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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2018

Program Name : B. Tech. (CE+RP) and B. Tech. APE - Gas **Semester : IV**
Course Name : Heat Transfer **Max. Marks : 100**
Course Code : GNEG 257 **Duration : 3 Hrs**
No. of page/s: 03

Note: Assume any missing data.
Instructions: Attempt **all** questions from **Section-A** (each carrying 10 marks) and **Section-B** (each carrying 12 marks) and any **one** Question **Section-C** (carrying 20 marks).

	Section-A (Attempt **All** Questions)		
1.	Derive the relation for velocity profile and temperature profile for laminar flow through a tube having outer radius r_0, wall temperature T_w and velocity at the centre of tube u_0.	**[10]**	**CO3**
2.(a)	In which medium - gas or liquid - will the use of fin be more effective & why?	**[3]**	**CO2**
(b)	One end of a wrought iron (k = 59 W/m-K) rod of 30 cm length and 3cm diameter is attached to a wall at 300 ^{0}C, while the second end is insulated. The surface of the rod is exposed to an environment at 25 ^{0}C and the convection heat transfer coefficient from the surface to the environment is 15 W/m^2-K Determine the rate of heat transfer from the rod and temperature at the insulated end.	**[7]**	
	SECTION B (Attempt **All** Questions)		
3.(a)	Consider a cylindrical shell of length *L,* inner radius r_1, and outer radius r_2, whose thermal conductivity varies linearly in a specified temperature range as $k = k_0(1 + \beta T)$, where k_0 and β are two specified constants. The inner surface of the shell is maintained at a constant temperature of T_1, while the outer surface is maintained at T_2. Assuming steady one dimensional heat transfer, obtain a relation for the temperature distribution in the shell.	**[7]**	**CO1**
(b)	In a nuclear reactor, 1-cm-diameter cylindrical uranium rods cooled by water from outside serve as the fuel. Heat is generated uniformly in the rods (k = 29.5 W/m-^{0}C) at a rate of 7 × 10^7 W/m^3. If the outer surface temperature of rods is 175^{0}C, determine the temperature at their center.	**[5]**	

4.	Water is heated from 15 ^{0}C to 65 ^{0}C as it flows through a 3cm internal diameter and 5m long tube. The tube is equipped with an electric resistance heater, which provides uniform heating throughout the surface of the tube. The outer surface of the heater is perfectly insulated so that the whole generated heat is given to the water in the tube. The water flow rate is 10 litres/minute. Determine the power rating of the heater. Also, find the inner surface temperature of the pipe at the exit. Take the following properties of air at mean film temperature of 40 ^{0}C: ρ = 994 kg/m^3, k = 0.62860 W/m-K, C_p = 4.178 kJ/kg-K, $\upsilon = 0.66 \times 10^{-6}$m^2/s	**[12]**	**CO3**
5.	A 4 cm OD pipe carrying slightly wet steam at 1.5bar is installed in a location where it is covered by water after a heavy rain, but is exposed to air under normal conditions. Compare the rate of heat transfer to air with the rate of heat transfer to water assuming both fluids are at 10 ^{0}C. The heat transfer coefficient in both cases can be determined by the following equation: $$Nu = 0.53(Ra)^{1/4}$$ There is no appreciable radiation in water compare with convection in water, but the heat loss by radiation to air compared with convection heat loss is considerable. The emissivity of the pipe surface can be taken as 0.9. The saturation temperature of steam at 1.5 bar is 110.8 ^{0}C. The properties of air and water at mean film temperature are: <table><tr><td>Property</td><td>Air</td><td>Water</td></tr><tr><td>ρ (kg/m^3)</td><td>1.06</td><td>983</td></tr><tr><td>C_p (kJ/kg-K)</td><td>1.008</td><td>4.186</td></tr><tr><td>k (W/m-K)</td><td>0.0285</td><td>0.65</td></tr><tr><td>μ (kg/m-s)</td><td>20×10^{-6}</td><td>0.467×10^{-6}</td></tr></table>	**[12]**	**CO3**
6.(a) **(b)**	Explain the regimes of boiling with the help of boiling curve. Saturated air-free steam at 85 ^{0}C condenses on the outer surface of 225 horizontal tubes of 12.7mm outer diameter arranged in a 15 × 15 array. Tube surfaces are maintained at 75 ^{0}C. Calculate the total condensation per metre length of the tube bundle. Properties of air are: ρ = 971.8 kg/m^3, $\mu = 360.7 \times 10^{-6}$ kg/m-s, h_{fg} = 2257 kJ/Kg, k = 0.67 W/m-K.	**[4]** **[8]**	**CO3**
7.(a) **(b)**	Derive Wien's Displacement law from the Planck's law. Determine the radiation heat loss in W/m of 20 cm diameter heating pipe when it is placed centrally in the brick duct of square section of 30 cm side. The pipe surface is maintained at a temperature of 200 ^{0}C, while the brick surface is maintained at 20 ^{0}C. Assume only radiation heat transfer between the pipe and brick duct. The emissivity of pipe and brick surface are 0.8 and 0.9, respectively. If the system is in steady sate then find the surface heat transfer coefficient of the brick duct, assuming the temperature of the surrounding of the duct is 10 ^{0}C.	**[4]** **[6+2]**	**CO4**

SECTION C (Attempt Any One)

8.(a) Define NTU and effectiveness of an exchanger. Derive a relation between NTU and effectiveness of an exchanger for a double pipe heat exchanger with counter flow configuration. List the assumptions, also. **[10]**

(b) An evaporator is to be fed with 5000 kg/hr of solution containing 10% of solute by weight. The feed at 40 ^{0}C is to be concentrated to a solution containing 40% by weight of solute under an absolute pressure of 1.03kg/cm^2. Steam is available at an absolute pressure of 3 atm (saturation temperature 134 ^{0}C). The overall heat transfer coefficient is 1500 kcal/hr-m^2-^{0}C. Calculate the heat transfer area that should be provided and the steam requirement. **[10]**

Temperature, ^{0}C	Enthalpy, kCal/kg	
	Vapor	Liquid
40	613.5	40.5
100	639.2	100.0
134	651.4	134.4

CO5

OR

(a) Describe the factors determining the allocation of the fluid streams to the shell or tube side in a shell & tube heat exchanger. **[5]**

(b) A parallel flow shell and tube heat exchanger has hot- and cold-water streams running through it and has the following data: **[7+8]**

$\dot{m}_h$ = 10 kg/min $\dot{m}_c$ = 25 kg/min

$C_{ph} = C_{pc}$ = 4.18 kJ/kg-K

T_{hi} = 70 ^{0}C, T_{ho} = 50 ^{0}C, T_{ci} = 25 ^{0}C

Individual heat transfer coefficient on both sides (h_i and h_o) = 60 W/m^2-K.

Calculate

(a) Area of heat exchanger.

(b) Exit temperature of hot and cold fluids, if the hot water flow rate is doubled. Assume heat transfer coefficient on both sides remains same.