KATHMANDU UNIVERSITY
End Semester Examination
July/August, 2024

Level : B.E.
Year : III
Time : 2 hrs. 30mins.

13 AUG 2024

Course : MEEG 301
Semester : I
F. M. : 55

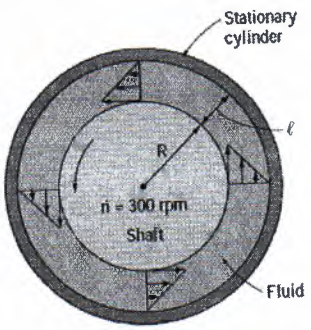
SECTION "C"

Attempt *ALL* questions. Assume suitable data if any is missing.

1.

a. What is the basic characteristics of a non-newtonian fluid. Explain the difference between dilatant and pseudoplastic fluid with typical examples. [3]

b. The viscosity of a fluid is to be measured by a viscometer constructed of two 40-cm-long concentric cylinders (see figure below). The outer diameter of the inner cylinder is 12 cm, and the gap between the two cylinders is 0.15 cm. The inner cylinder is rotated at 300 rpm, and the torque is measured to be 1.8 N m. Determine the viscosity of the fluid with proper explanation of the procedure. [5]



c. Explain the dependency of surface tension on temperature and impurities. Elaborate the advantage of such dependency using daily life example of washing clothes. [3]

2.

a. Consider a 8-m-long, 8-m-wide, and 2-m-high aboveground swimming pool that is filled with water to the rim. (a) Determine the hydrostatic force on each wall and the distance of the line of action of this force from the ground. (b) If the height of the walls of the pool is doubled and the pool is filled, will the hydrostatic force on each wall double or quadruple? Why?

b. A steady, incompressible, two-dimensional (in the *xy*-plane) velocity field is given by:

$$\vec{V} = (0.523 - 1.88x + 3.94y)\vec{i} + (-2.44 + 1.26x + 1.88y)\vec{j}$$

Calculate the acceleration field (find expressions for acceleration components a_x and a_y) and calculate the acceleration at the point $(x, y) = (2, 1.5)$. Also find if there is any stagnation point. [4]

c. Briefly explain the purpose of the Reynolds transport theorem (RTT). Write the RTT for extensive property B explaining each term in your own words. Further, write the RTT for the property 'energy'. What is this equation called?

P.T.O.

3.

a. Water flows at a rate of 0.035 m^3/s in a horizontal pipe whose diameter is reduced from 15 cm to 8 cm by a reducer. If the pressure at the centerline is measured to be 480 kPa and 445 kPa before and after the reducer, respectively, determine the irreversible head loss in the reducer. Take the kinetic energy correction factors to be 1.05. [5]

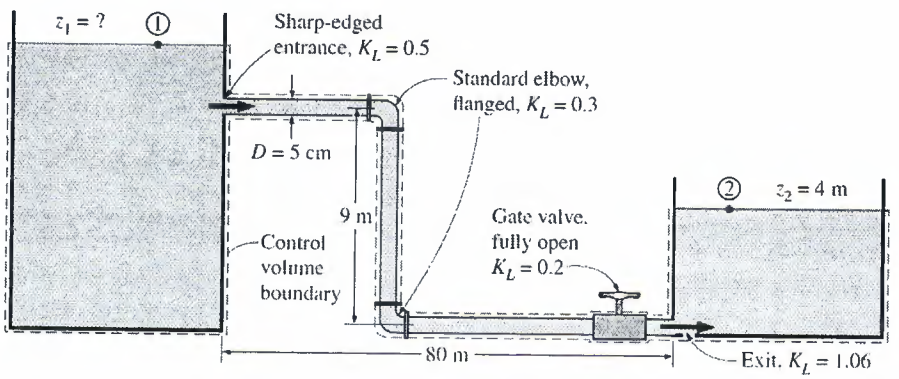
b. Explain static, dynamic and stagnation pressures. How do you measure these pressures and how do you determine the velocity of the fluid using the measurements of pressure? [4]

c. What is useful pump head? How is it related to the power input to the pump? [2]

4.

a. What are the various ways to find out flow rate of fluid flowing in pipe or duct? Explain the fundamentals behind measurement of flow rate using obstruction flowmeters using Bernoulli's equation and co-efficient of discharge. [5]

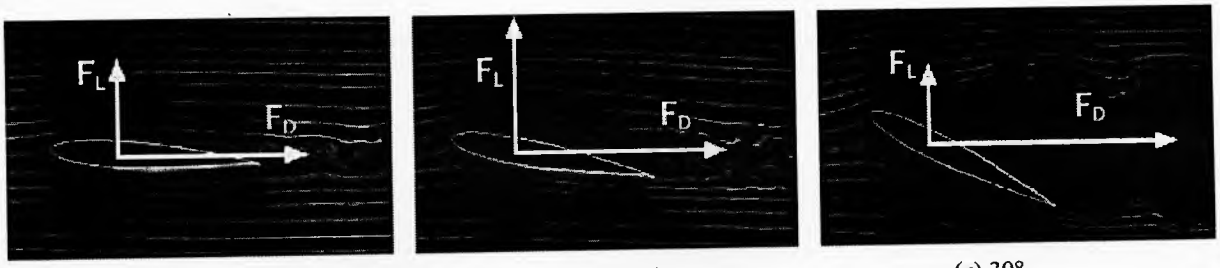
b. Water at 10°C flows from a large reservoir to a smaller one through a 5-cm diameter cast iron piping system, as shown in the following figure. Determine the elevation z_1 for a flow rate of 6 L/s. Consider the density and dynamic viscosity of water at 10°C are $\rho = 999.7$ kg/m^3 and $\mu = 1.307 \times 10^{-3}$ kg/m·s. The roughness of cast iron pipe is $\varepsilon = 0.00026$ m. [6]



5.

a. A commercial airplane has a total mass of 70,000 kg and a wing planform area of 150 m^2. The plane has a cruising speed of 558 km/h and a cruising altitude of 12,000 m, where the air density is 0.312 kg/m^3. The plane has double-slotted flaps for use during takeoff and landing, but it cruises with all flaps retracted. Assuming the lift and the drag characteristics of the wings can be approximated by NACA 23012 (Figure provided in the supplementary data sheet), (i) determine the minimum safe speed for takeoff and landing with and without extending the flaps, (ii) the angle of attack to cruise steadily at the cruising altitude, and (iii) the power that needs to be supplied to provide enough thrust to overcome wing drag. [6]

b. Describe friction drag and pressure drag referring to the following figures of airfoils subjected to various angle of attacks. Explain how pressure drag is decreased without compromising lift using slotted flaps. [3]



(*a*) 5° (*b*) 15° (*c*) 30°

c. What is induced drag? What is the main way to reduce induced drag of an airplane? [2]

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SECTION "A"

[15 Q. × 1 = 15 marks]

Choose and encircle in the most appropriate option from each set of choices

1. A cylindrical tank with a height of 10 meters is filled with water. If a small hole is drilled at the bottom of the tank, what is the velocity of the water jet exiting the hole? Assume the atmospheric pressure acts on the water surface.
   [ ] $\sqrt{10}$ m/s [ ] $\sqrt{20}$ m/s [ ] $\sqrt{30}$ m/s [ ] $\sqrt{40}$ m/s

2. Which of the following fluids is not a non-Newtonian fluid?
   [ ] Blood [ ] Paint [ ] Honey [ ] Air

3. Which of the following correctly describes the behavior of a Bingham plastic?
   [ ] It flows only after the applied stress exceeds a certain yield stress.
   [ ] Its viscosity decreases with increasing shear rate.
   [ ] It behaves like an elastic solid up to a yield stress and then flows like a Newtonian fluid.
   [ ] It behaves like a liquid at low shear stress and like a solid at high shear stress.

4. A rectangular gate with a height of 2 meters and width of 3 meters is submerged vertically in water such that the top edge is 1 meter below the water surface. What is the total hydrostatic force acting on the gate?
   [ ] 19.62 kN [ ] 29.43 kN [ ] 39.24 kN [ ] 49.05 kN

5. A fluid particle moves in a flow field described by the velocity components $u = 3x^2y$ and $v = -y^2+4x$. What is the acceleration of the fluid particle in the x-direction at point (1,2)?
   [ ] 12 m/s^2 [ ] 16 m/s^2 [ ] 20 m/s^2 [ ] 24 m/s^2

6. The locus of fluid particles that have passed sequentially through a prescribed point in the flow is called a
   [ ] Pathline [ ] Streamline [ ] Streakline [ ] Timeline

7. The Reynolds transport theorem establishes a relationship between _____ and _____.
   [ ] Control mass system, Control volume system
   [ ] Differential equation, Integral equation
   [ ] Non-conservative equation, Conservative equation
   [ ] Substantial derivative, Local derivative

8. A pump is used to increase the pressure of water from 100 kPa to 900 kPa at a rate of 160 L/min. If the shaft power input to the pump is 3 kW, the efficiency of the pump is
[ ] 0.532 [ ] 0.660 [ ] 0.711 [ ] 0.747 [ ] 0.855

9. The difference between the heights of energy grade line (EGL) and hydraulic grade line (HGL) is equal to
[ ] z [ ] $P/\rho g$ [ ] $V^2/2g$ [ ] $z + P/\rho g$ [ ] $z + V^2/2g$

10. According to Darcy's formula, the loss of head due to friction in the pipe is _____ (where f = Darcy's coefficient, l = Length of pipe, v = Velocity of liquid in pipe, and d = Diameter of pipe)
[ ] $flv^2/2gd$ [ ] flv^2/gd [ ] $3flv^2/2gd$ [ ] $4flv^2/2gd$

11. The wall shear stress _____ in the flow direction in the fully developed region (after the entrance region)
[ ] remains constant [ ] increases [ ] decreases [ ] will be zero

12. The critical Reynolds number for transition from laminar to turbulent flow in a smooth circular pipe is approximately:
[ ] 500 [ ] 1000 [ ] 2300 [ ] 5000

13. For a pipe flow, the hydraulic diameter is defined as:
[ ] The diameter of the pipe
[ ] Four times the cross-sectional area divided by the wetted perimeter
[ ] The square root of the cross-sectional area
[ ] The average of the maximum and minimum diameters

14. The lift coefficient C_L is defined as:
[ ] The ratio of lift force to the dynamic pressure
[ ] The ratio of lift force to the drag force
[ ] The ratio of lift force to the projected area
[ ] The ratio of lift force to the product of dynamic pressure and reference area

15. In a Venturi meter, what is the primary cause of the pressure drop between the inlet and throat?
[ ] Increase in velocity [ ] Decrease in fluid density
[ ] Increase in friction [ ] Decrease in cross-sectional area

SECTION "B"

[5 Q. × 1 = 5 marks]

Fill in the Blank

16. The static and stagnation pressures of a fluid in a pipe are measured by a piezometer and a pitot tube to be 200 kPa and 210 kPa, respectively. If the density of the fluid is 550 kg/m^3, the velocity of the fluid is _____.

17. For a thin airfoil, the lift coefficient C_L is approximately proportional to the _____ for small angles.

18. _____ is used to transform Lagrangian description into Eulerian description.

19. In turbulent flow, the friction factor depends on the Reynolds number and the _____ of the pipe.

20. In aerodynamics, the wingtip vortices produce _____drag.