Physics 1A: Mechanics
Winter 2016

Discussion: Week 2

Agnieszka Wergieluk
Graduate TA
awergieluk@ucla.edu
Office hours: Mondays, Tuesdays, Wednesdays 4-7 p.m. *by appointment!*
(Alternatively, just e-mail me your questions.)

Problem 1

a) A body travels in a straight line with a constant acceleration a. At $t = 0$, it is located at $x = x_0$ and has a velocity $v_x = v_0$. Show that its position and velocity at time $t > 0$ are given by

$$x(t) = x_0 + v_0 t + \frac{1}{2}at^2 \ ,$$
$$v(t) = v_0 + at \ .$$

b) Eliminate t from preceding equations and thus show that, at any time,

$$v_x^2 = v_0^2 + 2a(x - x_0) \ .$$

c) The formula you derived in part b) is a very useful one. Write down what were the assumptions made to derive it so that you know in what situations you can use it.

Problem 2

This is a homework problem. I will not include homework problems in discussions very often, but I want to make sure I get you started on this one!

A rocket of mass m blasts off vertically from the launch pad - its engines give it a constant upward acceleration of a and it feels no appreciable air resistance. When it has reached a height of h, its engines suddenly fail so that the only force acting on it is now gravity.

a) What is the maximum height this rocket will reach above the launch pad?

b) How much time after engine failure will elapse before the rocket comes crashing down to the launch pad, and how fast will it be moving just before it crashes?

c) Sketch a_y-t, v_y-t, and y-t graphs of the rocket's motion from the instant of the blast-off to the instant just before it strikes the launch pad. (Assume y-axis is in the direction of motion of the rocket, i.e. vertical.)

Problem 3

This is on original Corbin midterm problem.

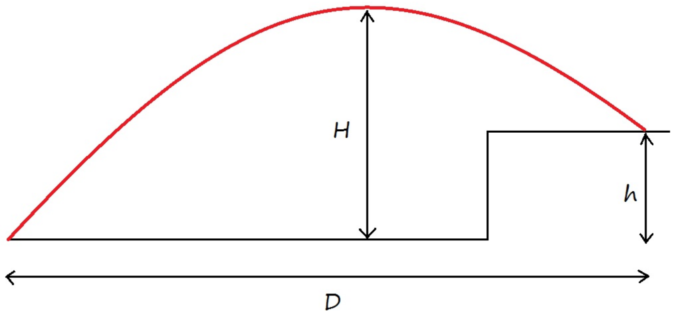
A projectile lands on a hill of height h, a horizontal distance D from where it was launched, after attaining a maximum height H. Find the following quantities in terms of h, H and D:

a) the time of the flight,

b) the horizontal and vertical components of the initial velocity vector,

c) the angle (above horizontal) that the projectile is fired at.

You may solve for these in any order that is convenient for you.



Problem 4

A plane flies due East with velocity v_p. The plane is equipped with a launcher that is able to horizontally fire a package with velocity v_l, perpendicular to the direction of the motion of the plane. The pilot of the plane did very poorly in his mechanics class, and this is the reason the following situation takes place. He is supposed to fire the package in such a way that it ends up in a secret pick-up location. He fires when the plane is a distance x_0 (as measured on the ground) north of the secret pick up location. Assuming that the operator chose the right distance to reach the package in the longitudinal direction,
a) what is the height h at which the plane flied at the moment the pilot launched the package?
b) by how much did the pilot overshoot in the latitudinal direction?

Problem 5

A student is standing in an elevator that is on the ground. At time $t = 0$ the elevator begins to ascend from the ground with uniform speed (the value of which we do not know). At time t_d (the "drop time") the student drops a marble through the floor. The marble falls with uniform acceleration g and hits the ground an amount of time T later.

a) Find the height of the elevator at the drop time t_d.

b) On physical grounds, what would you expect the answer to be in the limit

$$\frac{T}{t_d} \to 0 \ ?$$

Why?

c) Does your expectation of what would happen from part b) match your mathematical answer from part a)?

Problem 6

You are standing on a hill of a uniform slope ϕ. You want to throw the ball down the hill in such a way that its range is maximal. At what angle θ should you throw it? Assume the speed with which you throw the ball is v.
Hint: Assume for ease that the hill in infinitely long, i.e., there is no way you could overthrow the slope.

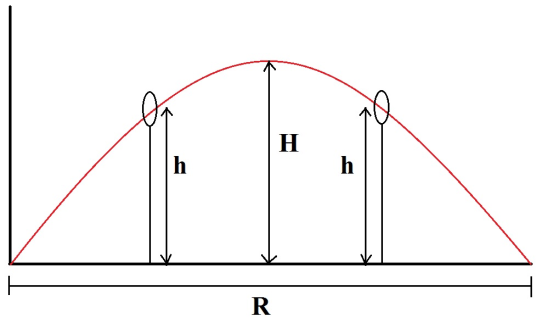
Problem 7

This is an original Corbin midterm problem. This is the kind of a crazy problem you should expect to see on your midterm in the 4th week. Corbin likes unusually sounding problems as they force you to really use your knowledge instead of just remembering solutions for standard setups.

Because there just really isn't anything better to do, a group of students studying for a Physics 1A Midterm decides to play the following game: they put together a catapult designed to throw squirrels through a parabolic arc of height H and range R. To make things a little more interesting, flaming hoops, each centered on a height h, have been mounted on movable poles and placed strategically so that they intersect the flight path of the thrown squirrels.

a) Find the horizontal and vertical components of the squirrels' initial velocity.

b) How much horizontal separation should there be between the poles?



Problem 8

This is another homework problem. I think it's extremely interesting and thus I wanted to make sure you do it.

When tossing an object - say a tennis ball - straight up, one usually observes that the object in question seems to "hang" for a bit at the highest point of its trajectory. This, of course, is a false observation (if any object hovered in air for no apparent reason, it would contradict our basic physics intuition, wouldn't it?). Is there, however, some explanation as to why it *seems* to us as if there is some hovering after all?

Let's see whether we can calculate this. Let $y_{\max}$ be the maximum height above the point of release. To explain why the object seems to hang in the air, calculate the ratio of the time it is between $y_{\max}/2$ and $y_{\max}$ to the time it takes it to go from the point of release to $y_{\max}/2$. You may ignore air resistance.

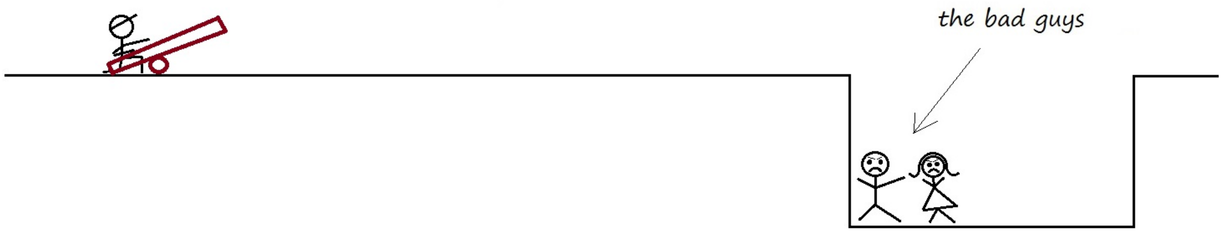
Problem 9

This homework problem used to appear on Corbin's midterms. I would not expect it again, but it's important you go over this.

An elevator starts from rest and maintains a constant upward acceleration of a. A bolt in the elevator ceiling h above the elevator floor works loose and falls out the instant the elevator begins to move.
a) How long does it take for the bolt to reach the floor of the elevator?
b) Just as it reaches the floor, how fast is the bolt moving according to an observer
i) in the elevator?
ii) Standing on the floor landings of the building?
c) According to each observer in part b), how far has the bolt traveled between the ceiling and floor of the elevator?

Problem 10

A group of terrorists is hiding in a sort of large, rectangular ditch of depth d. A SWAT team member stands a distance L from the edge of the ditch manning a mortar of a negligible height (that is, the depth d of the ditch is so big that it does not *really* matter that the mortar itself has some height - just assume that the projectiles are fired from the ground level). The terrorists may expect the attack and thus may cover down really close to the bottom edge of the ditch, as pictured. How close to the edge of the ditch can rockets reach if the muzzle speed of the projectile is v?



Note: Assume that the minimal range of the mortar is less than L.