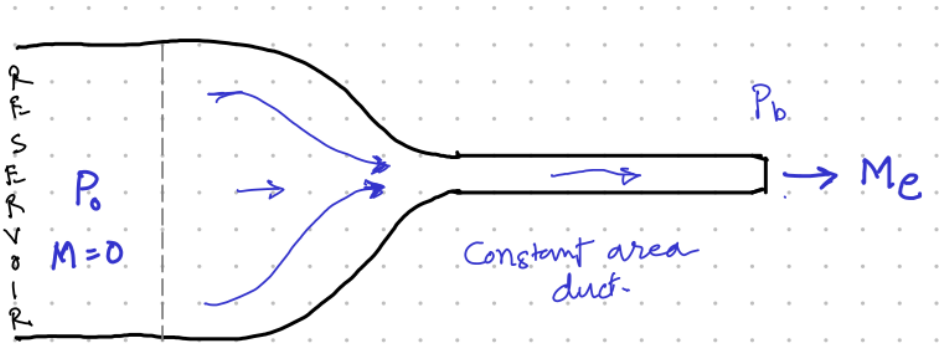
My first quiz

1. **convergingDuct**



Consider the converging duct shown above. For a fixed reservoir pressure (p_0), the exit Mach number (M_e) can be changed by reducing the back pressure (p_b). Plot a graph of $p_b/p_0 \in [0, 1]$ versus massflow rate ($\dot{m}$). Clearly mark the point on the graph at which $M_e = 1$.

Notes: (not included in XML)

- Long answer.

2. **energyEquation**

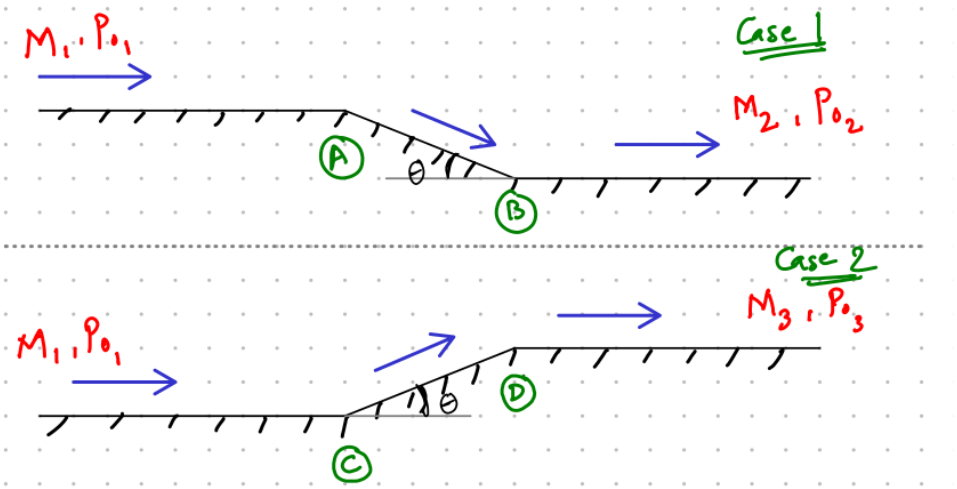
Show that the energy equation for inviscid adiabatic isentropic flow can be written as

$$\frac{u^2}{2} + \frac{\gamma}{\gamma - 1}\left(\frac{p_0}{\rho_0}\right)\left(\frac{p}{p_0}\right)^{(\gamma-1)/\gamma} = \frac{\gamma}{\gamma - 1}\frac{p_0}{\rho_0}$$

Notes: (not included in XML)

- Long answer.

3. **obliqueShockExpansionFan-numerical**



A supersonic flow at $M_1 = 2 + 0.1\Omega$ passes over a wall in two scenarios. In case 1, it reaches Mach number M_2 and total pressure p_{0_2}. In case 2, it reaches Mach number M_3 and total pressure p_{0_3}. Please note that the diagram shows two different cases. DO NOT consider it as a duct.

(a) Correctly identify the flow phenomenon at points A, B, C and D.

(b) Calculate M_2.

(c) Calculate M_3.

(d) Calculate p_{0_2}/p_{0_3}

(e) Which flow pattern is preferable and why?

It is given that $\theta = 10^o$. Ω is equal to the last digit of your SC number. For example, if your SC number is SC18B023, then $\Omega = 3$.

Notes: (not included in XML)

- Long answer.

4. **diamondShock**

Neatly draw the flow pattern after the exit of a C-D nozzle for the

(a) Under expanded flow

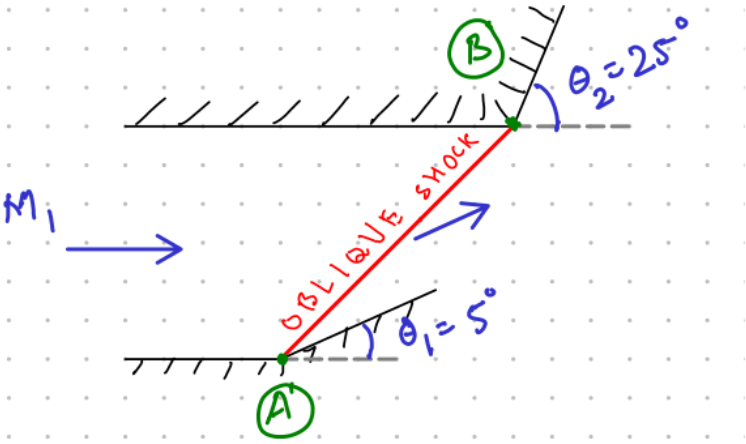
(b) Over expanded flow

Clearly show the slipstream, oblique shocks and expansion fans. Clearly identify regions with static pressures equal to p_e and p_b. Here, p_b is back pressure and p_e is exit pressure.

Notes: (not included in XML)

- Long answer.

5. **shockReflection-numerical**



Consider the flow as shown in figure with $M_1 = 2 + 0.1\Omega$. An oblique shock generated at corner A is reflected at corner B. Angles $\theta_1 = 5^o$ and $\theta_2 = 25^o$. What is the static pressure experienced by the upper wall after point B? The inlet pressure $p_1 = 1$ bar and temperature is $T_1 = 298$ K.

Ω is equal to the last digit of your SC number. For example, if your SC number is SC18B023, then $\Omega = 3$.

Notes: (not included in XML)

- Long answer.

6. **thinAirfoil-Cl-derivation**

Using thin airfoil theory, show that the coefficient of lift only depends on the angle of attack (α) for a general thin airfoil with camber variation $c(x)$ and thickness variation $t(x)$.

Notes: (not included in XML)

- Long answer.

7. **fannoFlow-massflowrate**

   Consider two constant area ducts (with friction) of equal area kept in the same flow. These ducts (A and B) are kept so far apart that they do not affect each other. Also given that $L_A < L_B$, where L is the length of the duct. Under what conditions will the following relations for massflow rate hold true.

   (a) $\dot{m}_A = \dot{m}_B$

   (b) $\dot{m}_A > \dot{m}_B$

   Answers without explanation will not be graded.

   Notes: (not included in XML)

   - Long answer.

8. **rayleightFlow-numerical**

   Air at a total pressure and temperature of 8 atm and 450 K enters a frictionless constant cross-section duct. A heat addition of 850 kJ/kg makes the flow to choke at the duct exit, determine the inlet Mach number and the total pressure and total temperature at the exit.

   Notes: (not included in XML)

   - Long answer.