Problem Set 4, Coding Questions

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1 Q1

The ratio between the densities are given by this formula:

$$\frac{\rho_1}{\rho_2} = \frac{\gamma - 1}{\gamma + 1} \tag{1}$$

$$\implies \rho_2 = \rho_1 \left(\frac{\gamma + 1}{\gamma - 1} \right) \tag{2}$$

$$\implies \rho_2 = 4\rho_1 \tag{3}$$

This is consistent with what we observed in the simulation.

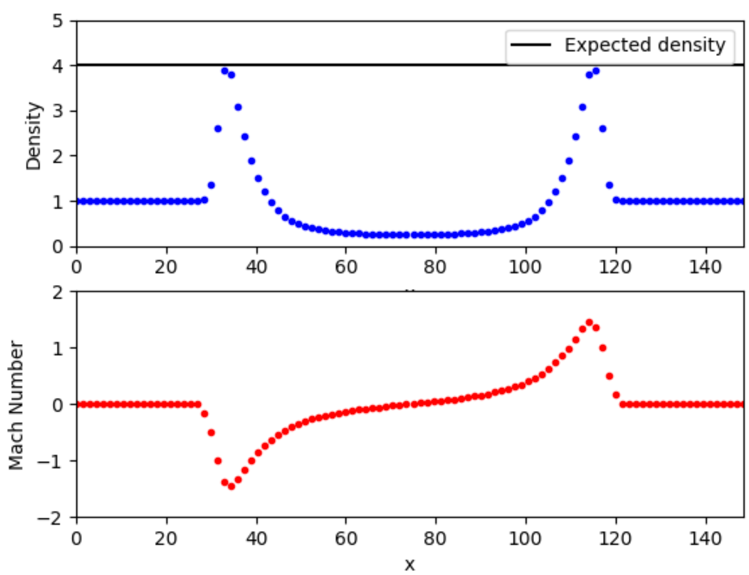

Figure 1: Density and Mach number as a function of position. The expected post-shock density is shown using a black line at $\rho = 4$. The density does indeed reach the expected value.

2 Q2

The width of a shock is given by this expression:

$$\Delta x = \frac{\nu}{U} \tag{4}$$
$$\propto \frac{\nu}{\mathcal{M}} \tag{5}$$
$$= \frac{dx^2}{2dt\mathcal{M}} \tag{6}$$

By varying dx and dt, and observing the width of the resulting waves, we should be able to confirm the relationship above.

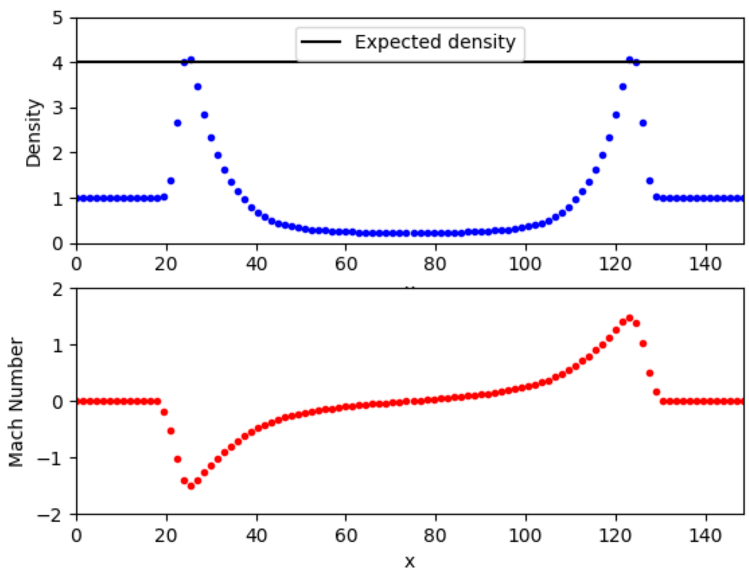

Figure 2: Base case with $dx = 1.5$ and $dt = 0.012$. The width is of approximately 10 units.

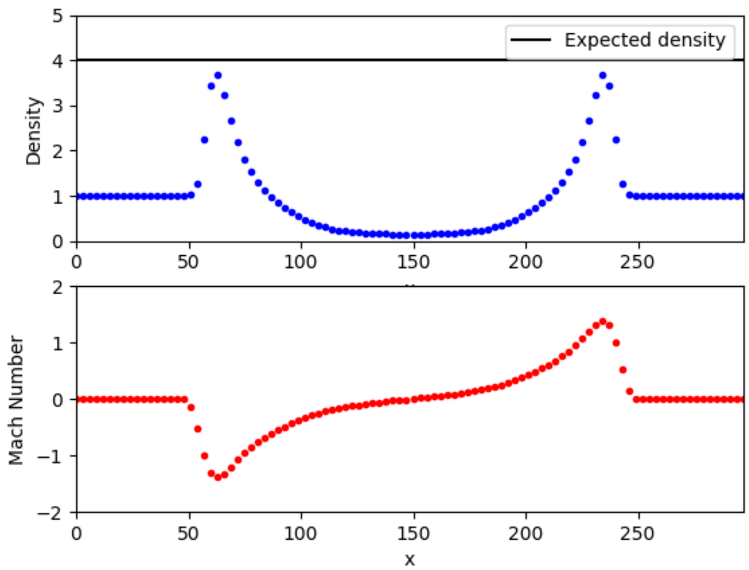

Figure 3: Here, dx has been doubled, leading to a width of 40 units, which is four times the original width.

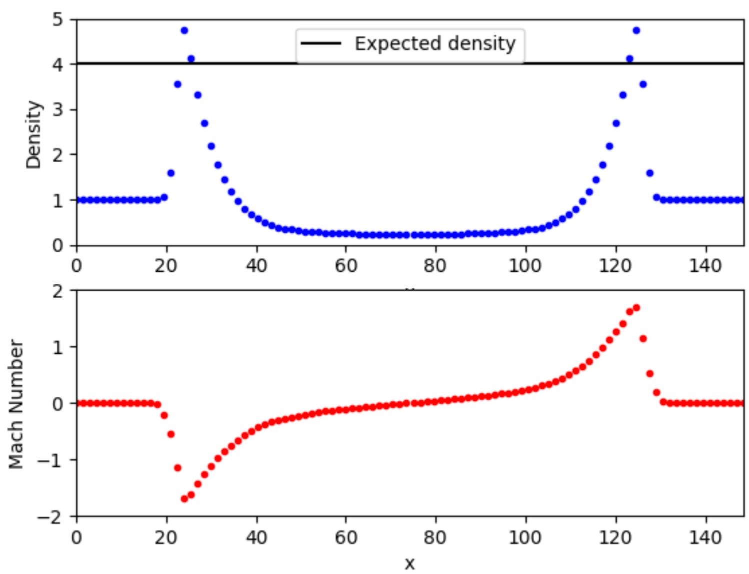

Figure 4: In this simulation, dt was doubled compared to the original case. This leads to an increase in the height of the shock with no change in the width. Rescaling the shock such that it recovers its original height would lead to a width divided by two.

We can conclude that the width of the the shock has the expected dependencies on dx and dt.