[Time- 03 Hours] **Total Marks: 80**

N. B : (1) Question no.1 is **Compulsory**.
(2) Attempt any **THREE** from question no.2 to 6.
(3) Use illustrative diagrams wherever possible.
(4) Assume suitable data if necessary and mention it clearly.

Q.1 Answer **Any Four** questions from the following :

a) Name the various modes of heat transfer and also explain its governing laws. 5

b) Explain EURO and BHARAT Norms. 5

c) Explain the term critical radius of insulation and Derive the same for a cylinder with usual notations. 5

d) Distinguish between film and Dropwise condensation. 5

e) 16.5 kg/s of the product at 650^0C (C_p = 3.55 kJ/kg^{0}C) ,in a chemical plant ,are to be used to heat 20.5 kg/s of the incoming fluid from 100^0C (C_p = 4.2kJ/kg^{0}C).If the overall heat transfer coefficient is 0.95 W/m^2 ^{0}C and the installed heat transfer surface is 44 m^2 .Assume Counter flow arrangement. Determine : 5
i) Capacity ratio
ii) NTU
iii) Effectiveness of heat exchanger

Q.2 (a) A steam pipe of inner diameter 150 mm , outer diameter 160 mm and 1metre long having thermal conductivity 58 W/m^{0}C is covered with two layers of insulation, of thickness 30 mm and 50 mm respectively and thermal conductivities 0.18 W/m^{0}C and 0.09 W/m^{0}C respectively. The temperature of inner surface of steam pipe is 320^0C and that of the outer surface of the insulation layer is 40^0C. 12
Determine :
i) The quantity of heat lost per metre length of steam pipe
ii) Layer contact temperatures

(b) Air at 20^0C and 1.013 bar flows over a flat plate at 40 m/s. The plate is 1m long and is maintained at 60^0C.Assuming unit depth, calculate the heat transfer from the plate.Use the following relation 4

$Nu_L = (Pr)^{0.33} [0.037 (Re_L)^{0.8} - 850]$

Properties of air at 40^0C are : ρ = 1.128 kg/m^3, k = 0.0275 W/m^{0}C, Cp = 1.005 kJ/kg^{0}C, Pr = 0.699, ν = 16.96 x 10^{-6} m^2/s.

(c) Define 'Heat Exchanger Effectiveness'. Draw temperature profile for Parallel flow heat exchanger, Counter flow heat exchanger. 4

Q.3 (a) Air at velocity of 2.8 m/s and at 30^0C flows over a flat plate along its length. The length ,width and thickness of the plate are 1m , 0.6m , 0.025m .The top surface of the plate is maintained at 90^0C.If the thermal conductivity of the plate material is 25W/m^{0}C.Calculate: 10
i) Heat lost by the plate
ii) Bottom temperature of the plate for the steady state condition
The thermo-physical properties of air at mean film temperature 60^0C are :
ρ = 1.06 kg/m^3, k = 0.02894 W/m^{0}C, Cp = 1.005 kJ/kg^{0}C, Pr = 0.696; ν = 18.97 x 10^{-6} m^2/s.
Choose the appropriate relation from the following:
Nu = 0.664 (Re)$^{1/2}$ (Pr)$^{1/3}$ – For Laminar flow

$Nu = 0.036 (Re)^{0.8} (Pr)^{1/3}$ – For Turbulent flow

(b) Explain the stages of combustion in C.I engine with the help of p-θ diagram. 10

Q.4 (a) A 15 mm diameter mild steel sphere (k= 42 W/m°C) is exposed to cooling airflow at 20^{0}C resulting in the convective coefficient h= 120 W/m^{20}C. Determine : 10

i) Time required to cool the sphere from 550^{0}C to 90^{0}C
ii) Instantaneous heat transfer rate 2 minutes after the start of cooling.
iii) Total energy transferred from the sphere during the first 2 minutes.

For mild steel take: ρ= 7850 kg/m^3, C_P =475 J/kg.^{0}C, α =0.045m^2/h.

(b) State and explain Fick's law diffusion mass transfer. Compare Fick's law diffusion mass transfer with Fourier's law of heat conduction. 05

(c) Define "Shape Factor" and explain its properties. 05

Q.5 (a) Cold water at 1495 kg/h enters at 25^{0}C through a parallel flow heat exchanger to cool 605 kg/h of hot water entering at 70^{0}C and leaving at 50^{0}C.The overall heat transfer coefficient is 795 W/m^2.K. For water C_P =4180 J/kg.K. Find area of heat exchanger by LMTD and NTU methods 12

(b) Calculate the diameter of fuel orifice of 4 stroke engine which develops 25 kW per cylinder at 2500 rpm. The specific fuel consumption is 0.3 kg/kW h and fuel is injected at a pressure of 150 bar over a crank travel of 25^0. The pressure in the combustion chamber is 40 bar. Coefficient of velocity is 0.875 and density of fuel is 876.2 kg/m^3 08

Q.6 (a) The following data were obtained from a test on a single cylinder ,4-stroke, oil engine: 12

Cylinder Bore	= 15 cm
Stroke	= 25 cm
Indicated mean effective pressure	= 7.355 bar
Engine speed	= 400 rpm
Brake torque	= 225Nm
Fuel consumption	= 3 kg/hr
Calorific value of fuel	= 44200 kJ/kg
Cooling water flow rate	= 4 kg/min
Cooling water temperature rise	= 42^{0}C
Specific heat of water	= 4.2 kJ/kg.K

Find out the following:

i) Mechanical Efficiency
ii) Brake thermal efficiency
iii) Specific fuel consumption on B.P basis
iv) Draw heat balance sheet on kW basis and percentage basis

(b) With usual notations, derive the formula for rate of heat transfer for an insulated tip fin of finite length from the following differential equation 08

$$\frac{d^2\theta}{dx^2} - m^2\theta = 0$$
