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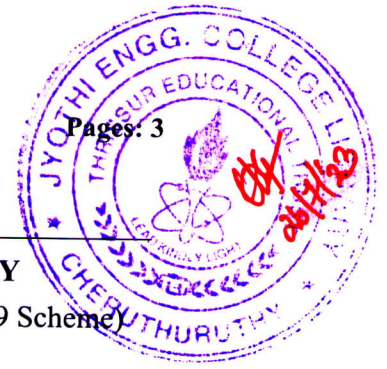
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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S6 (R, S) / S4 (PT) (R,S) Examination June 2023 (2019 Scheme)



Course Code: MET302

Course Name: HEAT AND MASS TRANSFER

Max. Marks: 100

Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

Marks

- 1 Distinguish between (i) steady and unsteady conduction (ii) 1-D and 2-D conduction. (3)
- 2 Write the assumptions used for Fourier's law of heat conduction (3)
- 3 Discuss the differences between natural and forced convection? (3)
- 4 Explain the significance of Reynolds number (3)
- 5 Discuss "correction factor" in heat exchanger analysis? (3)
- 6 Illustrate cross flow heat exchanger (3)
- 7 State and explain Kirchhoff's law of thermal radiation (3)
- 8 List and explain the factors affecting the rate of emission of radiation by a body (3)
- 9 Discuss the three modes of mass transfer (3)
- 10 What is convective mass transfer coefficient? What is its dimension? (3)

PART B

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

Module I

- 11 a) A 5 mm diameter and 2 m long electric wire is insulated with a 2 mm thick layer of fibrous cotton ($k=0.8\text{W/mK}$) followed by plastic layer ($k=0.15\text{ W/mK}$) of 3mm thickness. Electrical measurements indicate that a current of 20 A passes through the wire and there is a voltage drop of 25 V along the wire. If the insulated wire is exposed to air at $T_\infty = 30^\circ\text{C}$ with a convection heat transfer coefficient of $h = 12\text{ W/m}^2\text{-K}$, determine the temperature at the interface of the wire and the fibrous cotton cover in steady operation. (7)
- b) Explain critical thickness of insulation of a cylinder and derive an expression for the same. (7)

OR

- 12 a) Calculate the rate of heat loss through the vertical walls of a boiler furnace of size $4 \text{ m} \times 3 \text{ m}$ and 3 m high. The walls are constructed from an inner fire brick wall 25 cm thick of thermal conductivity 0.4 W/mK , a layer of ceramic blanket insulation of thermal conductivity 0.2 W/mK and 8 cm thick, and a steel protective layer of thermal conductivity 55 W/mK and 2 mm thick. The inside temperature of the fire brick layer was measured at 600°C and the temperature of the outside of the insulation 60°C . Also find the interface temperature of layers. (7)
- b) A steam pipe of 10 cm inner diameter and 11 cm outer diameter is covered with an insulating substance $k = 1 \text{ W/mK}$. The steam temperature is 200°C and ambient temperature is 20°C . If the convective heat transfer coefficient between insulating surface and air is $8 \text{ W/m}^2\text{K}$, find the critical radius of insulation and for this value of r_c , calculate the heat loss per m of pipe and the outer surface temperature. Neglect the resistance of the pipe material. (7)

Module II

- 13 a) When 0.6 kg of water per minute is passed through a tube of 2 cm diameter, it is found to be heated from 20°C to 60°C . The heating is achieved by condensing steam on the surface of the tube and subsequently the surface temperature of the tube is maintained at 90°C . Determine the length of the tube required for fully developed flow. (9)
- b) State and explain Newton's law of cooling. (5)

OR

- 14 a) A vertical pipe 80 mm diameter and 2 m height is maintained at a constant temperature of 120°C . The pipe is surrounded by still atmospheric air at 30°C . Find heat loss by natural convection. (10)
- b) Illustrate thermal boundary layer over a flat plate when the plate surface is hotter than fluid. (4)

Module III

- 15 a) Explain the classification of heat exchanger by the 'nature of heat exchange' with the help of diagrams. (7)
- b) Derive the expression for log mean temperature difference in parallel flow heat exchanger (7)

OR

- 16 a) A chemical having specific heat of 3.3 kJ/kgK enters a parallel flow heat exchanger at 120 °C with a mass flow rate of 20000 kg/h. The flow rate of cooling water is 50000 kg/h with an inlet temperature of 20 °C. The heat transfer area is 10 m² and overall heat transfer coefficient is 1050 W/m²K. Find the outlet temperature of water and chemical. (Take C_p of water =4.18kJ/kgK) (10)
- b) State the causes of fouling in heat exchanger. How fouling is accounted in heat exchanger analysis? (4)

Module IV

- 17 a) Compare white body with grey body (5)
- b) A boiler furnace, whose surfaces closely approximate black surface, is made in the shape of a cylinder of height 2.4 m and diameter 6 m. The base, top and curved surfaces are maintained at 800K, 1500K and 600K respectively. Determine net radiation heat transfer between top and curved surfaces. (9)

OR

- 18 a) Two large plates are maintained at a temperature of 900 K and 500 K respectively. Each plate has area of 6m². Compare the net heat exchange between the plates for the following cases. i) Both plates are black and ii) Plates have an emissivity of 0.5 (8)
- b) The filament of a 75 W light bulb may be considered as a black body radiating into a black enclosure at 70⁰ C. Considering the radiation, determine the filament temperature, if the filament diameter is 0.10 mm and length is 5 cm. (6)

Module V

- 19 a) State and explain governing law of diffusion mass transfer. (6)
- b) Explain steady state diffusion through a plane membrane (8)

OR

- 20 a) Air at 50 °C and 1 atm. flow over the surface of a water reservoir at an average velocity of 2.3 m/s. The water surface is 0.65 m long and 0.65 m wide. The water surface temperature is estimated to be 30°C. The relative humidity of air is 40%. The density of air is 1.105kg/m³ and its kinematic viscosity is 17.58 × 10⁻⁶ m²/s. Calculate the amount of water vapour evaporates per hour per square meter of water surface in kg/m²h. Diffusion coefficient= 0.256 × 10⁻⁴ m²/s. (14)
