VEER SURENDRA SAI UNIVERSITY OF TECHNOLOGY (VSSUT), ODISHA
Mid-Semester Examination for Academic Session 2025-26

COURSE NAME: B.Tech SEMESTER: 3rd

BRANCH NAME: MECHANICAL
SUBJECT NAME: Basic Thermodynamics

FULL MARKS: 30 TIME: 90 Minutes

Answer All Questions.
The figures in the right-hand margin indicate Marks. *Symbols carry their usual meaning.*
Use of Steam tables permitted

Q1. Answer all Questions. **[2 × 3]**

a) Air undergoes a frictionless isothermal compression process. Which of the following sentences are correct? (i)Work done is the same as heat transferred (ii) Internal energy remains constant (iii)Pressure increases but volume decreases (iv)Volume increases but pressure decreases. - CO1

b) 1kg of air is expanded so that its volume doubles. In which of the following cases is the work done more? For a constant-pressure process or for a constant-temperature process? - CO2

c) Determine the phase for water (at 120^{0}C, 500 kPa) using the steam table and indicate the relative position in the P–v, T–v diagrams. - CO3

Q2. **[8]**

A sealed rigid vessel has a volume of 1 m^3 and contains 2 kg of water at 100^{0}C. Determine whether the initial state is a compressed liquid, a superheated vapor, or a mixture of saturated liquid and vapor. The vessel is now heated. If a safety pressure valve is installed, at what pressure should the valve be set to have a maximum temperature of 200^0 C? - CO1

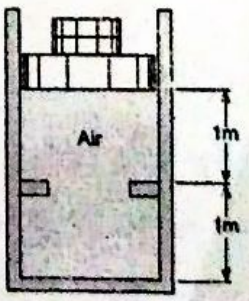
OR

A throttling calorimeter is used to measure the dryness fraction of the steam which is at a pressure of 8bar. The steam after passing through the calorimeter is at 1bar pressure and 115^{0}C. Calculate the dryness fraction of the steam. - CO1
Take C_{ps} = 2.1kJ/kg-K.

Q3. **[8]**

A piston/cylinder arrangement shown in the figure initially contains air at 150 kPa and 400^{0}C. The setup is allowed to cool to the ambient temperature of 20^{0}C. - CO2

a. Is the piston resting on the stops in the final state? What is the final pressure in the cylinder?
b. What is the work done per kg of air during the process?
C. Find the heat transfer per kg of air during the process.



OR

The heat capacity at constant pressure of a certain system is a function of temperature only and may be expressed as C_p = 2.093 + 41.87/(t+1000) J/^{0}C where t is the temperature of the system in ^{0}C. The system is heated while it is maintained at a - CO2

pressure of 1 atmosphere until its volume increases from 2000cm^3 to 2400cm^3 and its temperature increases from 0°C to 100°C.
a. Find the magnitude of the heat interaction.
b. How much does the internal energy of the system increase?

Q4. [8]

A centrifugal compressor in a gas turbine plant receives air with negligible velocity from the ambient at 1 bar and 300K. At the exit of the compressor, the pressure is 4 bar, the temperature is 480K, and the velocity is 25m/s. The mass flow rate of air through the compressor is 15kg/s. Assuming no loss of heat transfer to the surroundings, determine the power required to drive the compressor. Take C_p of air as 1.005KJ kJ/kg. - CO3

OR

- A room for four persons has two fans consuming 0.18 KW power and three 100W lamps. Ventilation air at a rate of 80kg/hr enters with an enthalpy of 84 kJ/kg and leaves with an enthalpy of 59 kJ/kg. If each person releases heat at the rate of 630 kJ/hr, determine the rate at which heat is to be removed by a room cooler so that a steady state is maintained in the room. - CO3

$h_1 = h_2$

$x = \frac{h - h_f}{h_g - h_f}$

at 8 bar $\Rightarrow$ 800 kPa

$h_f = 721.10$

$h_g = 2769.13$

$\Rightarrow 2048.08\, x = h_1 - 721.10$ (1)

at Pressure = 1 bar, $T = 115°C$

1 bar = 100 kPa

$T_{sat} = 99.62$

$T > T_{sat}$

$h_g = 2675.46$

$h_2 = h_g + C_p (T_2 - T_{sat})$

$h_2 = 2675.46 + 2.1 (115 - 99.62)$

$h_2 = 2707.758$

$\therefore h_1 = h_2$

$(2048.08)\, x = h_1 - 721.10$

$x = 0.97$

$x = 97\%$ dryness fraction.

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