CBCS SCHEME

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17ME44

# Fourth Semester B.E. Degree Examination, Jan./Feb. 2023
## Fluid Mechanics

Time: 3 hrs. Max. Marks: 100

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



### Module-1

1 a. Define the following properties of fluid with their units:
(i) Mass density (ii) Specific gravity (iii) Dynamic viscosity **(06 Marks)**

b. State and prove the Pascal's law. **(06 Marks)**

c. The dynamic viscosity of an oil, used for lubrication between a shaft and sleeve is 5 poise. The shaft is of 0.5 m diameter and rotates at 200 rpm. Calculate the power lost in the bearing for a sleeve length of 100 mm. The thickness of oil film is 1 mm. **(08 Marks)**

**OR**

2 a. Define the following terms: (i) Buoyancy (ii) Metacentre **(02 Marks)**

b. Derive an expression for total pressure force and depth of centre of pressure for a vertical plane surface submerged in water. **(10 Marks)**

c. A solid cylinder of diameter has a height of 3m. Find the metacentric height, when it is floating in water with its axis vertical. The specific gravity of cylinder is 0.6. **(08 Marks)**

### Module-2

3 a. Establish the relationship between stream function and velocity potential function. **(04 Marks)**

b. Derive an expression for continuity equation in Cartesian coordinates for three dimensions. **(08 Marks)**

c. The velocity potential function ($\phi$) is given by an expression $\phi = -\frac{xy^3}{3} - x^2 + \frac{x^3y}{3} + y^2$. Calculate the velocity components in x and y directions. Check the possibility of such a flow. **(08 Marks)**

**OR**

4 a. Derive Euler's equation of motion for a steady flow and deduce Bernoulli's equation and state the assumptions made for such a derivation. **(10 Marks)**

b. Give the relative merits and demerits of orifice meter with respect to venturimeter. **(04 Marks)**

c. A horizontal venturimeter with inlet diameter 20 cm and throat diameter 10 cm is used to measure the flow of water. The pressure at inlet is 17.658 N/cm$^2$ and the vacuum pressure at the throat is 30 cm of mercury. Find the discharge of water through venturimeter. Take $C_d = 0.98$. **(06 Marks)**

### Module-3

5 a. Define Reynold's number. What is its significance? **(04 Marks)**

b. Derive an expression for Hagen-Poiseuille formula for viscous flow of fluid. **(08 Marks)**

c. A fluid of viscosity 0.7 NS/m$^2$ and specific gravity 1.3 is flowing through a circular pipe of diameter 100 mm. The maximum shear stress at the pipe wall is given as 196.2 N/m$^2$. Calculate: (i) Pressure gradient (ii) Average velocity (iii) Reynold's number of the flow. **(08 Marks)**

**OR**

6 a. Derive Darcy-Weisbach equation to determine the loss of head due to friction in pipes. **(08 Marks)**

b. Differentiate between major losses and minor losses in pipe flow. **(04 Marks)**

c. An oil of specific gravity 0.9 and viscosity 0.06 poise is flowing through a pipe of diameter 200 mm at the rate of 60 litres/s. Calculate:
(i) Head lost due to friction for a 500 m length of pipe
(ii) Power required to maintain this flow **(08 Marks)**

## Module-4

7 a. Find: (i) Displacement thickness (ii) Momentum thickness for the velocity distribution in the boundary layer given by $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$. **(08 Marks)**

b. Define the following terms: (i) Lift force (ii) Drag force **(04 Marks)**

c. A man weighing 90 kgf descends to the ground from an aeroplane with the help of parachute against the resistance of air. The velocity with which the parachute, which is hemispherical in shape, comes down is 20 m/s. Find the diameter of parachute. Assume $C_D = 0.5$ and density of air = 1.25 kg/m$^3$. **(08 Marks)**

**OR**

8 a. Define the term similitude. Explain the following with reference to similitude:
(i) Geometric similarity
(ii) Kinematic similarity
(iii) Dynamic similarity **(08 Marks)**

b. Explain the term dimensionally homogeneous equation. **(02 Marks)**

c. The resisting force R of a supersonic plane during flight can be considered as dependent upon the length of aircraft $\ell$, velocity V, air viscosity $\mu$, air density $\rho$ and bulk modulus of air K. Express the functional relationship between these variables and the resisting force R. **(10 Marks)**

## Module-5

9 a. Define the following terms: (i) Mach number (ii) Mach angle **(04 Marks)**

b. Derive an expression for velocity of sound in terms of bulk modulus and density. **(08 Marks)**

c. An airplane is flying at an altitude of 15 km where the temperature is –50°C. The speed of the plane corresponds to mach number of 1.6. Assume $\gamma = 1.4$ and R = 287 J/kgK for air. Find the speed of the plane and mach angle $\alpha$. **(08 Marks)**

**OR**

10 a. Define the following terms: (i) Subsonic flow (ii) Supersonic flow **(04 Marks)**

b. Enumerate the engineering applications of CFD, bringing the advantages and limitations. **(08 Marks)**

c. Define the following terms and write the relevant equations for the same:
(i) Stagnation pressure (ii) Stagnation temperature **(08 Marks)**

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