B.E. CIVIL ENGINEERING EXAMINATION, 2022

(2ND Year 2nd Semester)

THERMODYNAMICS AND HEAT POWER

Time - Three Hours | Full Marks – 100

Answer **any (5)** questions.

Assume any suitable data, if required

Answers must be brief and to the point

Answer to all parts of a question must be together

Steam Tables/Charts can be used if necessary.

1. a) Define Intensive and Extensive properties of a system. Give two examples of each. 4

b) Define: Triple point, subcooled liquid, dryness fraction, phase boundary? 6

c) A vessel of volume 0.05 m^3 contains 5 kg of water at a pressure of 150 kPa. Determine (i) specific volume, (ii) temperature, (iii) enthalpy, (iv) entropy, and (v) internal energy. Plot the state point of the water on p-v and T-v planes. 10

2. a) State the First Law of Thermodynamics for a closed system undergoing a cycle. Also from this relation, prove that total energy is a property of a system 2+4

b) For an ideal gas, express entropy change in terms of temperatures and pressures of the two end states. 4

c) A gas of mass 2 kg undergoes a quasi-static expansion, which follows $p = a + 2bV$. The initial pressure and volume are 1200 kPa and 0.25 m^3, and the final pressure and volume are 250 kPa and 1.35 m^3, respectively. The specific internal energy of the gas is given by $u = 2pv - 70$ kJ/kg. Estimate the net heat transfer. Plot the process on p-v plane. 10

3. a) State the assumptions for the Steady & Non-uniform Flow (also called steady state steady flow) process. Incorporating these assumptions into the general First law of Thermodynamics equation for a control volume, derive the conservation of energy equation for a Steady & Non-uniform flow process. 10

b) Air enters a nozzle with an enthalpy of 2670 kJ/kg and a velocity of 72 m/s. At the exit of the nozzle, the enthalpy is 2580 kJ/kg. For a horizontal nozzle with negligible heat loss, find

(i) the velocity at the exit of the nozzle,

(ii) the mass flow rate of air, if area $A_1 = 0.098\ m^2$ and $v_1 = 0.179\ m^3/kg$, and

(iii) if $v_2 = 0.503\ m^3/kg$, find the area at the exit of the nozzle. 10

4. a) What is a throttling process? Show that it is an isenthalpic process. Compare throttling process with isentropic process. 2+3+3

b) Steam at 0.6 MPa, 200 °C enters an insulated nozzle with a velocity of 50m/s. It leaves at a pressure of 0.15MPa and a velocity of 600 m/s. Determine the final temperature of the steam if it is superheated or the quality if it is saturated in the final state. Plot the process on h-s diagram. 12

5. a) State the two statements of the Second law of Thermodynamics. Show that the violation of Clausius statement leads to the violation of K-P statement. 08

b) What is entropy? Show that entropy is a property. 2+4

c) A reversed Carnot cycle is used in a refrigeration plant for food storage. The plant maintains the food storage at a temperature of −7°C. The heat transferred from the food storage unit is at a rate of 6 kW. Determine the power required to drive the plant, if the heat is transferred from the food storage unit to the atmosphere, which is at a temperature of 27°C. 06

6. a) What is a reversible process? State the causes behind irreversibility in mechanical, thermal and chemical systems? 3+3

b) Show the following processes for water with proper labeling:

(i) Isothermal process from compressed liquid zone to superheated vapor zone on P-v diagram.

(ii) Isobaric process from superheated vapor zone to subcooled liquid zone on T-v diagram. 3+3

c) 250 g of water at 25°C is converted at constant pressure into ice at −5°C. Estimate the entropy change of the system. The latent heat of fusion of ice at 0°C is 335 J/g. Take specific heat cp of water as 4.182 J/g-K and that of ice to be half of this value. 8

7. a) Show that no heat engine operating between the same heat reservoirs can have an efficiency higher than that of a reversible heat engine. 4

b) How performances of heat engine, heat pump and refrigerator are measured? 6

c) 2.3 kg/s of steam flows isentropically through a turbine, entering at 1000 KPa and 500°C, and leaves at a pressure of 10 KPa. Determine the power output of the turbine. Plot the process on T-s diagram. 10

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