Time: 3 Hours **Marks: 80**

- ***Question No.1 is compulsory.***
- *Solve **ANY THREE** questions from the **remaining five** questions.*
- *Figure to the right indicates full marks.*
- *Assume suitable data wherever required, but justify the same.*

			Marks
Q. 1		Solve **ANY FOUR** questions from following. (Each question carries **5 marks**)	**20**
	a)	Discuss the effect of increase in temperature on thermal conductivity of materials which are conductors and insulators.	
	b)	Explain the following non dimensional numbers applied to heat transfer by convection: (i) Nusselt Number (ii) Prandtl Number (iii) Grashoff Number	
	c)	A steam pipe is insulated to reduce the heat loss. However, the measurement reveals that the rate of heat lost has increased instead of decreasing. Explain the reason for this phenomenon.	
	d)	Explain Biot number and Fourier number applied to transient heat transfer.	
	e)	Longer ignition lag in an SI engine and a shorter ignition lag in CI engine is desirable. Discuss the reason for this.	
	f)	Describe the effects of Thermal Converters and Catalytic Converters on emission reduction.	
Q. 2	**a)**	During the trial of a single-cylinder, four-stroke oil engine, having inner diameter 20 cm and stroke length 40 cm, the following results were obtained. Mean effective pressure = 6 bar Torque = 407 Nm Speed = 250 rpm Oil consumption = 4 kg/h Calorific value of fuel = 43 MJ/kg Cooling water flow rate = 4.5 kg/min Air used per kg of fuel = 30 kg Rise in cooling water temperature = 45°C Temperature of exhaust gases = 420°C Room temperature = 20°C Mean specific heat of exhaust gas = 1 kJ/kg K Specific heat of water = 4.18 kJ/kg K Calculate the ip, bp and draw up a heat balance sheet for the test in kJ/h.	**8**
	b)	A composite cylinder consists of 10 cm radius steel pipe of 25 mm thickness over which two layers of insulation 30 mm and 35 mm are laid. The conductivities are 25 W/mK, 0.25 W/mK and 0.65 W/mK for the pipe, first layer and second layer respectively. The inside is exposed to convection at 300°C with h = 65 W/m^{2}K.The outside is exposed to air at 30°C with h = 15 W/m^2 K. Determine the heat loss per metre legth of the pipe. Also calculate the interface temperatures.	**12**

Q. 3 **a)** A 6-cylinder 4-stroke C.I. engine develops 220 kW at 1500 r.pm. with brake specific fuel consumption of 0.273 kg/kWh. Determine the size of the single hole injector nozzle if the injection pressure is 160 bar and the pressure in the combustion chamber is 40 bar. The period of injection is 30° of crank angle. Specific gravity of fuel = 0.85 and orifice discharge coefficient = 0.9. **8**

b) A flat plate 1 m wide and 1.5 m long is to be maintained at 90°C in air when free stream temperature is 10 °C. Determine the velocity at which air must flow over the plate so that the rate of energy dissipation from the plate is 3.75 kW. Consider the range of convective heat transfer coefficient for laminar flow as $h < 10\ W/m^2\,^oC$ and turbulent flow as $h > 10\ W/m^2\,^oC$. Use the appropriate correlation from the correlations given below: **12**

$\overline{Nu} = \frac{\bar{h}L}{k} = 0.664(Re_L)^{1/2}(Pr)^{1/3}$ ..... for laminar flow

$\overline{Nu} = \frac{\bar{h}L}{k} = [0.036\,(Re_L)^{0.8} - 836](Pr)^{1/3}$ ..... for turbulent flow

Take the following properties of air at 50°C: ρ = 1.0877 kg/m^3, k = 0.02813 W/m°C, c_p = 1007.3 J/kg°C, μ = 2.029 × 10^{-5} kg/ms and Pr = 0.703.

Q. 4 **a)** A fin 5 mm thick and 45 mm long has its base on a plane plate which is maintained at 125°C. The ambient temperature is 25°C. The conductivity of fin material is 55 W/m°C and the convective heat transfer coefficient is 145 W/m^2 °C. Assuming heat loss by convection from the end of the fin determine: **8**

(i) Temperature at the end of the fin
(ii) Heat dissipated by the fin (per metre width).

b) In a certain double pipe heat exchanger hot water flows at a rate of 50000 kg/h and gets cooled from 95°C to 65°C. At the same time 50000 kg/h of cooling water at 30°C enters the heat exchanger. The flow conditions are such that overall heat transfer coefficient remains constant at 2270 W/m^2 K. Determine the heat transfer area required and the effectiveness, assuming two streams are in parallel flow. Assume for the both the streams c_p = 4.2 kJ/kg K. **12**

Q. 5 **a)** The effective temperature of a body having an area of 0.12 m^2 is 527°C. Calculate the following: **5**

(i) The total rate of energy emission,
(ii) The intensity of normal radiation

b) Explain Willan's line method for measurement of frictional power. **5**

c) Differentiate between the efficiency and effectiveness of an extended surface. **5**

d) Illustrate with suitable diagram, the temperature profile from inlet to outlet for the following: **5**

(i) Parallel flow heat exchanger
(ii) Counter flow heat exchanger
(iii) Condenser
(iv) Evaporator

Q. 6 **a)** Draw a boiling curve for water and identify the different boiling regimes. Explain each regime in brief. **5**

b) A four-stroke gas engine has a bore of 20 cm and stroke of 30 cm and runs at 300 rpm firing every cycle. If air-fuel ratio is 4:1 by volume an volumetric efficiency on NTP basis is 80%, determine the volume of gas used per minute. If the calorific value of the gas is 8 MJ/m^3 at NTP and the brake thermal efficiency is 25% determine the brake power of the engine. **5**

c) Explain the phenomenon of knocking in Spark Ignition (SI) engine. **5**

d) State and explain Fick's Law of diffusion. **5**

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