(3 Hours) **[Total Mark: 80]**

N.B. (1) Question No. 1 is compulsory
(2) Attempt any **Three** Question from Q. No. 2 to Q. No.6
(3) Make suitable assumption if required
(4) Illustrate answers with sketches wherever required

Q. 1 Solve any **four** questions from the following (Five marks each) 20

a) Derive an expression for one dimensional steady state heat conduction through plane wall.

b) Discuss the concept and application of steady and unsteady state heat transfer along with the practical example of each.

c) Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500 °C.
   i) Monochromatic emissive power at 1.2 µm
   ii) Wave length at which the emission is maximum
   iii) Total emissive power of the furnace if it is assumed as real surface with emissivity equal to 0.8

d) Discuss in detail about the effect of engine variables on detonation in Spark ignition engines.

e) A cylinder rod of 1 cm diameter and 1 m long is initially maintained at 300 °C. It is suddenly dropped in oil at 50 °C having convective heat transfer coefficient at 240 W/m^2K. Find the time required to cool the rod up to 120 °C. Properties of rod material is as follows:
Density = 8000 kg/m^3. C=400 J/kg/K. k= 60 W/mK

f) Engine oil at 60°C flows over the upper surface of a 5 m-long flat plate whose temperature is 20°C with a velocity of 2 m/s. Determine the total drag force and the rate of heat transfer per unit width of the entire plate.
Properties of oil are as follows:
Density=876 kg/m^3, Pr = 2870, Thermal conductivity = 0.144 W/m°C, Kinematic viscosity = 242 x 10^{-6} m^2/s

Q. 2 (a) An aluminum rod 2 cm diameter and 10 cm long protrudes from the wall maintained at 300 °C. The rod is exposed to surroundings at 15°C. Heat transfer coefficient between rod surfaces an environment is 20 W/m^2K. The thermal conductivity of the material is 200 W/mK. Find 12
   i) Total heat dissipated by rod
   ii) Temperature of road at 4 cm from the wall
   iii) Temperature at the end of rod
   iv) Fin efficiency
Assume that the rod end is insulated

(b) What are the different control methods for engine emissions 08

Q. 3 (a) The following details were noted in a test on a four-cylinder, four-stroke engine, diameter = 100 mm; stroke = 120 mm; speed of the engine = 1600 rpm; fuel consumption = 0.2 kg/min; calorific value of fuel is 44000 kJ/kg; difference in tension on either side of the brake pulley = 40 kg; brake circumference is 300 cm. If the mechanical efficiency is 80%, calculate 10
(i) brake thermal efficiency (ii) indicated thermal efficiency (iii) indicated mean effective pressure and (iv) brake specific fuel consumption

(b) Derive an expression for temperature distribution and heat dissipation in a straight fin of rectangular profile for insulated tip. 10

Q. 4 (a) A furnace walls made up of three layers , one of fire brick, one of insulating brick and one of red brick. The inner and outer surfaces are at 870°C and 40°C respectively. The respective co- efficient of thermal conductivities of the layer are 1.0, 0.12 and 0.75 W/mK and thicknesses are 22 cm, 7.5 cm, and 11 cm. Assuming close bonding of the layer at their interfaces, find the rate of heat loss per sq. meter per hour and the interface temperatures if the convective heat transfer coefficient of the atmosphere 40 W/m^2 °C and atmospheric temperature is 20 °C. 12

(b) Discuss about the actual and ideal valve timing diagram for four stroke petrol engine. 08

Q. 5 (a) A four stroke gas engine has a cylinder diameter of 25 cm and stroke 45cm. The effective diameter of the brake is 1.6m. The observations made in the test of the engine were as follows.
Duration of the test 40 minute, total number of revolutions = 8080. Total no of explosions = 3230, net load on the brake = 90 kg, mean effective pressure = 5.8 bar, volume of gas used = 7.5 m^3, pressure of gas indicated in a meter = 136 mm of water of gauge, atmospheric temperature = 17 °C, calorific value of the gas 19 MJ/m^3 at NTP. Rise in temperature of the jacket cooling water= 45 °C , Cooling Water Supplied 180 Kg. Draw up the heat balance sheet and estimate the indicated thermal efficiency and brake thermal efficiency. Assume atmospheric pressure as 760 mm of Hg 12

(b) State and explain different factors affecting on ignition delay period in compression ignition engine 08

Q. 6 (a) Water(mass flow rate of 1.4 kg/s, Cp= 4.187 kJ/kgK) is heated from 40 °C to 70 °C by an oil (mass flow rate 2kg/s, Cp 1.9 kJ/kgK) entering at 110 °C in a counter flow heat exchanger. If overall heat transfer coefficient is $350W/m^2K$, Calculate the surface area required. Also find the surface area required if it's a parallel flow heat exchanger. 08

(b) Explain the following (**Four marks each**) 12

i) What is the governing law of diffusion mass transfer?

ii) Draw a boiling curve for water and show and explain the different boiling regimes. Explain the phenomenon of condensation.

iii) Derive an expression for log mean temperature difference in parallel flow heat exchanger. State your assumption

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