**Reg. No. :** | | | | | | | | | | | | |

# Question Paper Code : 40049

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2021.

Third Semester

Aeronautical Engineering

AE 8301 — AERO ENGINEERING THERMODYNAMICS

(Common to Aerospace Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Bring out the differences between microscopic and macroscopic modes in thermodynamic studies.



2. What is the difference between a nozzle flow and a throttle process?

3. Compare two heat engines receiving the same Q, one at 1200 K and the other at 1800 K, they both reject heat at 500 K. Which one is better?

4. What is meant by Clausius inequality?

5. For a given compression ratio does an Otto cycle have higher or lower efficiency than a diesel cycle? Explain your answer.

6. What is meant by detonation?

7. What is meant by sensible heating?

8. Define critical point and triple point.

9. Define specific thrust and TSFC.

10. Define polytropic efficiency.

PART B — ($5 \times 13 = 65$ marks)

11. (a) (i) A piston-cylinder containing air expands at a constant pressure of 150 kPa from a temperature of 285 K to a temperature of 550 K. The mass of air in the cylinder is 0.05 kg. Determine the system heat and work for the process as well as the net work available if the surrounding pressure acting on the piston is 101.3 kPa. (8)

(ii) Explain in detail about the types of thermodynamic equilibrium. (5)

Or

(b) (i) In a remote area, water is to be supplied from underground water source, whose free surface is 100 m below ground level, using a water pump. This water is to be stored in a water tank at a height of 10 m from the ground level. This pump is connected with an inlet pipe of diameter 20 cm and outlet pipe of diameter 30 cm. Determine the power input to this pump for steady water supply of 20 I/s. Assume no heat interaction during this process. (8)

(ii) State Zeroth law of thermodynamics and demonstrate it with neat illustration. (5)

12. (a) (i) What is a Carnot cycle? Describe the processes involved in a Carnot cycle using P-v and T-s diagrams. Derive an expression for its thermal efficiency. (7)



(ii) Demonstrate the equivalence of Kelvin-Planck and Clausius statement. (6)

Or

(b) A quantity of air undergoes a thermodynamic cycle consisting of three processes. Process 1-2: constant volume heating from $p_1 = 0.1$ MPa, $T_1 = 16°C$, $V_1 = 0.02\ m^3$ to $p_2 = 0.42$ MPa.; Process 2-3: Constant pressure cooling. Process 3-1: Isothermal heating to initial state. Employing the ideal gas model with Cp = 1.05 kJ/kgK, evaluate the change of entropy for each process. Sketch the cycle on P-v and T-s coordinates. (13)

13. (a) (i) An ideal Otto cycle has compression ratio of 8. At the beginning of the compression process, air is at 100 kPa and 17°C, and 800 kJ/kg of heat is transferred to air the constant volume heat addition process. Assuming cold air standard assumption, determine

(1) the maximum pressure and temperature that occur during the cycle,

(2) the net work done,

(3) thermal efficiency and

(4) mean effective pressure for the cycle. (8)

(ii) Show that the thermal efficiency of Brayton cycle depends only on the pressure ratio. Also draw its P-v and T-s diagram. (5)

Or

(b) With a neat P–v and T–s diagram, explain the various processes involved in Dual cycle and also derive an expression for the efficiency of dual cycles. (13)

14. (a) (i) A pressure cooker contains 1.5 kg of saturated steam at 5 bar. Find the quantity of heat which must be rejected so as to reduce the quality to 60 % dry. Determine the pressure and temperature of the steam at the new state, the amount of total heat transferred. (7)

(ii) Explain in detail about the formation of superheated steam from –20°C of ice with T-v diagram. Also explain the various processes involved in it. (6)

Or

(b) Consider a steam power plant operating on the ideal Rankine cycle. Steam enters the turbine at 3 MPa and 350°C and is condensed in the condenser at a pressure of 10 kPa. Determine

(i) the thermal efficiency of this power plant,

(ii) the thermal efficiency if steam is superheated to 600°C instead of 350°C and

(iii) the thermal efficiency if the boiler pressure is raised to 15 MPa while the turbine inlet temperature is maintained at 600°C. (13)



15. (a) With neat sketches, explain in brief about the various classifications of jet engines. (13)

Or

(b) A turbojet aircraft flies at sea level at a Mach number of 1.5 at an altitude where ambient pressure and ambient temperature are 11.6 kPa and 205 K respectively. Mass flow rate is 50 kg/s, compressor pressure ratio is 1.2, temperature in combustion chamber is 1400 K. Assume the turbojet operates on ideal Brayton cycle. Take calorific value of fuel used as 45 MJ/kg, $\gamma$ = 1.4 $C_p$ = 1 kJ/kg-K. Calculate the thrust developed by the engine by assuming the nozzle exit pressure is equal to the ambient pressure. (13)

PART C — ($1 \times 15 = 15$ marks)

16. (a) (i) Air expands through a turbine from 500 kPa, 520°C to 100 kPa, 300°C. During expansion 10 kJ/kg-K of heat is lost to the surroundings which is at 98 kPa, 20°C. Neglecting the K.E and P.E changes, determine per kg of air

(1) the decrease in availability,

(2) the maximum work and

(3) the irreversibility. (8)

(ii) Air enters a compressor operating at steady state at a pressure of 1 bar, a temperature of 290 K and a velocity of 6 m/s through an inlet with an area of 0.1 $m^2$. At the exit, the pressure is 8 bar, the temperature is 450 K and the velocity is 2 m/s. Heat transfer from the compressor to the surroundings occurs at the rate of 180 kJ/min. Employing the ideal gas model, calculate the power input to the compressor. (7)

Or

(b) With your understanding, analyse why piston engine is not able to replace jet engines used in large and high speed aircrafts. (15)

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