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ME 181303

2024

B.Tech. 3rd Semester End-Term Examination

BASIC THERMODYNAMICS

Full Marks – 70

Time – Three hours

The figures in the margin indicate full marks
for the questions.

Answer question No. 1 and any *four* from the rest.

1. Choose the correct answer from the followings :
   1 × 10

   (i) Work done in a free expansion process is

   (a) + ve

   (b) –ve

   (c) zero

   (d) maximum

   (ii) Properties of substances like pressure, temperature and density, in thermodynamic coordinates are

   (a) path functions

   (b) point functions

   (c) cyclic functions

   (d) real functions

   (iii) Heat and work are

   (a) point functions

   (b) path functions

   (c) intensive properties

   (d) extensive properties.

   (iv) Zeroth law of thermodynamics

   (a) deals with conversion of mass and energy

   (b) deals with reversibility and irreversibility of process

   (c) states that if two systems are both in equilibrium with a third system, they are in thermal equilibrium with each other

   (d) deals with heat engines

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(v) Heat does not spontaneously flow from a colder body to a hotter one. Which of the following thermodynamics law states this?

(a) Zeroth law of thermodynamics

(b) First law of thermodynamics

(c) Second law of thermodynamics

(d) Third law of thermodynamics

(vi) Which of the following is known as the inequality of Clausius?

(a) cyclic integral of dW/T<=0

(b) cyclic integral of dW/T>=0

(c) cyclic integral of dQ/T>=0

(d) cyclic integral of dQ/T<=0

(vii) Entropy is a

(a) path function, intensive property

(b) path function, extensive property

(c) point function, intensive property

(d) point function, extensive property

(viii) What does the Mollier chart primarily illustrate?

(a) Temperature-Entropy relationship

(b) Pressure-Volume relationship

(c) Enthalpy-Entropy relationship

(d) Temperature-Volume relationship

(ix) For same compression ratio and for same heat added

(a) Otto cycle is more efficient than Diesel Cycle

(b) Diesel cycle is more efficient than Otto Cycle

(c) Efficiency depends on other factors

(d) None of the above

(x) The efficiency of Otto cycle can be increased by

(a) Increasing the compression ratio

(b) Decreasing the compression ratio

(c) By increasing as well as by decreasing the compression ratio

(d) None

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2. (a) Show that work is a path function, not a state function. What is an indicator diagram? 5 +10

(b) What is PMM1? At the inlet of a nozzle the enthalpy of fluid passing is 3000 kJ/kg and the velocity is 60 m/s. At the discharge end, the enthalpy is 2762 kJ/kg. The nozzle is horizontal and there is negligible. Heat loss from it.

(i) Find the velocity at exit from the nozzle

(ii) If the inlet area is 0.1 m² and specific volume at inlet is 0.187 m³/kg, find the mass flow rate.

(iii) If the specific volume at the nozzle exit is 0.498 m³/kg, find the exit area of the nozzle.

3. (a) Show that enthalpy of a fluid before throttling is equal to that after throttling. 5 + 10

(b) What is adiabatic mixing of fluids? Air flows steadily at the rate of 0.4 kg/s through an air compressor; entering at 6 m/s with a pressure of 1 bar and a specific volume of 0.85 m³/kg, and leaving at 4.5 m/s with a pressure of 6.9 bar and a specific volume of 0.16 m³/kg. The internal energy of the air leaving is 88 kJ/kg greater than that of air entering. Cooling water in a jacket surrounding the cylinder absorbs heat from the air at the rate of 59 W. Calculate the power required to drive the compressor and the inlet and outlet cross sectional areas.

4. (a) Establish the equivalence of Kelvin-Planck and Clausius statement. 5 + 10

(b) A heat pump working on the Carnot cycle takes in heat from a reservoir at 5°C and deliver heat to a reservoir at 60°C. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 840°C and rejects heat to a reservoir at 60°C. The reversible engine also drives a machine that absorbs 30 kilowatts. If the heat pump extracts 17 kJ/s from the 5° reservoirs, determine

(i) the rate of heat supply from 840° source and

(ii) the rate of heat rejection to the 60°C sink.

5. (a) Explain the working principle of the Rankine cycle with the help of a schematic diagram. Discuss each stage of the cycle and derive the expression for the thermal efficiency? 9 + 6

(b) A 1.8-m³ rigid tank contains steam at 220°C. One-third of the volume is in the liquid phase and the rest is in the vapor from. Determine

(i) the pressure of the steam,

(ii) the quality of the saturated mixture, and

(iii) the density of the mixture.

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6. (a) Derive an expression for the thermal efficiency of a Diesel cycle.　　7 + 8

(b) An engine working on the otto cycle is supplied with air at 0.1 MPa, 35°C. The compression ratio is 9. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency and the mean effective pressure. (For air c_p = 1.005, c_v = 0.718, and R = 0.287 kJ/kgK)

7. (a) Define caloric value of fuel. Differentiate between HCV and LCV of a fuel. Describe the working principle of Bomb Calorimeter.　　8 + 7

(b) A coal has the following composition by mass:

C = 90%, H_2 = 3%, S = 1%, O_2 = 2%, N_2 = 2% and remaining is ash. Find the HCV and LCV of the fuel.

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