Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

END Semester Examination, December 2018

Programme Name: B.Tech Power System Engineering **Semester : III**
Course Name : Heat and Mass Transfer process **Time : 03 hrs**
Course Code : EPEG2007 **Max. Marks : 100**
Nos. of page(s) : 4
Instructions:

SECTION A

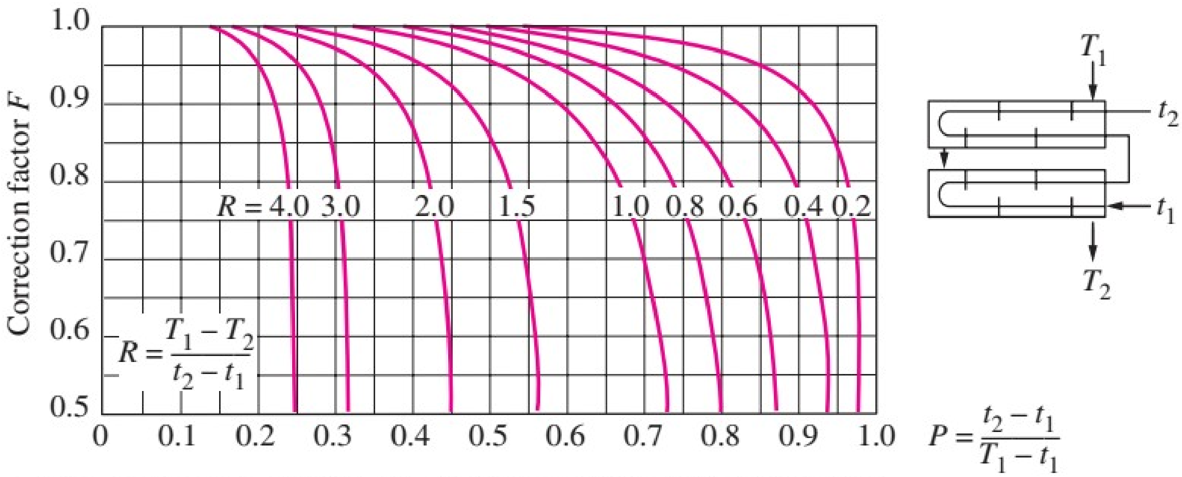
S. No.		Marks	CO
Q 1	Air at 25°C and 50% RH flows over water surface measuring 12 m × 6 m at a velocity of 2 m/s. Determine the water loss per day considering flow direction is along the 12 m side. $D = 0.26 \times 10^{-4}$ m^2/s, Sc = 0.60, $\nu = 15.7 \times 10^{-6}$ m^2/s.	4	CO1
Q 2 1.	By dimensional analysis show that for natural convection heat transfer the Nusselt number (Nu) can be expressed as a function of Grashof number (Gr) and Prandtl number (Pr).	4	CO1
Q 3 2.	State and Explain Wein's displacement Law and Kirchoff's Law of radiation. Describe Electrical Analogy for radiation heat transfer	4	CO2
Q 4 3.	Discuss the importance of heat exchangers for industrial use.	4	CO2
Q5	A 50 mm X 45 mm 20 mm cell phone charger has a surface temperature of Ts = 33 °C when plugged into an electrical wall outlet but not in use. The surface of the charger is of emissivity = 0.92 and is subject to a free convection heat transfer coefficient of h = 4.5 W/m^2K. The room air and wall temperatures are T = 22°C and Tsur = 20°C, respectively. If electricity costs C = $0.18/kWh. Determine the daily cost of leaving the charger plugged in when not in use.	4	CO3

SECTION B

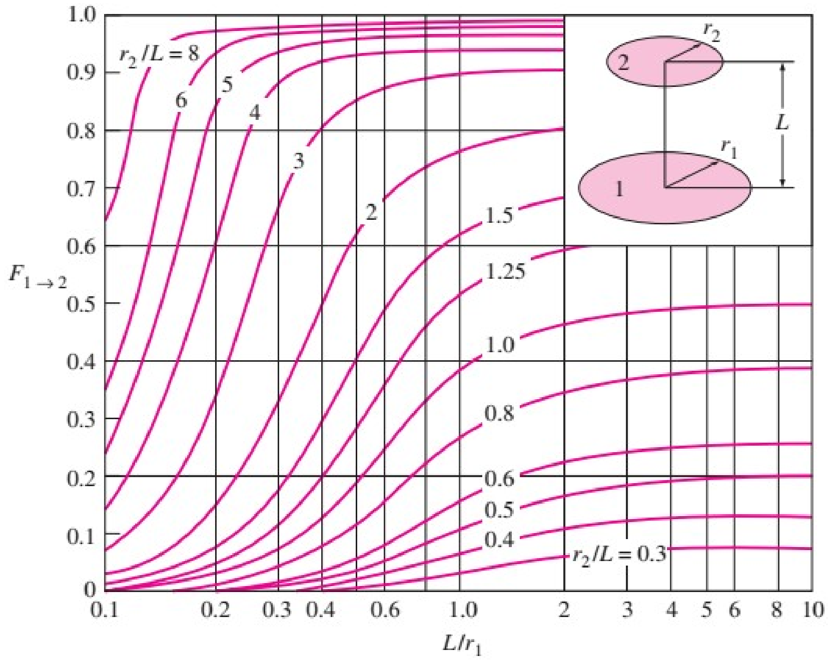
Q 6	Benzene liquid at 25°C is in a cylindrical glass jar of 5 cm dia at the bottom. Air column is 30 cm above the liquid. The air in the jar is stationary. Sufficient movement exists at the top to remove the diffused vapor so that the partial pressure of vapor at the top can be assumed as zero. Determine the diffusion rate. The partial pressure at the interface is 0.1 bar. $D = 0.0962 \times 10^{-4}$ m^2/s, R = 8315/78,	10	CO3
Q 7	A composite cylinder is made of 6 mm thick layers each of two materials of thermal	10	CO4

	conductivities of 30 W/m°C and 45 W/m°C. The inside is exposed to a fluid at 500°C with a convection coefficient of 40 W/m^2 °C and the outside is exposed to air at 35°C with a convection coefficient of 25 W/m^2K. There is a contact resistance of 1×10^{-3} m^2 °C/W between the layers. Determine the heat loss for a length of 2 m and the surface temperatures. Inside dia = 20 mm.		
Q 8	Derive equation of Logarithmic Mean Temperature Difference (LMTD) for parallel and counter-flow Heat-exchanger. **(or)** Hot oil is to be cooled in a double-tube counter-flow heat exchanger. The copper inner tubes have a diameter of 2 cm and negligible thickness. The inner diameter of the outer tube (the shell) is 3 cm. Water flows through the tube at a rate of 0.5 kg/s, and the oil through the shell at a rate of 0.8 kg/s. Taking the average temperatures of the water and the oil to be 45°C and 80°C, respectively, determine the overall heat transfer coefficient of this heat exchanger. $\rho = 990$ kg/m^3, Pr = 3.91, k = 0.637 W/m · °C, $\nu = \mu/\rho = 0.602 \times 10^{-6}$ m^2/s.	**10**	**CO3**
Q 9	The surface A1 and A2 having emissivities of 0.6 and 0.4 are maintained at 800 K and 400 K. (i) Determine the heat exchange between the surfaces per unit length considering these are long with the third side open and at 400 K. (ii) If surface 3 is well insulated, so that the surface is non absorbing determine the heat exchange.	**10**	**CO4**
	SECTION-C		
Q 10	A furnace is shaped like a long equilateral triangular duct. The width of each side is 1 m. The base surface has an emissivity of 0.7 and is maintained at a uniform temperature of 600 K. The heated left-side surface closely approximates a blackbody at 1000 K. The right-side surface is well insulated. Determine the rate at which heat must be supplied to the heated side externally per unit length of the duct in order to maintain these operating conditions.	**20**	**CO5**
4. 5. Q 11	A 2-shell passes and 4-tube passes heat exchanger is used to heat glycerin from 20°C to 50°C by hot water, which enters the thin-walled 2-cm-diameter tubes at 80°C and leaves at 40°C. The total length of the tubes in the heat exchanger is 60 m. The convection heat transfer coefficient is 25 W/m^2°C on the glycerin (shell) side and 160 W/m^2°C on the water (tube) side. Determine the rate of heat transfer in the heat exchanger (a) before any fouling occurs and (b) after fouling with a fouling factor of 0.0006 m^2°C/W occurs on the outer surfaces of the tubes. **(or)**	**20**	**CO5**

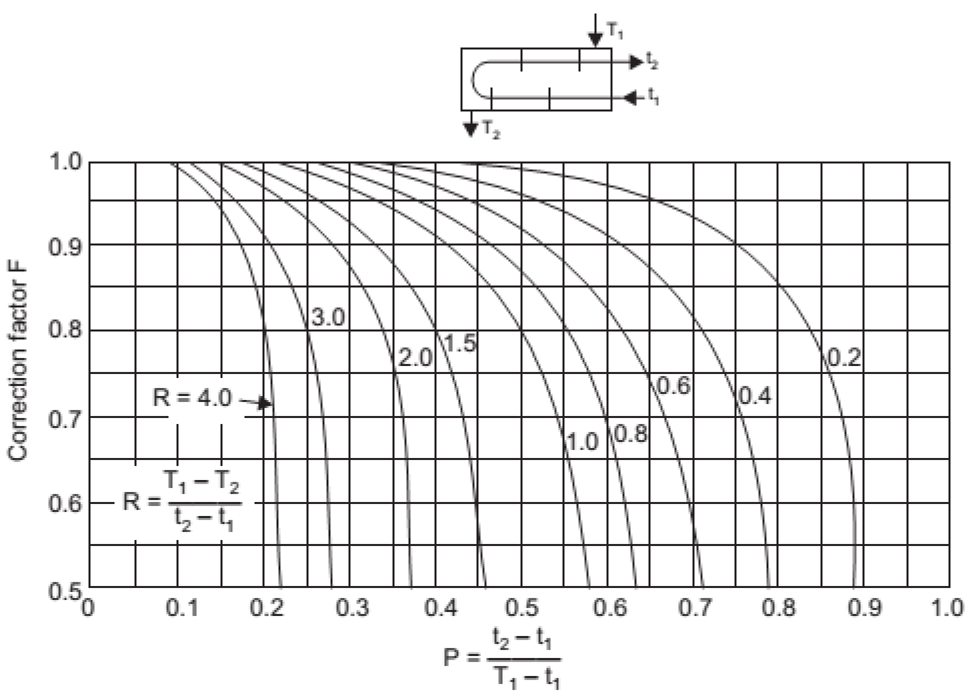
6.	In a refinery fuel oil is to be cooled from 100°C to 40°C by water at 25°C flowing on the outside of the tube. The inner diameter is 25 mm and the oil flow rate is 1 kg/s. Water is heated to 45°C. The tube is made of 0.5 % carbon steel of thickness 3 mm. The inner diameter of the outer pipe is 62.5 mm. The outside may be considered as insulated. The properties of oil at 70°C are: density = 858 kg/m^3, kinematic viscosity v = 60 × 10^{-6} m/s. k = 0.140 W/mK, specific heat = 2100 J/kg K. Determine the overall heat transfer coefficient. Consider good performance even after fairly long usage. Tube material k = 53.6 W/mK		



Two-shell passes and 4, 8, 12, etc. (any multiple of 4), tube passes



View factor between two coaxial parallel disks



Correction factor F for shell-and-tube heat exchangers with one shell pass and any multiple of two tube passes (2, 4, 6, etc., tube passes).

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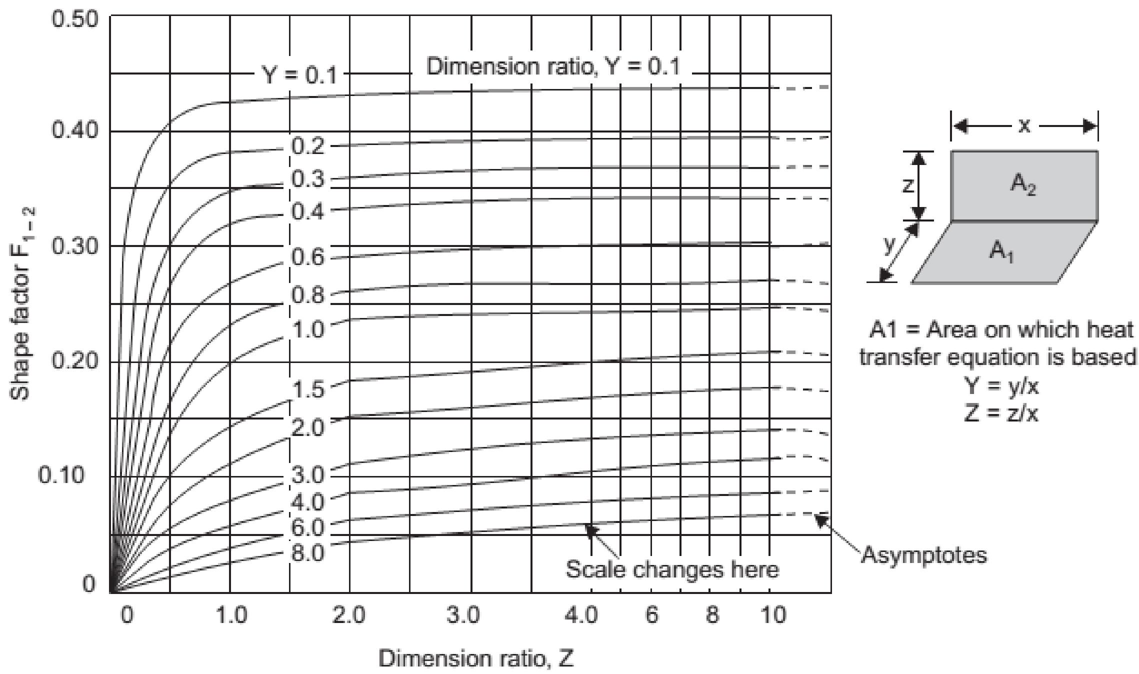
SECTION A

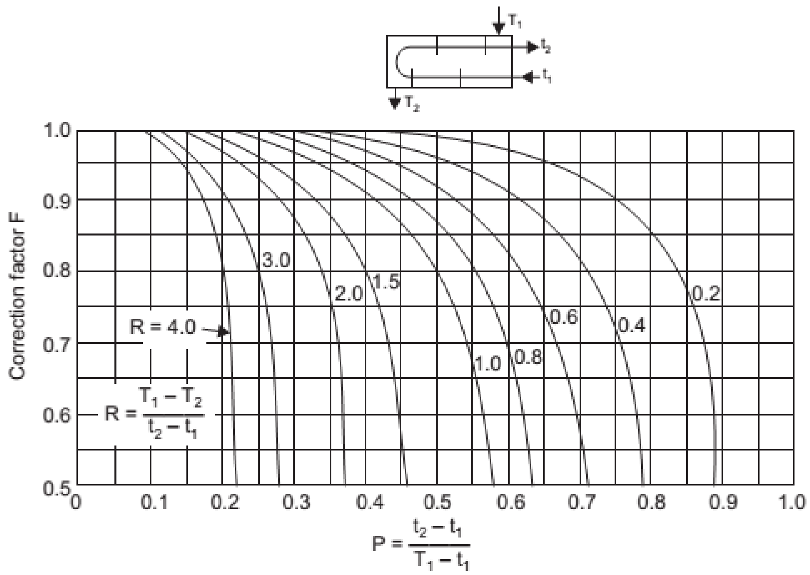
S. No.		Marks	CO
Q 1	(a) Window glass is found to transmit radiant energy in the wave lengths of 0.4 to 2.5 μm. Determine the fractions transmitted for a source temperature of (i) 5000 K (ii) 300 K. (b) Determine the shape factor from the floor of a furnace of 1 m × 2 m × 1.5 m size to the side surfaces and to the roof.	**4**	**CO1**
Q 2	Hydrogen gas is maintained at 4 bar and 1 bar on the opposite sides of a membrane of 0.5 mm thickness. At this temperature the diffusion coefficient is 8.7×10^{-8} m^2/s. The solubility of hydrogen in the material which depends on the pressure is 1.5×10^{-3} m^2/s bar. Determine the mass diffusion rate of hydrogen through the membrane.	**4**	**CO1**
Q 3	A solar collector surface has an absorptivity of 0.85 for wave lengths upto 3 μm and a value of 0.15 for wave lengths above this value. Determine assuming Kirchhoff's law holds good, the energy absorbed from a source at 5800 K if the flux is 800 W/m^2. Also determine the energy radiated by the body if its temperature was 350 K.	**4**	**CO2**
Q 4	A cross flow heat exchanger with both fluids unmixed is used to heat water flowing at a rate of 20 kg/s from 25°C to 75°C using gases available at 300°C to be cooled to 180°C. The overall heat transfer coefficient has a value of 95 W/m^2K. Determine the area required. For gas Cp = 1005 J/kgK. The properties of gas can be taken as equal to that of air.	**4**	**CO3**
Q 5	1000 lbm/h of oil at 100 °F enters a 1-in. ID heated copper tube. The tube is 12 ft long and its inner surface is maintained at 215°F Determine the outlet temperature of the oil. The following physical property data are available for the oil: Cp = 0.5 Btu/lbm °F, ρ= 55 lbm/ft^3, μ= 1.5 lbm/ft-h, k= 0.10 Btu/h ft °F.	**4**	**CO2**
	SECTION B		
Q 6 1.	A tank contains a mixture of CO_2 and N_2 in the mole proportions of 0.2 and 0.8 at 1 bar and 290 K. It is connected by a duct of sectional area 0.1 m^2 to another tank	**10**	**CO4**

	containing a mixture of CO_2 and N_2 in the molal proportion of 0.8 and 0.2. The duct is 0.5 m long. Determine the diffusion of CO_2 and N_2. $D = 0.16 \times 10^{-4}$ m^2/s.		
Q 7	2. Determination of mean temperature difference in the case of single tube parallel flow heat exchanger. A counter flow, concentric tube heat exchanger is used to cool the lubricating oil for a large industrial gas turbine engine. The flow rate of cooling water through the inner tube (Di= 25 mm) is 0.2 kg/s, while the flow rate of oil through the outer annulus (Do= 45 mm) is 0.1 kg/s. The oil and water enter at temperatures of 100 and 30C, respectively. Determine the length of pipe/tube to be made if the outlet temperature of the oil is to be 60C. Unused engine oil properties (T h= 80C): Cp= 2131 J/kg K, μ=3.25 10^{-2} N s/m2, k= 0.138 W/mK, water (Tc= 35C): Cp= 4178 J/kg K, μ= 725 10 6 Ns/m^2, k = 0.625, W/m K, Pr= 4.85.	**10**	**CO4**
Q 8	(a) In the case of furnace of 1 m × 2 m × 1.5 m size the side walls are well insulated so that these can be considered as reradiating. Determine the heat exchange if the floor is at 1000 K and the roof at 600 K. Also determine the apparent shape factor. (or) (b) Explain the different types of Heat exchangers according to the process with diagrams.	**10**	**CO3**
Q 9	A spherical container with OD 0.4 m and surface temperature of – 180°C is insulated by 8 cm thick layer of material with thermal conductivity $k = 0.028\,(1 + 5 \times 10^{-3}\,T)$ W/mK where T is in °C. If the outside surface is at 15°C, Determine the heat flow in.	**10**	**CO3**
SECTION C			
Q 10	A cylindrical shaped furnace is 1 m dia and 1 m high. The top surface having an emissivity of 0.7 emit a uniform heat flux of 7 kW/m^2. The bottom surface with an emissivity of 0.4 is maintained at 350 K. The sides are insulated and function as reradiating surfaces. Determine the heat transfer to bottom surface and also the temperatures of the top and sides. Hint: If flux is specified, then it has to be taken as radiocity.	**20**	**CO5**
Q11	Determine the area required for a shell and tube heat exchanger with two tube passes to cool oil at rate of 10 kg/s from 60 °C to 30 °C flowing in the shell using water at 20 °C passing through the tubes and heated up to 26°C. The specific heat of the oil is 2200 J/kg K. The value of overall heat transfer coefficient is 300 W/m^2 K. (or)	**20**	**CO5**

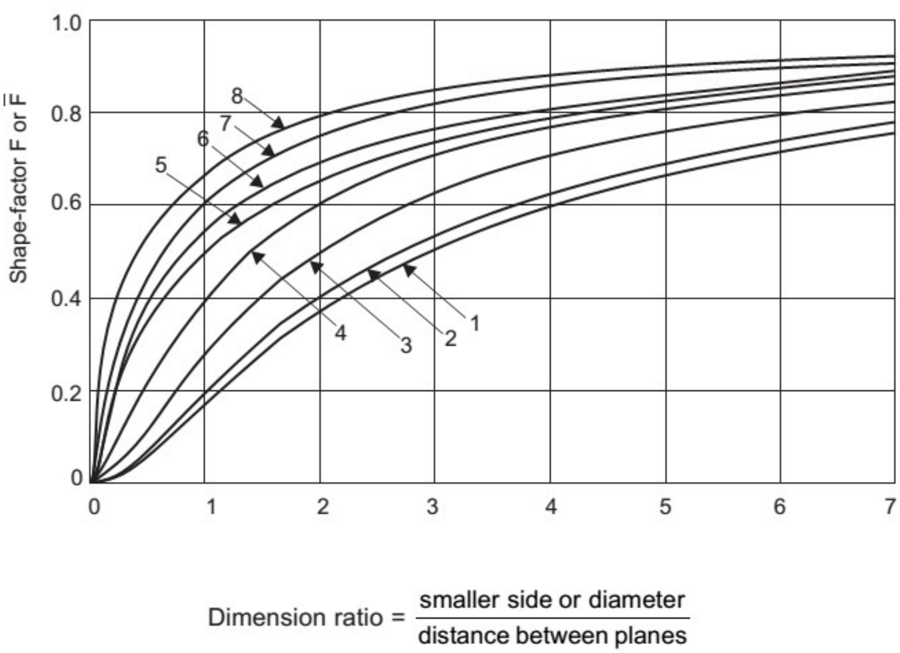
	In a condenser steam flows outside the tubes of radii 59 mm and 54 mm and sea water flows inside the tubes. The thermal conductivity of the tube material is 60 W/mK. The steam and water temperatures are below 50°C. The convection coefficient on the steam side is 12000 W/m2 K and the value on the water side is 650 W/m2K. Calculate the values of overall coefficients based on the (i) inside and (ii) outside areas. Also determine the percentage error involved in neglecting (i)		



Shape factor for adjacent rectangles in perpendicular planes sharing a common edge.



Correction factor F for shell-and-tube heat exchangers with one shell pass and any multiple of two tube passes (2, 4, 6, etc., tube passes).



Shape factors for equal and parallel squares, rectangles, and disks.