Compressible Flow Problems

Stagnation Properties

CF - 1 Air flows through a device such that the stagnation pressure is 0.6 MPa, the stagnation temperature is 400°C, and the velocity is 570 m/s. Determine the static pressure and temperature of the air at this state.

CF - 2 Air at 320 K is flowing in a duct at a velocity of (*a*) 1, (*b*) 10, (*c*) 100, and (*d*) 1000 m/s. Determine the temperature that a stationary probe inserted into the duct will read for each case.

CF - 3 Calculate the stagnation temperature and pressure for the following substances flowing through a duct: (*a*) helium at 0.25 MPa, 50°C, and 240 m/s; (*b*) nitrogen at 0.15 MPa, 50°C, and 300 m/s; and (*c*) steam at 0.1 MPa, 350°C, and 480 m/s.

CF - 4 Determine the stagnation temperature and stagnation pressure of air that is flowing at 36 kPa, 238 K, and 325 m/s.

Speed of Sound

CF - 5 The Airbus A-340 passenger plane has a maximum takeoff weight of about 260,000 kg, a length of 64 m, a wing span of 60 m, a maximum cruising speed of 945 km/h, a seating capacity of 271 passengers, a maximum cruising altitude of 14,000 m, and a maximum range of 12,000 km. The air temperature at the crusing altitude is about −60°C. Determine the Mach number of this plane for the stated limiting conditions.

CF - 6 Carbon dioxide enters an adiabatic nozzle at 1200 K with a velocity of 50 m/s and leaves at 400 K. Assuming constant specific heats at room temperature, determine the Mach number (*a*) at the inlet and (*b*) at the exit of the nozzle. Assess the accuracy of the constant specific heat approximation.

CF - 7 Nitrogen enters a steady-flow heat exchanger at 150 kPa, 10°C, and 100 m/s, and it receives heat in the amount of 120 kJ/kg as it flows through it. Nitrogen leaves the heat exchanger at 100 kPa with a velocity of 200 m/s. Determine the Mach number of the nitrogen at the inlet and the exit of the heat exchanger.

CF - 8 Assuming ideal gas behavior, determine the speed of sound in refrigerant-134a at 0.9 MPa and 60°C.

CF - 9 Determine the speed of sound in air at (*a*) 300 K and (*b*) 800 K. Also determine the Mach number of an aircraft moving in air at a velocity of 330 m/s for both cases.

One Dimensional Isentropic Flow

CF - 10 Calculate the critical temperature, pressure, and density of (*a*) air at 200 kPa, 100°C, and 250 m/s, and (*b*) helium at 200 kPa, 40°C, and 300 m/s.

CF - 11 Air at 25 psia, 320°F, and Mach number Ma = 0.7 flows through a duct. Calculate the velocity and the stagnation pressure, temperature, and density of air.

CF - 12 Air enters a converging–diverging nozzle at a pressure of 1200 kPa with negligible velocity. What is the lowest pressure that can be obtained at the throat of the nozzle?

CF - 13 In March 2004, NASA successfully launched an experimental supersonic-combustion ramjet engine (called a *scramjet*) that reached a record-setting Mach number of 7. Taking the air temperature to be −20°C, determine the speed of this engine.

CF - 14 Reconsider the scram jet engine discussed in Prob. 17–41. Determine the speed of this engine in miles per hour corresponding to a Mach number of 7 in air at a temperature of 0°F.

CF - 15 Air at 200 kPa, 100°C, and Mach number Ma = 0.8 flows through a duct. Calculate the velocity and the stagnation pressure, temperature, and density of the air.

CF - 16 Air enters a converging–diverging nozzle at a pressure of 1200 kPa with negligible velocity. What is the lowest pressure that can be obtained at the throat of the nozzle?