Registration No. | | | | | | | | | |

M.E./M.Tech. Degree Examinations, January 2017

First Semester

INTERNAL COMBUSTION ENGINEERING

IC16101 – ADVANCED HEAT TRANSFER

(Regulation 2016)

(Heat and Mass Transfer Data Book is permitted)

QP Code:792111

Time: Three hours **Maximum : 100 marks**

Answer **ALL** questions

PART A - (10 X 2 = 20 Marks)

1. Define - "Optimum Design" of fin profile.
2. What is radiation shield? Where is it used?
3. What is meant by eddy viscosity?
4. Define Reynolds analogy.
5. Differentiate between the mechanism of filmwise and dropwise condensation.
6. How are evaporators classified?
7. Define Thomas Algorithm, where it is used?
8. What is upwind scheme?
9. State Fick's law of diffusion.
10. Write down any two heat transfer correlations for IC engine.

PART B - (5 X16 = 80 Marks)

11. (a) Fins,12 in number, having k = 75 W/m-K and 0.75 mm thickness protrude 25 mm from a cylindrical surface of 50 mm diameter and 1m length placed in an atmosphere of 40˚C. If the cylindrical surface is maintained at 150˚C and the heat transfer is 23 W/m^2 –K, Calculate, **(16)**
    (i) The rate of heat transfer
    (ii) The percentage increase in heat transfer due to fins
    (iii) The temperature at the centre of fins
    (iv) The fin efficiency and the fin effectiveness.

(OR)

(b) Consider two large parallel plate one at t_1 = 727 ˚C with emissivity ε_1= 0.8 and other at t_2 = 227 ˚C with emissivity ε_2 = 0.4. An aluminum radiation shield with an emissivity, ε_s = 0.05 on both sides is placed between the plate. Calculate the percentage reduction in heat transfer rate between the two plates as a result of the shield. Use $\sigma = 5.67 \times 10^{-8}$ $W/m^2 - K^4$. **(16)**

12. (a) A 0.25 m diameter stainless steel ball (ρ = 8055 kg/m^3, c_p = 480 J/kg-K) is removed from the oven at a uniform temperature of 300˚C. The ball is then subjected to the flow of air at 1 atm. Pressure and 25 ˚C with a velocity of 3 m/s. The surface temperature of the ball eventually drops to 200 ˚C. Determine the average convection heat transfer coefficient during this cooling process and estimate how long the process will take. **(16)**

(OR)

(b) The crankcase of an IC engine measuring 80 cm x 20 cm may be assumed as a flat plate. The engine runs at a speed of 25 m/s and the crankcase is cooled by the air flowing past it, at the same speed. Calculate the heat lost from the crank surface maintained at 85˚C to the ambient air at 15˚C. Due to road induced vibration, the boundary layer becomes turbulent from the leading edge itself. **(16)**

13. (a) (i) Explain briefly the various regimes of saturated pool boiling. **(10)**

(ii) Differentiate between pool boiling and forced convection boiling. **(6)**

(OR)

(b) In a gas turbine power plant heat is being transferred in a heat exchanger from the hot gases leaving the turbine at 450 ˚C to the air leaving the compressor at 170 ˚C. The air flow rate is 5000 kg/h and fuel-air ratio is 0.015kg/kg. The overall heat transfer coefficient for the heat exchanger is 52.33 W/m^2 ˚C. The surface area is 50 m^2 and arrangement is cross-flow (both fluids unmixed). Calculate the following. (i) The exit temperatures on the air and gas sides and (ii) The rate of heat transfer in the exchanger. Take $c_{ph} = c_{pc}$= 1.05 kJ/kg ˚C. **(16)**

14. (a) Hot combustion gases of a furnace are flowing through a square chimney made of concrete (k = 1.4 $W/m\text{-}K$). The flow section of the chimney is 20*cm*x20 *cm* and the thickness of the wall is 20 *cm.* The average temperature of the hot gases in the chimney is T_i = 300˚C and the average convection heat transfer coefficient inside the chimney is h_i = 70 W/m^2 K. The chimney is losing heat from its outer surface to the ambient air at T_o = 20˚C by convection with a heat transfer coefficient of h_o = 21 $W/m^2\text{-}K$ and to the sky by radiation. The emissivity of the outer surface of the wall is ε = 0.9 and the effective sky temperature is estimated to be 260 K. Using the finite difference method with Δx = Δy = 10 cm and taking full advantage of symmetry, determine the temperatures at the nodal points of a cross section and the rate of heat loss for a 1-m long section of the chimney. **(16)**

(OR)

(b) A steel rod (k = 50 $W/m\text{-}˚C$) 3 mm in diameter and 10 *cm* long (Discretized into four element, Δx = 2.5 cm) is initially at a uniform temperature of 200˚C. At time zero it is suddenly immersed in a fluid having h = 50$W/m^2\text{-}˚C$ and T_α = 40˚C while one end is maintained at 200˚C. Determine the temperature distribution in the rod after 100s. The properties of steel are ρ = 7800 kg/m^3 and c =0.$47kJ/kg$ ˚C. **(16)**

15. (a) In a Stefan tube experiment with carbon tetrachloride and oxygen, the following data are noted: Diameter of the tube = 10 mm, length of tube above liquid surface = 150 mm, Temperature maintained = 0˚C, Pressure maintained = 760 mm Hg, Vapour pressure of CCl_4 at 0˚C = 33 mm Hg, Evaporation of CCl_4 = 0.03 g, Time of evaporation = 10 hours. Estimate the diffusion coefficient of carbon tetrachloride into air. **(16)**

(OR)

(b) Explain heat transfer correlations of the following:

(i) IC Engine **(6)**

(ii) Compressor **(5)**

(iii) Turbine **(5)**