Ref. No. PE/PC/B/T/213/2025

B. POWER ENGINEERING 2ND YEAR FIRST SEMESTER SUPPLE EXAMINATION 2024

SUBJECT: **ENGINEERING THERMODYNAMICS**

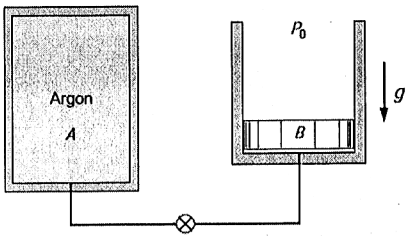
Time: 24 Hours **Full Marks: 100**

Use of Air and Steam Table permitted; Other charts are supplied with the Question Paper

CO1: Answer any one questions 20 marks

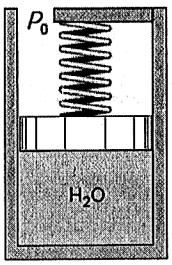
1.

An insulated 400-L tank, A (see Fig. 1), contains argon gas at 250 kPa and 30°C. Cylinder B, which is also insulated and has a frictionless piston of such mass that a pressure of 150 kPa will float it, is initially empty. The valve is opened, and argon flows into B and eventually reaches a uniform state of 150 kPa and 30°C throughout. What is the work done by the argon? Find the entropy generated in the process. What is the source of irreversibility? **20**



OR

A piston/cylinder assembly contains 1 kg of liquid water at 20°C and 300 kPa, as shown in Figure 2. There is a linear spring mounted on the piston such that when the water is heated, the pressure reaches 3 MPa with a volume of 0.1 m^3. (a) Find the final temperature. (b) Plot the process in a *P–v* and *T-s* diagrams. (c) Find the heat transfer and work done. Use steam table. **20**



CO2: Answer any two questions 40 marks

2.

a. Write down the energy equation for an open system and use it to show the expression of work done in an adiabatic turbine. **5**

b. Steam enters such an adiabatic turbine at a rate of 10 kg/s at 100 bar and 500°C and it exhausts at 10 bar. If the isentropic efficiency of the turbine is 90%, find the power developed and entropy generated per unit mass of steam flowing. **10**

c. If the ambient temperature is 300 K, find the lost power due to this generation of entropy using Guoy Stodola theorem. **5**

3.

a. Write down the two corrolaries of Second Law and deduce Clausius inequality from it. **5**

b. A proposed combined heat and power (CHP) plant receives 800 MW of heat from two heat sources: 500 MW is received at 1000 K, and the remaining at 600 K. The plant supplies 200 MW of heat to maintain a process chamber temperature at 127 °C, and the rejects heat to the ambient at 300 K. The CHP produces 400 MW of power. Find the entropy generated by the CHP. **15**

4. An electric motor operating at steady state draws a current of 10 A with a voltage of 220 V. The output shaft rotates at 900 rpm with a torque 22 N.m applied to an external load while the rest is dissipated as heat. The rate of heat transfer from the motor to its surroundings is related to the surface temperature T_b and the ambient temperature T_0 by the relationship $\dot{Q} = hA(T_b - T_0)$, where h = 50 W/m²K, A = 0.2 m², and T_0 = 300 K. Energy transfers are indicted by the arrows shown in the Fig. 3.

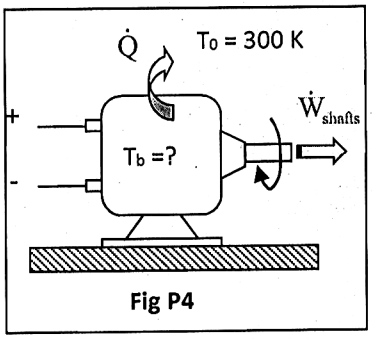


Fig P4

i. Determine the temperature T_b in K

ii. For just the motor as the system (i.e., its surface as the system boundary), calculate the rate of entropy generation within the system, and the rate of entropy transfer with heat.

iii. Also, find out the total entropy generated in the universe

20

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CO 3: 25 marks

5.

a. Draw the p-v and T-s diagrams of an Otto cycle and state the salient assumptions taken in defining an Otto cycle. What type of engines does this idealize? **5**

OR

With T-s diagrams, explain the effect of the followings on the performance of a Rankine cycle: (i) increase of superheat temperature, (ii) increase of operating pressure. **5**

b. A steam power plant operates on simple Rankine cycle between the pressure limits of 15 MPa and 10 kPa. The mass flow rate of steam through the cycle is 12 kg/s. Steam enters the turbines at 500°C. Estimate (a) efficiency, (b) work ratio, (c) specific steam consumption and (d) the second law efficiency of the cycle. (d) Comment if the cycle will ideally require reheating or not. Also, show the cycle on a T-s diagram with respect to saturation lines. **20**

OR

Consider an ideal air standard Brayton cycle in which the air into the compressor is at 100 kPa and 27°C, and the pressure ratio across the compressor is 10:1. The maximum operating temperature of the cycle is 1127°C, and the airflow rate is 20 kg/s. Determine the net work output, specific work, the work ratio, First-law and Second-law efficiency of the cycle. Plot the cycle on a p-v and T-s diagram. **20**

CO 4: 15 marks

6.

What do you mean by 1 T of refrigeration? What is the purpose of the expansion valve in a vapor compression refrigeration system? **5**

OR

A humid room-air at 1 atmosphere pressure has a dew point of 20^0C. Find out its relative humidity if a regular thermometer hung in the room reads 40 °C **5**

7. An ideal vapor compression refrigeration cycle with refrigerant R134a as the working fluid operates with an evaporator temperature of −10°C and a condenser temperature of 40°C. The mass flow rate of the refrigerant is 6 kg/min. Condition of the refrigerant at the compressor inlet is dry saturated. With attached property chart for R134a, find the Tonnage and COP of the refrigerator. Plot the cycle on a T-s and p-h diagram.

OR

A stream consisting of 20 m^3/min of moist air at 20°C, 1 atm, 80% relative humidity is heated using an electric heater until its temperature reaches 40°C. Find the relative humidity of the air at the heater exit, and also find the rating of the heater. Plot the process on a psychrometric diagram. Use the attached psychrometric chart **10**

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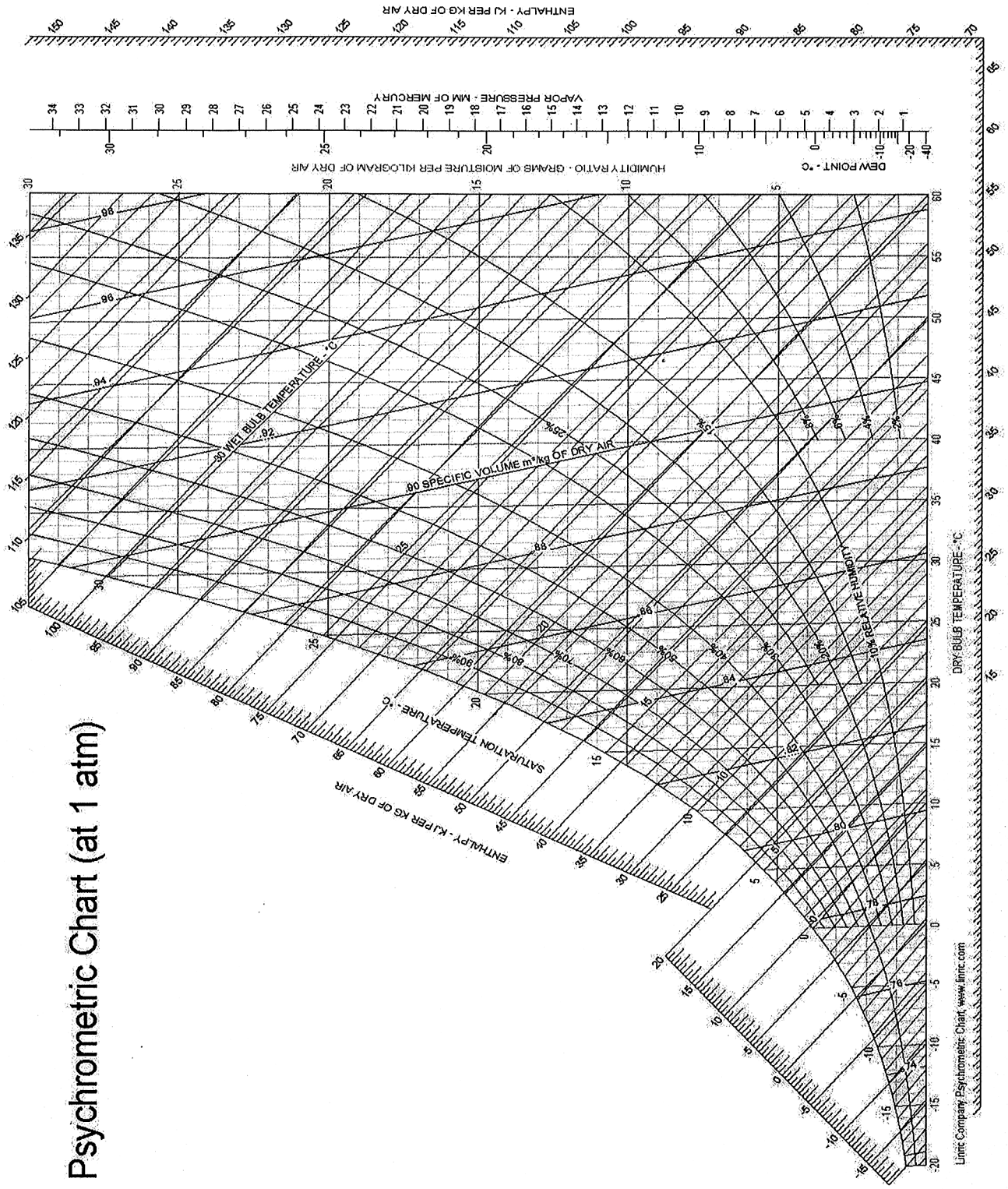

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