



PART B — (5 × 16 = 80 marks)

11. (a) Derive the energy equation. (16)

$$\frac{a^2}{r-1} + \frac{C^2}{2} = \frac{C_{\max}^2}{2} = \frac{a_0^2}{r-1} = \frac{a^{*2}}{2} \frac{r+1}{r-1}$$

Or

- (b) (i) An air jet at 400 K has sonic velocity. Determine (1) velocity of sound at 400 K, (2) velocity of sound at stagnation condition (3) maximum velocity of jet (4) stagnation enthalpy and (5) Mach number. (12)
- (ii) Write short notes on effect of Mach number on compressibility. (4)
12. (a) Derive an expression for mass flow rate through varying cross sectional passage for isentropic flow in terms of pressure ratio. (16)

Or

- (b) A supersonic wind tunnel is designed for  $M = 2$  with a throat section  $890 \text{ cm}^2$ . The air at 1.2 bar and  $25^\circ\text{C}$  is supplied with negligible velocity. Find the mass flow rate, the area of test section and the fluid property at the throat and test section. (16)
13. (a) Adiabatic flow of air takes place in a constant area duct. Because of friction, the Mach number increases from 0.3 to 0.7. The initial temperature of air is 400 K and the pressure is 20 bar. Determine (i) the final pressure (ii) the final temperature (iii) the ratio of density and (iv) mass flow per unit cross section. (16)

Or

- (b) (i) What are the effects of heat addition and removal from a gas during Rayleigh flow? (6)
- (ii) Prove that in a Rayleigh line at maximum entropy point Mach number is unity. (10)
14. (a) Starting from energy equation derive Prandtl-Mayer equation. (16)

Or

- (b) Estimate the Mach number, pressure, temperature and velocity of a gas at the downstream of a shock if the gas at the upstream of the shock has a pressure of 2 bar at 275 K. The upstream Mach number is 1.8. The specific heat ratio for gas is 1.3 while  $R$  is  $469 \text{ J/kgK}$ . (16)

15. (a) (i) With T-S diagram, explain the working of a turbo-jet system. (10)
- (ii) Give the differences with merits and demerits of turbo-prop and turbo-jet engine. (6)

Or

- (b) (i) Explain with the help of neat sketch the working of solid and liquid propellant rocket engine. (10)
- (ii) What are the properties of liquid propellants? (6)