}$

" " mercury $h_2 = 40\text{ cm} = 0.40\text{m}$

Pressure head above the left limb is equal to pressure head above the right limb.

$$P + \rho_1 g h_1 + \rho_2 g h_2 = 0.$$

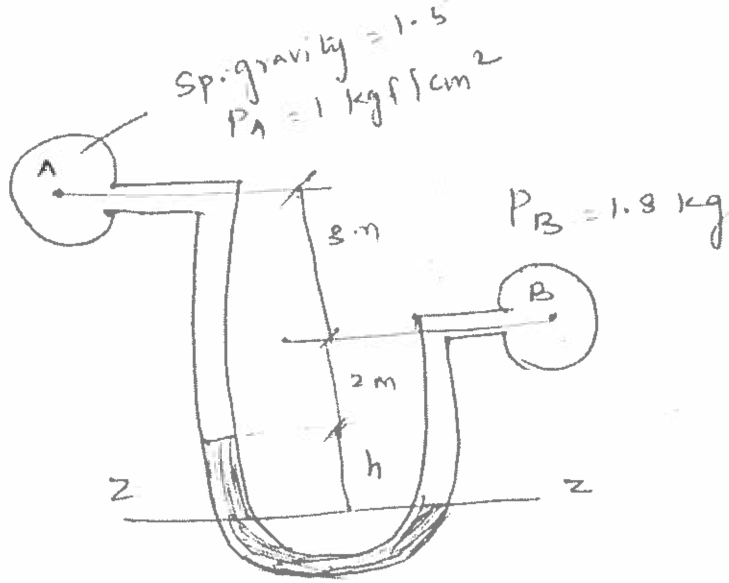
$$P + [800 \times 9.81 \times 0.15] + [13600 \times 9.81 \times 0.40] = 0.$$

$$P + 1177.2 + 53366.4 = 0.$$

$$\boxed{P = -54543.6 \text{ N/m}^2}$$

-ve sign indicates the vacuum pressure

(8) A differential manometer is connected at the two points A and B of two pipes as shown in fig. The pipe A contains a liquid of sp. gravity 1.5, while pipe B contains a liquid of sp. gravity 0.9. The pressure at A & B are 1 kgf/cm² & 1.80 kgf/cm² respectively. Find the difference in mercury level in the differential manometer.



Given :-

$S_1 = 1.5$ (pipe A)

$S_m = 13.6$

$\rho_1 = 1.5 \times 1000 = 1500\ kg/m^3$

$\rho_m = 13.6 \times 1000 = 13600\ kg/m^3$

$P_A = 1\ kgf/cm^2$

$P_A = 1 \times 9.81 \times 10^4\ N/m^2$

$P_B = 1.8\ kgf/cm^2$

$= 1.8 \times 9.81 \times 10^4\ N/m^2$

$S_2 = 0.9$ (pipe B)

$\rho_2 = 0.9 \times 1000 = 900\ kg/m^3$

To find: Difference in mercury level = h.

Pressure above zz axis

$$P_A + \rho_1 g h_1 + \rho_m g h_m = \rho_2 g (h+2) + P_B$$

$$[9.81 \times 10^4] + [1500 \times 9.81 \times (3+2)] + [13600 \times 9.81 \times h] =$$

$$900 \times 9.81\ [h+2] + [1.8 \times 9.81 \times 10^4]$$

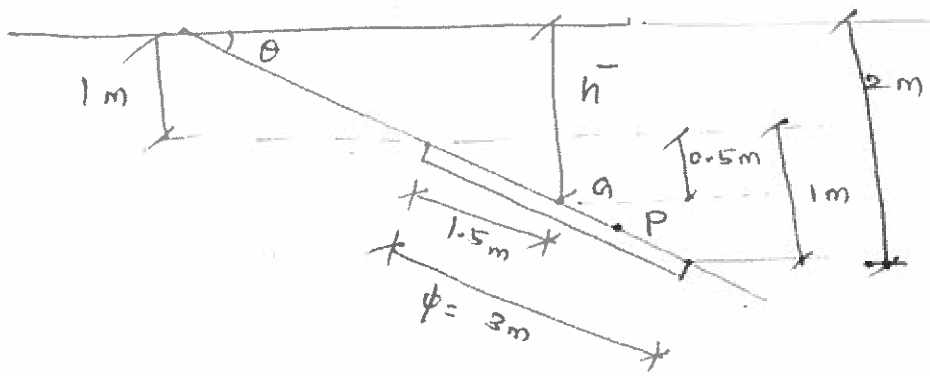
$124587\, h = 22563$

$h = 0.181\ m$

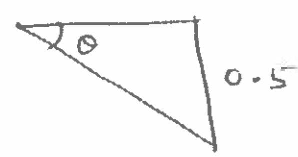
$$\boxed{h = 181\ mm}$$

Ans:- Difference in mercury level is $\boxed{h = 181\ mm}$

(9) A circular plate, 3m dia is submerged in water, so that the distance of its perimeter measured vertically below the water surface varies between 1m & 2m. Find (i) Total pressure (ii) Centre of pressure.



Given:- dia of circular plate = 3m



To find:-

(i) Total pressure (ii) centre of pressure.

Soln:- Total pressure F

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

$$A = \frac{\pi d^2}{4} = \frac{\pi \times (3)^2}{4} = 7.065\ m^2$$

$$\boxed{A = 7.065\ m^2}$$

C.G $\bar{h} = 1 + (0.5) = 1.5\ m$

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

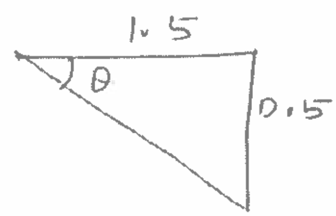
$= 1000 \times 9.81 \times 7.065 \times (1.5)$

$F = 103961.4\ N$

(ii) Centre of pressure

$$h^* = \frac{I_{G} \cdot \sin^2\theta}{A\bar{h}} + \bar{h}$$

$\sin\theta = ?$



$$\sin\theta = \frac{0.5}{1.5}$$

$\sin\theta = 0.333$

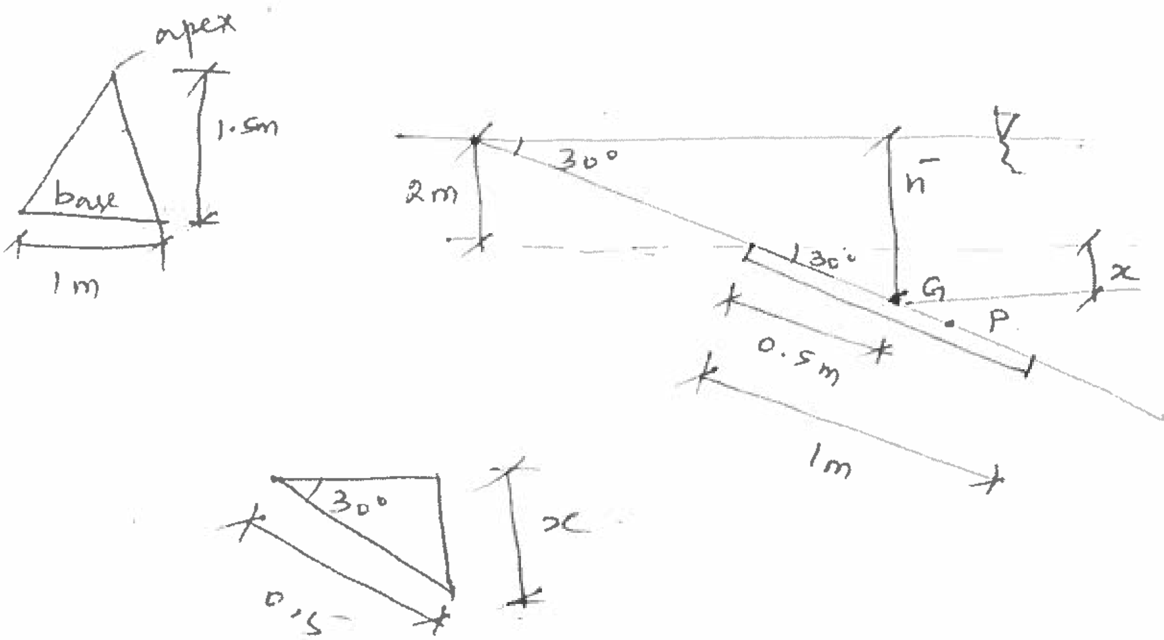
$$I_{G} = \frac{\pi d^4}{64} = \frac{\pi \times (3)^4}{64}$$

$I_{G} = 3.976\ m^4$

$$h^* = \left[\frac{3.976 \times (0.333)^2}{7.065 \times 1.5}\right] + 1.5$$

$h^* = 1.541\ m$ Centre of pressure

(10) A triangular plate 1m base & 1.5m height is immersed in water at an angle of 30° to the free surface of water. The base is parallel to and at a depth of 2m from the free water surface. The apex is below the base. Find Total pressure and centre of pressure



$$\sin 30^\circ = \frac{x}{0.5}$$

$$x = 0.5 \sin 30^\circ$$

$$x = 0.25m$$

Given:-

base of plate = 1.0m

height of plate = 1.5m

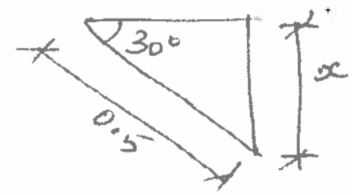
To find: (i) Total Pressure (ii) Centre of Pressure

(i) Total pressure $F = \rho g A \bar{h}$

$A = \frac{1}{2} bh$

$= \frac{1}{2} \times 1 \times 1.5$

$A = 0.75 \, m^2$



$\sin 30^\circ = \frac{x}{0.5}$

$x = 0.5 \sin 30^\circ$

$x = 0.25 \, m$

$\bar{h} = 2 + x$

$= 2 + 0.25$

$\bar{h} = 2.25 \, m$

$F = 1000 \times 9.81 \times 0.75 \times 2.25$

$F = 16554.3 \, N$

(ii) Centre of pressure

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

$$I_G = \frac{bh^3}{36} = \frac{1 \times (1.5)^3}{36} = 0.094 \, m^4$$

about base

$$h^* = \left[\frac{0.094 \times \sin^2(30^\circ)}{0.75 \times 2.25}\right] + 2.25$$

$h^* = 2.264 \, m$ centre of pressure.

FLUID KINEMATICS & DYNAMICS

CONTINUITY EQUATION

For, 3-D Flow, The Continuity equation is

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z} = 0$$ [For an incompressible steady flow]

For, 2-D Flow, The Continuity equation is

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

STREAM FUNCTION (ψ)

for steady flow $\psi = f(x, y)$

$$u = -\frac{\partial \psi}{\partial y}, \quad V = \frac{\partial \psi}{\partial x}$$

In Polar co-ordinates

$$V_r = -\frac{\partial \psi}{r . \partial \theta}, \quad V_\theta = \frac{\partial \psi}{\partial r}$$

Note:- The existence of ψ means a possible case of fluid flow, The flow may be rotational or irrotational

For irrotational flow,

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0$$

This is the Laplace equation for ψ.

* If stream function (ψ) exists, it is a possible case of fluid flow
* If stream function (ψ) satisfies Laplace equation, it is a possible case of an irrotational flow

Velocity potential Function [ϕ]

for steady flow $\phi = f(x, y, z)$

$$u = \frac{-\partial \phi}{\partial x}, \quad v = \frac{-\partial \phi}{\partial y}, \quad w = \frac{-\partial \phi}{\partial z}$$

u, v, w are the components of velocity in x, y and z directions respectively.

Laplace equation of ϕ [for 2-D case]

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0$$

Note:-

* If velocity potential (ϕ) exists, the flow should be irrotational
* If velocity potential (ϕ) satisfies, the Laplace equation, it represents the possible steady incompressible irrotational flow.

Relation between Stream function (ψ) and potential function (ϕ)

$$u = -\frac{\partial \psi}{\partial y}, \quad v = \frac{\partial \psi}{\partial x} \quad \text{(velocity components in terms of stream function)} \qquad (1)$$

Velocity components in terms of potential function

$$u = -\frac{\partial \phi}{\partial x}, \quad v = -\frac{\partial \phi}{\partial y} \quad \text{——} (2)$$

By comparing (1) & (2)

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

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

$$\boxed{\frac{\partial \phi}{\partial x} = \frac{\partial \psi}{\partial y} \quad \& \quad -\frac{\partial \phi}{\partial y} = \frac{\partial \psi}{\partial x}}$$

Cauchy - Rieman Equation

1. The Stream function for a two dimension flow is given by $\psi = 8xy$. calculate the velocity at the point (4,5). Find the velocity potential function ϕ.

Soln:

$$\psi = 8xy.$$

for the given velocity components

$$\frac{\partial \psi}{\partial x} = 8y = v$$

$$\frac{\partial \psi}{\partial y} = 8x = -u$$

Since

$$u = -\frac{\partial \psi}{\partial y}$$

$$v = \frac{\partial \psi}{\partial x}$$

∴ at the point (4,5)

$$-u = 8x$$

$$-u = 8(4) = 32$$

∴ $\boxed{u = 32 \text{ units}}$

$V = 8y$

$= 8 \times 5 = 40$

$\boxed{V = 40 \text{ units}}$

To find velocity potential function ϕ.

$u = -\frac{\partial \phi}{\partial x}$, $V = -\frac{\partial \phi}{\partial y}$

$u = -\frac{\partial \phi}{\partial x}$

$-8x = -\frac{\partial \phi}{\partial x}$

$8x = \frac{\partial \phi}{\partial x}$

$\boxed{\frac{\partial \phi}{\partial x} = 8x}$ —— (1)

$\because 8x = -u$

$\boxed{u = -8x}$

$V = -\frac{\partial \phi}{\partial y}$

$V = 8y$

$8y = -\frac{\partial \phi}{\partial y}$

$\boxed{\frac{\partial \phi}{\partial y} = 8y}$ —— (2)

$\frac{\partial \phi}{\partial x} = 8x$

Integrating w.r.to x (equ. (1))

$\phi = \frac{8x^2}{2} + K$.

$\phi = 4x^2 + K$ —— (3)

Differentiating equ. (3) w.r.to y.

$$\frac{\partial \phi}{\partial y} = \frac{\partial K}{\partial y} \quad \text{------} \quad (4)$$

Substituting the value of $\frac{\partial \phi}{\partial y} = -8y$ in equ (4)

$$-8y = \frac{\partial K}{\partial y} \quad - (5)$$

integrating equ (5) w.r.to y

$$\frac{-8y^2}{2} = K$$

$$\boxed{K = -4y^2}$$

Sub. the value of K in equ (3)

$$\phi = 4x^2 + K$$

$$\boxed{\phi = 4x^2 - 4y^2}$$

2. The velocity components in a two dimensional flow field for an incompressible flow field are expressed as

$u = \frac{y^3}{3} + 2x - x^2 y$, $V = xy^2 - 2y - \frac{x^3}{3}$.

(i) Show that these functions represents a possible case of an irrotational flow

(ii) Obtain an expression for stream function (ψ) and velocity potential function (ϕ) [Apr/May 2013]

Soln:

$$u = \frac{y^3}{3} + 2x - x^2 y$$

$$V = xy^2 - 2y - \frac{x^3}{3}$$

From the given velocity components

$$\frac{\partial u}{\partial x} = 2 - 2xy$$

$$\frac{\partial v}{\partial y} = 2xy - 2$$

Continuity eqn. for 2-D flow

$$\boxed{\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0}$$

If the above velocity components satisfy the Laplace equation, the flow is possible case of an irrotational flow

$$\therefore \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 2 - 2xy + 2xy - 2 = 0.$$

The case is possible

(ii) To obtain the expression for stream function (ψ)

$$u = -\frac{\partial \psi}{\partial y}$$

$$\frac{\partial \psi}{\partial y} = -u$$

$$\frac{\partial \psi}{\partial y} = -\left(\frac{y^3}{3} + 2x - x^2 y\right)$$

$$\frac{\partial \psi}{\partial y} = x^2 y - 2x - \frac{y^3}{3} \quad \text{--- (1)}$$

Integrating eqn (1) w.r.to 'x'

$$v = \frac{\partial \psi}{\partial x}$$

$$\frac{\partial \psi}{\partial x} = xy^2 - 2y - \frac{x^3}{3} \quad \text{--- (2)}$$

Integrating eqn (2) w.r.to x

$$\psi = \frac{x^2}{2} y^2 - 2xy - \frac{x^4}{12} + C \quad \text{--- (3)}$$

Differentiating eqn (3) w.r.to 'y'

$$\frac{\partial \psi}{\partial y} = \frac{x^2}{2} \times 2y - 2x + \frac{\partial c}{\partial y}$$

$$\frac{\partial \psi}{\partial y} = x^2 y - 2x + \frac{\partial c}{\partial y} \quad \text{--- (4)}$$

equating (1) & (4)

$$x^2y - 2x - \frac{y^3}{3} = x^2y - 2x + \frac{\partial c}{\partial y}$$

$$\frac{-y^3}{3} = \frac{\partial c}{\partial y}$$

$$\frac{\partial c}{\partial y} = \frac{-y^3}{3} \quad \text{--- (5)}$$

to find c, Integrate equ (5) w.r.to y

$$\boxed{C = \frac{-y^4}{12}}$$

Sub 'c' in (3)

$$\boxed{\psi = \frac{x^2}{2}y^2 - 2xy - \frac{x^4}{12} - \frac{y^4}{12}}$$

In case (ii) According to the Potential function

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

$$\frac{y^3}{3} + 2x - x^2y = -\frac{\partial \phi}{\partial x} \qquad xy^2 - 2y - \frac{x^3}{3} = -\frac{\partial \phi}{\partial y}$$

$$\frac{\partial \phi}{\partial x} = x^2y - 2x - \frac{y^3}{3} \quad \text{--- (1)} \qquad \frac{\partial \phi}{\partial y} = \frac{x^3}{3} - xy^2 + 2y \quad \text{--- (2)}$$

Integrate (1) w.r.t x.

$$\phi = \frac{x^3y}{3} - \frac{2x^2}{2} - \frac{y^3x}{3} + c$$

$$\phi = \frac{x^3y}{3} - x^2 - \frac{y^3x}{3} + c \quad \text{--- (3)}$$

Differentiate ③ w.r.to y

$$\frac{\partial \phi}{\partial y} = \frac{x^3}{3} - \frac{3y^2 x}{3} + \frac{\partial c}{\partial y}$$

$$\frac{\partial \phi}{\partial y} = \frac{x^3}{3} - y^2 x + \frac{\partial c}{\partial y} \quad \text{—— ④}$$

equate ② & ④.

$$\frac{x^3}{3} - xy^2 + 2y = \frac{x^3}{3} - y^2 x + \frac{\partial c}{\partial y}$$

$$\frac{\partial c}{\partial y} = 2y \quad \text{—— ⑤}$$

Integrate ⑤ w.r.to y

$$c = \frac{2y^2}{2}$$

$$\boxed{c = y^2}$$

Sub ⓒ in ③

$$\boxed{\phi = \frac{x^3 y}{3} - \frac{y^3 x}{3} - x^2 + y^2}$$

---

③ The velocity Potential (ϕ) is given by an expression

$$\phi = -\frac{xy^3}{3} - x^2 + \frac{x^3 y}{3} + y^2$$

(i) find the velocity components in x and y direction.

(ii) Show that ϕ represents a possible case of flow

Soln :-

$$\phi = \frac{-xy^3}{3} - x^2 + \frac{x^3 y}{3} + y^2$$

Velocity components

The partial derivative of ϕ w.r.t x & y are

$$\frac{\partial\phi}{\partial x} = \frac{-y^3}{3} - 2x + \frac{3x^2y}{3} \quad (\text{w.r.to } x) \text{ — } (1)$$

$$\frac{\partial\phi}{\partial y} = -\frac{3xy^2}{3} + \frac{x^3}{3} + 2y \quad (\text{w.r.to } y) \text{ — } (2)$$

The velocity components u and v are

$$u = -\frac{\partial\phi}{\partial x} = -\left[\frac{-y^3}{3} - 2x + \frac{3x^2y}{3}\right]$$

$$= \frac{y^3}{3} + 2x - \frac{3x^2y}{3}$$

$$\boxed{u = \frac{y^3}{3} + 2x - x^2y}$$

$$v = -\frac{\partial\phi}{\partial y}$$

$$= -\left[\frac{-3xy^2}{3} + \frac{x^3}{3} + 2y\right]$$

$$\boxed{v = xy^2 - \frac{x^3}{3} - 2y}$$

(ii) The given value of ϕ, will represent a possible case of flow if it satisfies the Laplace equation i.e.,

$$\frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} = 0$$

from eqn (1) & (2)

$$\frac{\partial\phi}{\partial x} = -\frac{y^3}{3} - 2x + \frac{3x^2y}{3}$$

$$\frac{\partial\phi}{\partial x} = -\frac{y^3}{3} - 2x + x^2y$$

$$\frac{\partial^2\phi}{\partial x^2} = -2 + 2xy$$

$$\frac{\partial \phi}{\partial y} = -xy^2 + \frac{x^3}{3} + 2y$$

$$\frac{\partial^2 \phi}{\partial y^2} = -2xy + 2.$$

$$\frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0.$$

$$-2 + 2xy - 2xy + 2 = 0.$$

$\therefore$ Laplace equation is satisfied and hence ϕ represent a possible case of flow

(4) Derive the Euler's equation of motion for steady flow of an ideal fluid. Using Euler's equation, derive the Bernoulli's equation and also write down the assumption made in the derivation of the above equation
[MAY/ JUNE 2013]

Soln:- This is equation of motion in which the forces due to gravity and pressure are taken into consideration

This is derived by considering the motion of a fluid element along a stream-line as.

Consider a stream-line in which the flow is taking place in S-direction as shown in fig

Consider a cylindrical element of c/s dA and length ds.

The forces acting on the cylindrical element are

1. pressure force $p.dA$ in the direction of flow.
2. pressure force $\left[p + \frac{\partial p}{\partial s} \cdot ds\right] dA$ opposite to the direction of flow.

3. Weight of element $\rho g \cdot dA \cdot ds$

Let 'θ' is the angle between the direction of flow and the line of action of the weight of element.

The resultant force on the fluid element in the direction of 's' must be equal to the mass of fluid element × acceleration in the direction 's'.

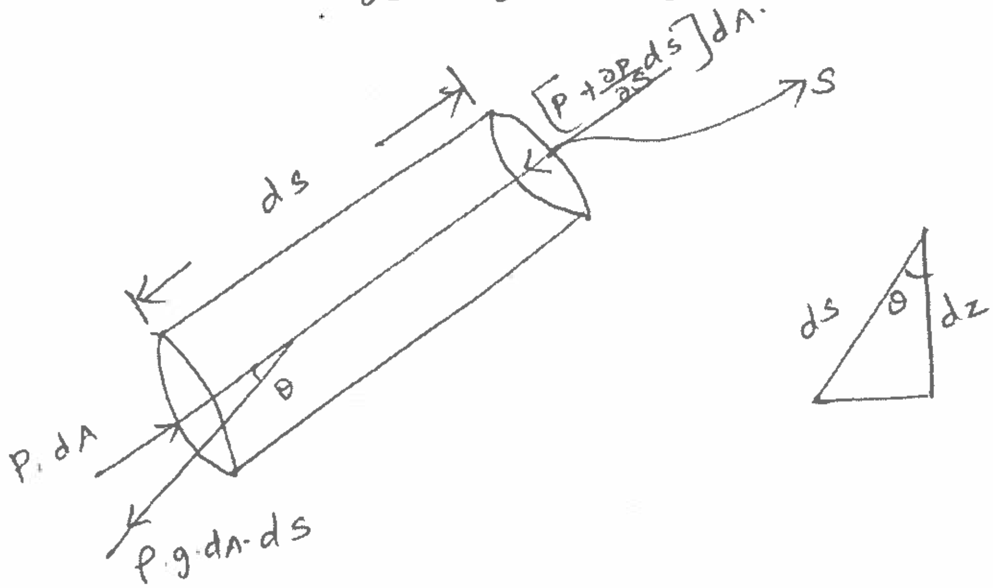
$$P \cdot dA - \left[P + \frac{\partial p}{\partial s} ds\right] dA - \rho \cdot g \cdot dA \cdot ds \cdot \cos\theta = \rho dA \cdot ds \times a_s \quad \text{——(1)}$$

$a_s \rightarrow$ acceleration in the direction 's'

$a_s = \frac{dv}{dt}$, where 'v' is a function of s and t.

$$a_s = \frac{\partial v}{\partial s} \cdot \frac{ds}{dt} + \frac{\partial v}{\partial t}$$

$$= v \cdot \frac{\partial v}{\partial s} + \frac{\partial v}{\partial t} \quad \left\{ \because \frac{ds}{dt} = v \right\}$$



If the flow is steady, $\frac{\partial v}{\partial t} = 0$

$$a_s = v \cdot \frac{\partial v}{\partial s}$$

Sub the value of a_s in equ (1).

$$p.dA - \left[p + \frac{\partial p}{\partial s} \cdot ds\right] dA - \rho g \cdot dA \cdot ds \cdot \cos\theta = \rho \cdot dA \cdot ds \times a_s$$

$$p.dA - p dA - \frac{\partial p}{\partial s} \cdot ds\, dA - \rho g \cdot dA\, ds \cdot \cos\theta = \rho \cdot dA \cdot ds \times v \cdot \frac{\partial v}{\partial s}$$

$$-\frac{\partial p}{\partial s} \cdot ds \cdot dA - \rho g \cdot dA \cdot ds \cos\theta = \rho \cdot dA \cdot ds \times v \cdot \frac{\partial v}{\partial s} \quad \text{—(2)}$$

dividing by $\rho \cdot ds \cdot dA$ equ (2) becomes

$$-\frac{\partial p}{\rho \cdot \partial s} - g \cos\theta = v \cdot \frac{\partial v}{\partial s}$$

$$\frac{\partial p}{\rho \cdot \partial s} + g \cos\theta + v \cdot \frac{\partial v}{\partial s} = 0$$

from fig. $\boxed{\cos\theta = \frac{dz}{ds}}$

$$\frac{1}{\rho} \cdot \frac{dp}{ds} + g \cdot \frac{dz}{ds} + \frac{v \cdot dv}{ds} = 0$$

(or) $\boxed{\frac{dp}{\rho} + g \cdot dz + v \cdot dv = 0} \rightarrow (3)$

Equ (3) is known as Euler's equation of motion

Bernoulli's equation:-

Bernoulli's equation is obtained by integrating the Euler's equation of motion

$$\frac{dp}{\rho} + g\, dz + v \cdot dv = 0 \rightarrow \text{Euler's equ}$$

$$\int \frac{dp}{\rho} + \int g \cdot dz + \int v \cdot dv = 0 \quad \text{constant.}$$

If the flow is incompressible, ρ is constant

and $\frac{p}{\rho} + gz + \frac{v^2}{2} = \text{Constant}$ ——— (1)

÷ by g

$\frac{p}{\rho g} + z + \frac{v^2}{2g} = \text{Constant}$

$$\boxed{\frac{p}{\rho g} + \frac{v^2}{2g} + z = \text{Constant}}$$

Equ (2) is Bernoullis' equation in which

$\frac{p}{\rho g}$ → pressure energy

$\frac{v^2}{2g}$ → Kinetic energy or Kinetic head

z → potential energy or potential head

Assumptions:-

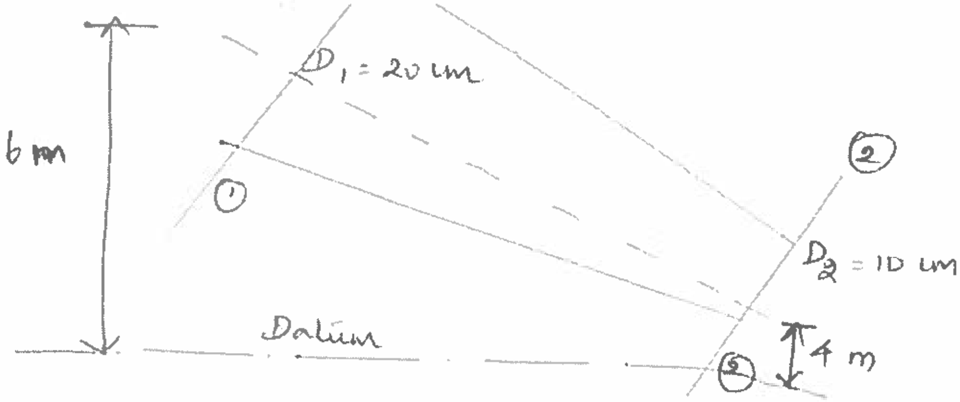
(1) The fluid is ideal, ie viscosity is zero.

(2) The flow is steady

(3) The flow is incompressible

(4) The flow is irrotational.

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



Given :-

$D_1 = 20$ cm $= 0.2$ m

$D_2 = 10$ cm $= 0.1$ m

$P_1 = 39.24$ N/cm^2 $= 39.24 \times 10^4$ N/m^2

$z_1 = 6$ m

$z_2 = 4$ m , $Q = 35$ lit/sec $= 0.035$ m^3/sec.

To find: $P_2 = ?$

Soln:

$$A_1 = \frac{\pi D_1^2}{4} = \pi \frac{(0.2)^2}{4} = 0.314 \text{ m}^2$$

$$A_2 = \frac{\pi D_2^2}{4} = \frac{\pi (0.1)^2}{4} = 0.00785 \text{ m}^2$$

$Q = 0.035$ m^3/s

by using continuity equ.

$$Q = A_1 V_1 = A_2 V_2$$

$$V_1 = \frac{Q}{A_1} = \frac{0.035}{0.314} = 1.114 \text{ m/s}$$

$$V_2 = \frac{Q}{A_2} = \frac{0.035}{0.00785} = 4.456 \text{ m/s}$$

by using Bernoulli equ. at sec ① & ②

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

$$\left[\frac{39.24 \times 10^4}{1000 \times 9.81}\right] + \left[\frac{(1.114)^2}{2 \times 9.81}\right] + 6 = \left[\frac{p_2}{1000 \times 9.81}\right] + \left[\frac{(4.456)^2}{2 \times 9.81}\right] + 4$$

$$40 + 0.063 + 6 = \frac{p_2}{9810} + 1.012 + 4$$

$$46.063 = \frac{p_2}{9810} + 5.012$$

$$P_2 = 41.051 \times 9810 \ N/m^2$$

$$= \frac{41.051 \times 9810}{(10)^4} \ N/cm^2$$

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

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

Given :- $d_1 = 30$ cm $= 0.3$ m

$d_2 = 15$ cm $= 0.15$ m

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

$$= \frac{\pi (30)^2}{4}$$

$$\boxed{a_1 = 706.85 \ cm^2}$$

$d_2 = 15$ cm $= 0.15$ m

$$a_2 = \frac{\pi \times (15)^2}{4}$$

$$\boxed{a_2 = 176.7 \ cm^2}$$

$C_d = 0.98$

Reading of differential manometer = x = 20 cm of mercury.

Diff. of pressure head is given by

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

$S_h \rightarrow$ sp. gravity of mercury = 13.6

$S_o \rightarrow$ " " " water = 1

$$h = 20\left[\frac{13.6}{1} - 1\right]$$

$$\boxed{h = 252 \text{ cm of water}}$$

The discharge thro' Venturimeter is given by

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

$$= 0.98 \times \frac{706.85 \times 176.7}{\sqrt{(706.85)^2 - (176.7)^2}} \times \sqrt{2 \times 9.81 \times 252}$$

$$= \frac{86067593.36}{684.4}$$

$$= 125756 \text{ cm}^3/\text{s}$$

$$\boxed{Q = 125.756 \text{ lit/sec}}$$

$\therefore$ The rate of flow $\boxed{Q = 125.756 \text{ lit/sec}}$

(7) An orificemeter with orifice dia. 10 cm is inserted in a pipe of 20 cm dia. The pressure gauges fitted upstream and downstream of the orificemeter gives readings of 19.62 N/cm^2 and 9.81 N/cm^2 respectively. Co-eff. of discharge for the orificemeter is given as 0.6. Find the discharge of water through pipe.

Given: dia of orifice $d_0 = 10$ cm

Area $a_0 = \frac{\pi \times (10)^2}{4} = 78.54 \text{ cm}^2$

dia of pipe $d_1 = 20$ cm.

Area $a_1 = \frac{\pi \times (20)^2}{4} = 314.16 \text{ cm}^2$.

$p_1 = 19.62 \ N/cm^2$

$p_1 = 19.62 \times 10^4 \ N/m^2$.

$$\frac{p_1}{\rho g} = \frac{19.62 \times 10^4}{1000 \times 9.81} = 20 \text{ m of water.}$$

$$\frac{p_2}{\rho g} = \frac{9.81 \times 10^4}{1000 \times 9.81} = 10 \text{ m of water.}$$

$$h = \frac{p_1}{\rho g} - \frac{p_2}{\rho g} = 20 - 10 = 10 \text{ m of water.}$$

$h = 1000$ cm of water.

$C_d = 0.6$

The discharge equ. $Q = \frac{C_d \cdot a_0 a_1}{\sqrt{a_1^2 - a_0^2}} \times \sqrt{2gh}$

$$Q = \frac{0.6 \times 78.54 \times 314.16}{\sqrt{(314.16)^2 - (78.54)^2}} \times \sqrt{2 \times 981 \times 1000}$$

$$= 68213.28 \ cm^3/s$$

$$\boxed{Q = 68.213 \ lit/s}$$

8. The following data relate to an inclined Venturimeter

Dia. of the pipe line = 400 mm

Inclination of the pipe line with the horizontal = 30°

Throat dia = 200 mm

The distance between the inlet and throat of the meter = 600 mm

Sp. gravity of oil flowing through the pipe line = 0.70

Sp. gravity of heavy U-tube liquid = 13.6

Reading (deflection) of the differential manometer = 50 mm

Determine the rate of flow in the pipe line [Nov / Dec 2013]

Given data:

Dia. of pipe d_1 = 400 mm = 0.4 m

Inclination to vertical, $\theta = 30^\circ$

Throat diameter, d_2 = 200 mm = 0.2 m

Distance, l = 600 mm = 0.6 m

Sp. gravity of oil $S = 0.7$

Sp. gravity of heavy liquid $S_m = 13.6$

Reading from manometer, x = 50 mm = 0.05 m

Solution :-

Area of entrance

$$a_1 = \frac{\pi d_1^2}{4} = \frac{\pi \times (0.4)^2}{4} = 0.1257 \, m^2$$

Area of throat section,

$$a_2 = \frac{\pi d_2^2}{4} = \frac{\pi \times (0.2)^2}{4} = 0.0314 \, m^2$$

$$Z_1 = 0$$

$$Z_2 = 0.2 \times \cos(30^\circ) = 0.173 \, m$$

We know that,

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

$$= 0.05 \left[\frac{13.6}{0.7} - 1 \right] = 0.921 \, m$$

$$\boxed{h = 0.921 \, m}$$

The discharge through the venturimeter is

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

$$= \frac{0.9 \times 0.1257 \times 0.0314}{\sqrt{(0.1257)^2 - (0.0314)^2}} \times \sqrt{2 \times 9.81 \times 0.921}$$

$$= 0.12406 \, m^3/s$$

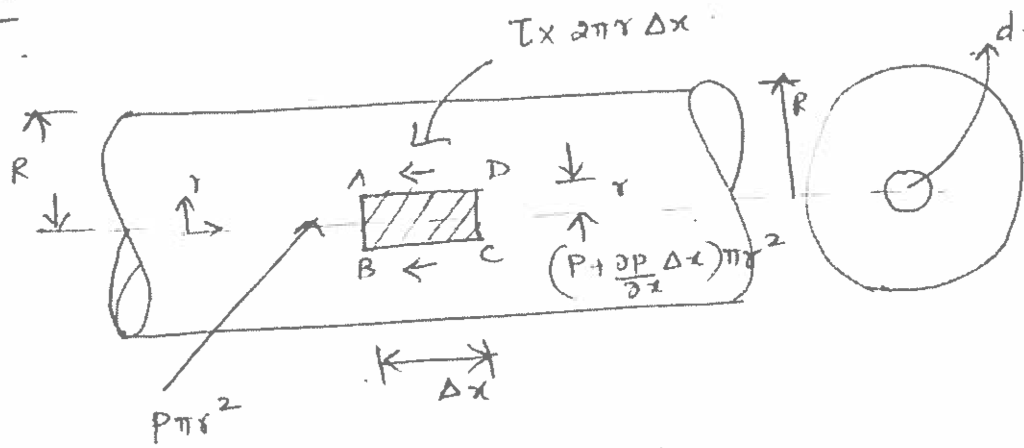
$$\boxed{\because 1 m^3 = 1000 \, lit}$$

$$\boxed{Q = 124.06 \text{ lit/sec}}$$

FLOW THROUGH PIPES

1. Derive an expression for the velocity distribution for the viscous flow through a circular pipe and sketch the shear stress distribution and velocity distribution across the section of the pipe [May/June 2013]

Soln:-



Viscous flow through a pipe

* Consider a hzl. pipe of radius 'R'.
* Viscous flow is from left to Right in the pipe
* Consider a fluid element of radius 'r', sliding in a cylindrical fluid element of radius (r+dr).
* Let the length of fluid element be Δx. 'p' is the intensity of pressure on face CD will be $\left[p + \frac{\partial p}{\partial x} \cdot \Delta x\right]$.

Then the forces acting on the fluid element are.

(1) Pressure force $p \times \pi r^2$ on face AB
(2) " " $\left[p + \frac{\partial p}{\partial x}\Delta x\right]\pi r^2$ on face CD.

(3) The shear force, $\tau \times 2\pi r \cdot \Delta x$ on the surface of fluid element.

As there is no acceleration, the summation of all forces in the direction of flow must be zero.

$$p\pi r^2 - \left[p + \frac{\partial p}{\partial x} \cdot \Delta x\right]\pi r^2 - \tau \times 2\pi r \cdot \Delta x = 0 \quad \text{---(1)}$$

$$-\frac{\partial p}{\partial x} \cdot \Delta x \cdot \pi r^2 - \tau \times 2\pi r \times \Delta x = 0.$$

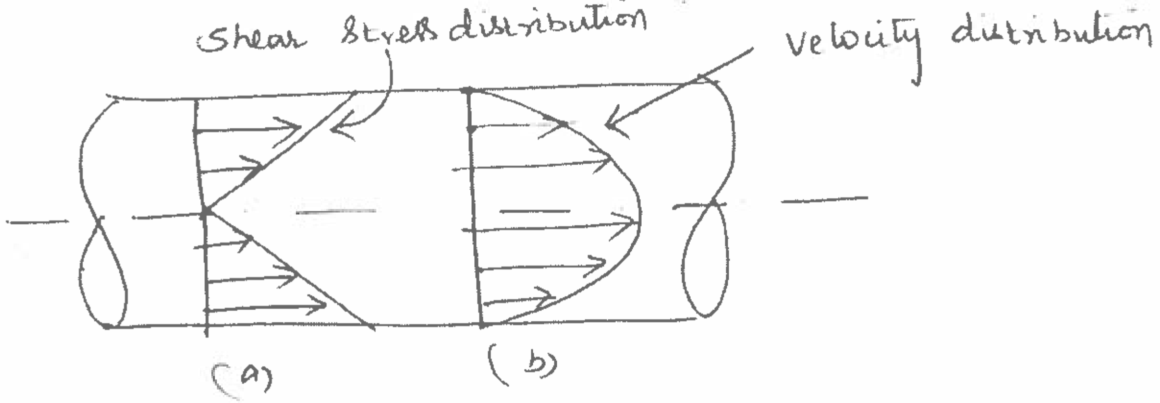
$$-\frac{\partial p}{\partial x} \cdot \Delta x \, \pi r^2 = \tau \times 2\pi r \times \Delta x$$

$$2\tau = -\frac{\partial p}{\partial x} \cdot r$$

$$\boxed{\tau = -\frac{\partial p}{\partial x} \cdot \frac{r}{2}} \quad \text{---(2)}$$

The shear stress 'τ' across a sec. varies with 'r' as $\frac{\partial p}{\partial x}$ across a sec. is constant.

Hence shear stress distribution across a section is linear as shown.



(i) <u>velocity distribution</u>.

To obtain the velocity distribution across a section, the value of shear stress

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

Sub in equ. (2).

But in the relation $\tau = \mu \cdot \frac{du}{dy}$,

y is measured from the pipe wall.

Hence, $y = R - r$ and.

$dy = -dr$

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

$\tau = \mu \cdot \frac{du}{-dr}$

$$\boxed{\tau = -\mu \cdot \frac{du}{dr}} \quad \text{--- (3)}$$

Sub. this value in equ. (2).

$-\mu \cdot \frac{du}{dr} = \frac{-\partial p}{\partial x} \cdot \frac{r}{2}$

$\frac{du}{dr} = \frac{1}{2\mu} \cdot \frac{\partial p}{\partial x} \cdot r.$

integrating the above equ. w.r. to 'r',

$\int \frac{du}{dr} = \frac{1}{2\mu} \frac{\partial p}{\partial x} \cdot \int r.$

$u = \frac{1}{2\mu} \cdot \frac{\partial p}{\partial x} \cdot \frac{r^2}{2} + c$

$$\boxed{u = \frac{1}{4\mu} \cdot \frac{\partial p}{\partial x} \cdot r^2 + c} \quad \text{--- (4)}$$

where, 'c' is the constant of integration and its value is obtained from the boundary condition that at

$$\boxed{r = R, \quad u = 0} \quad \text{--- (5)}$$

Sub. (5) in (4)

$$0 = \frac{1}{4\mu} \cdot \frac{\partial p}{\partial x} R^2 + c$$

$$C = -\frac{1}{4\mu} \cdot \frac{\partial p}{\partial x} \cdot R^2 \rightarrow (6)$$

Sub. (6) in (4)

$$u = \frac{1}{4\mu} \cdot \frac{\partial p}{\partial x} r^2 - \frac{1}{4\mu} \cdot \frac{\partial p}{\partial x} \cdot R^2$$

$$u = -\frac{1}{4\mu} \cdot \frac{\partial p}{\partial x} \left[R^2 - r^2\right] \rightarrow (7)$$

The value of μ, $\frac{\partial p}{\partial x}$ and R are Constant.

∴ The velocity 'u' varies with the square of 'r'.

The equ. (7) is parabola.

This shows the velocity distribution across the section of a pipe is parabolic.

(ii) Ratio of max velocity to Average velocity

The velocity is max, when $r = 0$, in equ (7)

Thus max. velocity U_{max} is obtained as

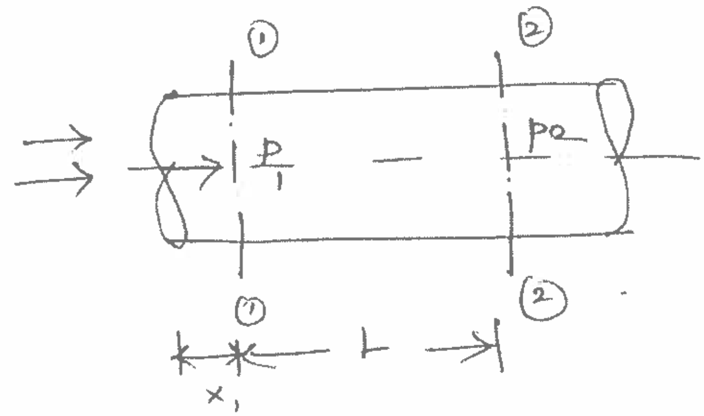
$$U_{max} = -\frac{1}{4\mu} \cdot \frac{\partial p}{\partial x} \cdot R^2$$

Ratio of max. velocity to average velocity is

$$\frac{U_{max}}{\bar{U}} = \frac{-\frac{1}{4\mu} \cdot \frac{\partial p}{\partial x} \cdot R^2}{\frac{1}{8\mu}\left(-\frac{\partial p}{\partial x}\right) \cdot R^2}$$

$$\frac{U_{max}}{\bar{U}} = 2$$

(iii) Drop of pressure for a given Length (L) of a pipe.



Average velocity $\bar{u} = \frac{1}{8\mu}\left(-\frac{\partial p}{\partial x}\right)R^2$ (or)

$$\left(-\frac{\partial p}{\partial x}\right) = \frac{8\mu\bar{U}}{R^2}$$

Integrating the above equ. w.r.to x, we get

$$-\int_1^2 dp = \int_2^1 \frac{8\mu\bar{U}}{R^2}\,dx$$

$$-\left[P\right]_2^1 = \frac{8\mu\bar{U}}{R^2}\left[x\right]_2^1$$

$$-\left[P_1 - P_2\right] = \frac{8\mu\bar{U}}{R^2}\left[x_1 - x_2\right]$$

$$P_1 - P_2 = \frac{8\mu\bar{U}}{R^2}\left[x_2 - x_1\right]$$

$$= \frac{8\mu\bar{U}}{R^2}\cdot L$$

$$= \frac{8\mu\bar{U}L}{(D/2)^2}$$

$$\boxed{P_1 - P_2 = \frac{32\mu\bar{U}L}{D^2}}$$

Where $P_1 - P_2$ is the drop of pressure.

$\therefore$ Loss of pressure head $= \frac{P_1 - P_2}{\rho g}$

$$\boxed{\frac{P_1 - P_2}{\rho g} = h_f = \frac{32 \mu \bar{U} L}{\rho g D^2}}$$

This equ. is called Hagen poiseuille formula.

(2) A crude oil of viscosity 0.97 poise and relative density 0.9 is flowing through a horizontal circular pipe of dia. 100 mm and of length 10 m. Calculate the difference of pressure at the two ends of the pipe, if 100 kg of the oil is collected in a tank in 30 sec.

Given:-

$\mu = 0.97$ poise

$= \frac{0.97}{10} = 0.097 \; Ns/m^2$

$\boxed{1 \text{ poise} = \frac{1}{10} \; Ns/m^2}$

Relative density $= 0.9$.

$\therefore \; \rho_o$ (or) density $= 0.9 \times 1000 = 900 \; kg/m^3$

Dia of pipe $D = 100$ mm $= 0.1$ m.

Length of pipe $= L = 10$ m

Mass of oil collected $= M = 100$ kg

$t = 30$ sec.

To find:- Pressure difference $[P_1 - P_2]$.

The difference of pressure $[P_1 - P_2]$ for viscous or laminar flow is given by.

$$P_1 - P_2 = \frac{32 \mu \bar{U} L}{D^2}$$

where, $\bar{U}$ = average velocity = $\frac{Q}{area}$.

mass of oil / sec = $\frac{100}{30}$ kg/s

$= \rho_o \times Q$

$= 900 \times Q$

$$\frac{100}{30} = 900 \times Q$$

$$Q = \frac{100}{30} \times \frac{1}{900}$$

$$\boxed{Q = 0.0037 \ m^3/sec}$$

$$\bar{U} = \frac{Q}{Area} = \frac{0.037}{\frac{\pi D^2}{4}}$$

$$= \frac{0.037}{\frac{\pi (0.1)^2}{4}} = 0.471 \ m/s$$

$$\boxed{\bar{U} = 0.471 \ m/s}$$

For laminar or viscous flow, the Reynolds no. (Re) is less than 2000.

Let us calculate the Re for this problem.

$$Re = \frac{\rho v D}{\mu}$$

$\rho = \rho_o = 900$

$V = \bar{u} = 0.471 \ m/s$

$D = 0.1 \ m$

$\mu = 0.097$

$$Re = \frac{900 \times 0.471 \times 0.1}{0.097}$$

$$Re = 436.91$$

As the Re no is less than 2000, the flow is laminar

$$P_1 - P_2 = \frac{32 \mu \bar{U} L}{D^2}$$

$$= \frac{32 \times 0.097 \times 0.471 \times 10}{(0.1)^2}$$

$$= 1462.28 \ N/m^2$$

$$= 1462.28 \times 10^{-4} \ N/cm^2$$

$$\boxed{P_1 - P_2 = 0.1462 \ N/cm^2}$$

(3) An oil of viscosity 0.1 NS/m² and relative density 0.9 is flowing through a circular pipe of diameter 50mm and of length 300m. The rate of flow of fluid through the pipe is 3.5 lit/s. Find the pressure drop in a length of 300m and also the shear stress at the pipe wall [May / June 2014]

Given: Viscosity $\mu = 0.1 \ NS/m^2$ [$\rho = 1000 \ kg/m^3$ of water]

Relative density = 0.9

∴ ρ_o (or) density of oil $= 0.9 \times 1000$

$= 900 \ kg/m^3$

$D = 50 \ mm$

$D = 0.05 \ m$

$L = 300 \ m$

$Q = 3.5$ lit/sec

$= \frac{3.5}{1000}\ m^3/s$

$Q = 0.0035\ m^3/s$

To find :-
(1) pressure drop, $P_1 - P_2$
(2) Shear stress at the pipe wall, τ_0

(1) Pressure drop $(P_1 - P_2) = \frac{32 \mu \bar{U} L}{D^2}$

$\bar{U} = \frac{Q}{Area}$

Area $= \frac{\pi D^2}{4} = \frac{\pi \times (0.05)^2}{4}$

$\bar{U} = \frac{0.0035}{\frac{\pi \times (0.05)^2}{4}} = 1.782\ m/s$

The Re, is $Re = \frac{\rho V D}{\mu}$

$\rho = 900\ kg/m^3$

V = average velocity $= \bar{U}$

$\bar{U} = 1.782\ m/s$

$Re = \frac{900 \times 1.782 \times 0.05}{0.1}$

$Re = 801.9$

$Re < 2000$, The flow is viscous (or) laminar

$$P_1 - P_2 = \frac{32 \mu \bar{U} L}{D^2}$$

$$= \frac{32 \times 0.1 \times 1.782 \times 300}{(0.05)^2}$$

$$= 684285 \ N/m^2$$

$$= 68428 \times 10^{-4} \ N/cm^2$$

$$\boxed{P_1 - P_2 = 68.43 \ N/cm^2}$$

This is the pressure difference.

(2) Shear stress at the pipe wall (τ_0)

The shear stress at any radius 'r' is given by the equation

$$\tau = -\frac{\partial p}{\partial x} \cdot \frac{r}{2}$$

Shear stress at pipe wall, where $r = R$ is given by

$$\tau_0 = -\frac{\partial p}{\partial x} \cdot \frac{R}{2}$$

$$-\frac{\partial p}{\partial x} = -\frac{(P_2 - P_1)}{x_2 - x_1}$$

$$= \frac{P_1 - P_2}{L}$$

$$-\frac{\partial p}{\partial x} = \frac{P_1 - P_2}{L}$$

$$-\frac{\partial p}{\partial x} = \frac{684288}{300} \ \frac{N/m^2}{m}$$

$$-\frac{\partial p}{\partial x} = 2280.96 \ N/m^3$$

$$R = D/2 = 0.05/2 = 0.025 \ m$$

$$\tau_0 = -\frac{\partial p}{\partial x} \cdot \frac{r}{2}$$

$$= 2280.96 \times \frac{0.025}{2}$$

$$\boxed{\tau_0 = 28.512 \ N/m^2}$$

(4) Determine the rate of flow of water through a pipe of diameter 20 cm and length 50 m when one end of the pipe is connected to a tank and other end of the pipe is open to the atmosphere. The pipe is horizontal and the height of water in the tank is 4 m above the centre of the pipe. Consider all minor losses and take $f = 0.009$ in the formula $h_f = \frac{4fLV^2}{2gd}$. Draw the Hydraulic gradient line and Total energy line.

Given:-

$L = 50 \ m$

$d = 20 \ cm = 0.2 m$

$H = 4 m$

$f = 0.009$

To find:- $V = ?$

Soln:- Applying Bernoulli's equ. at the top of the water surface in the tank and at the outlet of pipe. (taking point ① on the top and point ② at the outlet of pipe).

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} + z_2 .$$

Considering datum line passing thro' the centre of pipe

$$0 + 0 + 4 = 0 + \frac{v_2^2}{2g} + 0 + (h_i + h_f) .$$

$$4 = \frac{v_2^2}{2g} + h_i + h_f .$$

But the velocity in pipe = V

$$\therefore V_1 = V_2 .$$

$$h_f = \frac{4fLV^2}{2gd} .$$

Loss of head at entrance of pipe $h_i = \frac{0.5V^2}{2g}$

Substituting the values, we have

$$4 = \frac{V^2}{2g} + h_i + h_f$$

$$= \frac{V^2}{2g} + \frac{0.5V^2}{2g} + \frac{4fLV^2}{2gd} .$$

$$= \frac{V^2}{2g}\left[1 + 0.5 + \left[\frac{4 \times 0.009 \times 50}{0.2}\right]\right]$$

$$4 = 10.5\frac{V^2}{2g}$$

$$4 = \frac{10.5 \times V^2}{2 \times 9.81}$$

$$V^2 = \frac{4 \times 2 \times 9.81}{10.5}$$

$$\boxed{V = 2.734 \text{ m/sec}}$$

$$Q = A \times V$$

$$= \frac{\pi \times (0.2)^2}{4} \times 2.734$$

$$Q = 0.08589 \, m^3/sec$$

$$Q = 85.89 \text{ lit/sec}$$

$$V = 2.734 \, m/s$$

Head lost at entrance of pipe = h_i

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

$$= \frac{0.5 \times (2.734)^2}{2 \times 9.81}$$

$$h_i = 0.19 m$$

Head loss due to friction = $\frac{4fLV^2}{2gd}$

$$= \frac{4 \times 0.009 \times 50 \times (2.734)^2}{2 \times 9.81 \times 0.2}$$

$$\boxed{h_f = 3.428 \, m}$$

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(5) Find the head lost due to friction in a pipe of diameter 300 mm and length 50 m, through which water is flowing at a velocity of 3 m/s using (i) Darcy formula (ii) chezy's formula for which C = 60. Take ν for water = 0.01 stoke.

Given:- diameter of pipe d = 300 mm = 0.30 m

Length of pipe L = 50 m

Velocity of flow = V = 3 m/s

Chezys constant = C = 60

Kinematic viscosity = 0.01 cm^2/sec

$= 0.01 \times 10^{-4}$ m^2/s

(i) Darcy formula

$$h_f = \frac{4fLV^2}{4 \times 2g}$$

f → Co-eff. of friction is a function of Re.

but $Re = \frac{V \times d}{\nu} = \frac{3 \times 0.3}{0.01 \times 10^{-4}}$

$Re = 9 \times 10^5$

∴ Value of $f = \frac{0.079}{Re^{1/4}}$

$= \frac{0.079}{(9 \times 10^5)^{1/4}} = 0.00256$

$f = 0.00256$

∴ Head Lost $h_f = \frac{4 \times 0.0256 \times 50 \times (3)^2}{0.3 \times 2.0 \times 9.81}$

$$\boxed{h_f = 0.7828 \text{ m}}$$

(ii) Chezy's Constant

$V = C\sqrt{mi}$

$C = 60$

$m = \frac{d}{4} = \frac{0.30}{4} = 0.075$ m

$V = C\sqrt{mi}$

$3 = 60\sqrt{0.075 \times i}$

$$\boxed{i = 0.0333}$$

$$i = \frac{h_f}{L} = \frac{h_f}{50}$$

$$h_f = i \times 50$$

$$= 0.0333 \times 50$$

$$\boxed{h_f = 1.665 \text{ m}}$$

(6) A horizontal pipe of dia 500 mm is suddenly Contracted to a ϕ of 250 mm. The pressure intensities in the large and smaller pipe is given as 13.734 N/cm^2 and 11.772 N/cm^2 respectively. Find the loss of head due to Contraction if $C_c = 0.62$. Also determine the rate of flow of water.

<u>Given:-</u> Dia. of large pipe $D_1 = 500 \text{ mm} = 0.5 \text{ m}$

$$A_1 = \frac{\pi \times (0.5)^2}{4} = 0.1963 \text{ m}^2$$

Dia. of Smaller pipe $D_2 = 250 \text{ mm} = 0.25 \text{ m}$

$$A_2 = \frac{\pi (0.25)^2}{4} = 0.04908 \text{ m}^2$$

~~Pressure in large pipe~~ $P_1 = 13.734 \ N/cm^2$

$$= 13.734 \times 10^4 \ N/m^2$$

Pressure in Small pipe $P_2 = 11.772 \ N/cm^2$

$$= 11.772 \times 10^4 \ N/m^2$$

$$C_c = 0.62$$

Head lost due to Contraction $= \frac{V_2^2}{2g}\left[\frac{1}{C_c} - 1\right]^2$

$$= \frac{V_2^2}{2g}\left[\frac{1}{0.62} - 1.0\right]^2$$

$$h_c = 0.375 \frac{V_2^2}{2g}$$

from Continuity eqn we have $A_1 V_1 = A_2 V_2$

$$V_1 = \frac{A_2 V_2}{A_1} = \frac{\frac{\pi \times (D_2)^2}{4} \times V_2}{\frac{\pi \times (D_1)^2}{4}}$$

$$V_1 = \left[\frac{D_2}{D_1}\right]^2 \times V_2$$

$$V_1 = \left[\frac{0.25}{0.50}\right]^2 . V_2$$

$$V_1 = \frac{V_2}{4}$$

Applying Bernoulli's eqn before & after contraction

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

pipe is h2l. $Z_1 = Z_2$.

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

Sub. $h_c = 0.375 \frac{V_2^2}{2g}$ and $V_1 = \frac{V_2}{4}$ in the above equation.

$$\left[\frac{13.734 \times 10^4}{9.81 \times 1000}\right] + \left[\frac{(V_2/4)^2}{2 \times g}\right] = \left[\frac{11.772 \times 10^4}{9.81 \times 1000}\right] + \frac{V_2^2}{2g} + \frac{0.375 V_2^2}{2g}$$

$$14 + \frac{V_2^2}{16 \times 2g} = 12 + \frac{1.375 V_2^2}{2g}$$

$$14 - 12 = \frac{1.375 V_2^2}{2g} - \frac{1}{16} \times \frac{V_2^2}{2g}$$

$$2 = \frac{V_2^2}{2g} \times 1.3125$$

$$V_2^2 = \frac{2 \times 2 \times 9.81}{1.3125}$$

$$\boxed{V_2 = 5.467 \text{ m/s}}$$

(i) loss of head due to Contraction

$$h_c = \frac{0.375 V_2^2}{2g}$$

$$= \frac{0.375 \times (5.467)^2}{2 \times 9.81}$$

$$\boxed{h_c = 0.571 \text{ m}}$$

(ii) Rate of flow of water $Q = A_2 V_2$

$$= 0.04908 \times 5.467$$

$$= 0.2683 \text{ m}^3/\text{s}$$

$$\boxed{Q = 268.3 \text{ lit/s}}$$

UNIT - IV
BOUNDARY LAYER

Boundary Layer thickness - (δ)
Displacement thickness - (δ^*)
Momentum thickness - (θ)

① Derive the expression for displacement thickness. [May / June 2013]

* Consider the flow of a fluid having free - stream velocity equal to U over a thin smooth plate.
* At a sec 'x' from the leading edge consider a sec ① - ①
* The velocity of fluid at B is zero &
* at 'c', which lies on boundary layer is U
* Thus the velocity varies from zero at B to U at C,

Where, BC = thickness of boundary layer.

Distance $BC = \delta$

at the section ① - ①, consider the elemental strip.

$y \rightarrow$ distance of elemental strip from the plate.

dy = thickness of "

u = velocity of elemental strip

U = velocity of free - stream

b = width of plate

Then area of elemental strip $= dA = b \times dy$

Mass of fluid per second flowing through elemental strip } = $\rho \times$ velocity $\times$ Area of elemental strip.

$$= \rho u \times dA$$

$$= \rho u \times b \times dy$$

U is more than u, there will be a reduction in mass flowing per second, through elemental strip.

Reduction in mass / sec flowing through elemental strip } $= \rho U b dy - \rho u b \cdot dy$

$$= \rho b (U - u) dy$$

Total reduction in mass of fluids, flowing through BC due to plate } $= \int_0^\delta \rho b (U-u) dy$ —— ①

Lose of the mass of the fluid / sec flowing through the distance δ^* } $= \rho \times$ velocity $\times$ Area

$$= \rho \times U \times \delta^* b \quad \text{—— ②}$$

equating equ ① & ②

$$\rho U \delta^* b = \int_0^\delta \rho b (U - u) dy$$

$$\delta^* = \frac{1}{U} \int_0^\delta (U - u) dy$$

$$\boxed{\delta^* = \int_0^\delta \left[1 - \frac{u}{U}\right] dy}$$

② Find the displacement thickness, the momentum thickness and energy thickness for the velocity distribution in the boundary layer given by $\frac{u}{U} = \frac{y}{\delta}$, where u is the velocity at a distance y from the plate and $u = U$ at $y = \delta$, where δ = boundary layer thickness [NOV/DEC 2015]

Given: Velocity distribution $\frac{u}{U} = y/\delta$

To find: (1) Displacement thickness δ^*

(2) Momentum thickness θ

(3) Energy thickness δ^{**}

Soln: (1) Displacement thickness δ^*

$$\delta^* = \int_0^\delta \left[1 - \frac{u}{U}\right] dy \qquad \because \frac{u}{U} = \frac{y}{\delta}$$

$$= \int_0^\delta \left[1 - \frac{y}{\delta}\right] dy$$

$$= \left[y - \frac{y^2}{2\delta}\right]_0^\delta = \left[\delta - \frac{\delta^2}{2\delta}\right] = \left[\delta - \frac{\delta}{2}\right] = \frac{\delta}{2}.$$

$$\boxed{\delta^* = \frac{\delta}{2}}$$

(2) Momentum thickness (θ)

$$\theta = \int_0^\delta \frac{u}{U}\left(1 - \frac{u}{U}\right) dy$$

$$= \int_0^\delta \frac{y}{\delta}\left[1 - \frac{y}{\delta}\right] dy = \int_0^\delta \left(\frac{y}{\delta} - y^2/\delta^2\right) dy$$

$$= \left[\frac{y^2}{2\delta} - \frac{y^3}{3\delta^2}\right]_0^\delta = \left[\frac{\delta^2}{2\delta} - \frac{\delta^3}{3\delta^2}\right] = \left[\frac{\delta}{2} - \frac{\delta}{3}\right]$$

$$= \left[\frac{3\delta - 2\delta}{6}\right] = \frac{\delta}{6}$$

$$\boxed{\theta = \frac{\delta}{6}}$$

(3) Energy thickness δ^{**}

$$\delta^{**} = \int_0^\delta \frac{u}{U}\left[1 - \frac{u^2}{U^2}\right] dy$$

$$= \int_0^\delta \frac{y}{\delta}\left[1 - \frac{y^2}{\delta^2}\right] dy = \left[\frac{y^2}{2\delta} - \frac{y^4}{4\delta^3}\right]_0^\delta$$

$$= \left[\frac{\delta^2}{2\delta} - \frac{\delta^4}{4\delta^3}\right] = \left[\frac{\delta}{2} - \frac{\delta}{4}\right] = \left(\frac{2\delta - \delta}{4}\right)$$

$$\boxed{\delta^{**} = \frac{\delta}{4}}$$

(3) A thin plate is moving in still atmospheric air at a velocity of 5 m/s. The length of the plate is 0.6m and width 0.5m. Calculate (i) the thickness of the boundary layer at the end of the plate (ii) drag force on one side of the plate. Take density of air as 1.24 kg/m³ and kinematic viscosity 0.15 stokes.

[Nov/Dec 2015]

Given:- velocity of plate $U = 5\ m/s$

Length of plate $L = 0.6m$

width of plate $b = 0.5\ m$

density of air $\rho = 1.24\ kg/m^3$

Kinematic viscosity $\nu = 0.15$ Stokes

$V = 0.15 \times 10^{-4}\ m^2/s$

Reynold no. $Re = \frac{UL}{\nu} = \frac{5 \times 0.6}{0.15 \times 10^{-4}}$

$= 200000 = 2 \times 10^5$

$Re = 2 \times 10^5$

$Re < 5 \times 10^5$, hence boundary layer is laminar over the entire length of the plate

To find :- (1) Thickness of boundary layer at the end of the plate

(2) Drag force on one side of the plate is given by

Soln:- (1) Thickness of boundary layer

$\delta = \frac{4.91\, x}{\sqrt{Re_x}}$ — Blasius solution

$x = L$

$\delta = \frac{4.91 \times 0.6}{\sqrt{2 \times 10^5}} = 0.00658\ m$

$\boxed{\delta = 6.58\ mm}$

(2) Drag force on one side of the plate is given by

$C_D = \frac{F_D}{\frac{1}{2} \rho A U^2}$

$F_D = \frac{1}{2} \rho A U^2 \times C_D$

C_D from Blasius Solution

$$C_D = \frac{1.328}{\sqrt{Re_L}}$$

$$= \frac{1.328}{\sqrt{2\times 10^5}} = 0.002969$$

$$\boxed{C_D = 0.00297}$$

$$F_D = \frac{1}{2} \times 1.24 \times 0.6 \times 0.5 \times (5)^2 \times 0.00297$$

$$\boxed{F_D = 0.01373\ N}$$

$\because A = L \times b$

$\boxed{A = 0.6 \times 0.5}$

Ans:-

(1) Thickness of boundary layer $\delta = 6.58$ mm

(2) Drag force $F_D = 0.01373$ N.

(4) A plate of length 600 mm and 400 mm wide is immersed in a fluid of sp. gravity 0.9 and kinematic viscosity $\nu = 10^{-4}$ m/s. The fluid is moving with a velocity of 6 m/s. Determine (i) boundary layer thickness (ii) shear stress at the end of the plate (iii) Drag force on one side of the plate.

Given:- length L = 600 mm = 0.6 m

width b = 400 mm = 0.4 m

Sp. gravity of fluid $G = 0.9$

density $\rho = 0.9 \times 1000 = 900$ kg/m^3

velocity of fluid $U = 6$ m/s

$\nu = 10^{-4}$ m^2/s

To find :— (1) Boundary layer thickness
(2) Shear stress at the end of the plate
(3) drag force on one side of the plate

Soln:-

$$Re_L = \frac{U \times L}{\nu} = \frac{6 \times 0.6}{10^{-4}} = 3.6 \times 10^4$$

$Re_L < 5 \times 10^5$, boundary layer is laminar over the entire length of the plate

(1) Boundary Layer thickness at the end of the plate.

From Blasius eqn:

$$\delta = \frac{4.91\, x}{\sqrt{Re_x}}$$

$$x = L = 0.6\,m$$

$$\delta = \frac{4.91 \times 0.6}{\sqrt{3.6 \times 10^4}} = 0.0155\,m$$

$$\boxed{\delta = 15.5\ mm}$$

(2) Shear stress at the end of the plate

$$\tau_o = \frac{0.332\, \rho U^2}{\sqrt{Re_L}}$$

$$= \frac{0.0332 \times 900 \times (6)^2}{\sqrt{3.6 \times 10^4}}$$

$$\boxed{\tau_o = 56.6\ N/m^2}$$

(3) Drag force (F_D) on one side of the plate is given by

$$F_D = \frac{1}{2} \rho A U^2 \times C_D$$

$$C_D = \frac{1.328}{\sqrt{Re_L}}$$

$$= \frac{1.328}{\sqrt{3.6 \times 10^4}} = 0.00699$$

$$\boxed{C_D = 0.00699}$$

$$F_D = \frac{1}{2} \times 900 \times 0.6 \times 0.4 \times (6)^2 \times 0.00699$$

$$\boxed{F_D = 26.78 \text{ N}}$$

(5) Air is flowing over a smooth plate with a velocity of 10 m/s. The length of the plate is 1.2m and width 0.8m. If laminar boundary layer exists up to a value of $Re = 2 \times 10^5$, find the max distance from the leading edge upto which laminar boundary layer exists. Find the max. thickness of laminar boundary layer if the velocity profile is given by

$$\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

Take kinematic viscosity for air = 0.15 stokes

Soln:- Given :-

velocity of air $= U = 10 m/s$

Length of plate $L = 1.2 m$

Width of plate $b = 0.8 m$

$Re = 2 \times 10^5$

ν for air $= 0.15$ Stokes $= 0.15 \times 10^{-4} m^2/s$

To find :- (1) Find the max. distance from the leading edge up to which laminar boundary layer exists

(2) Thickness of boundary layer if the velocity profile is given

Soln:-

(1) $Re_x = \frac{\rho U x}{\mu} = \frac{U x}{\nu}$

$x \rightarrow$ distance from the leading edge up to which laminar layer exists

$Re_x = \frac{U x}{\nu}$

$x = \frac{Re_x \cdot \nu}{U} = \frac{2 \times 10^5 \times 0.15 \times 10^{-4}}{10}$

$x = 0.30 m$

$x = 300 mm$

(2) Max. thickness of the laminar boundary layer for the velocity profile $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$

$$\delta = \frac{5.48x}{\sqrt{Re_x}}$$

$$= \frac{5.48 \times 0.3}{\sqrt{2\times 10^5}} = 0.00367 \text{ m}$$

$$\boxed{\delta = 3.67 \text{ mm}}$$

6. A plate of length 750 mm and width 250 mm has been placed longitudinally in a stream of crude oil which flows with a velocity of 5 m/s. If the oil has a specific gravity of 0.8 and kinematic viscosity of 1 stoke, calculate the

(i) boundary layer thickness at the middle of the plate

(ii) shear stress at the middle of the plate and

(iii) friction drag on one side of the plate.

[Nov / Dec 2012 / Nov / Dec 2013].

Given data :-

Length of the plate, $L = 750$ mm $= 0.75$ m

~~Width of the plate, $b = 250$ mm $= 0.25$ m~~

Velocity, $U = 5$ m/s

Sp. gravity, $S = 0.8$

Kinematic viscosity, $\nu = 1$ Stoke $= 1\times 10^{-4}$ m/s

Soln:

(i) Boundary layer thickness at the middle of the plate.

At the middle of the plate $x = 0.75/2$

$$\boxed{x = 0.375 \text{ m}}$$

$$Re = \frac{Ux}{\nu} = \frac{5\times 0.375}{1\times 10^{-4}} = 18750 < 5\times 10^5$$

So, the boundary layer is laminar boundary layer.

Laminar boundary layer thickness,

$$\delta_{lam} = \frac{5x}{\sqrt{Re}}$$

$$= \frac{5 \times 0.375}{\sqrt{18750}} = 0.01369 \, m$$

$$\boxed{\delta_{lam} = 13.69 \, mm}$$

(ii) Shear stress at the middle of the plate.

By Blasius theory,

$$C_D = \frac{0.664}{\sqrt{(Re)_x}} = \frac{0.664}{\sqrt{18750}} = 4.85 \times 10^{-3}$$

We also know that

$$\text{Sp. gravity of oil, } S = \frac{\rho_{oil}}{\rho_{water}}$$

$$0.8 = \frac{\rho_{oil}}{1000}$$

$$\rho_{oil} = 800 \, kg/m^2$$

$$\text{Shear stress } \tau_0 = C_D \frac{1}{2} \rho U^2$$

$$= 4.85 \times 10^{-3} \times \frac{1}{2} \times 800 \times (5)^2$$

$$\boxed{\tau_0 = 48.49 \, N/m^2}$$

(iii) Friction drag on one side of the plate

At the trailing edge of the plate, $x = 0.75\,m$

$$Re_L = \frac{UL}{\nu} = \frac{5 \times 0.75}{1 \times 10^{-4}} = 37500 < 5 \times 10^5$$

So, that the boundary layer is also laminar boundary layer at the trailing edge.

Average drag co-eff.

$$C_D = \frac{1.328}{\sqrt{(Re)_L}} = \frac{1.328}{\sqrt{37500}}$$

$$C_D = 6.858 \times 10^{-3}$$

$\therefore$ Friction drag force = Stress $\times$ area

$$F_D = \int_0^L \tau_0 \times b \times dx$$

$$F_D = C_D \times \frac{1}{2} \rho U^2 \times b \times L$$

$$F_D = 6.858 \times 10^{-3} \times \frac{1}{2} \times 800 \times (5)^2 \times 0.25 \times 0.75$$

$$\boxed{F_D = 12.859\ N}$$

UNIT – V

DIMENSIONAL & MODEL ANALYSIS

① The efficiency η of a fan depends on the density ρ, the dynamic viscosity μ of the fluid, the angular velocity ω, dia D of the rotor and the discharge Q. Express η in terms of dimensionless parameters. [May/ June 2014]

Soln:-

The efficiency η depends on

$$\eta = K \cdot \rho^a \mu^b \omega^c D^d Q^e \quad \text{—①}$$

Sub dimensions on both sides of equ. ①

$$\eta = M^0 L^0 T^0$$
$$\rho = ML^{-3}$$
$$\mu = ML^{-1}T^{-1}$$
$$\omega = T^{-1}$$
$$D = L$$
$$Q = L^3 T^{-1}$$

$$M^0 L^0 T^0 = K \cdot [ML^{-3}]^a \cdot [ML^{-1}T^{-1}]^b [T^{-1}]^c D^d \cdot [L^3 T^{-1}]^e$$

Equating the powers of M, L, T on both sides

equ. Powers of 'M' (on LHS & RHS)

$$0 = a + b$$

Powers of 'L'

$$0 = -3a - b + d + 3e$$

Powers of T

$$0 = -b - c - e$$

$$a + b = 0$$

$$\boxed{a = -b}$$

$$-b - c - e = 0$$

$$-b - e = c$$

$$\boxed{-(b+e) = c}$$

$$0 = -3a - b + d + 3e$$

$$= -3(-b) - b + d + 3e$$

$$0 = 3b - b + d + 3e$$

$$0 = 2b + d + 3e$$

$$\boxed{d = -2b - 3e}$$

Sub. these values in equ ① we get

$$\eta = k \cdot \rho^{-b} \cdot \mu^{b} \, \omega^{-(b+e)} \, D^{(-2b-3e)} \, Q^{e}$$

$$= k \rho^{-b} \mu^{b} \omega^{-b} \omega^{-e} D^{-2b} D^{-3e} Q^{e}$$

$$= k \left[\frac{\mu^{b}}{\rho^{b} \omega^{b} D^{2b}} \right] \cdot \left[\frac{Q^{e}}{\omega^{e} D^{3e}} \right]$$

$$= k \left[\frac{\mu}{\rho \omega D^{2}} \right]^{b} \cdot \left[\frac{Q}{\omega D^{3}} \right]^{e}$$

$$\boxed{\eta = \phi \left[\left(\frac{\mu}{\rho \omega D^{2}} \right) \cdot \left(\frac{Q}{\omega D^{3}} \right) \right]}$$

(2) Explain in detail about

(a) Geometric Similarity
(b) Kinematic Similarity
(c) Dynamic Similarity [Nov/ Dec 2013]

(a) Geometric Similarity

The geometric similarity exists between the model and the prototype.

The ratio of all linear dimension in the model and prototype are equal.

$L_m \rightarrow$ Length of model
$b_m \rightarrow$ breadth of model
$D_m \rightarrow$ dia of model
$A_m \rightarrow$ Area of model
$\forall_m \rightarrow$ vol. of model

For geometric similarity between model & prototype, we must have the relation

$$\frac{L_p}{L_m} = \frac{b_p}{b_m} = \frac{D_p}{D_m} = L_r$$

$L_r \rightarrow$ is called scalar ratio

For Area ratio & vol. ratio, the relation should be given.

$$\frac{A_p}{A_m} = \frac{L_p \times b_p}{L_m \times b_m} = L_r \times L_r = L_r^2$$

$$\frac{\forall_p}{\forall_m} = \left[\frac{L_p}{L_m}\right]^3 = \left[\frac{b_p}{b_m}\right]^3 = \left[\frac{D_p}{D_m}\right]^3$$

(b) Kinematic Similarity

It means the similarity of motion between model and prototype.

Thus kinematic similarity is said to exist between the model & the prototype if the ratios of the velocity and acceleration at the corresponding points in the model and at the corresponding points in the prototype are same.

For kinematic similarity, we must have

$$\frac{V_{p_1}}{V_{m_1}} = \frac{V_{p_2}}{V_{m_2}} = V_r$$

$V_r \rightarrow$ is the velocity ratio.

For acceleration we must have

$$\frac{a_{p_1}}{a_{m_1}} = \frac{a_{p_2}}{a_{m_2}} = a_r$$

$a_r \rightarrow$ is the acceleration ratio

(c) Dynamic Similarity

It means the similarity of forces between the model and prototype. The similarity exists, if the ratios of the corresponding forces acting at the corresponding points are equal. Also the directions of the corresponding forces at the

Corresponding points should be same.

$$\frac{(F_i)_p}{(F_i)_m} = \frac{(F_v)_p}{(F_v)_m} = \frac{(F_g)_p}{(F_g)_m} = F_r$$

$F_i \rightarrow$ inertia force

$F_v \rightarrow$ viscous force

$F_r \rightarrow$ is the force ratio.

(3) (i) what is meant by dimensionless number and their significance.

(ii) Explain in detail about Reynold's Number, Froude number, Euler's number, Weber's number and Mach number [Nov/Dec 2010]

Soln:- Dimensionless numbers/ parameters

Dimensionless numbers are those numbers which are obtained by dividing the inertia force by viscous force or gravity force or pressure force or surface tension force or elastic force. As this is a ratio of one force to the other force, it will be a dimensionless number. These dimensionless numbers are also called non-dimensionless numbers.

1. Reynold's number.
2. Froude's number
3. Euler's number
4. Mach's number
5. Weber's number.

1. Reynolds' number (Re)

It is defined as the ratio of inertia force of flowing fluid and the viscous force of the fluid.

$$Re = \frac{Vd}{\nu} \text{ (or) } \frac{\rho V d}{\mu}$$

2. Froude Number (Fe)

The Froude's number is defined as the square root of the ratio of inertia force of a flowing fluid to the gravity force

$$Fe = \sqrt{\frac{F_i}{F_g}} = \frac{V}{\sqrt{Lg}}$$

$$F_i = \rho A V^2$$

$$F_g = \rho A L g$$

3. Euler's Number (Eu)

It is defined as the square root of the ratio of the inertia force of a flowing fluid to the pressure force.

$$E_u = \sqrt{\frac{F_i}{F_p}} \qquad \because F_p = p \times A$$

$$E_u = \frac{V}{\sqrt{P/\rho}} \qquad F_i = \rho A V^2$$

4. Weber's Number (We)

It is defined as the square root of the ratio of the inertia force of a flowing fluid to the surface tension force.

$$We = \sqrt{\frac{Fi}{Fs}}$$

$$Fs = \sigma \times L$$

$$Fi = \rho A v^2$$

$$We = \frac{V}{\sqrt{\sigma / \rho L}}$$

5. Mach's Number (M)

Mach's number is defined as the square root of the ratio of the inertia force of a flowing fluid to the elastic force

$$M = \sqrt{\frac{Fi}{Fe}}$$

$$Fe = K \times A$$

$$Fe = K \times L^2$$

$$M = \frac{V}{C}$$

(4) An oil of specific gravity 0.91 and viscosity of 0.03 poise is to be transported at the rate of $3\ m^3/s$ through a 1.3 m diameter pipe. Model tests were conducted on a 130 mm dia. pipe using water having viscosity of 0.01 poise. Find the velocity of flow and discharge in the model. (Apr/May 2015) (May/June 2013)

Given:-

Sp. gravity of oil = 0.91

$$\rho = 0.91 \times 1000 = 910\ kg/m^3$$

Viscosity of prototype $\mu_p = 0.03$ poise

$$\mu_p = \frac{0.03}{10} = 3 \times 10^{-3}\ Ns/m^2$$

Q for prototype $Q_p = 3\ m^3/s$

Dia of Prototype $D_p = 1.3\ m$

Dia of Model $D_m = 130\ mm = 0.13\ m$

Viscosity of Model $\mu_m = 0.01$ poise

$$\mu_m = \frac{0.01}{10} = 1\times10^{-3}\ NS/m^2$$

$$\rho_m = 1000\ kg/m^3 \text{ (water)}$$

To find :-

$V_m = ?$

$Q_m = ?$

Solu :-

$$\frac{\rho_m V_m D_m}{\mu_m} = \frac{\rho_p V_p D_p}{\mu_p}$$

$$\frac{V_m}{V_p} = \frac{\rho_p}{\rho_m} \cdot \frac{D_p}{D_m} \cdot \frac{\mu_m}{\mu_p}$$

$$= \frac{910}{1000} \times \frac{1.3}{0.13} \times \frac{1\times10^{-3}}{3\times10^{-3}} = 3$$

$$\frac{V_m}{V_p} = 3$$

$$\boxed{V_m = 3V_p}$$

$$Q_p = A_p \cdot V_p$$

$$3 = \frac{3.14 \times (1.3)^2}{4} \times V_p$$

$$\boxed{V_p = 2.26\ m/s}$$

$$V_m = 3 \times 2.26 = 6.78\ m/s$$

$$Q_m = A_m \cdot V_m$$

$$= \frac{3.14 \times (0.13)^2}{4} \times 6.78$$

$$= 0.089\ m^3/s$$

$$\boxed{Q_m = 89.94\ lit/sec}$$

(5) A spillway model built up to a scale of 1/10 is discharging water with a velocity of 1 m/s, under a head of 100 mm. Find the velocity of water of the prototype, if the head of water over the prototype is 5.5 metres.
[Nov/Dec 2012]

Given:- Linear scale ratio = $\frac{1}{10}$

Velocity of Model $V_m = 1\ m/s$

$H_m = 100\ mm = 0.1\ m$

$H_p = 5.5\ m$

To find:-

$V_p = ?$

Soln:- Velocity scale ratio $\frac{V_p}{V_m} = \sqrt{L_r}$

$$\frac{V_p}{V_m} = \sqrt{10}$$

$$V_p = V_m \times \sqrt{10} = 1 \times \sqrt{10} = 3.16\ m/s$$

Velocity of prototype $= 3.16\ m/s$

(6) A 7.2 m high and 15 m long spillway discharges 94 m^3/sec discharge under a head of 2.0 m. If a 1:9 scale model of this spillway is to be constructed determine model dimensions, head over spillway model and the model discharge. If model experiences a force of 7500 N. Determine the force on the prototype. [May / June 2014]

Given:- Height of prototype $h_p = 7.2\ m$

Discharge for prototype $Q_p = 94\ m^3/sec$

Length of prototype $L_p = 15\ m$

Head of prototype $H_p = 2\ m$

$F_m = 7500$ N

Linear scale ratio $L_r = 9$ $[\because 1:9]$

<u>To find</u> :-

$L_m = ?$

$H_m = ?$

$Q_m = ?$

$F_p = ?$

(i) Model dimensions (h_m & L_m)

$$\frac{h_p}{h_m} = \frac{L_p}{L_m} = L_r = 9$$

$$\frac{h_p}{h_m} = 9$$

$$h_m = \frac{h_p}{9} = \frac{7.2}{9} = 0.8 \text{ m}$$

$$\frac{L_p}{L_m} = 9$$

$$L_m = \frac{L_p}{9} = \frac{15}{9} = 1.67 \text{ m}$$

$$\boxed{\begin{aligned} h_m &= 0.8 \text{ m} \\ L_m &= 1.67 \text{ m} \end{aligned}}$$ Model dimensions

---

(ii) Head over spillway Model

$$\frac{H_p}{H_m} = 9 = L_r$$

$$H_m = \frac{H_p}{9} = \frac{2}{9} = 0.222 \text{ m}$$

$$\boxed{H_m = 0.222 \text{ m}}$$

(iii) Discharge through Model

$$\frac{Q_p}{Q_m} = L_r^{2.5}$$

$$Q_m = \frac{Q_p}{L_r^{2.5}} = \frac{94}{(9)^{2.5}} = 0.387\ m^3/s$$

$$\boxed{Q_m = 0.387\ m^3/s}$$

(iv) Force on the prototype $F_p = ?$

$$\frac{F_p}{F_m} = L_r^{(3)}$$

$$F_p = L_r^{(3)} \times F_m$$

$$= (9)^3 \times 7500$$

$$\boxed{F_p = 5467500\ N}$$

⑦ Determine the dimensions of the following quantities.
(1) Discharge (2) Kinematic viscosity (3) Force
(4) Specific weight [Nov/Dec 2013]

Soln: (1) Discharge

$$\text{Discharge} = \text{area} \times \text{velocity}$$

$$= L^2 \times \frac{L}{T}$$

$$= \frac{L^3}{T} = L^3 T^{-1}$$

$$\boxed{\text{Discharge} = L^3 T^{-1}}$$

(2) Kinematic viscosity $(\nu) = \mu/\rho$

$$\mu \Rightarrow \tau = \mu\left[\frac{du}{dy}\right]$$

$$\mu = \frac{\tau}{du/dy} = \frac{\text{Shear stress}}{\frac{L}{T}/L}$$

$$= \frac{\text{Shear stress}}{\frac{L}{T} \times \frac{1}{L}} = \frac{\text{Shear stress}}{\frac{1}{T}}$$

$$= \frac{\text{force / area}}{\frac{1}{T}} = \frac{\text{Mass} \times \text{acceleration}}{\text{area}}$$

$$= \frac{M \times L}{L^2 \times T^2 \times \frac{1}{T}} = \frac{M}{L \times T} = M L^{-1} T^{-1}$$

$\boxed{\mu = M L^{-1} T^{-1}}$ Kinematic viscosity

$$\nu = \mu / \rho$$

$$\rho = \text{Mass/Vol} = \frac{M}{L^3} = M L^{-3}$$

$$\nu = \frac{M L^{-1} T^{-1}}{M L^{-3}} = L^2 T^{-1}$$

(iii) Force = Mass × acceleration

$$= M \times \frac{L}{T^2} = M L T^{-2}$$

$\boxed{\text{Force} = M L T^{-2}}$

(iv) Specific weight = $\frac{\text{Weight}}{\text{Vol}} = \frac{\text{Force}}{\text{Vol}}$

$$= \frac{M L T^{-2}}{L^3} = M L^{-2} T^{-2}$$

$\boxed{\text{Sp. weight} = M L^{-2} T^{-2}}$

(8) Explain the types of Models. Mention the advantage and disadvantage of distorted models.

Soln: Types of Models

(1) Undistorted Models

(2) Distorted Models

Undistorted Models:-

The model which is geometrically similar to its prototype is known as Undistorted models. In such models, the conditions of similitude are fully satisfied. So, the results obtained from the model are used to predict the performance of the prototype easily. Based on it, the design, construction & interpretation of the model are simpler.

Distorted Models:-

A model which is not geometrically similar to its prototype but it may be similar in appearance with its prototype. So, the different scale ratios are used for linear dimensions such as length, breadth and height.

Usually, the following distortions may occur in distorted models

1. Geometrical distortion.
2. Material distortion.
3. Distortion of hydraulic quantities

(1) Geometrical distortion :-

The distortion occurs either in dimensions or in configuration. It can be corrected by using different scale values for vertical and horizontal dimensions.

(2) Material distortion :-

It arises due to the use of different materials for the model and prototype. To avoid it, the same materials have to be used as much as possible.

(3) Distortion of hydraulic quantities:

Due to uncontrollable hydraulic quantities, the distortion may occur. (eg) velocity, discharge etc

Reasons for adopting distorted Models.

(1) To maintain the accuracy
(2) To maintain the turbulent flow.
(3) To accomodate available facilities
(4) To obtain suitable bed materials
(5) ~~To obtain the required roughness Condition~~

Advantage of distorted Models :-

1. Accurate measurements can be possible
2. Surface Tension can be minimized as much as possible.
3. The operation is simplified due to small model size
4. Reynolds number of flow is sufficiently increased.

Disadvantages of distorted Models

1. Exit pressure and velocity distributions are not true
2. A model wave may differ from that of prototype
3. Both extrapolation and interpolation of results are difficult.

9. State Buckingham's π- Theorem's assumptions.

"If there are 'n' variables (dependent or independent variables) in a physical phenomenon and if these variables contain 'm' fundamental dimensions (M, L, T), then the variables are arranged into (n-m) dimensionless terms. Each term is called π-term.

Methods of Selecting Repeating Variables.

The no of repeating variables = no of fundamental dimensions of the problem.

The choice of repeating variables is governed by

① As far as possible, the dependent variable should not be selected as repeating variables.

② The repeating variables should be chosen in such a way that one variable contains geometric property, other variable contains flow property and third variable contains fluid property.

* Variables with geometric property are
① length(l) ② dia 'd' ③ Height, 'H' etc.

* Variable with flow property.
① velocity 'V' ② Acceleration

* Variables with fluid property

(i) μ (ii) ρ (iii) ω

(3) The repeating variables selected should not form a dimensionless group.

(4) The repeating variables together must have the same number of fundamental dimensions.

(5) No two repeating variables should have the same dimensions.

Fluid Mechanics Questions and Answers(MCQs)

1. Fluid is a substance that
(a) cannot be subjected to shear forces
(b) always expands until it fills any container
(c) has the same shear stress.at a point regardless of its motion (d) cannot remain at rest under action of any shear force (e) flows.
Ans: d

2. Fluid is a substance which offers no resistance to change of
(a) pressure
(b) flow
(c) shape
(d) volume
(e) temperature.

Ans: c

3. Practical fluids
(a) are viscous
(b) possess surface tension
(c) are compressible
(d) possess all the above properties
(e) possess none of the above properties.

Ans: d

4. In a static fluid
(a) resistance to shear stress is small
(b) fluid pressure is zero
(c) linear deformation is small (d) only normal stresses can exist (e) viscosity is nil.
Ans: d

5. A fluid is said to be ideal, if it is
(a) incompressible
(b) inviscous

(c) viscous and incompressible (d) inviscous and compressible
(e) inviscous and incompressible.
Ans: e

6. An ideal flow of any fluid must fulfill the following
(a) Newton's law of motion
(b) Newton's law of viscosity
(c) Pascal' law (d) Continuity equation
(e) Boundary layer theory.
Ans: d

7. If no resistance is encountered by displacement, such a substance is known as (a) fluid
(b) water
(c) gas (d) perfect solid (e) ideal fluid.
Ans: e

8. The volumetric change of the fluid caused by a resistance is known as
(a) volumetric strain
(b) volumetric index
(c) compressibility (d) adhesion
(e) cohesion. Ans:
c

9. Liquids
(a) cannot be compressed
(b) occupy definite volume
(c) are not affected by change in pressure and temperature
(d) are not viscous
(e) none of the above.
Ans: e

10. Density of water is maximum at
(a) 0°C
(b) 0°K
(c) 4°C
(d) 100°C (e) 20°C.
Ans: c

11. The value of mass density in kgsecVm4 for water at 0°C is (a)
1
(b) 1000
(c) 100
(d) 101.9
(e) 91
Ans: d

12. Property of a fluid by which its own molecules are attracted is called (a) adhesion
(b) cohesion
(c) viscosity (d) compressibility
(e) surface tension.
Ans: b

13. Mercury does not wet glass. This is due to property of liquid known as (a) adhesion
(b) cohesion
(c) surface tension
(d) viscosity
(e) compressibility.
Ans: c

14. The property of a fluid which enables it to resist tensile stress is known as
(a) compressibility
(b) surface tension
(c) cohesion
(d) adhesion (e) viscosity.
Ans: c

15. Property of a fluid by which molecules of different kinds of fluids are attracted to each other is called
(a) adhesion
(b) cohesion
(c) viscosity (d) compressibility (e) surface tension.
Ans: a

16. The specific weight of water is 1000 kg/m"

(a) at normal pressure of 760 mm
(b) at 4°C temperature
(c) at mean sea level (d) all the above
(e) none of the above.
Ans: d

17. Specific weight of water in S.I. units is equal to
(a) 1000 N/m3
(b) 10000 N/m3
(c) 9.81 xlO3 N/m3 (d) 9.81 xlO6N/m3 (e) 9.81 N/m3.
Ans: c

18. When the flow parameters at any given instant remain same at every point, then flow is said to be
(a) quasi static
(b) steady state
(c) laminar
(d) uniform (e) static.
Ans: d

19. Which of the following is demensionless
(a) specific weight
(b) specific volume
(c) specific speed
(d) specific gravity
(e) specific viscosity.
Ans: d
20. The normal stress in a fluid will be constant in all directions at a point only if
(a) it is incompressible
(b) it has uniform viscosity
(c) it has zero viscosity (d) it is frictionless (e) it is at rest.
Ans: e

21. The pressure at a point in a fluid will not be same in all the directions when the fluid is (a) moving
(b) viscous
(c) viscous and static (d) inviscous and moving (e) viscous and moving.

Ans: e

22. An object having 10 kg mass weighs 9.81kg on a spring balance. The value of 'g' at this place is
(a) 10m/sec2
(b) 9.81 m/sec2
(c) 10.2/m sec (d) 9.75 m/sec2 (e) 9 m/sec .
Ans: a

23. The tendency of a liquid surface to contract is due to the following property (a) cohesion
(b) adhesion
(c) viscosity
(d) surface tension (e) elasticity.
Ans: d

24. The surface tension of mercury at normal temperature compared to that of water is (a) more
(b) less
(c) same
(d) more or less depending on size of glass tube
(e) none of the above. Ans: a

25. A perfect gas
(a) has constant viscosity
(b) has zero viscosity
(c) is in compressible
(d) is of theoretical interest (e) none of the above.
Ans: e

26. For very great pressures, viscosity of moss gases and liquids
(a) remains same
(b) increases
(c) decreases
(d) shows erratic behavior (e) none of the above.
Ans: d

27. A fluid in equilibrium can't sustain

(a) tensile stress
(b) compressive stress
(c) shear stress
(d) bending stress
(e) all of the above.
Ans: c

28. Viscosity of water in comparison to mercury is
(a) higher
(b) lower
(c) same
(d) higher/lower depending on temperature (e) unpredictable.
Ans: a

29. The bulk modulus of elasticity with increase in pressure
(a) increases (b)
decreases
(c) remains constant
(d) increases first up to certain limit and then decreases
(e) unpredictable.
Ans: a

30. The bulk modulus of elasticity
(a) has the dimensions of 1/pressure
(b) increases with pressure
(c) is large when fluid is more compressible (d) is independent of pressure and viscosity (e) is directly proportional to flow.
Ans: b

31. A balloon lifting in air follows the following principle
(a) law of gravitation
(b) Archimedes principle
(c) principle of buoyancy (d) all of the above
(e) continuity equation.
Ans: d

32. The value of the coefficient of compressibility for water at ordinary pressure and temperature in kg/cm is equal to

(a) 1000
(b) 2100
(c) 2700 (d) 10,000 (e) 21,000.
Ans: e

33. The increase of temperature results in
(a) increase in viscosity of gas
(b) increase in viscosity of liquid
(c) decrease in viscosity of gas (d) decrease in viscosity of liquid (e) (a) and (d) above.
Ans: d

34. Surface tension has the units of
(a) newtons/m
(b) newtons/m
(c) new tons/m
(d) newtons
(e) newton m. Ans: c

35. Surface tension
(a) acts in the plane of the interface normal to any line in the surface
(b) is also known as capillarity
(c) is a function of the curvature of the interface (d) decreases with fall in temperature (e) has no units.
Ans: a

36. The stress-strain relation of the newtoneon fluid is
(a) linear
(b) parabolic
(c) hyperbolic (d) inverse type
(e) none of the above.
Ans: a

37. A liquid compressed in cylinder has a volume of 0.04 m3 at 50 kg/cm2 and a volume of 0.039 m3 at 150 kg/cm2. The bulk modulus of elasticity of liquid is (a) 400 kg/cm2
(b) 4000 kg/cm2
(c) 40 x 105 kg/cm2

(d) 40 x 106 kg/cm2
(e) none of the above.
Ans: b

38. The units of viscosity are
(a) metres2 per sec
(b) kg sec/metre
(c) newton-sec per metre2 (d) newton-sec per meter (e) none of the above.
Ans: b

39. Kinematic viscosity is dependent upon
(a) pressure
(b) distance
(c) level
(d) flow
(e) density.
Ans: e

40. Units of surface tension are
(a) energy/unit area
(b) distance
(c) both of the above (d) it has no units
(e) none of the above.
Ans: c

41. Which of the following meters is not associated with viscosity
(a) Red wood
(b) Say bolt
(c) Engler
(d) Orsat
(e) none of the above.
Ans: d

42. Choose the correct relationship
(a) specific gravity = gravity x density
(b) dynamicviscosity = kinematicviscosity x density
(c) gravity = specific gravity x density

(d) kinematicviscosity = dynamicviscosity x density (e) hydrostaticforce = surface tension x gravity. Ans: b

43. Dimensions of surface tension are
(a) MIL°T2
(b) MIL°Tx
(c) MIL r2
(d) MIL2T2 (e) MIL°t.
Ans: a

44. For manometer, a better liquid combination is one having
(a) higher surface tension
(b) lower surface tension
(c) surface tension is no criterion (d) high density and viscosity (e) low density and viscosity.
Ans: a

45. If mercury in a barometer is replaced by water, the height of 3.75 cm of mercury will be following cm of water
(a) 51 cm
(b) 50 cm
(c) 52 cm (d) 52.2 cm
(e) 51.7 cm. Ans:
a

46. Choose the wrong statement.
Alcohol is used in manometer, because
(a) its vapour pressure is low
(b) it provides suitable meniscus for the inclined tube
(c) its density is less
(d) it provides longer length for a given pressure difference (e) it provides accurate readings.
Ans: a

47. Increase in pressure at the outer edge of a drum of radius R due to rotation at corad/sec, full of liquid of density p will be
(a) pco2/?2
(b) pco2/?2/2

(c) 2pa2R2
(d) pa2R/2
(e) none of the above.
Ans: b

48. The property of fluid by virtue of which it offers resistance to shear is called
(a) surface tension
(b) adhesion
(c) cohesion
(d) viscosity
(e) all of the above.
Ans: d
49. Choose the wrong statement (a)
fluids are capable of flowing
(b) fluids conform to the shape of the containing vessels
(c) when in equilibrium, fluids cannot sustain tangential forces
(d) when in equilibrium, fluids can sustain shear forces
(e) fluids have some degree of comprehensibility and offer little resistance to form.
Ans: d

50. The density of water is 1000 kg/m3 at
(a) 0°C
(b) 0°K
(c) 4°C (d) 20°C (e) all temperature.
Ans: c

51. If w is the specific weight of liquid and k the depth of any point from the surface, then pressure intensity at that point will be
(a) h
(b) wh
(c) w/h (d) h/w
(e) h/wh.
Ans: b

52. Choose the wrong statement
(a) Viscosity of a fluid is that property which determines the amount of its resistance to a shearing force
(b) Viscosity is due primarily to interaction between fluid molecules

(c) Viscosity of liquids decreases with in-crease in temperature (d) Viscosity of liquids is appreciably affected by change in pressure (e) Viscosity is expressed as poise, stoke, or saybolt seconds.

Ans: d

53. The units of kinematic viscosity are

(a) metres2 per sec

(b) kg sec/metre

(c) newton-sec per metre (d) newton-sec per metre (e) none of the above.

Ans: a

54. The ratio of absolute viscosity to mass density is known as

(a) specific viscosity

(b) viscosity index

(c) kinematic viscosity

(d) coefficient of viscosity

(e) coefficient of compressibility. Ans: c

55. Kinematic viscosity is equal to

(a) dynamic viscosity/density

(b) dynamicviscosity x density

(c) density/dynamic viscosity

(d) 1/dynamicviscosity x density (e) same as dynamic viscosity.

Ans: a

56. Which of the following is the unit of kinematic viscosity

(a) pascal

(b) poise

(c) stoke

(d) faraday

(e) none of the above.

Ans: c

57. A one dimensional flow is one which

(a) is uniform flow

(b) is steady uniform flow

(c) takes place in straight lines

(d) involves zero transverse component of flow (e) takes place in one dimension.

Ans: d

58. Alcohol is used in manometers because
(a) it has low vapour pressure
(b) it is clearly visible
(c) it has low surface tension
(d) it can provide longer column due to low density (e) is provides suitable meniscus.
Ans: d
59. A pressure of 25 m of head of water is equal to
(a) 25 kN/m2
(b) 245 kN/m2
(c) 2500 kN/m2 (d) 2.5kN/m2
(e) 12.5 kN/m2.
Ans: b

60. Specific weight of sea water is more that of pure water because it contains (a) dissolved air
(b) dissolved salt
(c) suspended matter (d) all of the above (e) heavy water.
Ans: d

61. If 850 kg liquid occupies volume of one cubic meter, men 0.85 represents its
(a) specific weight
(b) specific mass
(c) specific gravity (d) specific density
(e) none of the above.
Ans: c

62. Free surface of a liquid tends to contract to the smallest possible area due to force of
(a) surface tension
(b) viscosity
(c) friction (d) cohesion (e) adhesion.
Ans: a

63. A bucket of water is hanging from a spring balance. An iron piece is suspended into water without touching sides of bucket from another support. The spring balance reading will
(a) increase (b)
decrease
(c) remain same
(d) increase/decrease depending on depth of immersion
(e) unpredictable.
Ans: c

64. Falling drops of water become spheres due to the property of
(a) adhesion
(b) cohesion
(c) surface tension (d) viscosity
(e) compressibility.
Ans: c

65. A liquid would wet the solid, if adhesion forces as compared to cohesion forces are (a) less
(b) more
(c) equal
(d) less at low temperature and more at high temperature (e) there is no such criterion.
Ans: b

66. If cohesion between molecules of a fluid is greater than adhesion between fluid and glass, then the free level of fluid in a dipped glass tube will be
(a) higher than the surface of liquid
(b) the same as the surface of liquid
(c) lower than the surface of liquid (d) unpredictable
(e) none of the above.
Ans: c

67. The point in the immersed body through which the resultant pressure of the liquid may be taken to act is known as
(a) meta center
(b) center of pressure
(c) center of buoyancy (d) center of gravity (e) none of the above.

Ans: b

68. The total pressure on the surface of a vertical sluice gate 2 m x 1 m with its top 2 m surface being 0.5 m below the water level will be
(a) 500 kg
(b) 1000 kg
(c) 1500 kg
(d) 2000 kg
(e) 4000 kg.
Ans: d

69. The resultant upward pressure of a fluid on a floating body is equal to the weight of the fluid displaced by the body. This definition is according to
(a) Buoyancy
(b) Equilibrium of a floating body
(c) Archimedes' principle (d) Bernoulli's theorem
(e) Metacentric principle.
Ans: c

70. The resultant upward pressure of the fluid on an immersed body is called
(a) upthrust
(b) buoyancy
(c) center of pressure (d) all the above are correct
(e) none of above is correct.
Ans: b

71. The conditions for the stable equilibrium of a floating body are
(a) the meta-center should lie above the center of gravity
(b) the center of buoyancy and the center of gravity must lie on the same vertical line
(c) a righting couple should be formed (d) all the above are correct
(e) none of the above is correct.
Ans: d

72. Poise is the unit of
(a) surface tension
(b) capillarity
(c) viscosity

(d) shear stress in fluids (e) buoyancy.
Ans: c

73. Metacentric height is given as the distance between
(a) the center of gravity of the body and the meta center
(b) the center of gravity of the body and the center of buoyancy
(c) the center of gravity of the body and the center of pressure (d) center of buoyancy and metacentre (e) none of the above.
Ans: a

74. The buoyancy depends on
(a) mass of liquid displaced
(b) viscosity of the liquid
(c) pressure of the liquid displaced (d) depth of immersion (e) none of the above.
Ans: a

75. The center of gravity of the volume of the liquid displaced by an immersed body is called (a) meta-center
(b) center of pressure
(c) center of buoyancy (d) center of gravity (e) none of the above.
Ans: c

76. A piece of metal of specific gravity 13.6 is placed in mercury of specific gravity 13.6, what fraction of it volume is under mercury? (a) the metal piece will simply float over the mercury
(b) the metal piece will be immersed in mercury by half
(c) whole of the metal piece will be immersed with its top surface just at mercury level
(d) metal piece will sink to the bottom (e) none of the above.
Ans: c

77. The angle of contact in case of a liquid depends upon
(a) the nature of the liquid and the solid
(b) the material which exists above the free surface of the liquid
(c) both of die above
(d) any one of the above
(e) none of die above.
Ans: c

78. Free surface of a liquid behaves like a sheet and tends to contract to smallest possible area due to the (a) force of adhesion
(b) force of cohesion
(c) force of friction (d) force of diffusion
(e) none of die above.
Ans: b

79. Rain drops are spherical because of
(a) viscosity
(b) air resistance
(c) surface tension forces (d) atmospheric pressure (e) none of the above. Ans: c

80. Surface energy per unit area of a surface is numerically equal to ..
(a) atmospheric pressure
(b) surface tension
(c) force of adhesion (d) force of cohesion (e) viscosity.
Ans: b

81. The capillary rise at 20°C in a clean glass tube of 1 mm bore containing water is approximately
(a) 1 mm
(b) 5 mm
(c) 10 mm
(d) 20 mm
(e) 30 mm.
Ans: e

82. The difference of pressure between the inside and outside of a liquid drop is
(a)p = Txr
(b) p = T/r
(c) p = T/2r
(d) p = 2T/r
(e) none of the above.
Ans: d

83. If the surface of liquid is convex, men
(a) cohesion pressure is negligible (b)
cohesion pressure is decreased

(c) cohesion pressure is increased
(d) there is no cohesion pressure (e) none of the above.
Ans: c

84. To avoid vaporisation in the pipe line, the pipe line over the ridge is laid such that it is not more than
(a) 2.4 m above the hydraulic gradient
(b) 6.4 m above the hydraulic gradient
(c) 10.0 m above the hydraulic gradient (d) 5.0 above the hydraulic gradient (e) none of the above.
Ans: b

85. To avoid an interruption in the flow of a syphon, an air vessel is provided (a) at the inlet
(b) at the outlet
(c) at the summit
(d) ay nay point between inlet and outlet (e) none of the above.
Ans: c

86. The vapour pressure over the concave surface is
(a) less man the vapour pressure over the plane surface
(b) equal to the vapour pressure over the plane surface
(c) greater than the vapour pressure over the plane surface
(d) zero
(e) none of the above.
Ans: a

87. The property by virtue of which a liquid opposes relative motion between its different layers is called
(a) surface tension
(b) co-efficient of viscosity
(c) viscosity
(d) osmosis
(e) cohesion.
Ans: c

88. The process of diffusion of one liquid into the other through a semi-permeable membrane is called
(a) viscosity
(b) osmosis
(c) surface tension (d) cohesion
(e) diffusivity.
Ans: b

89. The units of dynamic or absolute viscosity are
(a) metres2 per sec
(b) kg sec/meter
(c) newton-sec per meter (d) newton-sec2 per meter (e) none of the above.
Ans: c

90. The continuity equation is connected with
(a) viscous/unviscous fluids (b)
compressibility of fluids
(c) conservation of mass
(d) steady/unsteady flow
(e) open channel/pipe flow.
Ans: c

91. The rise or depression of liquid in a tube due to surface tensionwim increase in size of tube will
(a) increase
(b) remain unaffected
(c) may increase or decrease depending on the characteristics of liquid (d) decrease
(e) unpredictable.
Ans: d
92. Liquids transmit pressure equally in all the directions. This is according to (a) Boyle's law
(b) Archimedes principle
(c) Pascal's law (d) Newton's formula (e) Chezy's equation.
Ans: c

93. Capillary action is due to the
(a) surface tension

(b) cohesion of the liquid
(c) adhesion of the liquid molecules and the molecules on the surface of a solid (d) all of the above
(e) none of the above.
Ans: d

94. Newton's law of viscosity is a relationship between
(a) shear stress anctthejiate of angular distortion
(b) shear stress and viscosity
(c) shear stress, velocity and viscosity
(d) pressure, velocity and viscosity
(e) shear stress, pressure and rate of angular distortion. Ans: a

95. The atmospheric pressure with rise in altitude decreases
(a) linearly
(b) first slowly and then steeply
(c) first steeply and then gradually (d) unpredictable
(e) none of the above.
Ans: b

96. Pressure of the order of 10"' torr can be measured by
(a) Bourdon tube
(b) Pirani Gauge
(c) micro-manometer (d) ionisastion gauge (e) McLeod gauge.
Ans: d
97. Operation of McLeod gauge used for low pressure measurement is based on the principle of (a) gas law
(b) Boyle's law
(c) Charle's law (d) Pascal's law
(e) McLeod's law.
Ans: b

98. An odd shaped body weighing 7.5 kg and occupying 0.01 m3 volume will be completely submerged in a fluid having specific gravity of (a) 1
(b) 1.2
(c) 0.8
(d) 0.75
(e) 1.25.

Ans: d

99. In an isothermal atmosphere, the pressure
(a) decreases linearly with elevation
(b) remains constant
(c) varies in the same way as the density (d) increases exponentially with elevation
(e) unpredictable.
Ans: c

100. Mercury is often used in barometer because
(a) it is the best liquid
(b) the height of barometer will be less
(c) its vapour pressure is so low that it may be neglected (d) both (b) and (c) (e) it moves easily.
Ans: d

101. Barometer is used to measure (a)
pressure in pipes, channels etc.
(b) atmospheric pressure
(c) very low pressure
(d) difference of pressure between two points
(e) rain level.
Ans: b

102. Which of the following instrument can be used for measuring speed of a submarine moving in deep sea
(a) Venturimeter
(b) Orifice plate
(c) hot wire anemometer (d) rotameter (e) pitot tube.
Ans: e

103. Which of the following instrument can be used for measuring speed of an aeroplane (a) Venturimeter
(b) Orifice plate
(c) hot wire anemometer (d) rotameter (e) pitot tube.
Ans: e

Code No. : 5416/N

FACULTY OF ENGINEERING

B.E. 2/4 (Civil) II Semester (New) (Main) Examination, May/June 2012

FLUID MECHANICS – I

Time : 3 Hours] [Max. Marks : 75

***Note :** Answer **all** questions from Part **A**, answer **any five** questions from Part **B**.*

PART – A (25 Marks)

1. Define Newton's law of viscosity. **2**
2. Define surface tension. Prove the relationship between surface tension and pressure inside drop let of liquid is given by $p = \frac{4\sigma}{d}$. **2**
3. Explain the terms path line and streak line. **2**
4. Differentiate between forced vortex and free vortex flow. **2**
5. The stream function for a two-dimensional flow is given $\psi = 2xy$. Calculate the velocity at the point P(2, 3). Find the velocity potential function ϕ. **3**
6. What is difference between momentum equation and impulse equations ? **2**
7. Prove that the error in discharge due to the error in the measurement of head over a rectangular notch is given by $\frac{dQ}{Q} = \frac{3dH}{2H}$. **3**

   when Q = discharge through rectangular notch and H = head over the rectangular notch.
8. State the Bernoulli's theorem for compressible flow. **3**
9. Define Mach number. What is significance of mach number in compressible fluid flow ? **3**
10. Define the term momentum correction factor. **3**

(This paper contains 2 pages)

P.T.O.

PART – B (50 Marks)

11. a) Define the continuity equation and obtain an expression for a three dimensional flow. 6

    b) The velocity potential function ϕ is given by $\phi = x^2 - y^2$. Find the velocity components in x and y direction. Also show that ϕ represents a possible case of fluid flow. 4

12. a) Starting with Euler's equation of motion along a stream line, obtain Bernoulli's equation by its integration. List all the assumptions made. 5

    b) Water is flowing through a pipe having diameters 30 cm and 15 cm at the button and upper end respectively. The intensity of pressure at the bottom end is 14.715 N/cm^2. Determine the difference in datum head if the rate of flow through pipe is 50 liters/sec. 5

13. a) A rectangular channel is 15 m wide has a discharge of 200 liters per second which is measured by a right angled V-notch Weir. Find the position of the apex of the notch from the bed of the channel with maximum depth of water not to exceed 1 m. Take $C_d = 0.62$. 6

    b) Explain the principle of venturimeter with a neat sketch. Prove the expression for the rate of flow of fluid through it. 4

14. a) What do you understand by stagnation pressure ? Obtain an expression for stagnation pressure of a compressible fluid in terms of approaching mach number and pressure. 6

    b) Find the mach number when an aeroplane is flying at 1000 km/hour through still air having pressure of 7 N/cm^2 and temperature of $-5°C$. Take R = 287.14 J/kg K. Calculate the pressure and temperature of air at stagnation point. Take K = 14. 4

15. a) What for Hagen Poiseuille's formula is helpful ? Derive an expression for Hagen Poiseuille's formula. 6

    b) A liquid is pumped through a 15 cm diameter and 300 m long pipe at the rate of 20 tonnes per hour the density of liquid is 910 kg/m^3 and Kinematic viscosity = 0.002 m^2/s. Determine Reynold's number. 4

16. a) State the significance of Mody's diagram in flow through pressure conduits. 5

    b) Derive an expression for Bernoulli's equations when process is adiabatic. 5

17. Write the short notes of following :

    a) Elbowmeter. 3

    b) Mach cone 3

    c) Reynolds experiment. 4

1,000

Code No. : **5416/N**

FACULTY OF ENGINEERING

B.E. 2/4 (Civil) II Semester (New) (Main) Examination, May/June 2012

FLUID MECHANICS – I

Time : 3 Hours] [Max. Marks : 75

Note : *Answer **all** questions from Part **A**, answer **any five** questions from Part **B**.*

PART – A **(25 Marks)**

1. Define Newton's law of viscosity. **2**

2. Define surface tension. Prove the relationship between surface tension and pressure inside drop let of liquid is given by $p = \frac{4\sigma}{d}$. **2**

3. Explain the terms path line and streak line. **2**

4. Differentiate between forced vortex and free vortex flow. **2**

5. The stream function for a two-dimensional flow is given $\psi = 2xy$. Calculate the velocity at the point P(2, 3). Find the velocity potential function ϕ. **3**

6. What is difference between momentum equation and impulse equations ? **2**

7. Prove that the error in discharge due to the error in the measurement of head over a rectangular notch is given by $\frac{dQ}{Q} = \frac{3dH}{2H}$. **3**

   when Q = discharge through rectangular notch and H = head over the rectangular notch.

8. State the Bernoulli's theorem for compressible flow. **3**

9. Define Mach number. What is significance of mach number in compressible fluid flow ? **3**

10. Define the term momentum correction factor. **3**

(This paper contains 2 pages)

P.T.O.

PART – B

(50 Marks)

11. a) Define the continuity equation and obtain an expression for a three dimensional flow. 6

b) The velocity potential function ϕ is given by $\phi = x^2 - y^2$. Find the velocity components in x and y direction. Also show that ϕ represents a possible case of fluid flow. 4

12. a) Starting with Euler's equation of motion along a stream line, obtain Bernoulli's equation by its integration. List all the assumptions made. 5

b) Water is flowing through a pipe having diameters 30 cm and 15 cm at the button and upper end respectively. The intensity of pressure at the bottom end is 14.715 N/cm². Determine the difference in datum head if the rate of flow through pipe is 50 liters/sec. 5

13. a) A rectangular channel is 15 m wide has a discharge of 200 liters per second which is measured by a right angled V-notch Weir. Find the position of the apex of the notch from the bed of the channel with maximum depth of water not to exceed 1 m. Take $C_d = 0.62$. 6

b) Explain the principle of venturimeter with a neat sketch. Prove the expression for the rate of flow of fluid through it. 4

14. a) What do you understand by stagnation pressure ? Obtain an expression for stagnation pressure of a compressible fluid in terms of approaching mach number and pressure. 6

b) Find the mach number when an aeroplane is flying at 1000 km/hour through still air having pressure of 7 N/cm² and temperature of – 5°C. Take R = 287.14 J/kg K. Calculate the pressure and temperature of air at stagnation point. Take K = 14. 4

15. a) What for Hagen Poiseuille's formula is helpful ? Derive an expression for Hagen Poiseuille's formula. 6

b) A liquid is pumped through a 15 cm diameter and 300 m long pipe at the rate of 20 tonnes per hour the density of liquid is 910 kg/m³ and Kinematic viscosity = 0.002 m²/s. Determine Reynold's number. 4

16. a) State the significance of Mody's diagram in flow through pressure conduits. 5

b) Derive an expression for Bernoulli's equations when process is adiabatic. 5

17. Write the short notes of following :

a) Elbowmeter. 3

b) Mach cone 3

c) Reynolds experiment. 4

1,000

Code No. 2045

FACULTY OF ENGINEERING

B.E. 2/4 (Civil) II-Semester (Main) Examination, April / May 2013

Subject : Fluid Mechanics - I

Time : 3 Hours **Max. Marks: 75**

Note: Answer all questions of Part - A and answer any five questions from Part-B.

PART – A (25 Marks)

1. Differentiate between notch and weir. (2)
2. What is hydrostatic variation of pressure force? (2)
3. Define momentum correction factor. (2)
4. What do you mean by velocity of approach in a notch? (2)
5. Define temporal acceleration. (2)
6. Darcy-Weisbach equation can be used only for turbulent flows-yourcomment. (3)
7. What is meant by lower critical Reynolds number in pipe flows? (3)
8. Define Stream function and velocity potential. (3)
9. What is Mach cone? (3)
10. What is an equivalent pipe? (3)

PART – B (5x10=50 Marks)

11.(a) Derive the expression for variation of pressure in a static fluid. (5)
(b) A hydraulic lift consists of a 28cm diameter ram which slides in a 28.015cm diameter cylinder, the annular space being filled with oil having kinematic viscosity of 0.025 cm^2/s and specific gravity 0.85. If the rate of travel of the ram is 10.15 m/min, find the frictional resistance when 3.25m of the ram is engaged in the cylinder. (5)

12.(a) Derive Bernoulli's equation from Euler's equation of motion clearly stating the assumptions involved. (5)
(b) A pipe bend tapers in the direction of flow from a diameter of 500mm to a diameter of 250mm and turns through 450 in the horizontal plane. The pressure at inlet is 40 kPa. If the pipe is conveying oil of specific gravity of 0.85, find the magnitude and direction of the resultant force on the bed when the oil flows at a rate of 150 litres / s. (5)

13.(a) Derive the expression for discharge through a Venturimeter fitted to an inclined pipe line. (5)
(b) In an experiment on a 90° V-notch the flow is collected in vertical cylindrical tank 0.9m diameter. It is found that the depth of water in the tank increases by 0.65 m in 16.8 s when the head over the notch is 0.2m. Determine the coefficient of discharge through the notch. (5)

14.(a) Derive the equation for velocity of pressure wave or elastic wave in a compressible fluid. (5)

(b) Air is flowing through a pipe with a velocity of 285m/s where its pressure temperature are 0.6 bar (absolute) and 300K. The pipe along the flow changes in diameter and its pressure at that section is 0.9 bar (absolute). Taking Y as 1.4 and R as 287Nm/kg0K, and assuming the adiabatic flow, find the velocity of flow at this section. (5)

15.(a) Explain the concept of equivalent pipe and generate the relevant expression. (5)

(b) Oil of viscosity 0.1 Pa-s and specific gravity 0.9, flows through a horizontal pipe of 25 mm diameter. If the pressure drop per metre length of the pipe is 12kPa, determine (i) the rate of flow in N/min (ii) the shear stress at the pipe wall (iii) the Reynolds number of the flow (iv) the power required per 50m length of pipe to maintain flow. (5)

16.(a) Derive the expression for loss of energy due to sudden contraction in a circular pipe. (5)

(b) Oil of specific gravity 0.9 flows in a 300mm diameter at the rate of 120 litres per second and the pressure at a point A is 24.525 kPa. If the point A is 5.2 m above the datum line, calculate the total energy at point A in terms of meters of oil. (5)

17. Write short notes on the following:

(a) Rotameter (3)

(b) Pascal's Law (3)

(c) Vapour pressure (4)

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Code No. 463/CBCS

FACULTY OF ENGINEERING

B.E. (Civil) IV - Semester (CBCS) (Main) Examination, May/June 2018

Subject : Fluid Mechanics - II

Time : 3 Hours **Max. Marks: 70**

Note: Answer all questions from Part-A & any five questions from Part-B.

PART – A (20 Marks)

1 Write the significance of Reynolds number. 2

2 Find the diameter of a single pipe of length 1500m to replace three pipes of length 600m, 500m and 300m and diameters 300mm, 200mm and 100mm. 2

3 Explain the terms hydraulic gradient line and total energy line. 2

4 Define water hammer phenomenon. 2

5 Differentiate between friction drag and pressure drag. 2

6 Define laminar sublayer. 2

7 Define specific energy and critical depth. 2

8 State the Froude number values for critical, subcritical and supercritical states of flow. 2

9 List the different surface profiles. 2

10 If a hydraulic jump occurs at a point where the upstream depth is 0.25m, what would be the depth after the hydraulic jump, if the discharge per unit width q=0.625 m^3/s per metre width. 2

PART - B (50 Marks)

11 (a) Derive Hagen Poisuille's equation for laminar flow through circular pipes. 5

(b) A pipe 200mm in diameter and 45m long conveys water at a velocity of 2.5 m/s. Find the head lost in friction. Take f= 0.006. 5

12 (a) Explain different types of pipes, based on pipe materials. 5

(b) Water flowing in a long pipe of diameter 150mm and thickness 6mm is suddenly stopped by closing the valve at the discharge end. The quantity of water flowing is 18 litres/sec. Find the rise in pressure, taking the modulus of elasticity of pipe material as 1.962×10^5 N/mm^2 and bulk modulus of water as 1.962×10^3 N/mm^2. 5

13 (a) Explain the drag on a flat plate, held perpendicular to the direction of flow of fluid. 5

(b) If the velocity distribution in the boundary layer is given by $\frac{u}{U} = \frac{y}{\delta}$, determine the displacement thickness, momentum thickness and energy thickness. 5

14 (a) Derive Chezy's equation for uniform flow. 5

(b) A channel of trapezoidal section has sides sloping at 60^0 with the horizontal and a bed slope of 1 in 800 and conveys a discharge of 12m^3/s. Find the bottom width and depth of flow for most economical section. Take Chezy's constant C=70. 5

15 (a) Explain specific energy diagram and determine the expression for critical depth. 5

(b) A rectangular channel 7.5m wide has a uniform depth of flow of 2m and has a bed slope of 1 in 3000. If due to weir constructed at the downstream end of the channel, water surface at a section is raised by 0.75m, determine the water surface slope with respect to the horizontal at this section. Take n=0.02. 5

16 (a) Derive an expression for the celerity of a positive surge. 5

(b) Calculate the total drag, shear drag and pressure drag exerted on 1m length of an infinite circular cylinder which has a diameter equal to 30mm, air of density 1.236 Kg/m^3 flowing past the cylinder with velocity 3.6 m/min. Take total drag coefficient equal to 1.4 and shear drag coefficient equal to 0.185. 5

17 Write short notes on 10

(i) Momentum thickness

(ii) Separation of Boundary layer.

(iii) Hydraulic jump.

*****

ASSIGNMENT QUESTIONS

1.	a) Explain briefly the physical properties of fluid ie Mass density, Weight density, Specific gravity and also explain the concept of capillary rise and fall in a fluid. b) What is Pascal's law? Derive the equation of Pascal's law ie,(Px = Py= Pz).	CO1
2.	a) Derive the continuity equation for 3-Dimensional. b) The velocity potential function $\emptyset=(-xy^3-x^2+x^3y+y^2)$ find i)The velocity component in X and Y direction. ii) Show that $\emptyset$ represents a possible case of flow.	CO2
3.	A 40cm diameter pipe conveying water, branches into two pipes of diameter 30cm and 20cm respectively. If the average velocity in the 40cm diameter pipe is 3m/sec. Find the discharge in this pipe. Also determine the velocity in 20cm pipe if the average velocity in 30cm diameter pipe is 2m/sec.	CO2
4.	Derive the Euler's equation of motion.	CO3

ASSIGNMENT QUESTIONS

1.	Explain briefly about convective and local acceleration also with surface and body forces.	CO3
2.	Definition and types of free and forced vortex flow.	CO3
3.	Measurement of discharge through different Notches and Weir.	CO3
4.	Discharge through an orifice meter, Bernoulli's equation for adiabatic and isothermal conditions.	CO4

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6	161019732007	78	161019732090
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NAWAB SHAH ALAM KHAN COLLEGE OF ENGINEERING AND TECHNOLOGY, OSMANIA UNIVERSITY, Hyderabad
DEPARTMENT OF CIVIL ENGINEERING

B.E. II YEAR, IV SEM - ATTAINMENT CALCULATIONS - Academic Year: 2020-21

Subject: FLUID MECHANICS **Subject Code:** PC403CE **Faculty:** Mr.Mohd Azheruddin

S.No.	Hall Ticket No.	CIE - 1											CIE - 2											CIE		SEE
		ASG-1 (5M)	ASG-2 (5 M)	Part-1 Q1-abcd (6 M)		Q 2 (7 M)	Q 3 (7 M)	BEST OF Q2&Q3	Q 4 (7 M)	Q 5 (7 M)	BEST OF Q4&Q5	CIE-1 TOTAL (30 M)	ASG-1 (5M)	ASG-2 (5 M)	Part-1 Q1abcd (6 M)		Q 2 (7 M)	Q 3 (7 M)	BEST OF Q2&Q3	Q 4 (7 M)	Q 5 (7 M)	BEST OF Q4&Q5	CIE-2 TOTAL (30 M)	Average CIE	TOTAL Marks	End Exam
		CO1	CO2	CO1	CO2	CO1	CO1	CO1	CO2	CO2	CO2		CO3	CO4	CO3	CO4	CO3	CO3	CO3	CO4	CO4	CO4		(30 M)	(100 M)	(70 M)
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3	161019732003	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5		5	5	24	25	74	49
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5	161019732006	5	5	3	2	4		4		7	7	26	5	5	2	2		4	4	5		5	23	25	53	28
6	161019732007	5	5	3	2	4		4	7		7	26	5	5	2	2		4	4	6		6	24	25	74	49
7	161019732008	5	5	3	2	4		4		7	7	26	5	5	2	2		5	5	7		7	26	26	54	28
8	161019732009	5	5	3	2		4	4	7		7	26	5	5	2	2	5		5	7		7	26	26	82	56
9	161019732010	5	5	3	2		4	4	7		7	26	5	5	2	2	5		5	6		6	25	26	54	28
10	161019732011	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	7		7	26	26	61	35
11	161019732013	5	5	3	2	4		4		7	7	26	5	5	2	2	6		6	7		7	27	27	90	63
12	161019732014	5	5	3	2	6		6	7		7	28	5	5	2	2	6		6	7		7	27	28	56	28
13	161019732016	5	5	3	2		4	4	7		7	26	5	5	2	2	7		7	7		7	28	27	76	49
14	161019732017	5	5	3	2	4		4		7	7	26	5	5	2	2	5		5	7		7	26	26	26	0
15	161019732018	5	5	3	2	5		5	7		7	27	5	5	2	2	6		6	7		7	27	27	76	49
16	161019732019	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	5		5	24	25	74	49
17	161019732020	5	5	3	2	4		4		7	7	26	5	5	2	2		6	6	7		7	27	27	69	42
18	161019732021	3	5	3	2	4		4		4	4	21	5	5	2	2		3	3	2		2	19	20	76	56
19	161019732022	5	5	3	2		6	6	7		7	28	5	5	2	2		6	6	7		7	27	28	63	35
20	161019732023	5	5	3	2		4	4	5		5	24	5	5	2	2	5		5	5		5	24	24	73	49
21	161019732024	5	5	3	2	4		4	7		7	26	5	5	2	2	4		4	6		6	24	25	67	42
22	161019732025	5	5	3	2		4	4	7		7	26	5	5	2	2	5		5	5		5	24	25	53	28
23	161019732026	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	5		5	24	25	74	49
24	161019732027	4	3	3	2		4	4	4		4	20	5	4	2	2	3		3	4		4	20	20	69	49
25	161019732028	5	5	3	2	4		4	5		5	24	5	5	2	2	5		5	5		5	24	24	66	42
26	161019732029	5	5	3	2	4		4	7		7	26	5	5	2	2	7		7	7		7	28	27	76	49
27	161019732030	5	3	3	2		3	3	4		4	20	3	3	2	2	3		3	4		4	17	19	47	28
28	161019732031	5	5	3	2	4		4	7		7	26	4	5	2	2	3		3	4		4	20	23	58	35
29	161019732032	5	5	3	2		4	4	7		7	26	5	5	2	2		7	7	7		7	28	27	55	28
30	161019732033	5	5	3	2	4		4	7		7	26	5	5	2	2		7	7	7		7	28	27	69	42
31	161019732034	5	5	3	2		5	5	7		7	27	5	5	2	2	7		7	7		7	28	28	63	35
32	161019732036	5	5	3	2	4		4	4		4	23	5	5	2	2	3		3	5		5	22	23	65	42
33	161019732038	5	5	3	2	4		4	7		7	26	5	5	2	3		7	7	7		7	29	28	70	42
34	161019732039	5	5	3	2		4	4	7		7	26	5	3	2	2	5		5	5		5	22	24	52	28
35	161019732040	5	5	3	2	5		5	7		7	27	5	5	2	2	7		7	7		7	28	28	70	42
36	161019732041	5	5	3	2	4		4	7		7	26	5	5	4	2		7	7	7		7	30	28	70	42
37	161019732042	5	5	3	2		4	4	7		7	26	5	3	2	2	3		3	3		3	18	22	57	35
38	161019732043	5	5	3	2	4		4	7		7	26	5	5	2	2	7		7	7		7	28	27	83	56
39	161019732044	5	5	3	2	4		4	7		7	26	5	5	2	2		7	7	7		7	28	27	55	28
40	161019732045	5	5	3	2		4	4	7		7	26	5	5	2	2	5		5	5		5	24	25	74	49
41	161019732046	5	5	3	2		4	4	7		7	26	5	5	2	2	7		7		7	7	28	27	55	28
42	161019732047	5	5	3	2	4		4	7		7	26	5	5	2	2		5	5	5		5	24	25	60	35
43	161019732050	5	5	3	2	4		4	7		7	26	5	5	2	2		5	5	5		5	24	25	67	42
44	161019732051	5	5	3	2	4		4	7		7	26	5	5	2	2	3		3	5		5	22	24	66	42
45	161019732052	5	5	3	2		4	4	7		7	26	5	5	2	2	5		5	5		5	24	25	53	28
46	161019732054	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	7		7	26	26	61	35
47	161019732055	5	5	3	2	4		4	7		7	26	5	5	4	2	6		6	7		7	29	28	56	28
48	161019732056	5	5	3	2		4	4	7		7	26	5	5	2	2	4		4	4		4	22	24	66	42

49	161019732057	5	5	3	2	4		4	7		7	26	5	5	2	3	5		5	5		5	25	26	68	42
50	161019732058	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	7		7	26	26	54	28
51	161019732059	5	5	3	2	4		4	7		7	26	5	3	2	2	5		5	5		5	22	24	52	28
52	161019732061	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	5		5	24	25	67	42
53	161019732062	5	5	3	2	4		4	7		7	26	5	5	2	3	6		6	7		7	28	27	83	56
54	161019732063	5	5	3	2		4	4	7		7	26	5	5	2	3	6		6	7		7	28	27	83	56
55	161019732064	5	5	3	2	4		4	7		7	26	5	5	2	2	7		7	7		7	28	27	83	56
56	161019732065	5	5	3	2	4		4		7	7	26	5	5	2	2	4		4	5		5	23	25	53	28
57	161019732066	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	7		7	26	26	75	49
58	161019732067	5	5	3	2	3		3		5	5	23	5	5	2	2	5		5	6		6	25	24	66	42
59	161019732069	5	5	3	2	4		4	7		7	26	5	5	2	3	6		6	7		7	28	27	69	42
60	161019732070	5	5	3	2	4		4		7	7	26	5	5	2	4	5		5	7		7	28	27	83	56
61	161019732071	5	5	3	2	4		4	7		7	26	5	5	2	2		5	5		5	5	24	25	74	49
62	161019732072	5	5	3	2	4		4	7		7	26	5	5	2	4		6	6		5	5	27	27	55	28
63	161019732073	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	7		7	26	26	82	56
64	161019732074	5	5	4	3	4		4		7	7	28	5	5	3	3	5		5	7		7	28	28	77	49
65	161019732076	5	3	3	2	4		4		5	5	22	5	5	2	3	5		5	7		7	27	25	60	35
66	161019732077	5	5	3	2	4		4	7		7	26	5	5	2	2	3		3		5	5	22	24	52	28
67	161019732078	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	5		5	24	25	53	28
68	161019732080	5	5	3	2	5		5	7		7	27	5	5	3	3	5		5	7		7	28	28	70	42
69	161019732081	5	5	3	2	4		4	7		7	26	5	5	2	3	5		5	4		4	24	25	60	35
70	161019732082	5	5	3	2	4		4		7	7	26	5	3	2	2		5	5	5		5	22	24	73	49
71	161019732083	5	5	3	2	4		4		6	6	25	3	4	2	2	3		3	3		3	17	21	49	28
72	161019732084	5	5	3	2	4		4	7		7	26	5	5	2	3	6		6	7		7	28	27	27	0
73	161019732085	5	5	3	2	4		4	7		7	26	5	5	3	3		6	6	7		7	29	28	77	49
74	161019732086	5	5	3	3	6		6		7	7	29	3	5	2	2	7		7	7		7	26	28	77	49
75	161019732087	5	4	3	2	4		4	5		5	23	3	3	2	2	4		4		5	5	19	21	77	56
76	161019732088	5	5	3	2	6		6	7		7	28	5	5	2	3		5	5		7	7	27	28	77	49
77	161019732089	5	5	3	2	4		4	7		7	26	5	5	2	4		6	6		7	7	29	28	84	56
78	161019732090	5	5	3	2	5		5		7	7	27	5	5	3	3		5	5	7		7	28	28	56	28
79	161019732091	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	7		7	26	26	68	42
80	161019732092	5	5	3	2	4		4		7	7	26	5	5	4	3	6		6	7		7	30	28	56	28
81	161019732093	5	5	3	2	6		6	7		7	28	5	5	2	3	6		6	7		7	28	28	63	35
82	161019732095	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5		5	5	24	25	53	28
83	161019732096	5	5	3	2		4	4	7		7	26	5	5	2	2	5		5		5	5	24	25	53	28
84	161019732097	5	5	3	2		4	4	7		7	26	5	5	2	2	5		5		7	7	26	26	61	35
85	161019732098	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	5		5	24	25	67	42
86	161019732099	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	7		7	26	26	54	28
87	161019732301	5	5	3	2	6		6		7	7	28	5	5	2	3		6	6		5	5	26	27	90	63
88	161019732302	5	5	3	2	4		4		7	7	26	5	5	2	2		5	5	7		7	26	26	61	35
89	161019732303	5	5	3	2	4		4	7		7	26	5	4	2	2	4		4		5	5	22	24	66	42
90	161019732304	5	5	3	4	6		6	6		6	29	5	5	3	3	5		5	4		4	25	27	62	35
91	161019732305	5	5	3	2	4		4	7		7	26	5	3	2	2	3		3	4		4	19	23	58	35
92	161019732306	5	5	3	2	4		4	7		7	26	5	4	2	2	3		3	5		5	21	24	73	49
93	161019732307	5	5	3	2	4		4		7	7	26	5	5	3	3	5		5		7	7	28	27	62	35
94	161019732308	5	5	3	2	4		4	7		7	26	5	5	2	3	6		6	7		7	28	27	62	35
95	161019732309	5	4	3	2	4		4		5	5	23	5	3	2	2	3		3	4		4	19	21	63	42
96	161019732310	5	5	3	2	4		4	7		7	26	5	5	3	3	5		5	7		7	28	27	69	42
97	161019732311	5	5	3	2	4		4	7		7	26	5	5	2	2	5		5	5		5	24	25	88	63
98	161019732312	5	5	3	2		5	5	7		7	27	5	5	3	3	5		5			0	21	24	24	0
99	161019732313	5	5	3	2		4	4	7		7	26	5	5	2	2		5	5	5	7	7	26	26	61	35
100	161019732314	5	5	3	2	4		4	7		7	26	5	5	2	2		5	5	7		7	26	26	68	42
101	161019732315	5	5	3	2		4	4	7		7	26	5	5	2	2	5		5	5		5	24	25	67	42
102	161019732316	5	5	3	2	4		4	7		7	26	5	5	3	3	5		5	7		7	28	27	69	42
103	161019732317	5	5	3	2	4		4		7	7	26	5	5	2	2	5		5	5		5	24	25	81	56
104	161019732318	4	4	3	2	4		4		6	6	23	4	3	2	2	3		3	5		5	19	21	56	35
105	161019732319	5	5	4	2	5		5		7	7	28	5	5	3	3	5		5	6		6	27	28	56	28
106	161019732320	5	3	3	2	4		4	6		6	23	4	3	2	2	3		3	4		4	18	21	56	35
107	161019732321	5	4	3	2	4		4	5		5	23	3	3	2	2	3		3	4		4	17	20	62	42

CO2	2	2	1	2	-	-	-	-	-	-	-	2	-	-		3
CO3	3	1	2	2	-	-	-	-	-	-	-	2	1	2		3
CO4	3	2	2	-	-	-	-	-	-	-	-	1	-	2		3
Average	2.5	1.5	1.5	2.3333	0	0	0	0	0	0	0	1.75	1	2		3

C02 = (DIRECT ATTAINMENT*0.8) + (INDIRECT ATTAINMENT*0.2)
C03 = (DIRECT ATTAINMENT*0.8) + (INDIRECT ATTAINMENT*0.2)
C04 = (DIRECT ATTAINMENT*0.8) + (INDIRECT ATTAINMENT*0.2)

Course PO Attainments

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	
Direct Attainment	2.50	1.50	1.50	2.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75	1.00	2.00	

PO ATTAINMENTS
DIRECT ATTAINMENT (PO1)= (Average of PO1*Average of CO Direct Attainment)/3
Similar for PO2 TO PO12 & PSO1 TO PSO3

NAWAB SHAH ALAM KHAN COLLEGE OF ENGINEERING AND TECHNOLOGY						
DEPARTMENT OF CIVIL ENGINEERING						
CO Feedback form						
Academic Year 2020-2021						
Course Name with Code	FM & C 222					
Class	BE Civil - IV Semester					
Faculty Name						
CO Attainment	**Internal Attainment**	**External Attainment**	**DIRECT ATTAINMENT LEVEL**	**Indirect Attainment**	**Overall Attainment**	**COPO MAPPING**
CO 1	3	3	3.00	2.38	3	1.76
CO 2	3	3	3.00	2.38	3	1.76
CO 3	3	3	3.00	2.35	3	1.69
CO 4	3	3	3.00	2.40	3	1.80
Overall Course Attainment			3.00	2.38	**3.00**	**1.75**
Set Target for the course						
Course Attainment						
Status(Yes/No)						**YES**

Percentage of students attained CO	**CO attainment rubric**
$\%CO \geq 80$	3
$65 \leq \%CO < 80$	2
$\%CO < 65$	1

H.O.D

Action taken for course outcome attainment feedback:

- Student performance can be enhanced further by involving them to prepare a model for innovation in teaching and learning programme under the institute.
- Taking much longer time than the usual for the assessment and evaluation, for about three to five years roughly.