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Internal Assessment Test 2 – January 2022

Sub:	Fluid Mechanics					Sub Code:	18CV33	Branch:	CV
Date:	25.01.2022	Duration:	90 mins	Max Marks:	50	Sem/Sec:	III		OBE

Answer all questions.
Provide neat sketches wherever necessary

		MARKS	CO	RBT
1	State Impulse-Momentum equation and give an application. List all the forces present in fluid motion and list the forces used for Euler's equation.	[10]	CO 4	L1

Mom...

It is based on law of conservation of momentum on the momentum principle which states that the net force acting on a fluid mass = change in momentum of flow/unit time is that dis the force acting on a fluid mass M is given by newton's second law of motion.

$F = ma$ where a is same acting in the same distance as force F

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

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

$$= \frac{d(mv)}{dt}$$ (m is constant s can be taken inside the diff)

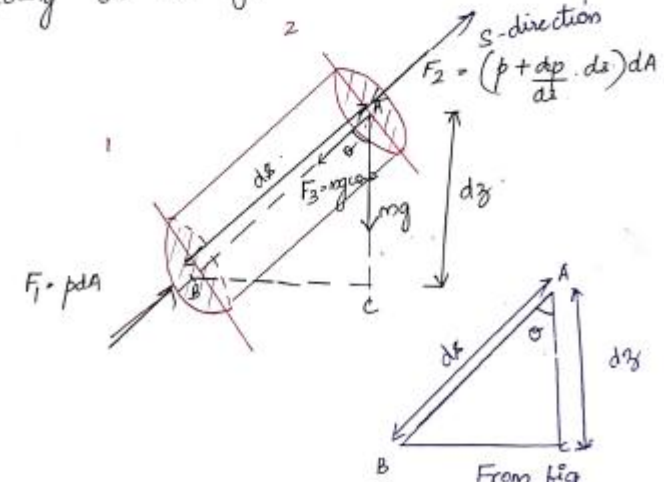
$$F = \frac{d(mv)}{dt}$$ —— momentum principle

$$F \cdot dt = d(mv)$$ impulse-momentum Equation.

	Acc to Newton's second law of mo the net force F_x ~~as~~ acting on a fluid in the direction of x is equal to mass the fluid element multiplied by the acc the x-dir. Thus mathematically $F_x = Ma_x$. there are more than one for $\sum F_x = Ma_x$ In the fluid flow, the following forces a (i) F_g, gravity force. (ii) F_p, the pressure force (iii) F_v, force due to viscosity (iv) F_t, force due to turbulence ? eddies, ne (v) F_c, force due to compressibility. Thus, in eqn, the net force $F_x = (F_g)_x + (F_p)_x + (F_v)_x + (F_t)_x + (F_c$			
2	State and prove Bernoulli's equation for motion of fluid along a stream line. List the assumptions for the equation. Bernoulli's equation states that in a steady, incompressible flow, the sum of pressure head $\left(\frac{p}{\rho g}\right)$, velocity head $\left(\frac{v^2}{2g}\right)$ and datum head (z) is a constant	[10]	CO 4	L3

Bernoulli's Equation and Bernoulli's Equation from Euler's Equation

Consider a stream line in which flow is taking place in s-direction as shown in figure. Consider a cylindrical element of cross section dA and length ds. The forces acting on the fluid element are.



From fig

$\cos\theta = \frac{dz}{ds}$

1) Force due to pressure at section -1

$F_1 = pdA$ — (1)

2) Force due to pressure at section -2

$F_2 = \left(p + \frac{dp}{ds} \cdot ds\right) dA$ —(2)

3) Weight of the fluid element along s-direction

$F_3 = mg\cos\theta$

m = mass = $\rho \times$ volume

$= \rho \times dA \times ds$ — (3)

$\cos\theta = \frac{dz}{ds}$ $\quad F_3 = \rho dA ds\, g \frac{dz}{ds}$ —(4)

Using equation of motion along s-direction

$\Sigma F_s = ma_s$

$F_1 - F_2 - F_3 = ma_s$ — (5)

where a_s = acc due to gravity along s-direction

$a_s = \frac{dV}{dt}$. But V is a function of s and t

$a_s = \frac{\partial V}{\partial t} + \frac{\partial V}{\partial t} = \frac{\partial V}{\partial s}\cdot\frac{\partial s}{\partial t} + \frac{\partial V}{\partial t} = 0$

Assuming steady flow

$\frac{\partial V}{\partial t} = 0$, $\frac{\partial V}{\partial s} = \frac{dV}{ds}$ (dependent only on distance.

$\frac{\partial s}{\partial t} = V$

$\therefore a_s = \frac{dV}{ds} \cdot V$ — (6)

Substituting (1), (2), (3), (4) and (6) in (5), we have

$$pdA - \left(p + \frac{dp}{ds} \cdot ds\right) dA - \rho\, dA\, ds\, g \frac{dz}{ds} = \rho\, dA\, ds \frac{dV}{ds} \cdot V$$

$$\cancel{pdA} - \cancel{pdA} - \frac{dp}{ds} \cdot ds\, dA - \rho\, dA\, ds\, g \frac{dz}{ds} = \rho\, dA\, ds \frac{dv}{ds} v$$

Taking all terms one one side,

$$\frac{dp}{ds} \cdot ds\, dA + \rho\, dA\, ds\, g \frac{dz}{ds} + \rho\, dA\, ds \frac{dv}{ds} \cdot V = 0$$

dividing by ds throughout, we have.

$$dp\, ds\, dA + \rho\, dA\, ds\, g\, dz + \rho\, dA\, ds\, dv\, V = 0$$

dividing by mg = ρdAdsg throughout, we have

$$\frac{dp}{\rho g} + dz + \frac{vdv}{g} = 0$$

This is Euler's Equation

Integrating the terms, we have

$$\int \frac{dp}{\rho g} + \int dz + \int \frac{vdv}{g} = 0$$

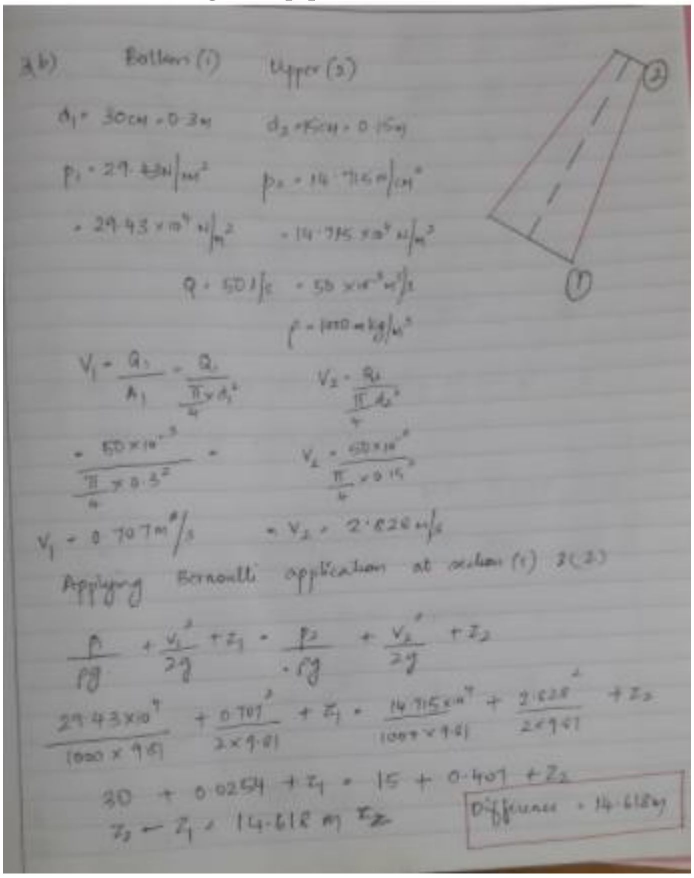
$$\frac{p}{\rho g} + z + \frac{v^2}{2g} = \text{constant} \rightarrow \text{Bernoulli's equation}$$

Note
$\frac{v^2}{2g}$ = velocity head
Kinetic head
z = potential head
datum head
Head = $\frac{\text{Energy}}{\text{Weight}}$

Assumptions (for derivation of Bernoulli's eqn)

1) The liquid is ideal & incompressible
2) the flow is steady & continuous
3) The flow is along a streamline(i.e) it is one-dimensional
4. vel is uniform over a sect^n & is equal to the mean vel.
5 The only forces acting on the fluid are gravity forces & pressure forces.

3	a) What is static and stagnation pressure in a pitot tube. At a stagnation point the fluid velocity is zero. In an incompressible flow, stagnation pressure is equal to the sum of the free-stream static pressure and the free-stream dynamic pressure. Stagnation pressure is sometimes referred to as pitot pressure because it is measured using a pitot tube. b) Water flowing through a pipe having diameter 30cm and 15cm at the bottom and upper end respectively. The intensity of pressure at the bottom is 29.43N/cm^2 and the	[10]	CO 4	L3

	pressure at the upper end is 14.715N/cm^2. Determine the difference datum head if the rate of flow through the pipe is 50l/s.  			

4	a) Write the equation of force along x and y direction for a pipe bend and explain the terms in the equation. $F_x = p_1A_1 - p_2A_2\cos\theta - \rho * Q * (v_2\cos\theta - v_1)$ $F_y = -p_2A_2\sin\theta - \rho * Q v_2 \sin\theta$ $F_r = \sqrt{F_x{}^2 + F_y{}^2}$ $\tan\phi = \frac{F_y}{F_x}$ wrt to x axis b) 250l/s of water is flowing in a pipe having diameter 300mm. If the pipe is bent by 135°, find the magnitude and direction of the resultant force on the bend, when the pressure of water flowing is 39.24N/cm^2.	[10]	CO4	L3

	4 b) $Q = 250\ l/s = 0.25\ m^3/s$ $d_1 = d_2 = d = 300mm = 0.3m$, $A_1 = A_2 = A = \frac{\pi}{4} \times 0.3^2 = 0.0707\ m^2$ $p_1 = p_2 = p = 39.24\ N/cm^2 = 39.24 \times 10^4\ N/m^2$ $\theta = 135^\circ$, $V_1 = V_2 = V = \frac{Q}{A} = \frac{0.25}{0.0707} = 3.536\ m/s$ $F_x = \rho Q(V_1 - V_2 \cos\theta) + p_1 A_1 - p_2 A_2 \cos\theta$ $F_y = -\rho Q V_2 \sin\theta - p_2 A_2 \sin\theta$ $F_x = 1000 \times 0.25 \times (3.536 - 3.536 \times \cos 135) + 39.24 \times 10^4 \times 0.0707 - 39.24 \times 10^4 \times 0.0707 \times \cos 135^\circ$ $F_x = 48868.79\ N$ $F_y = -1000 \times 0.25 \times 3.536 \times \sin 135 - 39.24 \times 10^4 \times 0.0707 \sin 135^\circ$ $= -20242.11956\ N$  $F_R = \sqrt{F_x^2 + F_y^2}$ $F_R = 52895.198\ N$ $\tan\theta = \frac{F_y}{F_x} \Rightarrow \theta = \tan^{-1} \frac{20242.11956}{48868.79} = 22.5^\circ$			
5	The 20cm x 10cm venturimeter is provided in a vertical pipe line carrying oil of specific gravity 0.8, the flow being upwards. The difference in elevation of the throat section and entrance section of the venturimeter is 50cm. The differential U tube mercury manometer shows a gauge deflection of 40cm. Calculate i) the discharge of oil, ii) the pressure difference between the entrance and throat section. Take Cd = 0.98.(Use the equations carefully. The direction of flow is an important parameter to be considered.)	[10]	CO4	L4

5 (a)

$d_1 = 20cm = 0.2m$

$A_1 = \frac{\pi}{4} \times 0.2^2 = 0.0314m^2$

$d_2 = 10cm = 0.1m$

$A_2 = \frac{\pi}{4} \times 0.1^2 = 7.853 \times 10^{-3}$

$z_1 = 0$, $z_2 = 50cm = 0.5m$

$x = 40cm = 0.4m$

$$\left(\frac{p_1}{\rho g} + z_1\right) - \left(\frac{p_2}{\rho g} + z_2\right) = h = x\left(\frac{S_{hg}}{S_{oil}} - 1\right)$$

$S_{hg} = 13.6$ $S_{oil} = 0.8$

$$h = x\left(\frac{S_{hg}}{S_{oil}} - 1\right) = 0.4 \times \left(\frac{13.6}{0.8} - 1\right)$$

$h = \cancel{5.644m}$ 6.4 of oil

$$h = \left(\frac{p_1}{\rho g} + z_1\right) - \left(\frac{p_2}{\rho g} + z_2\right) \Rightarrow \left(\frac{p_1}{\rho g} - \frac{p_2}{\rho g}\right) + 0 - 0.5 = 5.644$$

Difference in pressure = $(p_1 - p_2) = (\cancel{5.644}\ 6.4 + 0.5) \times 0.8 \times 1000 \times 9.81$

$= 54151.2\ N/m^2$

$$Q = \frac{C_d\, \pi A_1 A_2 \sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}} = \cancel{0.304}\ 0.0891 m^3/s$$