Code: 20A03302 **R20**

B.Tech II Year I Semester (R20) Supplementary Examinations August/September 2023

THERMODYNAMICS

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

PART – A

(Compulsory Question)

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1 Answer the following: (10 X 02 = 20 Marks)

(a) Define and explain zeroth law of Thermodynamics. Why is it called so? 2M

(b) Derive the expression for heat transfer in a polytropic process. 2M

(c) Define Kelvin Plancks and Clausis statements for Second law of Thermodynamics. 2M

(d) Write the difference between heat engine and heat pump? 2M

(e) Define Clausius inequality. 2M

(f) Define Irreversibility. 2M

(g) What is the purpose of mollier charts? 2M

(h) Define dryness fraction. 2M

(i) Draw the p-V diagram for Dual cycle. 2M

(j) Define the term thermal efficiency. 2M

PART – B

(Answer all the questions: 05 X 10 = 50 Marks)

2 A pump discharges a liquid into a drum at the rate of 0.032 m^3/s. The drum, 1.50 m in diameter and 4.20 m in length, can hold 3000 kg of the liquid. Find the density of the liquid and the mass flow rate of the liquid handled by the pump. 10M

OR

3 Air enters the compressor of a gas- turbine plant at ambient conditions of 100 KPa and 25^0C with a low velocity and exits at 1MPa and 347^0C with a velocity of 90 m/s .The compressor is cooled at a rate of 1500 KJ/min and the power input to the compressor is 250 KW. Determine the mass flow rate of air through the compressor. Assume Cp = 1.005 KJ/KgK. 10M

4 Prove that Kelvin- Planck statement and Clausis statement of Second law of Thermodynamics are equivalent. 10M

OR

5 Two Carnot engines A and B are operated in series. The first one receives heat at 870 K and reject to a reservoir at T. B receives heat rejected by the first engine and in turn rejects to a sink at 300 K. Find the temperature T for (i) Equal work outputs of both engine (ii) Same efficiencies. 10M

6 Air at 20°C and 1.05 bar occupies 0.025 m^3. The air is heated at constant volume until the pressure is 4.5 bar, and then cooled at constant pressure back to original temperature. Calculate 10M

(i) The net heat flow from the air.

(ii) The net entropy change.

(iii) Sketch the process on T-s diagram.

OR

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7 2 kg of air at 500 kpa 80°C expands adiabatically in a closed system until its volume is doubled and its temperature become equal to that the surrounding at 100 kpa and 5°C. Find maximum work, change in availability and the irreversibility. 10M

8 A vessel of volume 0.04 m^3 contains a mixture of saturated water and steam at a temperature of 250°C. The mass of the liquid present is 9 kg. Find the pressure, mass, specific volume, enthalpy, entropy and internal energy. 10M

OR

9 Explain Joule-Kelvin effect. What is inversion temperature? 10M

10 An engine working on the otto cycle has an air standard cycle efficiency of 56% and rejects 544 KJ/kg of air. The pressure and temperature of air at the beginning of the compression are 0.1 MPa and 60^0C respectively. Determine compression ratio of the engine, work done per kg of air, pressure and temperature at the end of compression and maximum pressure in the cycle. 10M

OR

11 Derive an expression for thermal efficiency of Diesel cycle by showing all the processes on p-V & T-S diagrams. 10M

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Code: 20A03302 **R20**

B.Tech II Year I Semester (R20) Supplementary Examinations April/May 2024

THERMODYNAMICS

(Mechanical Engineering)

Time: 3 hours Max. Marks: 70

PART – A

(Compulsory Question)

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1 Answer the following: (10 X 02 = 20 Marks)

(a) List down 3 systems that store energy, explaining which form of energy. 2M

(b) When the hot air at high pressure flows in long pipes it eventually cools to ambient temperature. How does that change the flow? 2M

(c) A windmill produces power on a shaft taking kinetic energy out of the wind. Is it a heat engine? Is it a perpetual machine? Explain. 2M

(d) Which is more valuable with respect to work output: thermal energy reservoirs at 675 K and 325 K or thermal energy reservoirs at 625 K and 275 K? 2M

(e) When a substance has completed a cycle v, u, h and s are unchanged. Did anything happen? Explain. 2M

(f) Is the reversible work between two states the same as ideal work for the device? 2M

(g) Steam at 100 100℃ is passed into 1.1 kg of water contained in calorimeter of water equivalent 0.02 kg at 15℃ till the temperature of the calorimeter rises to 80℃. What is the mass of steam condensed? 2M

(h) If you raise the pressure in an isothermal process does enthalpy go up or down for a liquid or solid? What do you need to know if it is a gas phase? 2M

(i) Brief on the actual Otto engine cycle. 2M

(j) Concise on regeneration Brayton cycle. 2M

PART – B

(Answer all the questions: 05 X 10 = 50 Marks)

2 (a) A piston/cylinder arrangement is connected to a 1-m^3 tank by a pipeline with a valve in between. Initially both (tank and piston/cylinder) contain water. Condition of fluid in tank and piston/cylinder arrangement are 100 kPa, saturated vapor and 400 ℃, 300 kPa, 1 m^3 respectively. The valve is now opened and the water in both comes to a uniform state. Find the initial mass in tank and piston/cylinder arrangement. If the process results in a temperature of 200℃, find the heat transfer and work. 7M

(b) A mass of 3 kg nitrogen gas at 2000 K cools at constant volume with 500 W. What is dT/dt? 3M

OR

3 (a) A 4 kg/s steady flow of ammonia runs through a device where it goes through a polytropic process. The inlet state is 150 kPa, -20℃ and the exit state is 400 kPa, 80℃, where all kinetic and potential energies can be neglected. Find the polytropicexponent and the specific work and the specific heat transfer. 7M

(b) In a parallel flow (same direction) heat exchanger 1 kg/s air at 500 K flows into one channel and 2 kg/s air flows into the neighbouring channel at 300 K. If it is infinitely long what is the exit temperature? 3M

4 (a) 0.5 kg of air executes a Carnot power cycle having a thermal efficiency of 50%. The heat transfer to the air during isothermal expansion is 40 kJ. At the beginning of the isothermal expansion the pressure is 7 bar and the volume is 0.12 m^3. Determine the maximum and minimum temperatures for the cycle, the volume at the end of isothermal expansion, and the work and heat transfer for each of the four processes. For air CP = 1.008 kJ/kg. K, Cv = 0.721 kJ/kg. K. 7M

(b) An air-conditioner provides 1 kg/s of air at 15°C cooled from outside atmospheric air at 35℃. Estimate the amount of power needed to operate the air-conditioner. Clearly state all assumptions made. 3M

OR

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5	(a)	A heat pump cycle is used to maintain the interior of a building at 20℃. At steady state, the heat pump receives energy by heat transfer from well water at 10°C and discharges energy by heat transfer to the building at a rate of 120,000 kJ/h. Over a period of 14 days, an electric meter records that 1490 kWh of electricity is provided to the heat pump. Determine (i) the amount of energy that the heat pump receives over the 14-day period from the well water by heat transfer, in kJ. (ii) the heat pump's coefficient of performance. (iii) the coefficient of performance of a reversible heat pump cycle operating between hot and cold reservoirs at 20°C and 10℃.	8M
	(b)	A consumer buys a new refrigerator with no freezer compartment and a deep freezer for the new kitchen. Which of these devices would you expect to have a lower COP? Why?	2M
6	(a)	A piston/cylinder has 2 kg water at 1000 kPa, $250°C$ which is now cooled with a constant loading on the piston. This isobaric process ends when the water has reached a state of saturated liquid. Find the work and heat transfer.	5M
	(b)	A handheld pump for a bicycle has a volume of 25CC when fully extended. You now press the plunger (piston) in while holding your thumb over the exit hole so that an air pressure of 300 kPa is obtained. The outside atmosphere is at P0, T0. Consider two cases: (i) it is done quickly (∼1 s), and (ii) it is done very slowly (∼1 h). State assumptions about the process for each case. b. Find the final volume and temperature for both cases.	5M
		OR	
7	(a)	A steam turbine receives steam at 6 MPa, 800℃. It has a heat loss of 49.7 kJ/kg and an isentropic efficiency of 90%. For an exit pressure of 15 kPa and surroundings at $20°C$, find the actual work and the reversible work between the inlet and the exit.	5M
	(b)	A geothermal source provides 10 kg/s of hot water at 500 kPa, $150°C$ flowing into a flash evaporator that separates vapor and liquid at 200 kPa. Find the three fluxes of availability (inlet and two outlets) and the irreversibility rate.	5M
8	(a)	Ice at $-3\ °C$, 100 kPa, is compressed isothermally until it becomes liquid. Find the required pressure.	4M
	(b)	A cylinder containing ammonia is fitted with a piston restrained by an external force that is proportional to cylinder volume squared. Initial conditions are $10°C$, 90% quality and a volume of 5 L. A valve on the cylinder is opened and additional ammonia flows into the cylinder until the mass inside has doubled. If at this point the pressure is 1.2 MPa, what is the final temperature?	6M
		OR	
9	(a)	A 500-L tank stores 100 kg of nitrogen gas at 150 K. To design the tank the pressure must be estimated and three different methods mentioned below are suggested. Which is the most accurate, and how different in percent are the other two? (i) Nitrogen tables or, (ii) Ideal gas or, (iii) Generalized compressibility chart.	5M
	(b)	How close to ideal gas behavior is ammonia at saturated vapor, 100 kPa? How about saturated vapor at 2000 kPa?	5M
10		An air-standard dual cycle has a compression ratio of 14 and a cutoff ratio of 1.2. The pressure ratio during the constant-volume heat addition process is 1.5. Determine the thermal efficiency, amount of heat added, the maximum gas pressure and temperature when this cycle is operated at 80 kPa and 20℃ at the beginning of the compression. If the state of the air at the beginning of the compression is 80 kPa and -20℃ find the above parameters.	10M
		OR	
11		A gas turbine plant has air supplied at 1 bar, 27°C for being compressed through pressure ratio of 10. Compression of air is achieved in two stages with perfect inter cooling in between at optimum pressure. The maximum temperature in cycle is 1000 K and compressed air at this temperature is sent for expansion in two stages of gas turbine. First stage expansion occurs upto 3 bar and is subsequently reheated upto 995 K before being sent to second stage. Fuel used for heating in combustion chamber has calorific value of 42,000 kJ/kg. Considering Cp = 1.0032 kJ/kg. K throughout cycle determine, net output, thermal efficiency and air fuel ratio when air flows into compressor at 30 kg/s. Take isentropic efficiency of compression and expansion to be 85% and 90% respectively.	10M

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