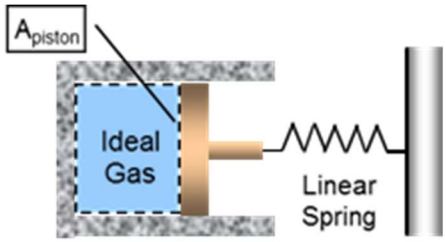
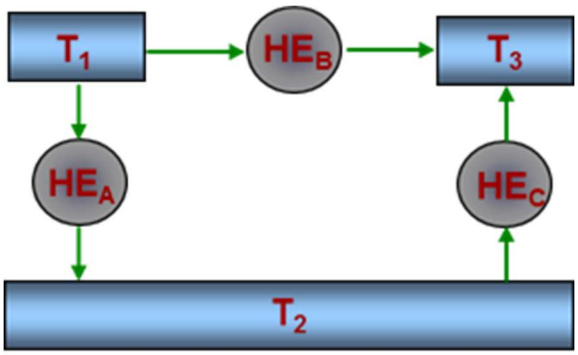
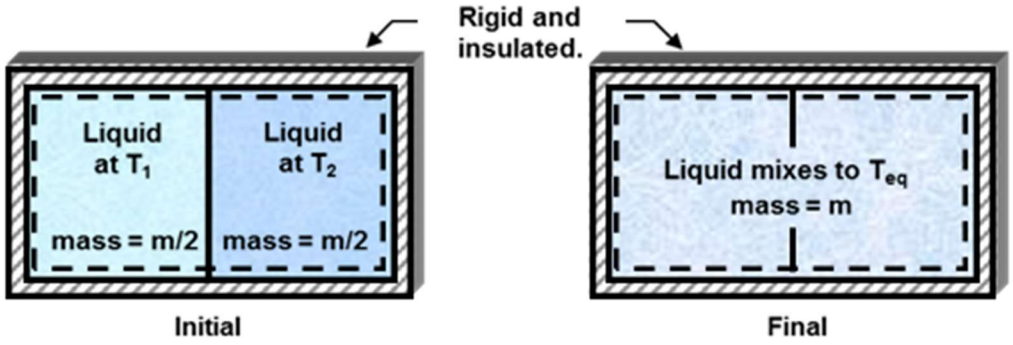
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2021

Programme Name: B. Tech ASE, ASEA **Semester : III**
Course Name : Thermodynamics and heat Transfer **Time : 3 hr**
Course Code : MECH-2022 **Max. Marks: 100**
Nos. of page(s) : 04
Instructions: Make use of *sketches/plots* to elaborate your answer. Brief and to the point, answers are expected.

Q. No.	Section A (5Q x 4M = 20 Marks)	Marks	CO
1	Determine the direction of any heat transfer between the given two systems. Consider two closed systems A and B. System A contains 3000 kJ of thermal energy at 20°C, whereas system B contains 200 kJ of thermal energy at 50°C. Now the systems are brought into contact with each other.	**4**	**C01**
2	Discuss the application of first law and explain why it is called as quantitative law.	**4**	**C01**
3	Discuss the origin of the entropy and increase in entropy principle of universe.	**4**	**C01**
4	Analyze and compare out of following case a given heat flow and for the same thickness the temperature drop across the material will be maximum. a. Copper b. Steel c. Glass wool d. Refractory bricks e. Air	**4**	**C03**
5	Discuss the physical significance of following Dimensionless number in forced convection heat transfer. A. Nusselt Number B. Prandtl Number	**4**	**C01**
	Section B (4Q x 10M = 40 Marks)		
6	A piston-and-cylinder device is oriented horizontally and a compressed spring exerts a force on the back of the piston, as shown below. The gas inside the cylinder is cooled slowly and, as the cooling proceeds, the spring pushes the piston farther into the cylinder. During the cooling process, the spring exerts a force that decreases linearly with position. Initially, the gas occupies a volume of 8.4 L while the spring exerts a force of 1.2 kN on the back of the piston. At the end of the process, the gas occupies 3.7 L and the spring exerts a force of 0 kN on	**10**	**C02**

	the piston. The area of the piston face is 200 cm^2 and atmospheric pressure is 100 kPa.  Assume the gas behaves as an ideal gas and friction is negligible. Determine: (a) The initial and final pressure inside the cylinder (b) The boundary work		
7	Three Carnot heat engines operate between three thermal reservoirs, as shown in the diagram, below. Derive an equation for the thermal efficiency of HE_C (η_C), in terms of the thermal efficiency of HE_A (η_A) and the thermal efficiency of HE_B (η_B).  	**10**	**C02**
8	A power cycle exchanges heat with only two thermal reservoirs at 500°R and 2000°R. QH = 4500 Btu/h. For each of the following, calculate the rate of entropy generation in Btu/°R and state whether the power cycle is internally reversible, internally irreversible or impossible. a) η = 83%, b) η = 75%, c) η = 44% **OR** The initial and final states of a sealed, insulated, rigid tank are shown below. Each side of the tank contains a different incompressible liquid at a different temperature, T1 and T2. The mass of liquid initally on each side of the tank is the same: m1 = m2 = m/2. The barrier between the two sides of the tank is removed and the two liquids mix and eventually reach the final equilibrium state. Assume each liquid has a constant heat capacity and there are no thermal effects due to the mixing of the	**10**	**C04**

	fluids. **a.)** Show that S_{gen} is given by the following equation: $$S_{gen} = m\,C\,Ln\left[\frac{T_1+T_2}{2(T_1T_2)^{1/2}}\right]$$  **b.)** Show that S_{gen} must be positive.		
9	A steel tube with 5 cm ID, 7.6 cm OD and k=15W/m ºC is covered with an insulative covering of thickness 2 cm and k = 0.2 W/m ºC. A hot gas at 330^0C with h = 400 W/m^2 ºC flows inside the tube. The outer surface of the insulation is exposed to cooler air at 30ºC with h = 60 W/m2ºC. Calculate the heat loss from the tube to the air for 10 m of the tube and the temperature drops resulting from the thermal resistances of the hot gas flow, the steel tube, the insulation layer and the outside air.	**10**	**C03**
	Section C (2Q x 20M = 40 Marks)		
10	A) The drinking water needs of a production facility with 20 employees is to be met by a bubbler type water fountain. The refrigerated water fountain is to cool water from 22 to 8°C and supply cold water at a rate of 0.4 L per hour per person. Heat is transferred to the reservoir from the surroundings at 25°C at a rate of 45 W. If the COP of the refrigeration system is 2.9, determine the size of the compressor in W, that will be suitable for the refrigeration system of this water cooler. B) Steam enters an adiabatic turbine steadily at 7 MPa, 500^0C, and 45 m/s, and leaves at 100 kPa and 75 m/s. If the power output of the turbine is 5 MW and the isentropic efficiency is 77 percent, determine (a) the mass flow rate of steam through the turbine, (b) the temperature at the turbine exit, and (c) the rate of entropy generation during this process.	**20**	**C05**
11	A commercial airplane is modelled as a flat plate, which is 1.5 m wide, and 8 m long in size. It is maintained at 20°C. The airplane is flying at a speed of 800 Km/hr in air at 0°C and 60 cm of Hg pressure. Calculate the heat loss from wing if the flow is made to flow parallel to the width of the wing. The properties of air at avg temp. 10°C, conductivity (K) = 2.511 x 10^{-2} W/m-K and Kinematics viscosity = 14.16 x	**20**	**C03**

	10^{-6} m^2/ sec. Pr = 0.705 **OR** A) Two large parallel planes with emissivities of 0.3 and 0.5 are maintained at temperatures of 527^0 C and 127^0C respectively. A radiation shield having emissivities of 0.05 on both sides is placed between them. Calculate (i) Heat transfer rate between them without shield. (ii) Heat transfer rate between them with shield. **[10]** B) A 4-m x 5-m x 7-m room is heated by the radiator of a steam-heating system. The steam radiator transfers heat at a rate of 10,000 kJ/h, and a 100-W fan is used to distribute the warm air in the room. The rate of heat loss from the room is estimated to be about 5000 kJ/h. If the initial temperature of the room air is 10 ^{0}C, determine how long it will take for the air temperature to rise to 20 ^{0}C. Assume constant specific heats at room temperature. Consider the same question if the heat is transferred through 4 side of the wall, what will be thickness of wall if the outside temperature is 5°C having thermal conductivity is 0.8 W/m-K and inside convection heat transfer coefficient is 2 W/m^2-K. Take wall area 5 x 7 m^2. **[10]**		