Assignment-10

1. Air being released from a tyre through its valve is found to have a temperature of $15^{o}C$. Assuming that the air in the tyre is at the ambient temperature of $30^{o}C$, find the velocity of the air at the exit of the valve. The process can be assumed to be adiabatic. (Ans.173.6m/s.)
2. A gas with a molecular weight of 4 and a specific heat ratio of 1.67 flows through a variable area duct. At some point in the flow, the velocity and temperature respectively are 180 m/s and $10^{o}C$. At some other point in the flow, the temperature is $-10^{o}C$. Find the velocity at this point in the flow assuming that the flow is adiabatic. (Ans. 489.5 m/s)
3. At a section of a circular duct through which air is flowing, the pressure is 150 kPa, the temperature is $35^{o}C$, the velocity is 250 m/s, ans the diameter is 0.2m. If, at this section, the duct diameter is increasing at a rate of 0.1 m/m. find dp/dx, dV/dx, and dρ/dx (214.2 kPa/m, 505.5 s^{-1}, 1.73 kg/m^4)
4. Calculate the speed of sound at 288 K in hydrogen, helium, and nitrogen. Under what conditions will the speed of sound in hydrogen be equal to the helium? (Ans. 1294.6 m/s, 915.4 m/s, 346.0 m/s. $T_{He}=1.68T_{H2}$ (in Kelvin).
5. A very weak pressure wave, i.e., a sound wave, across which the pressure rise is 30 Pa moves through air which has a temperature of $30^{o}C$ and a pressure of 101 kPa. Find the density change, the temperature change, and the velocity change across this wave. (Ans: 2.46 x $10^{-4}kg/m^3$, 0.0259 K, 0.074 m/s)
6. An airplane is travelling at 1500 km/h at an altitude where the temperature is $-60^{o}C$. What is the Mach at which the airplane is flying? (Ans 1.139)
7. An airplane can fly at a speed of 800 km/h at sea-level where the temperature is $15^{o}C$. If the airplane flies at the same Mach number at an altitude where the temperature is $-44^{o}C$, find the speed at which the airplane is flying at this attitude. (Ans: 713.4 km/hr)
8. The test section of a supersonic wind tunnel is square in cross-section with a side length of 1.22m. The Mach number in the test section is 3.5, the temperature is $-100^{o}C$, and the pressure is 20 kPa. Find the mass flow rate of air through the test section. (Ans: 376.8 kg/s)
9. Air flows through a convergent—divergent duct with an inlet area of $5cm^2$ and an exit area of 3.8 cm^2. At the inlet section the air velocity is 100 m/s, the pressure is 680 kPa, and the temperature is $60^{o}C$. Find the mass flow rate through the nozzle and, assuming isentropic flow, the pressure and velocity at the exit section. (Ans: 0.391 kg/s, 159.7 m/s or 492.1 m/s)
10. The exhaust gases from a rocket engine can be assumed to behave as a perfect gas with a specific heat ratio of 1.3 and a molecular weight of 32. The gas is expanded from the combustion chamber through the nozzle. At a point in the nozzle where the cross- sectional area is $0.2m^2$ the pressure, temperature and mach number are 1500 kPa, $800^{o}C$, and 0.2 respectively. At some other point in the nozzle, the pressure is found to be 80 kPa. Find the Mach number.
    (Ans: M=2.554)
11. A pitol-static tube is placed in a subsonic air flow. The static temperature and pressure in the air flow are $30^{o}C$ and 101 kPa, respectively. The difference between the pitot and static pressure is measured using a manometer and is found to be 250mm of mercury. Find the air velocity, assuming the flow to be incompressible and taking compressibility effects into account.
    (Ans: 239.5 m/s, 227.1 m/s)

12. A pitot tube indicates a pressure of 155 kPa when placed in an air stream in which the temperature is 15°C and the Mach number is 0.7. Find the static pressure in the flow. Also find the stagnation temperature in the flow.
    (T_o = 316.2 K)
13. A conical diffuser has an inlet diameter of 15 cm. The pressure temperature and velocity at the inlet to the diffuser are 70 kPa, 60°C, and 180 m/s respectively. If the pressure at the diffuser exit is 78 kPa, find the exit diameter of the diffuser. (18.75 cm)
14. When an aircraft is flying at subsonic velocity, the pressure at its nose, i.e., at the stagnation point, is found to be 160 kPa. If the ambient pressure and temperature are 100 kPa and 25°C respectively, find the speed and the Mach
    (Ans: 0.848, 293.3 m/s)