Name: Enrolment No:	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

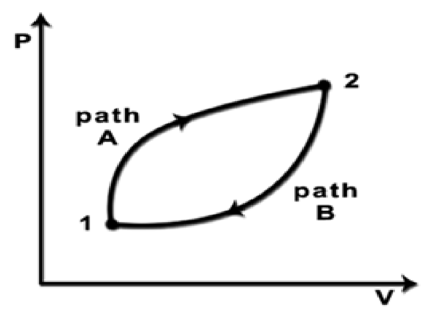
END Semester Examination, December 2021

Programme Name: B.Tech- Mechatronics **Semester : III**
Course Name : Engineering Thermodynamics **Time : 03 hrs.**
Course Code : MECH 2014 **Max. Marks: 100**
Nos. of page(s) : 4

Instructions:

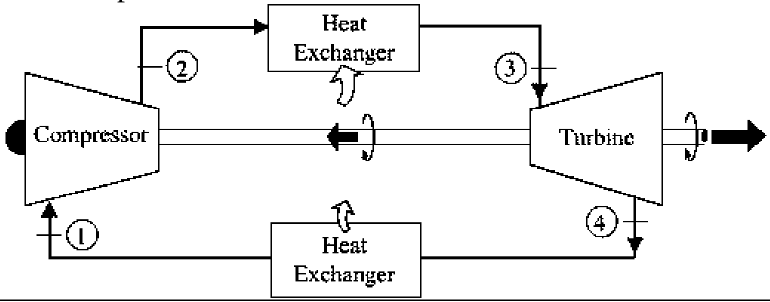
i. *There are three sections viz. Section A, Section B and Section C. Section A carries 20 marks, Section B carries 40 marks and Section C carries 30 marks*
ii. *Attempt all the questions in Section A, B and C*
iii. *Make appropriate assumptions wherever required*

SECTION A – 20 Marks

S. No.		Marks	CO
Q 1	A heat engine receives heat from a source at 1000 ˚C at a rate of 520 KJ/s and rejects the waste heat to a medium at 298 K. The power output of heat engine is 180 Kw. Determine the reversible power and the irreversibility rate for this process.	**4**	**CO2**
Q 2	Identify open system or a closed system: (a) Human Being (b) Bicycle tire (c) A refrigerator (d) Planet earth	**4**	**CO1**
Q 3	A finite thermal system having heat capacity, $C = 0.04\ T^2$, J/K initially at 600 K. Estimate the maximum work obtainable from the thermal system if the surrounding is at 300 K.	**4**	**CO2**
Q.4	Consider the cycle made of path A followed by path B shown below. The following integrals have been evaluated. $\int_1^2 \left(\frac{\partial Q}{T}\right)_A = -24.7\ kJ/K$ $\int_2^1 \left(\frac{\partial Q}{T}\right)_B = 41.3\ \ kJ/K$  	**4**	**CO1**
Q.5	Explain limitations of second law of thermodynamics?	**4**	**CO1**

SECTION B-40 Marks

Q 6	A house is to be maintained at 25 ^{0}C in summer as well as in winter. For this purpose, it is proposed to use a reversible device as a refrigerator in summer and as a heat pump in winter. The ambient temperature is 40 ^{0}C in summer and 3 ^{0}C in winter. The energy losses as heat from the roof and the wall is estimated at 5 kW per degree celsius	**10**	**CO3**

	temperature difference between the room and the ambient conditions. Calculate the power required to operate the device in summer and in winter		
Q 7	A 1.8-m3 rigid tank contains steam at 220°C. One third of the volume is in the liquid phase and the rest is in the vapor form. Determine (a) the pressure of the steam, (b) the quality of the saturated mixture, and (c) the density of the mixture.	**10**	**CO2**
Q.8	An inventor claims to have developed a device which requires no energy transfer by work or heat transfer, yet able to produce hot and cold stream or air from a single stream of air at an intermediate temperature of 21 ^{0}C and a pressure of 5.2 bar, separate streams of air exit at a temperature of 1 bar. Sixty percent of mass entering the device exists at the lower temperature. Evaluate the inventor's claim, assuming ideal gas as working fluid and neglecting change in kinetic and potential energy.	**10**	**CO4**
Q.9	A compressor, operating at steady-state, increases the pressure of an air stream from 1 bar to 10 bar while losing 4.2 kW of heat to the surroundings. At the compressor inlet, the air is at 25 ^{o}C and has a velocity of 14 m/s. At the compressor outlet, the air is at 350 ^{o}C and has a velocity of 2.4 m/s. If the compressor inlet has a cross-sectional area of 500 cm^2 and the air behaves as an ideal gas, determine the power requirement of the compressor in kW.	**10**	**CO3**
SECTION C (40 Marks)			
Q 10	Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350 °C and is condensed in the condenser at a pressure of 10 kPa. Calculate (a) the thermal efficiency of this power plant, (b) the thermal efficiency if steam is superheated to 600 °C instead of 350 °C	**20**	**CO4**
Q.11	A 50-kg iron block and a 20-kg copper block, both initially at 80°C, are dropped into a large lake at 15°C. Thermal equilibrium is established after a while as a result of heat transfer between the blocks and the lake water. Determine the total entropy change for this process. Assuming the surroundings to be at 20°C, determine the amount of work that could have been produced if the entire process were executed in a reversible manner. Specific heat of iron block and copper block is 0.45 and 0.38 J/g ^{0}C respectively. ***OR***	**20**	**CO4**
	Air enters the compressor of an ideal air standard Brayton cycle at 100 kPa, 25 ^{o}C, with a volumetric flow rate of 8 m^3 /s. The compressor pressure ratio is 12. The turbine inlet temperature is 1100 ^{o}C.  	**20**	

	(a) Analyze entropy generation of the system and comment on possibility and impossibility of the system (a) Calculate Exergetic efficiency of the cycle		