Problem Sheet 3b

1. A diffuser, shown in Fig. P6.36, has air entering at 100 kPa and 300 K with a velocity of 200 m/s. The inlet cross-sectional area of the diffuser is 100 mm^2. At the exit, the area is 860 mm^2, and the exit velocity is 20 m/s. Determine the exit pressure and temperature of the air. [Ans. 123·9 kPa 319·7 K]

Hint $\dot{m} = \rho AC$

ρ = density, A = Cross section Area

C = Velocity

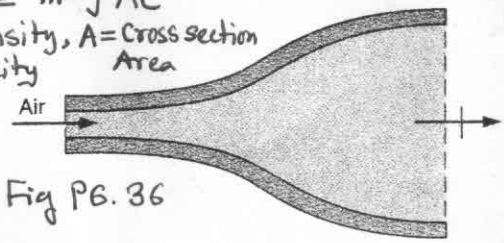


Fig P6.36

2. The front of a jet engine acts as a diffuser, receiving air at 900 km/h, −5°C, and 50 kPa, bringing it to 80 m/s relative to the engine before entering the compressor (see Fig. P6.39). If the flow area is reduced to 80% of the inlet area, find the temperature and pressure in the compressor inlet.

[Ans: 22·9°C, 215·7 kPa]

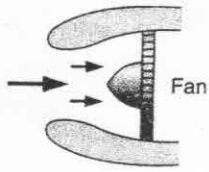


FIGURE P6.39

3. Helium is throttled from 1.2 MPa and 20°C to a pressure of 100 kPa. The diameter of the exit pipe is so much larger than that of the inlet pipe that the inlet and exit velocities are equal. Find the exit temperature of the helium and the ratio of the pipe diameters.

4. In a jet engine a flow of air at 1000 K, 200 kPa, and 40 m/s enters a nozzle, where the air exits at 500 m/s, 90 kPa. What is the exit temperature, assuming no heat loss?

5. Two steady flows of air enter a control volume, shown in Fig. P6.80. One is 0.025 kg/s of flow at 350 kPa, 250°C (state 1), and the other enters at 450 kPa, 15°C (state 2). A single flow exits at 100 kPa, −40°C (state 3). The control volume rejects 1 kW of heat to the surroundings and produces 4 kW of power output. Neglect kinetic energies and determine the mass flow rate at state 2.

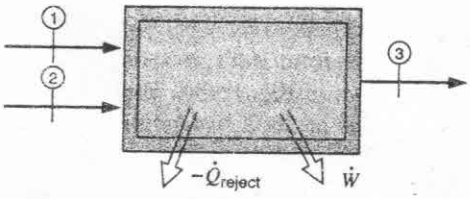


FIGURE P6.80

6. Two air flows are combined to a single flow. One flow is 1 m^3/s at 20°C and the other is 2 m^3/s at 200°C, both at 100 kPa as in Fig. P6.93. They mix without any heat transfer to produce an exit flow at 100 kPa. Neglect kinetic energies and find the exit temperature and volume flow rate.

[Ans: 119·6 °C, 3 m^3/s]

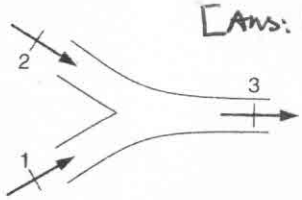
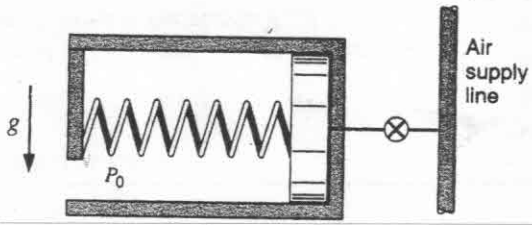


FIGURE P6.93

7. A 500-L insulated tank contains air at 40°C and 2 MPa. A valve on the tank is opened, and air escapes until half the original mass is gone, at which point the valve is closed. What is the pressure inside then?

8. An insulated spring-loaded piston/cylinder device, shown in Fig. P6.132, is connected to an air line flowing air at 600 kPa and 700 K by a valve. Initially the cylinder is empty and the spring force is zero. The valve is then opened until the cylinder pressure reaches 300 kPa. By noting that $u_2 = u_{line} + C_v(T_2 - T_{line})$ and $h_{line} - u_{line} = RT_{line}$, find an expression for T_2 as a function of P_2, P_0, and T_{line}. With P_0 = 100 kPa, find T_2.



[Ans: 773·7 K]