Supersonic Pre-Lab

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Question 1.

- A) Light source and first mirror
  - **Yes**, it is important, so that the light is properly collimated into parallel rays.
  - The light source must be at the focal point of the mirror.
  - Hence, $d_A = 762\ \text{mm}$.
- B) First and second mirrors
  - **No**.
  - Assuming that the difraction index field can be placed arbitrarily between the two mirrors, the deflection can always be contained within the domain of the mirrors.
  - The light is collimated, so there are no focusing or disperson effects that we need to account for.
  - Hence, the separation is NOT important.
- C) Second mirror and knife edge
  - **Yes**, the distance between the second mirror and the knife edge is important as we want the knife edge to be placed at the focal point of the incoming light rays to allow for the transmittance of ONLY the disturbed light.
  - The blade should be placed at the focal length of the second lens which is $d_C = 762\ \text{mm}$.

Question 2.

Use the isentropic pressure relation. The stagnation conditions are equal to atmospheric conditions (Pressure 101.325 kPa, Specific Heat Ratio 1.4).

$$\frac{P_\circ}{P} = \left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{\gamma}{\gamma - 1}}$$

The maximum possible pressure resulting in sonic flow at the throat would resuilt in $M = 1$ at nozzle exit. Therefore, we can solve for P imposing $M = 1$.

$$\frac{1\ \text{atm}}{P} = \left(1 + \frac{(1.4) - 1}{2} (1)^2\right)^{\frac{(1.4)}{(1.4) - 1}}$$

$$P = 0.528\ \text{atm} = \boxed{53.5\ \text{kPa}}$$

That is, the pressure at the exit cannot exceed 0.528 atm in order to maintain sonic flow at the throat.