Question Paper Code : 21028

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2013.

Fifth Semester

Aeronautical Engineering

AE 2303/AE 53/ AE 1303/10122 AE 503 — AERODYNAMICS – II

(Regulation 2008/2010)

Time : Three hours Maximum : 100 marks

Use of gas tables permitted.

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Define compressibility.

2. What do you mean by overexpanded nozzle and what is its effect?

3. What is the importance of Hugoniot relation?

4. Why Mach number behind a normal shock cannot be supersonic? Obtain the limiting value of it.

5. Differentiate between like reflection and unlike reflection.

6. What is meant by shock polar?

7. State the importance of Rayleigh supersonic Pitot formula.

8. Define wave drag.

9. Define lower and upper critical Mach numbers.

10. What is the need for sweep back in supersonic vehicles?

PART B — (5 × 16 = 80 marks)

11. (a) (i) Show that heat is a path function and not a property. (5)

(ii) A stationary mass of gas is compressed without friction from an initial state of 0.3 m^3 and 0.105 MPa to a final state of 0.15 m^3 and 0.105 MPa, the pressure remaining constant during the process. There is a transfer of 37.6 kJ of heat from the gas during the process. How much does the internal energy of the gas change? (6)

(iii) Show that energy is a property of a system. (5)

Or

(b) (i) A reversible heat engine operates between two reservoirs at temperatures of 600°C and 40°C. The engine drives a reversible refrigerator which operates between reservoirs at temperature of 40°C and −20°C. The heat transfer to the heat engine is 2000 kJ and the net work output of the combined engine refrigerator plant is 360 kJ.

(1) Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40°C.

(2) Reconsider (1) given that the efficiency of the heat engine and the COP of the refrigerator are each 40% of their maximum possible values. (10)

(ii) Give the Clausius' statement of the second law and establish the equivalence of Kelvin-Planck and Clausius statements. (6)

12. (a) An engine working on the Otto cycle is supplied with air at 0.1 MPa, 35°C. The compression ratio is 8. Heat supplied is 2100 kJ/kg. Calculate the maximum pressure and temperature of the cycle, the cycle efficiency, and the mean effective pressure. (Take for air c_p = 1.005 kJ/kg K, c_v = 0.718 kJ/kg K and R = 0.287 kJ/kg K).

Or

(b) (i) Show that the efficiency of the Brayton cycle depends only on the pressure ratio. (8)

(ii) For the same compression ratio and heat rejection, which cycle is most efficient :

Otto, Diesel or Dual? Explain with $p-v$ and $T-s$ diagrams. (8)

13. (a) (i) Describe a simple ideal Rankine cycle with a schematic diagram. Explain the processes involved by T-S diagram. (8)

(ii) A Steam power plant operates between a boiler pressure of 4 MPa and 300°C and a condenser pressure of 50 kPa. Determine the thermal efficiency of the cycle assuming the cycle to be a simple ideal Rankine cycle. (8)

Or

14. (a) (i) Based on small perturbation theory, derive the linearized velocity potential equation for compressible flows. (10)

(ii) Based on the above equation, establish the Prandtl-Glauert rule. (6)

Or

(b) Consider a subsonic flow with an upstream Mach number of M_∞. This flow moves over a wavy wall with a contour given by $y_W = h\cos(2\pi/l)$, where y_W, where y_W is the ordinate of the wall, h is the amplitude, and l is the wavelength. Assume that h is small. Using small perturbation theory, derive an equation for the velocity potential and the surface pressure coefficient.

15. (a) Consider an infinitely thin flat plate at a 5° angle of attack in a Mach 2.6 freestream. Calculate the lift and drag coefficients using shock expansion theory.

Or

(b) (i) Make use of sketches and plots to explain,

(1) Shock wave-boundary layer interaction increases drag.

(2) The effects of thickness, camber and aspect ratio of wings.

$(2 \times 4 = 8)$

(ii) Explain the transonic area rule. (8)

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