

Announcements

This assignment is due at the beginning of the APC meeting on **Sunday, September 27**. Bring written work and be ready to present at least one solution.

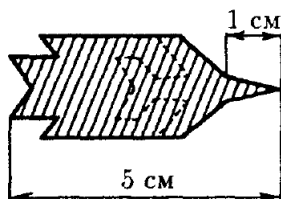
How to work

For each problem, show your assumptions and reasoning, not only the final answer. For an estimate, an answer within an order of magnitude is usually enough: explain how you chose the relevant length, mass, time, or speed scales. When relevant, check various limiting cases and the dimensions of the formulas you obtain.

Problems

Solve all unstarred problems. The starred problem is a challenge problem.

1. An important skill for any physicist is to quickly estimate some quantity without a detailed calculation. In this set of problems you are asked for an *estimate*, which means that it is totally fine to be wrong by a factor of ~ 10 . You can search for some background information as needed, but try to use your intuition and common sense first. Don't be afraid to make guesses in some of the intermediate steps, especially if you are unsure how to proceed. For inspiration and more problems of this kind, search for *Fermi estimate problems*.
 - (a) Recent satellite measurements show that the North American continent is slowly drifting at a rate of about 1 cm per year. Assuming the continent is roughly 50 km thick, estimate the kinetic energy the continental US has due to this motion. How does this energy compare to the kinetic energy of a person walking?
 - (b) Estimate the mass of a black hole the size of a pebble.
2. The figure shows a blurred photograph of a moving airplane. The actual airplane is 30 m long, and its nose is 10 m long. The dashed outline shows the airplane's position at one end of the 0.10 s exposure. Use the scale in the figure to determine the airplane's speed.



3. A particle travels the first half of a distance at constant speed v_0 . During the time required to travel the remaining half, it moves at speed v_1 for the first half of that time and at speed v_2 for the second half. Find its average speed over the entire journey.
4. Athletes form a line of length l and run together with speed v in the direction along this line. A coach runs towards them with speed $u < v$. Upon meeting the coach each athlete instantly turns around and starts running in the opposite direction with the same speed v . What will be the length of the line of athletes after they all turn around?
- 5.★ A billiard table has length a and width b . A ball is launched from the middle of the side b at some angle α to that side. Find all α such that after several collisions the ball returns exactly to the initial point.