SET 2

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

THIRD SEMESTER B.TECH DEGREE EXAMINATION, DECEMBER 2018

Course Code: CE203

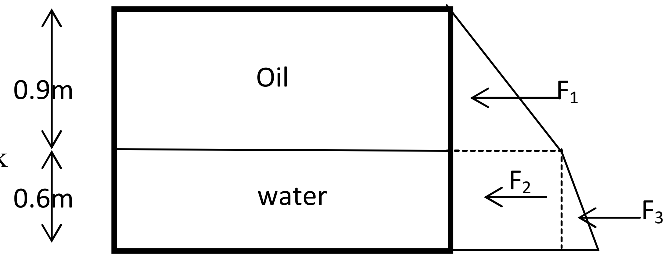
Course Name: FLUID MECHANICS -I

Max. Marks: 100 Duration: 3 Hours

Scheme of evaluation

PART A

1. a)Definition of gauge pressure, vacuum pressure and absolute pressure - 1 mark each
   chart -2 marks
   Total -5 marks

   b) Figure- 1 mark
   γ_{oil} = 0.9 x 9810 = 8829 N/m^3 - 0.5 mark
   pressure at interface = 8829 x 0.9 = 7946 N/m^2
   - 1 mark
   pressure at bottom = 7946 + 9810 x 0.6
   = 7946 + 5886 = 13832 N/m^2
   - 1 mark

   $F_1 = \frac{1}{2}$ x 7946 x 0.9 x 1.5 = 5364 N - 1 mark

   acting at $\frac{2}{3}$ x 0.9 = 0.6 m below the surface. - 1 mark

   F_2 = 7946 x 0.6 x 1.5 = 7152 N acting at 0.9 + $\frac{0.6}{2}$ = 1.2 m below the surface. - 1 mark

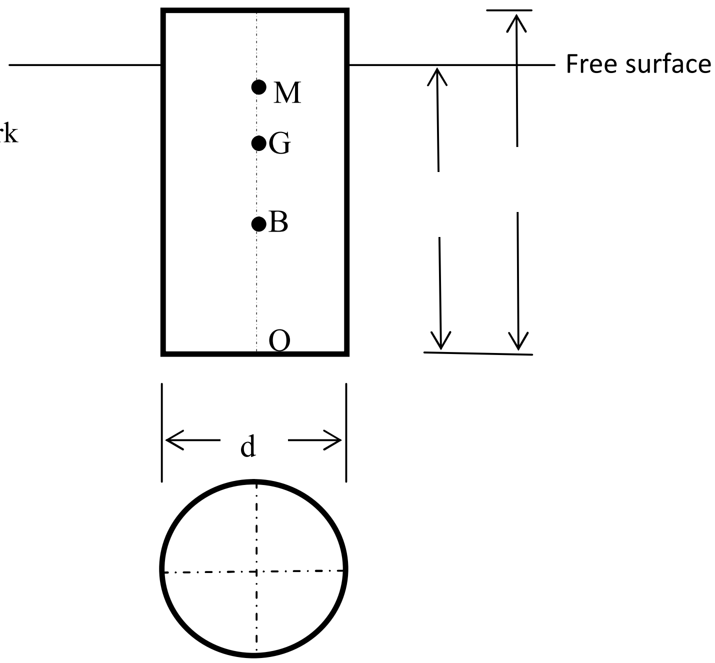
   $F_3 = \frac{1}{2}$ x 5886 x 0.6 x 1.5 = 2649 N acting at 0.9 + $\frac{2}{3}$ x 0.6 = 1.3 m below the surface - 1 mark

   Total force = $F_1 + F_2 + F_3$ = 15165 N- 1 mark

   Centre of pressure = $\frac{5364 \times 0.6 + 7152 \times 1.2 + 2649 \times 1.3}{15165}$ = 1.005m below the free surface and on the vertical passing through the centre of gravity of the side. – 1.5 marks

   Total -10 marks

2. a) Figure - 1 mark

   H = 0.15 m, d = 0.3 m, A = $\frac{\pi}{4}$ x d^2

   W = U

   $0.9 \times \gamma_w \times A \times H = 1.03 \times \gamma_w \times A \times h$ - 1 mark

   $\therefore$ h = 0.131m – 0.5 mark

   $\overline{OB} = \frac{h}{2}$ = 0.0655 m – 0.5 mark

   $\overline{OG} = \frac{H}{2}$ = 0.075 m - 0.5 mark

   $\overline{BG} = \overline{OG} - \overline{OB}$ = 0.0095 m – 0.5 mark

$\overline{BM} = \frac{I}{V}$……. 1 mark

$I = \frac{\pi}{64} d^4$……. 1 mark

$V = \frac{\pi}{4} d^2 h$……. 1 mark

$\overline{BM} = \frac{d^2}{16h}$ = 0.0429 - 1mark

As $\overline{BM} > \overline{BG}$ the cylinder will be floating in stable equilibrium - 1 mark

Total – 9 marks

b) Derivation of continuity equation for one dimensional flow with figure – **6 marks**

3. a) Forced vortex flow with example – 2 marks

free vortex flow with example – 2 marks

Total – 4 marks

b) $a_x = \frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}$ = 2t + (t^2 + 3y) x 0 + (4t + 5x) x 3 = 14t + 15x – 2 marks

$a_y = \frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}$ = 4 + (t^2 + 3y) x 5 + (4t + 5x) x 0 = 4 + 5 t^2 + 15y – 2 marks

At point (5,3) at time t = 2 units a_x = 103 – 1 mark & a_y = 69 – 1 mark

$a = \sqrt{{a_x}^2 + {a_y}^2}$ = 123.98 units – 1 mark

Total – 7 marks

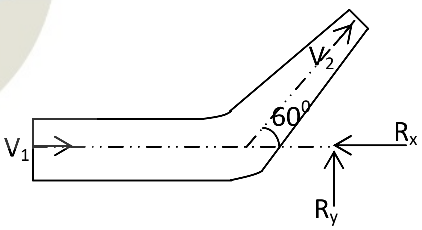
c) (i) rotational flow and irrotational flow - 2 marks

(ii) streamline and path-line - 2 marks

Total – 4 marks

PART B

4. a) Figure - 1 mark



$Q = A_1V_1 = A_2V_2$ - 1 mark

$A_1 = \frac{\pi}{4} \times 0.6^2$

$A_2 = \frac{\pi}{4} \times 0.3^2$

V_1 = 3.1 m/s & V_2 = 12.4 m/s - 1 mark

p_1 = 171.675 kN/m^2

Applying Bernoulli's equation between inlet and outlet

$\frac{p_1}{\gamma} + \frac{{V_1}^2}{2g} = \frac{p_2}{\gamma} + \frac{{V_2}^2}{2g}$ - 1 mark

substituting and solving, p_2 = 99.572 kN/m^2

Applying momentum equation in x direction,

$p_1A_1 – p_2A_2 \cos 60^0 - R_x = \rho Q(V_2 \cos 60^0 - V_1)$ - 1 mark

substituting and solving, R_x = 42.305 kN- 2 marks

Applying momentum equation in x direction,

$R_x – p_2A_2 \sin 60^0 = \rho Q(V_2 \sin 60^0)$ - 1 mark

substituting and solving, R_y = 15.502 kN - 2 marks

$R = \sqrt{R_x^2 + R_y^2} = 45.065$ kN - 1 mark

$\alpha = \tan^{-1}\frac{15.502}{42.305} = 20.12^0$ - 1 mark

Total – 12 marks

b) Definition - 2 marks, equation - 1 mark - **Total – 3 marks**

5. (a) $Q = 1.84\,(L - 0.1nH_1)(H_1^{1.5} - h_a^{1.5})$ – 1 mark

L = 40 – 11 x0.6 = 33.4 m – 1 mark

$h_a = \frac{V_a^2}{2g} = 0.2039$ m – 1 mark

$H_1 = 1.2 + 0.2039 = 1.4039$ m

n = 12 x 2 = 24 – 1 mark

Substitution -2 marks

$Q = 86.78\ m^3/s$ – 1 mark

Total – 7 marks

(b) Large orifice $Q = \frac{2}{3}C_d b\sqrt{2g}\left(H_2^{3/2} - H_1^{3/2}\right)$ (1 Mark)

H_2=1.22+0.61=1.83 m (1 Mark) ; H_1=0.61 m (1 Mark)

Q=3.241 m^3/s (1 Mark)

Considering as small orifice

$Q = C_d a\sqrt{2gH}$ (1 Mark)

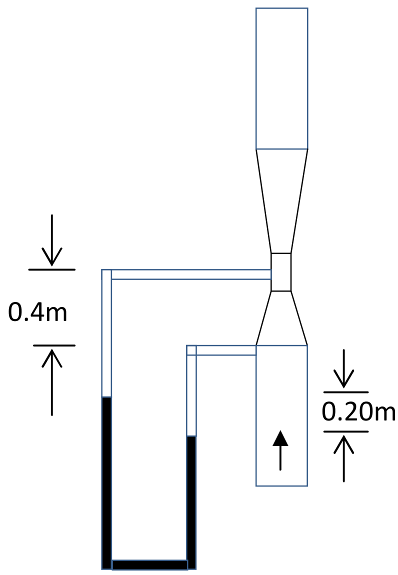
H=0.61+(1.22/2)=1.22 m (1 Mark)

Q=3.276 m^3/s (1 Mark)

% Error=1.08 (1 Mark)

Total – 8 marks

6. (a) Figure - 1 mark



$h = x\left(\frac{S_m}{S} - 1\right) = 3$ m of oil - 2 marks

$Q = C_d A_1 A_2 \frac{\sqrt{2gh}}{\sqrt{A_1^2 - A_2^2}}$ - 2 marks

$A_1 = \frac{\pi}{4} \times 0.3^2 = 0.0707\ m^2$

$A_2 = \frac{\pi}{4} \times 0.10^2 = 0.00785\ m^2$

$Q = 0.059\ m^3/s$ - 2 marks

$h = \left(\frac{p_1}{\gamma} + z_1\right) - \left(\frac{p_2}{\gamma} + z_2\right) = 3$ m - 1 mark

$\left(\frac{p_1}{\gamma} - \frac{p_2}{\gamma}\right) - (z_2 - z_1) = 3$ m

$z_2 - z_1 = 0.4$ m

$p_1 - p_2 = 28.351\ kN/m^3$ - 2 marks

Total – 10 marks

(b) definition of three coefficients – 1mark each and relation – 2 marks

Total – 5 marks

PART C

7. (a) Derivation of Hagen –Poiseulle equation with figure – **10 marks**

(b) $A_1 = \frac{\pi}{4} \times 0.1^2 = 0.00785 \text{ m}^2$

$A_2 = \frac{\pi}{4} \times 0.2^2 = 0.0314 \text{ m}^2$

$Q = 0.15 \text{ m}^3/\text{s}$

$V_1 = \frac{Q}{A_1} = 19.1$ m/s - 1 mark

$V_2 = \frac{Q}{A_2} = 4.77$ m/s - 1 mark

$h_L = \frac{(V_1 - V_2)^2}{2g} = 10.5$ m - 2 marks

$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_L$ - 1 marks

$z_1 = z_2$

$p_1 - p_2 = 67.7 \text{ kN/m}^2$ -1 marks

Total – 6 marks

(c) Definition of Hydraulic Grade Line and Total Energy Line – 2 marks each.

Total – 4 marks

8. (a) $\delta^* = \int_0^\delta (1 - \frac{v}{V})dy$ - 1 mark

$d\eta = \frac{dy}{\delta}$ - 1 mark

when $y = 0, \eta = 0$ and when $y = \delta, \eta = 1$ - 1 mark

$\delta^* = \delta \int_0^1 (1 - \frac{3}{2}\eta + \frac{1}{2}\eta^3)d\eta$ - 1 mark

$\delta^* = \frac{3}{8}\delta$ - 2 marks

$\theta = \int_0^\delta \frac{v}{V}(1 - \frac{v}{V})dy$ - 1 mark

$\theta = \delta \int_0^1 (\frac{3}{2}\eta - \frac{1}{2}\eta^3)(1 - \frac{3}{2}\eta + \frac{1}{2}\eta^3)d\eta$ - 1 mark

$\theta = \frac{39}{280}\delta$ - 2 marks

Total – 10 marks

(b) friction drag - 2 marks, pressure drag - 2 marks

Total – 4 marks

(c) Four factors affecting the boundary layer thickness - **6 marks**

9. (a) Figure -2 Marks

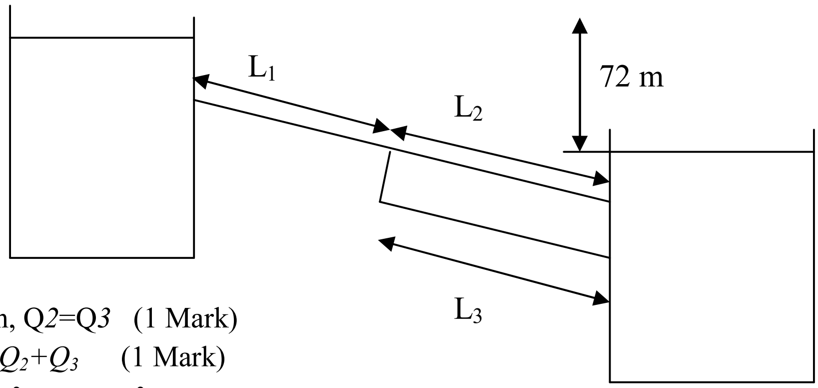
Case I Single Pipe

$$72 = \frac{flV^2}{2gD} \quad \text{(1 Mark)}$$

$V=Q/A$

Q=0.2126 m/sec (1 Mark)

Case 2 Including parallel pipes



$h_{f2}=h_{f3}$

from which, Q2=Q3 (1 Mark)

Also, $Q1=Q_2+Q_3$ (1 Mark)

$$72 = \frac{fL_1V_1^2}{2gD} + \frac{fL_2V_2^2}{2gD} \quad \text{(2 Mark)}$$

Substituting and solving

Q_1=0.268 m^3/s (1 Mark)

Increase in discharge =0.056 m^3/sec (1 Mark)

Total – 10 marks

(b) $\tau_o = -\frac{\partial p}{\partial x}\frac{R}{2}$ - 1 mark

$h_f = \frac{p1-p2}{\gamma}$, $-\frac{\partial p}{\partial x} = \frac{p1-p2}{L} = h_f\gamma$ - 2 marks

$\tau_o = 20 \times 0.85 \times 9810 \times \frac{0.15}{2500 \times 2} = 5$ N/m^2 - 1 mark

$\tau = \tau_o \frac{r}{R} = 5 \times \frac{0.1}{0.15} = 3.33$ N/m^2 - 1 mark

$h_f = \frac{32\mu VL}{\gamma D^2}$ - 1 mark

V = 0.75 m/s - 2 marks

$R_e = \frac{\rho VD}{\mu} = 765$ - 1 mark

$f = \frac{64}{R_e} = 0.084$ - 1 mark

Total – 10 marks