OCT-R-295

B. Tech. EXAMINATION, 2020

Semester III (CBS)

FLUID MECHANICS

ME-302

Time : 3 Hours *Maximum Mark*

The candidates shall limit their answers precisely to the answer-book (40 page) issued to them and no supplementary/continuation sheet will be issued.

Note : Attempt *Five* questions in all, selecting *one* question from each Sections A, B, C and D. Q. No. 9 is compulsory. Use of non-programmable calculator is allowed.

Section A

1. **(a)** An oil of viscosity 5 poise is used for lubrication between a shaft and sleeve. The diameter of the shaft is 0.5 m and it rotates at 200 r.p.m.

Calculate the power lost in oil for a sleeve length of 100 mm. The thickness of oil film is 1.0 mm. 5

(b) A rectangular pontoon 12 m × 9 m × 3 m weighs 1380 kN and is floating in sea water of specific weight, 10 kN/m^3. A boiler 6 m diameter and weighing 864 kN is placed on the upper deck of pontoon. The centre of gravity of boiler and the pontoon may be assumed at their geometrical centres and on the same vertical line. Determine the metacentric height and comment on the stability of the system. 5

2. a) Determine the total pressure on a circular plate of diameter 1.5 m which is placed vertically in water in such a way that the centre of the plate is 3 m below the free surface of water. Find the position of centre of pressure also. 5

(b) Derive an expression for pressure variation in a fluid at rest. 5

Section B

3. a) Derive continuity equation in Cartesian coordinates. 5

(b) Check whether the flow defined by the stream function $\psi = 2xy$ is irrotational ? If so, determine the corresponding velocity potential. 5

4. (a) The velocity components in a two-dimensional flow field for an incompressible fluid are as follows :

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

Obtain an expression for the stream function ψ. 5

(b) In a two-dimensional incompressible flow, the fluid velocity components are given by :

$$u = x - 4y \text{ and } v = -y - 4x$$

Show that the velocity potential exists and determine its form. Find also the stream function. 5

Section C

5. (a) Derive an expression for the loss of head due to friction in pipe. 5

(b) An oil of viscosity 10 poise flows between two parallel fixed plates which are kept at a distance of 50 mm apart. Find the rate of flow of oil between the plates if the drop of pressure in a length of 1.2 m be 0.3 N/cm^3. The width of the plates is 200 mm. 5

6. Derive the Euler's equation of motion along a streamline, and hence derive the Bernoulli's theorem. 10

Section D

7. (a) Explain Rayleigh's method and discuss its limitations. 5

(b) For the velocity profile for laminar boundary layer :

$$\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^2$$

Determine the boundary layer thickness, shear stress, drag force and coefficient of drag in terms of Reynolds Number. 5

8. (a) The pressure difference ΔP in a pipe of diameter D and length l due to viscous flow depends on the velocity V, viscosity μ and density ρ. Using Buckingham's π theorem, obtain an expression for ΔP. 5

(b) For the velocity profile for laminar boundary layer :

$$\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^3 + \left(\frac{y}{\delta}\right)^4$$

obtain an expression for the boundary layer thickness, shear stress, drag force on one side of the plane and coefficient of drag in term of Reynolds Number. **5**

Section E

(Compulsory Question)

9. All questions are compulsory : **10×2=20**

(a) Explain surface tension and capillary.

(b) Explain the cause of hydraulic jump in open channel flow.

(c) Explain Prandtl mixing length and its significance.

(d) Explain Stable, Neutral, and Unstable bodies with the help of example.

(e) Explain metacentre and its significance.

(f) Drag friction.

(g) Define Reynolds number and its significance.

(h) Define the importance of non-dimensional flow parameters in evaluation of flow field.

(i) Couette flow.

(j) Explain drawbacks of laminar boundary layer in open and duct flows.. Give your idea to avoid its formation.