Reg. No. : | E | N | G | G | T | R | E | E | . | C | O | M |

Question Paper Code : 50024

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2024.

Third Semester

Aeronautical Engineering

AE 3351 – AERO ENGINEERING THERMODYNAMICS

(Common to: Aerospace Engineering)

(Regulations 2021)

Time : Three hours Maximum : 100 marks

(Steam Tables, a Mollier Chart are permitted.
Heat Transfer Data Book also permitted)

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Distinguish between open and closed systems.
2. List the limitation of first law of Thermodynamic.
3. Express the clausius inequality for various processes.
4. Why Carnot cycle cannot be realized in practice?
5. Draw the p–v and T–s diagram for Stirling cycle.
6. Sketch the schematic arrangement of open cycle gas turbine plant and name the components.
7. Draw the p–T (pressure – Temperature) diagram for a pure substance.
8. what is the effect of reheat on
   (a) The cycle efficiency
   (b) The network output and
   (c) Steam rate of a steam power plant.
9. How jet engines are classified?
10. Define convection heat transfer.

PART B — (5 × 13 = 65 marks)

11. (a) (i) Derive the steady flow energy equation for a nozzle. State the assumptions made. (5)

(ii) In a gas turbine installation, the gases enter the turbine at the rate of 5 kg/s with a velocity of 50 m/s and enthalpy of 900 kJ/kg and leave the turbine with 150 m/s and enthalpy of 400 kJ/kg. The loss of heat from the gases to the surroundings is 25 kJ/kg. Assume R=0.285 kJ/kg K, C_p=1.004 kJ/kg K and inlet conditions to be at 100 kPa and 27°C. Determine the work done and diameter of the inlet pipe. (8)

Or

(b) (i) 25 people attended an farewell party in a small room of size 10X8 m and have 5 m ceiling. Each person gives up 350 kJ of heat per hour. Assuming that the room is completely sealed off and insulated, calculate the air temperature rise occurring in 10 minutes. Assume C_v = 0.718 kJ/kg K and R = 0.287 kJ/kg K and each person occupies a volume of 0.005 m^3. Take p = 101.325 kPa and T = 20°C. (8)

(ii) 1 kg of gas at 1.1 bar, 27°C is compressed to 6.6 bar as per the law $pV^{1.3}$ = Constant. Calculate the work and heat transfer when the gas is argon (Ar) with molar mass of 40 kg/k mol and Cp = 0.52 kJ/kg K. (5)

12. (a) A heat pump working on the carnot cycle takes in heat from a reservoir at 5°C and delivers heat to a reservoir at 60°C. A heat engine is driven by a source at 840°C and rejects heat to a reservoir at 60°C. The reversible heat engine, in addition to drive the heat pump, also drives a machine that absorbs 30 kW. If the heat pump extracts 17 kJ/s from the 5°C reservoir, determine.

(i) The rate of heat supply from the source and (7)

(ii) The rate of heat rejection to the sink. (6)

Or

(b) 5 m^3 of air at 2 bar, 27°C is compressed up to 6 m bar pressure following $pV^{1.3}$ = Constant. It is subsequently expanded to adiabatically to 2 bar. Considering the two processes to be reversible, determine the network, net heat transfer and change in entropy. Also plot the processes on T–s and p–V diagrams.

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

Or

(b) In a Rankine cycle, the steam at inlet to turbine is saturated at a pressure of 35 bar and the exhaust pressure is 0.2 bar. The flow rate of steam 9.5 kg/s. Determine the

(i) Pump work

(ii) Turbine work

(iii) Rankine efficiency

(iv) Condenser heat flow

(v) Work ratio and

(vi) Specific steam consumption. (3+3+2+2+3)

14. (a) (i) Derive the air standard efficiency of Otto cycle. (6)

(ii) An engine 20 cm bore and 30 cm stroke works on Otto cycle. The clearance volume is 1600 cm^3. The initial pressure and temperature are 1 bar and 60°C. If the maximum pressure is limited to 24 bar, find the following:

(1) Air standard efficiency

(2) Mean effective pressure of the cycle (7)

Or

(b) In engine working on a dual cycle, the temperature and pressure at the beginning of the cycle are 90°C and 1 bar. The compression ratio is 9. The maximum pressure is limited to 68 bar and total heat supplied per kg of air is 1750 kJ. Determine the air standard efficiency and mean effective pressure.

15. (a) With a neat sketch explain the principle and working of Turbo-Prop Engine Discuss its advantages, disadvantages and applications.

Or

(b) The following particulars refers to furnace wall

Hot gas temperature = 2000°C

Room air temperature = 45 °C

Heat flow by radiation from gases to inside surface of the wall = 23.36 kW/m²

Convective heat transfer coefficient at the interior surface = 11.63 W/m² K.

Thermal conductance of the wall = 58 W/m K

Heat flow by radiation from external surface to the surroundings 9.3 kW/m².

Interior wall surface temperature = 1000°C.

Determine for the external surface of the wall:

(i) Surface temperature (7)

(ii) Convective conductance (6)

PART C — (1 × 15 = 15 marks)

16. (a) The specific impulse of a rocket is 125 s and the flow rate of propellant is 44 kg/s. The nozzle throat area is 18 cm² and the pressure in the combustor is 25 bar. Determine the thrust coefficient, propellant flow coefficient, specific propellant consumption and characteristic velocity.

Or

(b) A reheat cycle operating between 30 bar and 0.04 bar has a superheat and reheat temperature of 450°C. The first expansion takes place till the steam is dry saturated and the reheat is given. Neglecting feed pump work. Determine the ideal cycle efficiency.