Problem 1 (18 pts)

Your research advisor doesn't know what he is doing and thinks that oblique-shock strength is only dependent on β. Using $\frac{p_2}{p_1}$ as a metric of shock "strength", come up with a way to graphically show the relationship between the β **and** $M_{1,\infty}$ effects on oblique-shock strength. You may assume $\gamma = 1.4$ and a weak-shock solution. You must ensure that your data plotted is physically possible for a straight, attached, left-running shock. Write a paragraph or two discussing your findings.

Problem 2 (52 pts)

The following pages each show a supersonic shape travelling from right-to-left. They are: (1) a flat plate at zero angle of attack, (2) a flat plate at positive angle of attack, (3) a diamond wedge, (4) a biconvex, and (5) a diamond-block. You may assume isentropic flow everywhere other than for the shock waves and that all geometric points are "aerodynamically sharp". For each, you are asked to do the following tasks. You can justify your answers as you see fit. Your plots should indicate similarities/changes relatively to scale.

(a - 10 pts.) Draw/label all of the shock waves observed on the body.

(b - 10 pts.) Plot the freestream pressure you would measure at the surface from upstream to downstream of the body. For the flat plate at angle of attack, please plot the pressure on both the top and bottom surfaces with different color and/or marker type.

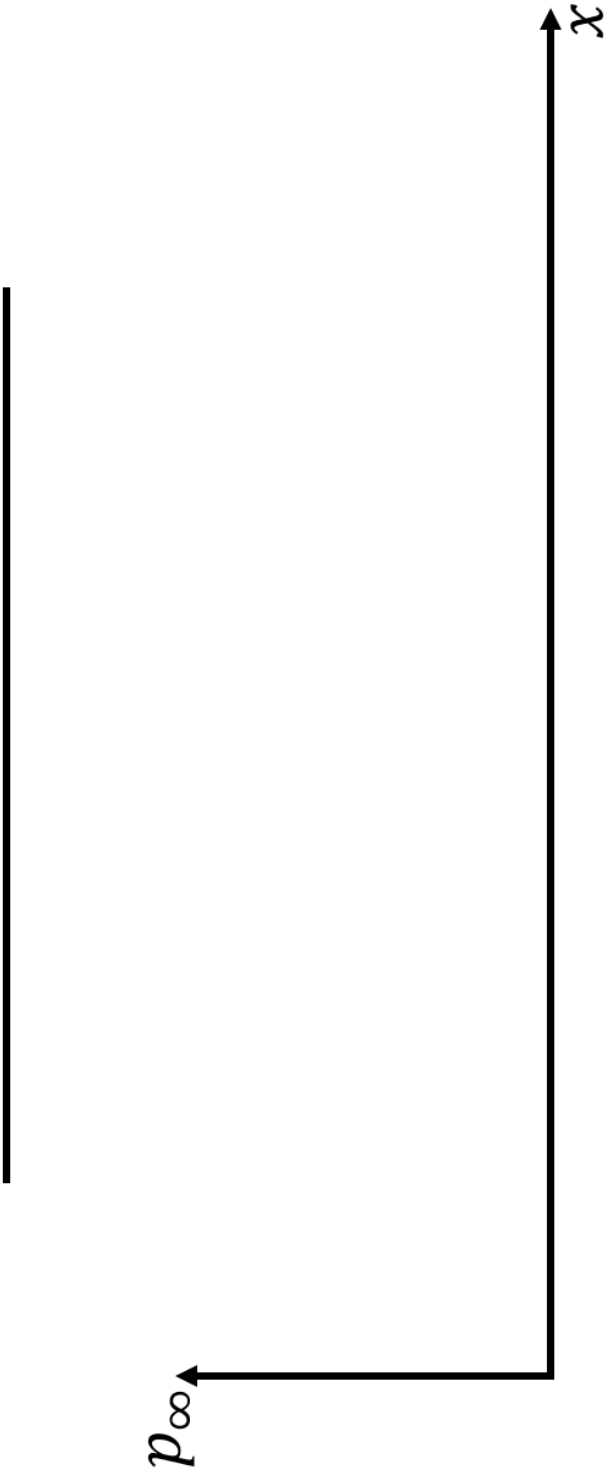
(c - 10 pts.) On the same plot (with different color and/or marker type), plot the pressure (if different) if the body is pitched slightly upward (i.e., less than any of the body's governing half angle). Show for both the top and bottom of the geometries.

(d - 10 pts.) On the same plot (with different color and/or marker type), plot the pressure (if different) if the body is moving at a larger Mach number.

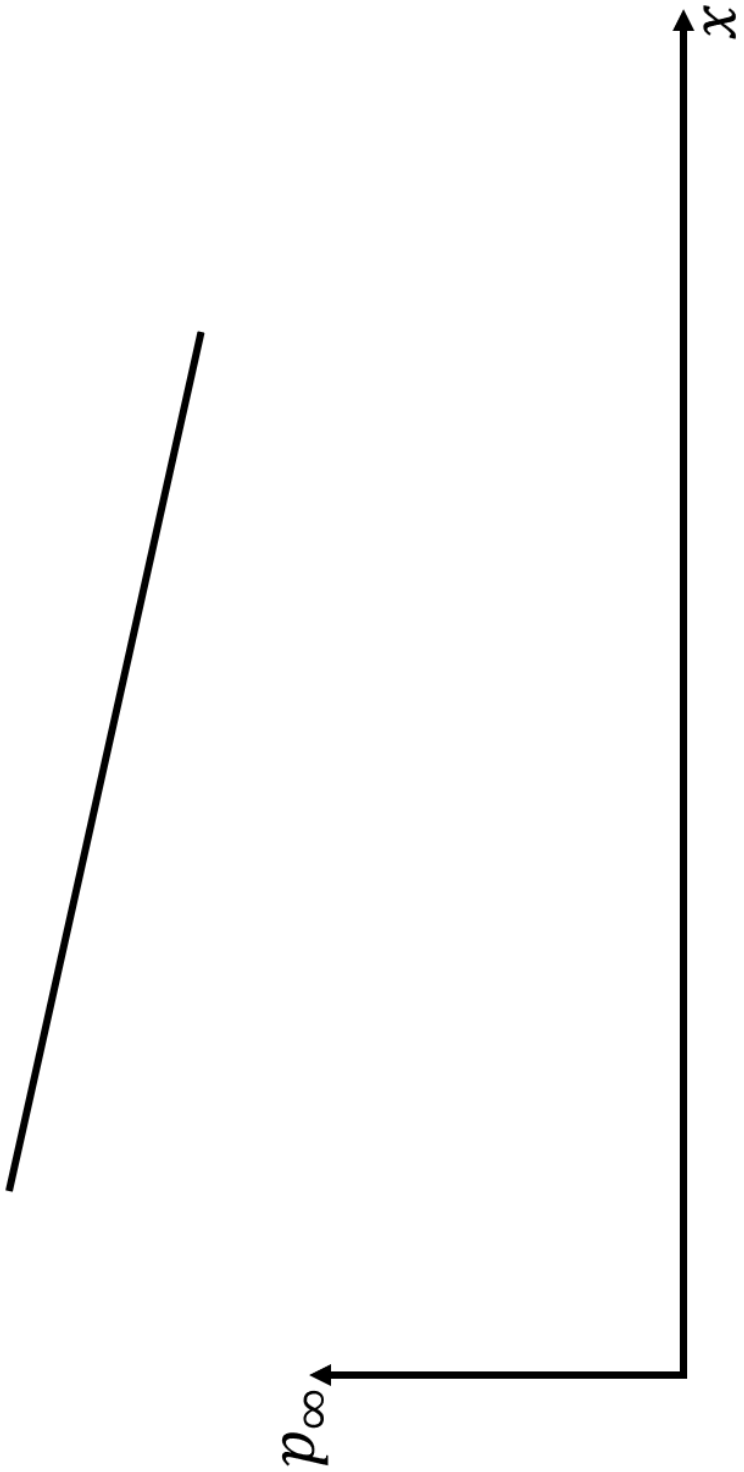
(e - 2 pts.) Would any of your original plots from part (b) change if you were instead taking measurements on the ground as the body flew overhead? Here you may assume that the body is flying low to the ground so shocks will not interact. Briefly justify your answer.

(f - 10 pts.) Will any of the bodies create lift or have drag? Briefly justify your answer.

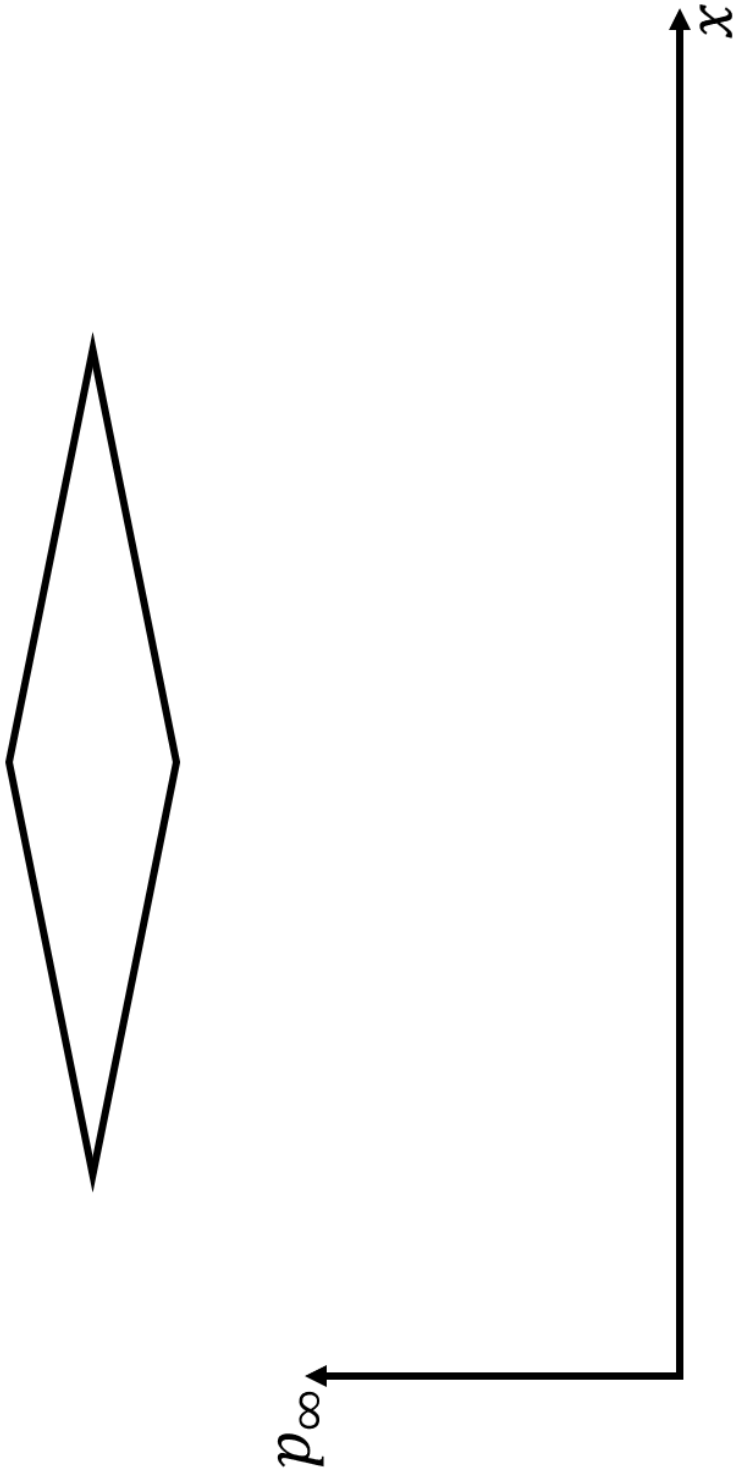
Homework 5



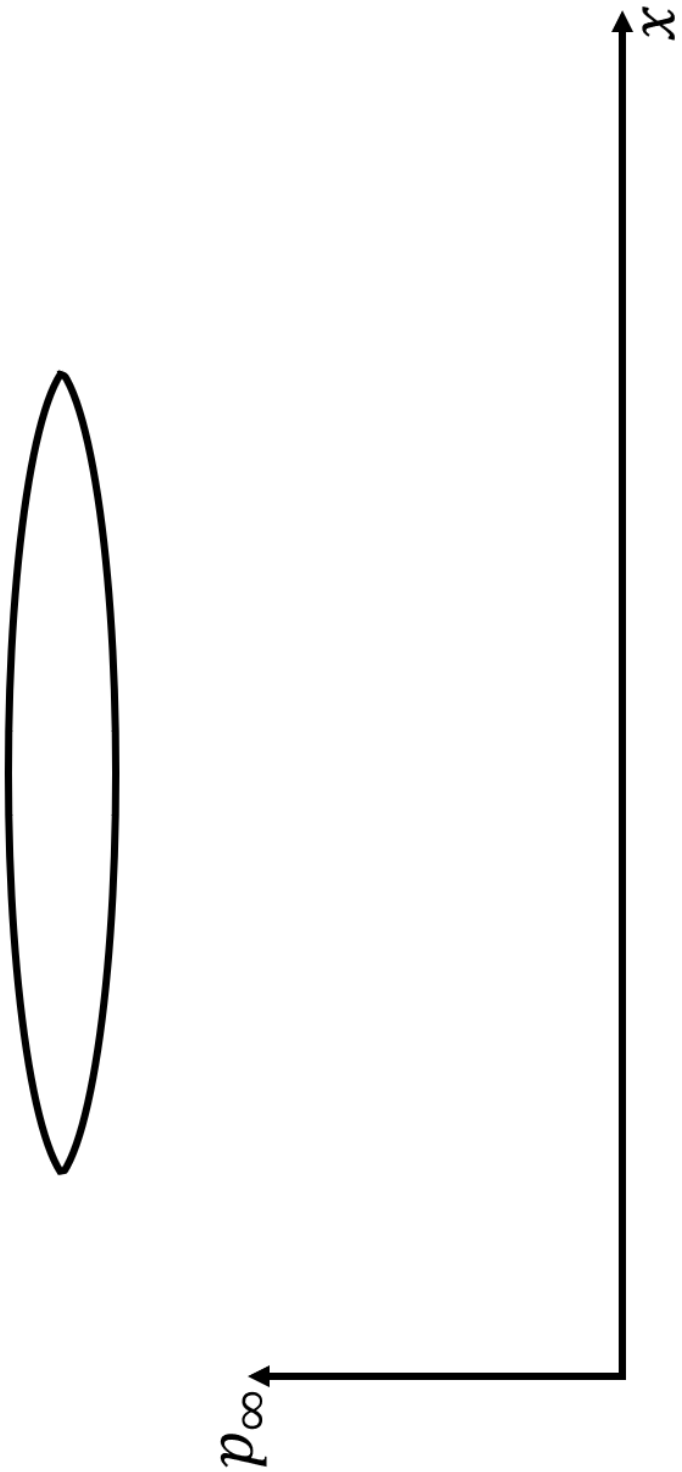
Homework 5

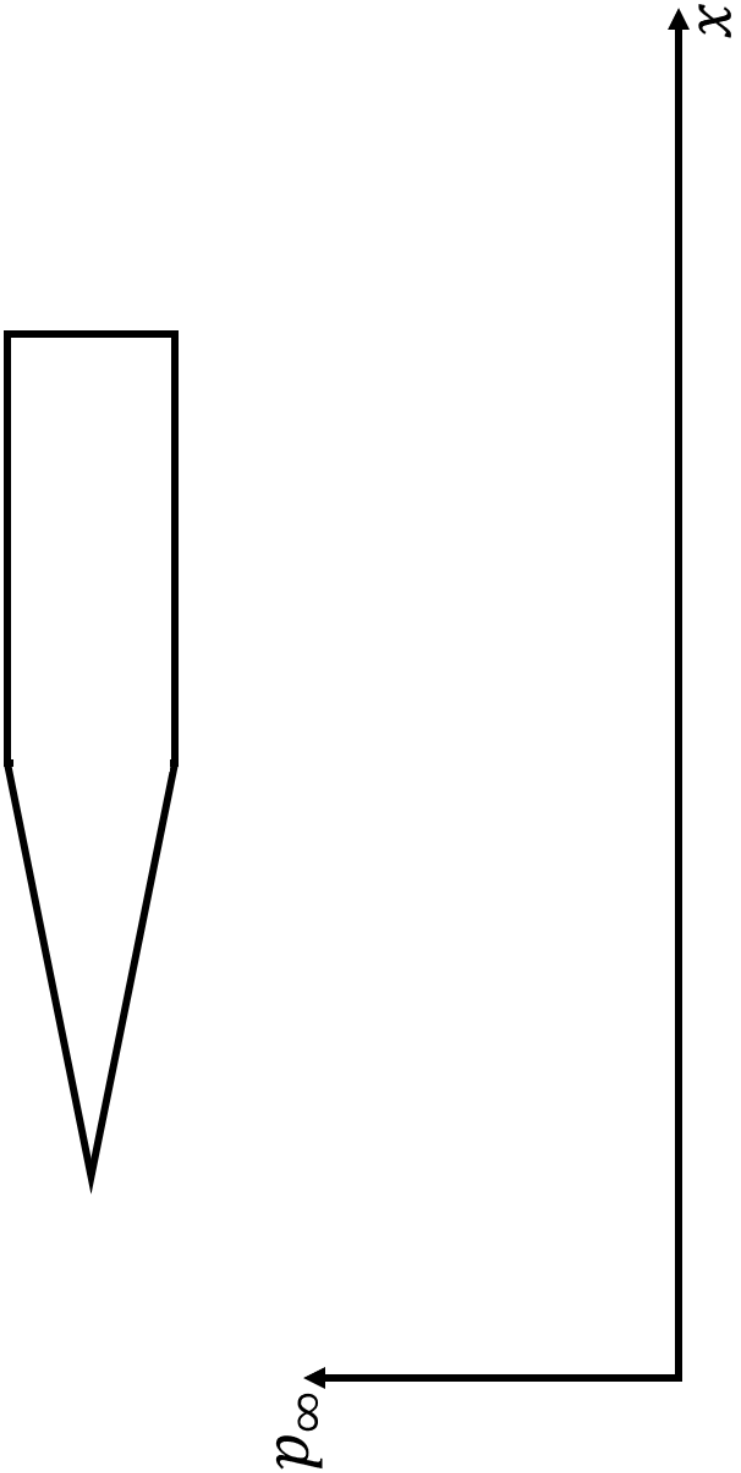


Homework 5



Homework 5




x
p_∞

Problem 3 (30 pts)

The schematic below illustrates a representative intersection of shock waves of opposite families, as discussed in lecture. This is representative of certain supersonic inlets (e.g., the F-15). Calculate the freestream pressure in regions 4 and 4' and the flow direction Φ behind the refracted shocks for $M_1 = 3$, $p_1 = 1$ atm, $\theta_2 = 20°$, and $\theta_3 = 15°$. You can use any iterative technique you'd like to solve.

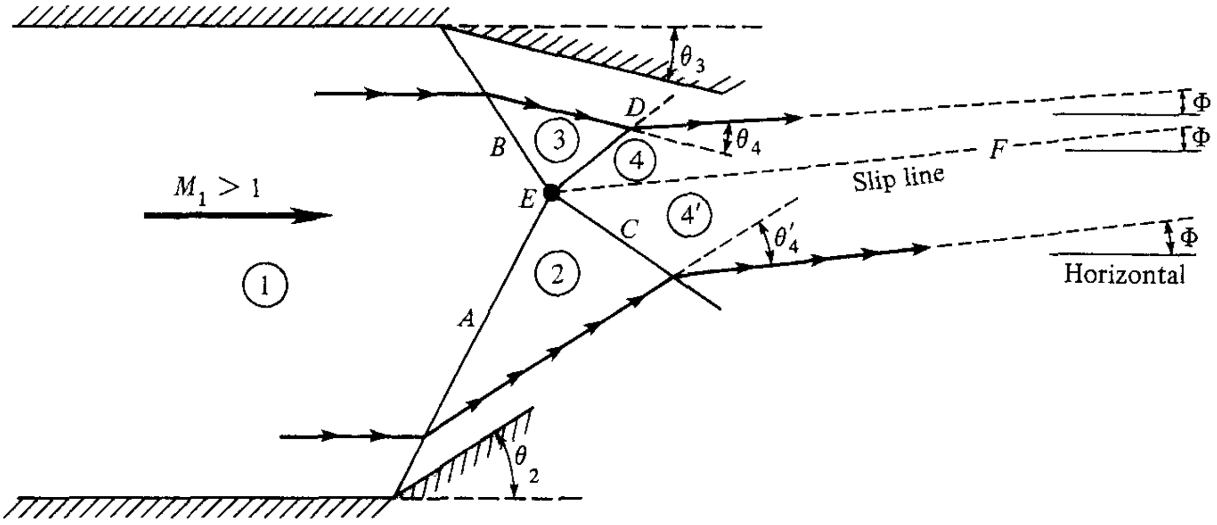


Figure 4.23 | Intersection of shocks of opposite families.