

II B.Tech II Semester Regular Examinations, Apr/May 2008
FLUID MECHANICS AND HEAT TRANSFER
(Common to Mechatronics and Production Engineering)

Time: 3 hours**Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

1. (a) Define bulk modulus of fluids. What is its significance? [8]
 (b) A cylindrical shaft of 90 mm diameter rotates about a vertical axis inside a fixed cylindrical tube of length 50 cm and 95 mm internal diameter. If the space between the tube and the shaft is filled by a lubricant of dynamic viscosity 2 poise, determine the power required to overcome viscous resistance when the shaft is rotated at a speed of 240 rpm. [8]
2. (a) What do you understand by uniform flow and non uniform flow ? What are the practical examples? [8]
 (b) The stream function of a flow is given by $\psi = x^3 - 3xy^2$. Find the velocity at a point (3,2) and the velocity potential function. [8]
3. (a) State the momentum equation. How will you apply momentum equation for determining the force exerted by a flowing liquid on a pipe bend? [8]
 (b) A 45° reducing bend is connected in a pipe line, the diameters at the inlet and outlet of the bend being 40cm and 20 cm respectively. Find the force exerted by water on the bend if the intensity of pressure at inlet of bend is 21.58 N/cm². The rate of flow of water is 500 lit/sec. [8]
4. The population of a city is 8×10^5 and it is to be supplied with water from a reservoir 6.4 km away. Water is to be supplied at the rate of 0.14 m^3 per head per day and half the supply is to be delivered in 8 hours. The full supply level of the reservoir is R.L 180.00. and its lowest water level is R.L.105.00. The delivery end of the main is at R.L 22.50 and the head required there is 12m. Find the diameter of the pipe. Take $f = 0.04$. [16]
5. Prove that the heat loss per square metre of outside surface area of a hollow sphere heated from within is equal to

$$q = \frac{2k(T_1 - T_2)}{(D_2 - D_1) \frac{D_2}{D_1}}$$

where T_1 and T_2 are the temperatures and D_1 and D_2 are the diameters of the inner and outer surfaces respectively. [16]

6. (a) Explain the difference between laminar and turbulent flow.
 (b) Derive an equation for the film heat transfer coefficient in forced convection using dimensional analysis. What are its limitations. [6+10]

7. (a) When a body is said to be black? What is the range of wave lengths it absorbs?
(b) Compute the radiant energy loss from 1 cm diameter opening in a thin walled furnace located in a large enclosure, if the temperature with in the furnace is 900°C and the surroundings are at 20°C . [6+10]
8. Steam is condensed in a single pass condenser at a pressure of 0.5 bar. The condenser consists of 100 thin walled tubes of 2.5 cm nominal diameter and 2m length .The cooling water enters and leaves at a temperature of 10°C and 50°C with a mean velocity of 2 m/Sec. The condensing heat transfer coefficient is $5 \text{ KW}/\text{m}^2\text{-K}$. Find
(a) Overall heat transfer coefficient for heat exchanger
(b) Condensation rate of steam
(c) Mean temperature of metal at the center of condenser length. [16]

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1. (a) Define viscosity. Derive the equation for the viscosity. [8]
 (b) The space between two parallel plates kept 3mm apart is filled with an oil of dynamic viscosity 0.2 N- Sec / m^2 . What is the shear stress on the lower fixed plate if the upper one is moved with a velocity of 1.5 m /sec ? [8]
2. (a) What is a flow net? What are its uses ? Give examples. [8]
 (b) The flow field is described by $V = (-Y^2) \mathbf{i} - (6x) \mathbf{j}$. What is the equation of the stream line to pass through a point (12,15). [8]
3. (a) What is a orifice meter. Derive an expression for the discharge through a orifice meter. [8]
 (b) A vertical venturimeter has its inlet and throat diameters as 25 cm and 12.5 cm Respectively. A differential mercury manometer connected to the inlet and throat points gives a reading of 25cm. Find the rate of flow. Take $C_d=0.98$. The liquid flowing through the meter is water. [8]
4. Derive the equation for head loss in pipes due to friction. Explain the variation of friction factor with Reynolds number. [16]
5. Prove that the heat loss per square metre of outside surface area of a hollow sphere heated from within is equal to

$$q = \frac{2k(T_1 - T_2)}{(D_2 - D_1) \frac{D_2}{D_1}}$$

where T_1 and T_2 are the temperatures and D_1 and D_2 are the diameters of the inner and outer surfaces respectively. [16]

6. (a) Explain the difference between natural and forced convection.
 (b) State the Buckingham's II-theorem. Using dimensional analysis obtain an expression for Nusselt number in terms of Reynolds and Prandtl numbers. [4+12]
7. (a) Explain the term shape factor?
 (b) A spherical liquid oxygen tank 0.3 m in diameter is enclosed concentrically in a spherical container of 0.4m diameter and the space in between is evacuated. The tank surface is at -183°C and has an emissivity 0.2. The container surface is at 15°C and has an emissivity 0.25. Determine the net radiant heat transfer rate. [4+12]

8. (a) Derive an expression for effectiveness of a counter flow heat exchanger using NTU method .
- (b) Water ($C_p = 4200 \text{ J/kg K}$) enters a counter flow double pipe heat exchanger at 39°C at the rate of 273.6 kg/hr .It is heated by oil ($C_p = 1880 \text{ J/kg-K}$) flowing at the rate of 547.2 kg/hr from an inlet temperature of 118°C find the total heat transfer rate per m^2 .Take $U = 342 \text{ W/m}^2\text{-K.v}$ [8+8]

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1. (a) What is kinematic viscosity ? What are its units? [6]
 (b) Two coaxial cylinders 10 cm and 9.75 cm in diameter and 2.5 cm high have both their ends open and have a viscous liquid filled in between. A torque of 1.2 N- m is produced on the inner cylinder when the outer one rotates at 90 rpm. Determine the coefficient of viscosity of the liquid. [10]
2. (a) What is a flow net? What are its uses ? Give examples. [8]
 (b) The flow field is described by $V = (-Y^2) \mathbf{i} - (6x) \mathbf{j}$. What is the equation of the stream line to pass through a point (12,15). [8]
3. (a) State and prove Euler' equation of motion. Obtain Bernoulli's equation from Euler's equation [8]
 (b) At a certain section A of a pipe line carrying water, the diameter is 1m, the pressure is 98.1kN/m² and the velocity is 3m/sec. At another section B which is 2 m higher than A, the diameter is 0.7m and the pressure is 59.2 k N / m². What is the direction of flow? [8]
4. Derive the equation for head loss in pipes due to friction. Explain the variation of friction factor with Reynolds number. [16]
5. A standard 5 cm steel pipe carrying steam is insulated with 7.5 cm layer of glass wool. The outer surface temperature of the pipe is 200⁰C and that of the covering is 65⁰C. Estimate the heat loss from pipe and assume the value of thermal conductivity of steel. [16]
6. (a) 0.05 kg/s of CO₂ gas at 400K flowing in a 20 mm diameter pipe. For viscosity take $\mu = \frac{1.56 \times 10^{-6} T^{3/2}}{(233+T)} \text{ kg/ms}$. Calculate its Reynolds number and state whether flow is laminar or turbulent.
 (b) Draw a labeled schematic diagram showing the features of a velocity boundary layer for forced convection over a flat plate. Also show in the diagram the essential differences between the laminar and turbulent parts of the boundary layer. [8+8]
7. (a) When a body is said to be black? What is the range of wave lengths it absorbs?
 (b) Compute the radiant energy loss from 1 cm diameter opening in a thin walled furnace located in a large enclosure, if the temperature with in the furnace is 900⁰C and the surroundings are at 20⁰C. [6+10]

8. (a) Derive an expression for logarithmic mean temperature difference for the case of counter flow exchanger .
- (b) A liquid chemical flows through a thin walled copper tube of 12 mm diameter at the rate of 0.5 kg/sec water flows in opposite direction at the rate 0.37 kg/sec through the annular space formed by this tube and a tube diameter of 20 mm . The liquid chemical enters and leaves at 100°C and 60°C ,while water enters at 10°C . Find the length of tube required. Also find the length of tube required if the water flows in the same direction as liquid chemical. The properties of water and liquid chemical are [8+8]

PROPERTIES 27°C	LIQUID CHEMICAL AT 80°C	WATER AT
ρ , Kg/m^3	1078	995
μ , $\text{Kg}/\text{m}\cdot\text{Sec}^2$	3200×10^{-6}	853×10^{-6}
C_p , $\text{J}/\text{Kg}\cdot\text{K}$	2050	4180
K , W/mK	0.261	0.614

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1. (a) Hydrostatic pressure of a fluid always acts normal to the surface with which it is in contact. Why? [8]
(b) If the pressure at a point below the sea is 200 KN/m^2 , what is the pressure 30m below this point? [8]
2. (a) When do you say the flow is rotational or irrotational ? Give suitable examples? [8]
(b) A stream function is given by $\psi = x^3 - y^3$. Show that the flow can not be a potential flow. [8]
3. (a) Explain momentum thickness, energy thickness and displacement thickness. [8]
(b) Find the frictional drag on one side of the plate 20cm wide and 50cm long placed longitudinally in a stream of crude oil (specific gravity 0.925, kinematic viscosity 0.9 stoke) flowing with undisturbed velocity of 5 m/sec. Also find the thickness of boundary layer and the shear stress of the trailing edge of the plate. [8]
4. A pipe 50 mm dia is 6 m long and the velocity of flow of water in the pipe is 2.4 m/s. what loss of head and the corresponding power would be saved if the central 2m length of pipe was replaced by 75mm dia pipe, the change of section being sudden? Take $f = 0.04$ for the pipes of both diameter. Consider the minor losses also. [16]
5. A standard 5 cm steel pipe carrying steam is insulated with 7.5 cm layer of glass wool. The outer surface temperature of the pipe is 200°C and that of the covering is 65°C . Estimate the heat loss from pipe and assume the value of thermal conductivity of steel. [16]
6. (a) Derive the two dimensional energy equation for the thermal boundary layer over a flat plate.
(b) Calculate the rate of free convection heat loss from 25 cm diameter sphere maintained at 90°C and exposed to atmospheric air at 10°C . [8+8]
7. (a) State and explain Lamberts Cosine law.
(b) A person standing 10m from a point heat source is subjected to a radiation intensity of $200 \times 10^6 \text{ J/hr m}^2$. How far should he stand from the heat source to feel and intensity of half the previous value? [4+12]

8. A heat exchanger (17.2 m^2) is used to cool oil at 200°C by water available at 20°C . The mass flow and sp.heat of oil are 10000 kg/hr and 1.9 kJ/kg-K and corresponding values for water are $300 \text{ W/m}^2\text{-K}$. Find the outlet temperature of oil and water for parallel flow and counter flow arrangements using LMTD method and (2) NTU method. [16]
