Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

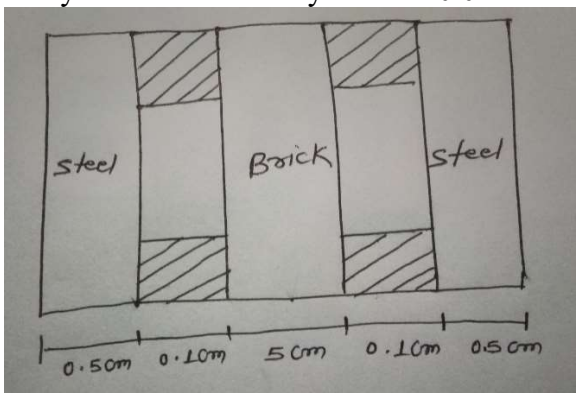
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2022

Course: Thermodynamics and Heat transfer **Semester : III**
Program: B. Tech Aerospace **Time : 03 hrs.**
Course Code: MECH 2022 **Max. Marks: 100**

Instructions: Make use of sketches/plots to elaborate your answer. Brief and to-the-point, answers are expected.
Assume suitable data if needed.
Steam table allowed

SECTION A

Q. No	**(5Qx4M=20Marks)**	**Marks**	**CO**
1	Explain the increase of entropy principle with a suitable example.	**4**	**CO1**
2	Determine the COP of a refrigerator that removes heat from the food compartment at a rate of 5040 kJ/h for each kW of power it consumes. Also, determine the rate of heat rejection to the outside air.	**4**	**CO2**
3	Discuss the various process of steam power plant with neat sketch.	**4**	**CO1**
4	Explain Newton's law of cooling for convection heat transfer and importance of convective heat transfer coefficient.	**4**	**CO3**
5	Define the following term for radiation heat transfer. a) Black body b) Grey body c) Opaque surface d) Total emissivity	**4**	**CO3**
	SECTION B **(4Qx10M= 40 Marks)**		
6	Prove that efficiency of reversible engine depends on the temperature of source and sink and is independent of working substances.	**10**	**CO2**
7	5-kg of air at 427°C and 600 kPa are contained in a piston-cylinder device. The air expands adiabatically until the pressure is 100 kPa and produces 600 kJ of work output. Assume air has constant specific heats evaluated at 300 K. (a) Determine the entropy change of the air, in kJ/kg·K (b) Since the process is adiabatic, is the process realistic? Using concepts of the second law, support your answer	**10**	**CO3**
8	A Carnot heat pump is to be used to heat a house and maintain it at 25 ^{0}C in winter. On a day when the average outdoor temperature remains at about 2 ^{0}C,	**10**	**CO2**

	the house is estimated to lose heat at a rate of 55,000 kJ/h. If the heat pump consumes 4.8 kW of power while operating, determine (a) how long the heat pump ran on that day; (b) the total heating costs, assuming an average price of 11 Rs /kWh for electricity; and (c) the heating cost for the same day if resistance heating is used instead of a heat pump. **OR** A Carnot heat engine receives heat from a reservoir at 900°C at a rate of 800 kJ/min and rejects the waste heat to the ambient air at 27°C. The entire work output of the heat engine is used to drive a refrigerator that removes heat from the refrigerated space at -5°C and transfers it to the same ambient air at 27°C. Determine (a) the maximum rate of heat removal from the refrigerated space and **[03]** (b) the total rate of heat rejection to the ambient air**.** **[03]** (c) discuss the Clausius inequality **[04]**		
9	Calculate the rate of heat transfer per unit area of a layer of 5 cm thick insulating brick having conductivity of 1.5 W/m-K is placed between 0.5 cm thick steel plates. The conductivity of mild steel is 50 W/m-K. the faces of brick adjacent to the plate are rough having solid to solid contact of 30% of the total area. The height of the asperities is 0.1 cm. if the outer plate surface temperature are 100°C and 500°C respectively. Take conductivity of air is 0.02 W/m-K.  	**10**	**CO3**
	SECTION-C **(2Qx20M=40 Marks)**		
10	In Rankine cycle operating on water superheated vapour enter the turbine at 100 bar and 500^0C. the condenser pressure in 0.10 bar. The net power output of the cycle is 150 MW. If the turbine and pump have isentropic efficiencies of 85% and 70 % respectively. Determine for the modified cycle- a) The thermal efficiency b) The mass flow rate of steam in kg/hr for a net output of 150 MW. c) The mass flow rate of condenser cooling water entering at 20^0C and leaving at 35^0C with negligible pressure changes. Ignore all heat losses to the surroundings from the various components of the cycle. d) Draw the complete block diagram and discuss the effect of increasing the boiler pressure	**20**	**CO5**

11	A steel pipe having a diameter of 2 cm, outer diameter of 2.4 cm and thermal conductivity of steel of 54 W/mK carries hot water at 95°C. heat transfer coefficient between the inner surface of steel pipe and hot water is 600 W/m2K. An asbestos insulation with thermal conductivity of 0.2 W/mK and thickness 2 cm is put on the steel pipe. Heat is lost from the outer surface of the asbestos insulated pipe to the surrounding air at 30°C, heat transfer coefficient for the outer surface of the insulation being 8 W/m2K. Determine a) The rate of heat transfer per meter length of the pipe**.** **[05]** b) Determine the temperature at the inner, outer and surface of the steel pipe and the outer surface of the insulation. **[06]** c) What do you understand by the term critical radius of insulation **[04]** d) What is the value of critical radius in the above question. **[05]** **OR** 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 10^{-6} m^2/ sec. Pr = 0.705	**20**	**CO4**