Reg No.:_______________ Name:__________________________

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Third Semester B.Tech Degree Examination December 2020 (2019 Scheme)

Course Code: MET203

Course Name: MECHANICS OF FLUIDS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks Marks

1	Consider a soap bubble. Is the pressure inside the bubble higher or lower than the pressure outside? Explain.	3
2	Define the resultant hydrostatic force acting on a submerged surface, and the centre of pressure.	3
3	What does the word kinematics mean? Explain what the study of fluid kinematics involves?	3
4	What flow property determines whether a region of flow is rotational or irrotational? Discuss.	3
5	What is the hydraulic grade line? How does it differ from the energy grade line?	3
6	Define static, dynamic and hydrostatic pressure. Under what conditions is their sum constant for a flow stream?	3
7	Define equivalent length for minor loss in pipe flow. How is it related to the minor loss coefficient?	3
8	Explain how flow rate is measured with obstruction type flowmeters. Compare orificemeters and venturimeters with respect to cost, size, head loss and accuracy.	3
9	What is a boundary layer? What causes a boundary layer to develop?	3
10	What is the primary reason for nondimensionalizing an equation?	3

PART B

Answer any one full question from each module. Each question carries 14 marks

Module 1

11	a.	Consider two identical fans, one at sea level and the other on top of a high mountain running at identical speeds. How would you compare (a) the volume flow rates and (b) the mass flow rates of these two fans?	8
	b.	You may have noticed that dams are much thicker at the bottom. Explain why dams are built that way?	6
12	a.	Differentiate between (i) Specific weight and Specific volume (ii) Dynamic viscosity and Kinematic viscosity (iii) Real fluid and Ideal fluid	6

b. A manometer is used to measure the pressure in a tank. The fluid used has a specific gravity of 0.80 and the manometer column height is 50 cm. If the local atmospheric pressure is 98 kPa, determine the absolute pressure within the tank. 8

Module 2

13 The velocity potential function is given by $\varphi = 10(x^2 - y^2)$. Calculate the velocity components at the point (4,5). 14

14 The velocity components in a steady two-dimensional incompressible flow are given by u = 6x and v = -6y. Prove that the flow satisfies law of conservation of mass. 14

Module 3

15 a. Air enters a nozzle steadily at 2.21 kg/m^3 and 30 m/s and leaves at 0.762 kg/m^3 and 180 m/s. If the inlet area of the nozzle is 80 cm^2, determine (a) the mass flow rate through the nozzle (b) exit area of the nozzle. 4

b. A 1 m^3 rigid tank initially contains air whose density is 1.18 kg/m^3. The tank is connected to a high pressure supply line through a valve. The valve is opened and air is allowed to enter the tank until the density in the tank rises to 7.20 kg/m^3. Determine the mass of air that has entered the tank. 10

16 a. Consider a device with one inlet and one outlet. If the volume flow rates at the inlet and at the outlet are the same, is the flow through this device necessarily steady? Why? 4

b. A pressurized tank of water has a 10 cm diameter orifice at the bottom where water discharges to the atmosphere. The water level is 3 m above the outlet. The tank air pressure above the water level is 300 kPa (absolute) while the atmospheric pressure is 100 kPa. Neglecting frictional effects, determine the initial discharge rate of water from the tank. 10

Module 4

17 a. Consider the flow of air and water in pipes of same diameter at the same temperature and at the same mean velocity. Which flow is more likely to be turbulent? Why? 4

b. Consider fully developed laminar flow in a circular pipe. If the diameter of the pipe is reduced by half while the flow rate and the pipe length are 10 held constant, the head loss will (a) double (b) triple (c) quadruple (d) increase by a factor of 8 or (e) increase by a factor of 16. Explain.

18 a. What is hydraulic diameter? How is it defined? What is it equal to for a circular pipe of diameter D? 5

b. Water at 10°C (**Density= 999.7 kg/m^3 and dynamic viscosity= 1.307x10^{-3} Ns/m^2**) is flowing steadily in a 0.20 cm diameter, 15 m long pipe at an average velocity of 1.2 m/s. Determine (a) the pressure drop, (b) head loss and (c) the pumping power requirement to overcome this pressure drop. 9

Module 5

19 a. For each statement, choose whether it is true or false and discuss your answer briefly. These statements concern a laminar boundary layer on a flat plate. 8

1. At a given x location, if the Reynolds number were to increase, the boundary layer thickness would also increase.
2. As outer flow velocity increases, so does the boundary layer thickness.
3. As the fluid viscosity increases, so does the boundary layer thickness.
4. As the fluid density increases, so does the boundary layer thickness.

b. Write the primary dimensions of the universal ideal gas constant R_u. (Use the ideal gas law, $PV = nR_uT$, where P is pressure, V is volume, T is absolute temperature, and n is the number of moles of the gas.) 6

20 a. The **pressure drop Δp**, for steady, incompressible viscous flow through a straight horizontal pipe depends on the **pipe length l**, the **average velocity V**, the **fluid viscosity μ**, the **pipe diameter D**, the **fluid density ρ**, and the average "**roughness" height e**. Determine a set of dimensionless groups that can be used to correlate data. 10

b. Consider laminar flow over a flat plate. How does the local friction coefficient change with position? 4

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Third Semester B.Tech Degree Examination December 2021 (2019 scheme)

Course Code: MET203

Course Name: MECHANICS OF FLUIDS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions. Each question carries 3 marks Marks

1	What is viscosity? What is the cause of it in liquids and in gases?	3
2	Consider a 4 kg copper cube and a 4 kg copper ball submerged in a liquid. Will the buoyant forces acting on these two bodies be the same or different? Explain.	3
3	A stationary probe is placed in a fluid flow and measures pressure and temperature as functions of time at one location in the flow. Is this a Lagrangian or an Eulerian measurement? Explain.	3
4	What is the definition of a streamline? What do streamlines indicate?	3
5	Does the amount of mass entering a control volume have to be equal to the amount of mass leaving during an unsteady-flow process? Explain.	3
6	What are the three major assumptions used in the derivation of the Bernoulli equation?	3
7	Someone claims that the shear stress at the centre of a circular pipe during fully developed laminar flow is zero. Do you agree with this claim? Explain.	3
8	Explain why the friction factor is independent of the Reynolds number at very large Reynolds numbers.	3
9	Define boundary layer thickness, momentum thickness and displacement thickness.	3
10	What is the primary reason for nondimensionalizing an equation?	3

PART B

Answer any one full question from each module. Each question carries 14 marks

Module 1

11	An infinite plate is moved over a second plate on a layer of liquid. For small gap width, d = 0.3 mm, we assume a linear velocity distribution in the liquid. The liquid viscosity is 0.065 Ns/m^2 and its specific gravity is 0.90. Lower	14

plate is fixed and the upper plate is moving with a velocity of 0.3 m/s. Determine :

(a) The kinematic viscosity of the liquid, in m^2/s.

(b) The shear stress on the upper plate, in N/m^2

(c) The shear stress on the lower plate, in Pa.

(d) The direction of each shear stress calculated in parts (b) and (c).

12 (a) What is the difference between gage pressure and absolute pressure? 14

(b) Express Pascal's law and give example of it.

(c) A vacuum gage connected to a tank reads 30 kPa at a location where the barometric reading is 755 mm Hg. Determine the absolute pressure in the tank. Take density of mercury as 13,590 kg/m^3.

Module 2

13 A steady, incompressible, two dimensional velocity field is given by the following components in the xy plane : 14

u = 1.1+ 2.8x + 0.65y and v = 0.98 - 2.1x - 2.8y

Calculate the acceleration field (find expressions for acceleration components **a_x and a_y**.), and calculate the acceleration at the point (x, y) = (-2, 3).

14 Consider the flow field given by **$\psi = ax^2 - ay^2$** where a = 5 s^{-1}. Show that the flow is irrotational. Determine the velocity potential for this flow. 14

Module 3

15 A pitot tube is inserted in an air flow to measure the flow speed. The tube is inserted so that it points upstream into the flow and the pressure sensed by the tube is the stagnation pressure. The static pressure is measured at the same location in the flow using a wall pressure tap. If the pressure difference is 42 mm of mercury, determine the flow speed. 14

16 Air enters a nozzle steadily at 2.5 kg/m^3 and 28 m/s and leaves at 0.81 kg/m^3 and 178 m/s. If the inlet area of the nozzle is 80 cm^2, determine (a) the mass flow rate through the nozzle and (b) the exit area of the nozzle. 14

Module 4

17 Water at 30°C (**Density = 990 kg/m^3 and dynamic viscosity = 8.9 $x10^{-4}$ Pas**) is flowing through a 6 mm diameter 1 m long horizontal pipe steadily at an average velocity of 1 m/s. Determine (a) the head loss (b) the pressure drop, and (c) the pumping power requirement to overcome this pressure drop. 14

18 (a) Explain why the friction factor is independent of the Reynolds number at very large Reynolds numbers. 14

(b) Consider laminar flow in a circular pipe. Will the wall shear stress be higher near the inlet of the pipe or near the exit? Why?

Module 5

19 Consider two-dimensional laminar boundary-layer flow along a flat plate. Assume the velocity profile in the boundary layer is sinusoidal, 14

$$\frac{u}{U} = sin\left(\frac{\pi}{2}\frac{y}{\delta}\right)$$

Find expressions for : (a) The rate of growth δ, as a function of x. (b) The displacement thickness δ*, as a function of x.

20 The drag force F, on a smooth sphere depends on the relative speed V, the sphere diameter D, the fluid density ρ, and the fluid viscosity μ. Obtain a set of dimensionless groups that can be used to correlate experimental data. 14

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