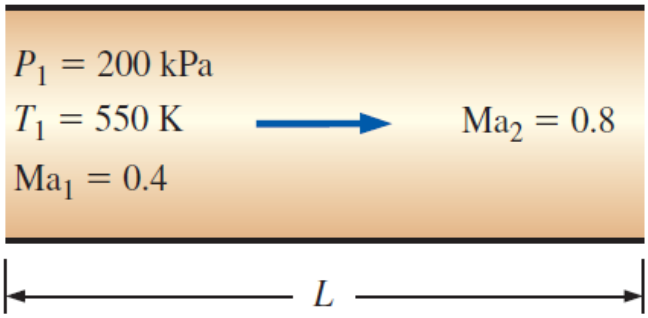
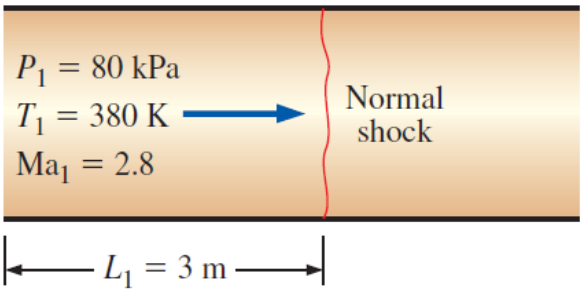
SPC 407
Sheet 6
Compressible Flow – Fanno Flow

1. What is the effect of friction on flow velocity in subsonic and supersonic Fanno flow?
2. Consider supersonic Fanno flow that is decelerated to sonic velocity (Ma=1) at the duct exit as a result of frictional effects. If the duct length is increased further, will the flow at the duct exit be supersonic, subsonic, or remain sonic? Will the mass flow rate of the fluid increase, decrease, or remain constant as a result of increasing the duct length.?
3. Consider supersonic Fanno flow of air with an inlet Mach number of 1.8. If the Mach number decreases to 1.2 at the duct exit as a result of friction, does the (a) stagnation temperature T_0, (b) stagnation pressure P_0, and (c) entropy s of the fluid increase, decrease, or remain constant during this process?
4. What is the characteristic aspect of Fanno flow? What are the main approximations associated with Fanno flow?
5. Air enters a 12-cm-diameter adiabatic duct at Ma_1=0.4, T_1=550 K, and P_1= 200 kPa. The average friction factor for the duct is estimated to be 0.021. If the Mach number at the duct exit is 0.8, determine the duct length, temperature, pressure, and velocity at the duct exit.



6. Air enters a 15-m-long, 4-cm-diameter adiabatic duct at V_1=70 m/s, T_1=500 K, and P_1=300 kPa. The average friction factor for the duct is estimated to be 0.023. Determine the Mach number at the duct exit, the exit velocity, and the mass flow rate of air.
7. Consider the adiabatic flow of air through a pipe of 0.2-ft inside diameter and 3-ft length. The inlet flow conditions are M_1 = 2.5, P_1 = 0.5 atm. And T_1 = 52OR. Assuming the local friction coefficient equals a constant of 0.005, calculate the following flow conditions at the exit: M_2, P_2, T_2, and P_{02}?.

8. Air enters a 5-cm-diameter, 4-m-long adiabatic duct with inlet conditions of $Ma_1 = 2.8$, $T_1 = 380$ K, and $P_1 = 80$ kPa. It is observed that a normal shock occurs at a location 3 m from the inlet. Taking the average friction factor to be 0.007, determine the velocity, temperature, and pressure at the duct exit.



9. Helium gas with k=1.667 enters a 6-in-diameter duct at Ma_1=0.2, P_1=60 psia, and T_1=600 R. For an average friction factor of 0.025, determine the maximum duct length that will not cause the mass flow rate of helium to be reduced.
10. Air enters a 15-cm-diameter adiabatic duct with inlet conditions of V_1 = 150 m/s, T_1 = 500 K, and P_1 = 200 kPa. For an average friction factor of 0.014, determine the duct length from the inlet where the inlet velocity doubles. Also determine the pressure drop along that section of the duct.
11. The stagnation chamber of a wind tunnel is connected to a high-pressure air bottle farm which is outside the laboratory building. The two are connected by a long pipe of 4-in inside diameter. If the static pressure ratio between the bottle farm and the stagnation chamber is 10, and the bottle-farm static pressure is 100 atm, how long can the pipe be without choking? Assume adiabatic, subsonic, one-dimensional flow with a friction coefficient of 0.005.
12. Air in a room at T_0 = 300 K and P_0 = 100 kPa is drawn steadily by a vacuum pump through a 1.4-cm-diameter, 35-cm-long adiabatic tube equipped with a converging nozzle at the inlet. The flow in the nozzle section can be approximated as isentropic, and the average friction factor for the duct can be taken to be 0.018. Determine the maximum mass flow rate of air that can be sucked through this tube and the Mach number at the tube inlet.