SPC 407
Sheet 5
Compressible Flow – Rayleigh Flow

1. Consider subsonic Rayleigh flow of air with a Mach number of 0.92. Heat is now transferred to the fluid and the Mach number increases to 0.95. Does the temperature T of the fluid increase, decrease, or remain constant during this process? How about the stagnation temperature T_0?
2. Consider subsonic Rayleigh flow that is accelerated to sonic velocity (Ma = 1) at the duct exit by heating. If the fluid continues to be heated, will the flow at duct exit be supersonic, subsonic, or remain sonic?
3. Argon gas enters a constant cross-sectional area duct at $Ma_1 = 0.2$, $P_1 = 320$ kPa, and $T_1 = 400$ K at a rate of 1.2 kg/s. Disregarding frictional losses, determine the highest rate of heat transfer to the argon without reducing the mass flow rate.
4. Air is heated as it flows subsonically through a duct. When the amount of heat transfer reaches 67 kJ/kg, the flow is observed to be choked, and the velocity and the static pressure are measured to be 680 m/s and 270 kPa. Disregarding frictional losses, determine the velocity, static temperature, and static pressure at the duct inlet.
5. Compressed air from the compressor of a gas turbine enters the combustion chamber at $T_1 = 700$ K, $P_1 = 600$ kPa, and $Ma_1 = 0.2$ at a rate of 0.3 kg/s. Via combustion, heat is transferred to the air at a rate of 150 kJ/s as it flows through the duct with negligible friction. Determine the Mach number at the duct exit, and the drop in stagnation pressure $P0_1 - P0_2$ during this process.
6. Air flows with negligible friction through a 4-in diameter duct at a rate of 5 lbm/s. The temperature and pressure at the inlet are $T_1 = 800$ R and $P_1 = 30$ psia, and the Mach number at the exit is $Ma_2 = 1$. Determine the rate of heat transfer and the pressure drop for this section of the duct.

7. Consider a 16-cm-diameter tubular combustion chamber. Air enters the tube at 450 K, 380 kPa, and 55 m/s. Fuel with a heating value of 39,000 kJ/kg is burned by spraying it into the air. If the exit Mach number is 0.8, determine the rate at which the fuel is burned and the exit temperature. Assume complete combustion and disregard the increase in the mass flow rate due to the fuel mass.
8. Consider supersonic flow of air through a 7-cm-diameter duct with negligible friction. Air enters the duct at $Ma_1 = 1.8$, $P0_1 = 140$ kPa, and $T0_1 = 600$ K, and it is decelerated by heating. Determine the highest temperature that air can be heated by heat addition while the mass flow rate remains constant.