Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2021

Course: Thermodynamics (MECH 2020) **Semester: III**

Program: B. Tech Mechanical

Time: 3 Hours **Max. Marks: 100**

SECTION A

Note: 1. For Q-1 to Q-6, Type the final answer only. Write precisely and to the point.
2. Steam table and Mollier's chart is allowed in the examination hall.

S. No.		Marks	CO
Q-1	Show that the COP of Heat Pump is greater than the COP of a refrigerator by unity.	**4**	**CO1**
Q-2	(a) What do you understand by triple point? (b) What is critical state? Explain the terms critical pressure, critical temperature and critical volume of water?	**4**	**CO1**
Q-3	What do you understand by the entropy principle? When the system is at equilibrium why would any conceivable change in entropy be zero?	**4**	**CO1**
Q-4	Classify internal combustion engines. What is air standard efficiency?	**4**	**CO1**
Q-5	What do you understand by degree of superheating and degree of sub cooling?	**4**	**CO1**

SECTION B

Q-6	In a turbo machine handling an incompressible fluid with density of 1000 kg/m^3 the condition of the fluid at the rotor entry and exit are as given below			**10**	**CO2**
		Inlet	*Exit*		
	Pressure	*1.15 MPa*	*0,05 MPa*		
	Velocity	*30 m/s*	*15.5 m/s*		
	Height above Datum	*10 m*	*2 m*		
	If the volume flow rate of the fluid is 40 m^3/s, estimate the net energy transfer from the fluid as work.				

<table>
<tr><td>Q-7</td><td>It takes 10 kW to keep the interior of a certain house at 20°C when the outside temperature is 0°C. This heat flow is usually obtained directly by burning gas or oil. Calculate the power required if the 10 kW heat flow were supplied by operating a reversible heat engine with the house as the upper reservoir and the outside surrounding as the lower reservoir, so that the power were used only to perform work needed to operate the engine.</td><td>10</td><td>CO2</td></tr>
<tr><td>Q-8</td><td>A solar powered heat pump receives heat from a solar collector at $T_{h,}$ rejects heat to the atmosphere at T^a, and pumps heat from a cold space at Tc. The three heat transfer rates are Q_h, Q_a and Q_c respectively. Derive an expression for the minimum ratio Q_h/Q_c, in terms of three temperatures. If T_h= 400 K, T_a= 300 K, T_c= 200 k, Q_c =12 kW, what is he minimum Q_h? If the collector captures 0.2 kW/m^2, What is the minimum collector area required.</td><td>10</td><td>CO3</td></tr>
<tr><td>Q-9</td><td>Evaluate the entropy change of the universe because of the following processes: (a) A copper block of 500 g mass and with Cp of 150 J/K at 100°C is placed in a lake at 8°C. (b) The same block, at 8°C, is dropped from a height of 150 m into the lake. (c) Two such blocks, at 100 and 0°C, are joined together.</td><td>10</td><td>CO4</td></tr>
<tr><td></td><td>SECTION C</td><td></td><td></td></tr>
<tr><td>Q-10</td><td>Complete the following table of properties for 1 kg of water (liquid, Vapour or mixture)
<table>
<tr><th>S.No</th><th>P (bar)</th><th>T (°C)</th><th>v (m^3/kg)</th><th>x (%)</th><th>Superheat (°C)</th><th>h (kJ/kg)</th><th>s (kJ/kg K)</th></tr>
<tr><td>1</td><td>-</td><td>35</td><td>25.22</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>2</td><td>-</td><td>-</td><td>0.001044</td><td>-</td><td>-</td><td>419.04</td><td>-</td></tr>
<tr><td>3</td><td>-</td><td>212.42</td><td>-</td><td>90</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>4</td><td>1</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>6.104</td></tr>
<tr><td>5</td><td>10</td><td>320</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>6</td><td>5</td><td>-</td><td>0.4646</td><td>-</td><td>-</td><td></td><td>-</td></tr>
<tr><td>7</td><td>4</td><td>-</td><td>0.4400</td><td>-</td><td>-</td><td></td><td>-</td></tr>
<tr><td>8</td><td>-</td><td>500</td><td>-</td><td>-</td><td>-</td><td>3445.3</td><td>-</td></tr>
</table></td><td>20</td><td>CO3</td></tr>
</table>

Q 11	(a) Why do isotherms on Mollier's diagram become horizontal in the superheated region at low pressure? (c) Steam at 25 bar, 380°C, is expanded in a steam turbine to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water in the boiler, (a) Assuming all ideal processes, find per kg of steam the network and the cycle efficiency (b) if the turbine and pump have each 80% efficiency, find the percentage reduction in the network and cycle efficiency **OR** (a) Show that the efficiency of the Otto cycle depends only on the compression ratio. (b) In an Air standard Otto, cycle the compression ratio is 7, and the compression begins at 35 °C, 0.1 MPa, the maximum temperature of the cycle is 1100°C. Find (a) the temperature and pressure at the cardinal points of the cycle, (b) the heat supplied per kg of air, (c) the work done per kg of air (d) the cycle efficiency, and (e) the mean effective pressure of the cycle.	**20**	**CO4**