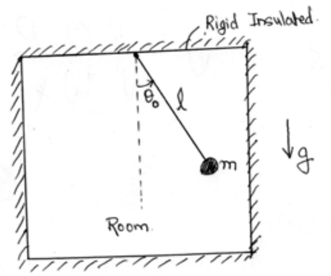
Aerodynamics II (AE-311) (2019-20 – I Semester)

Assignment 1 (Due date: August 23, 2019)

Problem1: Show that $\left(\frac{\partial p}{\partial \rho}\right)_s = \gamma \left(\frac{\partial p}{\partial \rho}\right)_T$. Verify this for a perfect gas.

Problem 2: A simple pendulum is placed in a heat-insulated, rigid container. At t = 0 the pendulum is allowed to begin to oscillate from an initial displacement. What is the change of entropy of the system between the initial and the final state, i.e., the state after the motion has subsided.



Problem 1:

Show that the mass flow rate of a calorically perfect gas through a chocked nozzle is given by

$$\dot{m} = \frac{p_0 A^*}{\sqrt{T_0}} \sqrt{\frac{\gamma}{R}\left(\frac{2}{\gamma+1}\right)^{(\gamma+1)/(\gamma-1)}}$$

Problem 2:

A supersonic wind tunnel nozzle is to be designed for M = 2 with a throat section 1m^2 in area. The supply pressure and the temperature at the nozzle inlet, where the velocity is negligible, are 7×10^5 N/m^2 and 40^{o}C, respectively. The preliminary design is to be based on the assumption that the flow is one dimensional at the throat and the test section. Compute the mass flow, the test section area, and the fluid properties at the throat and the test section.

Problem 3:

Air at 300^{o}K and 10^5 N/m^2 enters a diffuser with a velocity of 245 m/s. The diffuser is to be designed to reduce the velocity of the air to 60 m/s. The mass flow rate through the diffuser is 13.6 kg/s. Assuming the flow to be isentropic, determine (a) inlet diameter, (b) outlet diameter, and (c) rise in static temperature and pressure.

Problem 4:

Air flows isentropically through a converging nozzle. At a section where the nozzle area is 1.2×10^{-3} m^2, the local pressure, temperature, and Mach number are 400 kPa, 5^{o}C, and 0.52, respectively. The back pressure is 200 kPa. The Mach number at the throat, the mass flow rate, and the throat area are to be determined using (a) isentropic flow relations and (b) tables for isentropic flow.

Problem 5:

Air at a temperature of 284 K and atmospheric pressure flows isentropically through a convergent-divergent nozzle. The velocity at the inlet is 150 m/s and the inlet area is 10 cm^2. If the flow at the nozzle exit is supersonic, find (a) the Mach number at the inlet, (b) stagnation temperature and pressure, (c) the temperature and pressure at the throat, (d) the mass flow rate, the velocity and Mach number at the exit if T_{exit} = 220 K, and (f) the area at the throat.

Problem 6:

Consider a convergent-divergent nozzle with exit and throat areas of 0.5 m^2 and 0.25 m^2, respectively. The inlet reservoir pressure is 1 atm and the exit static pressure is 0.6 atm. For this pressure ratio, the flow will be supersonic in a portion of a nozzle, terminating with a normal shock inside the nozzle. Calculate the local area ratio (A/A^*) at which the normal shock is located inside the nozzle.