ADVANCED PHYSICS CLUB

SEPTEMBER 24, 2023

Useful resources

The updates, homework assignments, and useful links for APC can be found on SchoolNova's web page:
`https://schoolnova.org/nova/classinfo?class_id=adv_phy_club&sem_id=ay2023`
The practical information about the club and contacts can be found on the same web page.

Today's meeting

Today we welcomed all the participants into the club, discussed the normal form of operation and then had fun with some qualitative physics questions.

The first homework is on kinematics of uniform motion. Please solve the problems at home! During the club meeting we will only have time to discuss the solutions that you already have. You can also think in advance which problem(s) you may want to present at our the meeting.

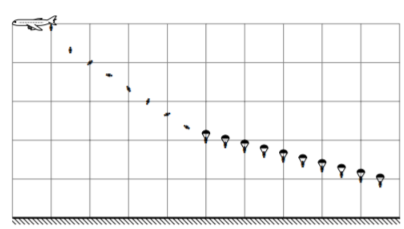
Problems are listed in no particular order. Problems marked with a star are somewhat more challenging. If you feel like you need some clarification about the formulation of any problem, you are always welcome to email apc@schoolnova.org

Homework

1. Jack and John participate in a running competition. They are supposed to run 3 km. Jack got tired after running 3/4 of the distance and walked the rest of the distance sometimes stopping for rest. John only ran 1/4 of the distance and then walked without stopping. They finished at the same time. For how long did Jack stop in total? Both of them run with speed 12 km/h and walk with speed 6 km/h.

2. Athletes run one behind another as one line of length l with velocity v. A coach runs towards them with velocity $u < v$. Upon coming up to the coach each athlete instantly turns around and starts running in the opposite direction with the same speed v. What will the length of the line of athletes be after they all turn around?

3. An airplane full of skydivers flies horizontally with a constant speed. Skydivers jump out of the plane keeping the constant time interval after the previous skydiver. They very quickly reach constant (and same for all of them) terminal speed v and move with it until opening the parachute. After opening the parachute at some particular height their speed quickly becomes u (also the same for all of them). The arrangement of skydivers is shown on the figure. Assuming they move strictly vertically, find ratio of speeds $\frac{v}{u}$.

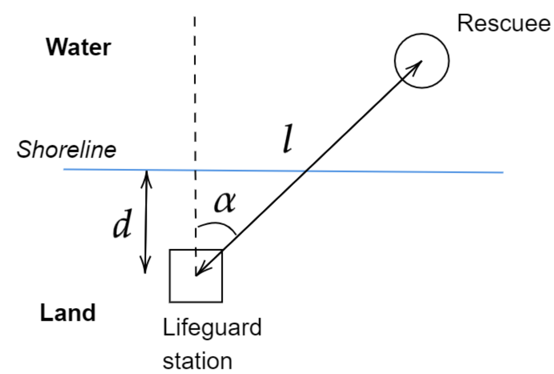


4. It's raining and the rain drops are falling down vertically with velocity u. A round ball (say, a soccer ball) is rolling horizontally on the ground with velocity v. How many times more rain drops will fall on this ball compared to a second ball, the same size as the first but lying still, during the same amount of time? Would the answer be different, if the ball wasn't round (say, a football)?

***5.** A bus is moving on a straight road with constant speed v. You have noticed the bus when it was at some point A. Find the shape of the region from which you can still catch the bus (by arriving to a point on the road earlier or at the same time as the bus). You can run with speed $u < v$.

***6.** Four turtles are initially located in the vertices of a square with side a. They start moving at the same time with constant speed v. Each turtle always moves in the direction towards its clockwise neighbor. Where and after what time will the turtles meet? What if there were three turtles in the vertices of an equilateral triangle?

7. In a water rescue operation a lifeguard has to run to the shoreline and then swim to the rescuee as fast as possible. The lifeguard can run with speed v which is larger that the swimming speed u. If the rescuee happens to be right in front of a lifeguard tower the optimal choice of a trajectory is clear - run and then swim along the same straight line, at 90° to the shoreline. But what happens if the rescuee is at some angle (see figure)?



(a) Draw the optimal trajectory *qualitatively*.

(b) (optional intermediate step) There is a very important condition the optimal trajectory must satisfy which can be formulated without finding the trajectory explicitly but it defines the trajectory unambiguously. What is this condition?

*(c) Find the optimal trajectory explicitly, given the angle α, distance l and distance from the lifeguard tower to the shore d.

FOR THE NEXT MEETING

IMPORTANT: The next club's meeting is at 3:30pm, via Zoom, on Sunday, **October 1**.