B.E. ENGINEERING FOURTH YEAR SECOND SEMESTER SUPPLEMENTARY EXAMINATION, 2023

ENGINEERING THERMODYNAMICS

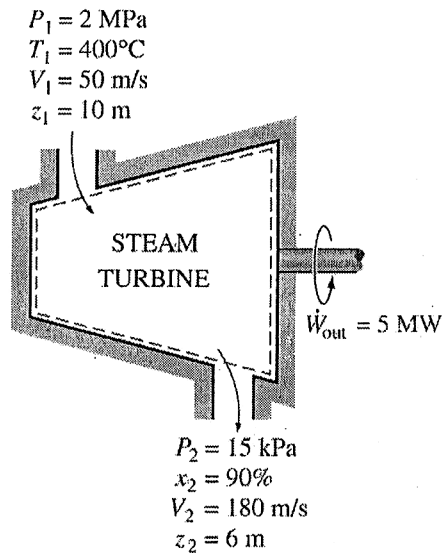Time: Three hours   Full Marks 100

	All parts of the same question must be answered together. Assume any unfurnished data suitably **Use of Thermodynamic Tables and Charts permitted**	
	Group I **Answer any one question**	
Q:1.(a) (b) (c) (d)	What is the difference between intensive and extensive properties? What is a quasi-equilibrium process? What is its importance in engineering? What is the difference between gage pressure and absolute pressure? What is the state postulate?	10
(e)	The density of mercury changes approximately linearly with temperature as $\rho_{Hg} = 13\ 595 - 2.5\ T$ kg/m³ (*T* in Celsius), so the same pressure difference will result in a manometer reading that is influenced by temperature. If a pressure difference of 100 kPa is measured in the summer at 35°C and in the winter at −15°C, what is the difference in column height between the two measurements?	10
2 (a) (b) (c)	What are point and path functions? Give some examples. Liquid water is heated, so it becomes superheated vapor. Can specific heat be used to find the heat transfer? Explain. A room is heated by an iron that is left plugged in. Is this a heat or work interaction? Take the entire room, including the iron, as the system.	10

(d)	A vertical piston with freely propagating piston contains 0.1 kg air at 1.2 bar and a small electrical resistor. The resistor is wired to an external 12 volt battery. When a current of 1.5 amps is passed through the resistor for 90 seconds, the piston sweeps a volume of 0.01 m³.
	Assume
	    (i) Piston and cylinder are insulator
	    (ii) Air behaves as an ideal gas with c_v = 700 J/kg K
	Find the rise in temperature of gas.
		10

	Group II **Answer any three questions**	
Q:3.(a)	What is the difference between the critical point and the triple point?	3

[Turn over

(b)	What is the difference between R and R_u? How are these two related?	3
(c)	Steam at 0.6 MPa and 200°C enters an insulated nozzle with a velocity of 50 m/s. It leaves at a pressure of 0.15 MPa and a velocity of 600 m/s. Determine the final temperature if the steam is superheated in the final state and the quality if it is saturated.	14
Q.4.(a)	In the absence of any friction and other irreversibilities, can a heat engine have an efficiency of 100 percent? Explain.	4
(b)	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 (*b*) the total rate of heat rejection to the ambient air.	16
Q:5 (a)	Prove that the COP of a reversible heat pump operating between two given temperatures is the maximum.	10
(b)	An inventor claims to have developed a refrigeration unit which maintains the refrigerated space at −10°C while operating in a room where the temperature is 25°C, and which has a COP of 8.5. How do you evaluate his claim? How would you evaluate his claim of a COP of 7.5?	10
Q:6 (a)	Show that through one point there can pass only one adiabatic.	4
(b)	A system undergoes a process between two fixed states first in a reversible manner and then in an irreversible manner. For which case is the entropy change greater? Why?	4
(c)	Two bodies of equal mass m and heat capacity C are at temperatures T_1 and T_2 respectively $(T_1 > T_2)$. If the first body is used as the source of heat for a reversible engine and the second as sink, show that the maximum work obtainable from such an arrangement is $mC(\sqrt{T1} - \sqrt{T2})^2$.	12
	Group III **Answer any one questions**	
Q:7.(a)	Why is the Carnot cycle not suitable as an ideal cycle for all power-producing cyclic devices?	3
(b)	What is the difference between spark-ignition and compression-ignition engines?	4
(c)	Derive the expression of thermal efficiency of Otto cycle in terms of compression ratio.	13
8. (a)	What four processes make up the simple ideal Rankine cycle?	3
(b)	Consider a simple ideal Rankine cycle with fixed turbine inlet conditions. What is the effect of lowering the condenser pressure on?	4

(c)	The power output of an adiabatic steam turbine is 5 MW, and the inlet and the exit conditions of the steam are as indicated in following figure	
	$P_1 = 2$ MPa $T_1 = 400°C$ $V_1 = 50$ m/s $z_1 = 10$ m STEAM TURBINE $\quad \dot{W}_{out} = 5$ MW $P_2 = 15$ kPa $x_2 = 90\%$ $V_2 = 180$ m/s $z_2 = 6$ m	
	(a) Compare the magnitudes of Δh, Δke, and Δpe. (b) Determine the work done per unit mass of the steam flowing through the turbine. (c) Calculate the mass flow rate of the steam	13
9.	An ideal Otto cycle has a compression ratio of 7.5. At the beginning of the compression process, air is at 150 kPa and 17°C, and 840 kJ/kg of heat is transferred to air during the constant-volume heat-addition process. Accounting for the variation of specific heats of air with temperature, determine (a) the maximum temperature and pressure that occur during the cycle, (b) the net work output, (c) the thermal efficiency, and (d) the mean effective pressure for the cycle.	20