Recitation Questions

Week 3, Day 1

These recitation problems, along with those on your homework, will prepare you very well for the group exam in your second recitation this week and the exam on Tuesday. In these problems you will practice:

- Working with vector quantities as separate $x-$ and $y-$components
- Writing down the equations of motion that describe an object's motion in two dimensions
- Interpreting statements in words about motion in two dimensions as statements about algebraic variables
- Solving those equations algebraically as directed by your statements

Question 1: a hiker[1] crosses a stream

A hiker in the Adirondacks encounters a stream that is too wide to jump across. So she doesn't get her boots wet, she takes them off and throws them across before walking barefoot through the water.

Suppose that the stream is 12 m across, and she throws her boot from ground level at an angle $\theta = 35^\circ$ above the horizontal.

First, you will calculate the minimum velocity she must throw the boot with to get it across the stream. Then you'll figure out what happens if she throws it at this speed but at a different angle than she intended to.

1. Draw a diagram of the boot's path in the air. Choose a coordinate system: what point are you considering ($x = 0, y = 0$), and which directions are positive? *(This is important because it gives you a picture that orients you to how the boot moves, and the coordinate system lets you translate the picture into mathematics.)*

2. You know the initial velocity vector $\vec{v}_0$ as a magnitude and direction, but to do your calculations you will need to know its $x-$ and $y-$components. By doing trigonometry, determine $v_{x,0}$ and $v_{y,0}$ in terms of v_0, $\sin\theta$, and $\cos\theta$. *(Since it is easiest to work with $x-$ and $y-$components, you will want to convert any vectors given to you in magnitude/direction form to components first.)*

[1] This problem is based on a true story; the hiker was a long-time PHY211 coach who graduated from ESF in 2018. Yes, she really threw a boot into a stream.

3. Write expressions for the $x-$ and $y-$components of its position and velocity as a function of time. These expressions will have lots of variables in them (a_x, a_y, $v_{x,0}$, $v_{y,0}$, x_0, and y_0) – that's okay. *(It is always a good idea to work from "general" to "specific"; writing down the equations of motion in the most general way and then substituting in what you know will make sure you don't go astray.)*

4. Do you know anything about any of those variables? If so, which ones? *(It is always a good idea to keep track of things you know and things you want to find. Here, you know som+ething about the starting velocity and the acceleration.)*

5. With what initial velocity v_0 must she throw her boot in order to get it across the stream? *(I've skipped some steps here for you: you will want to write down a sentence in terms of your algebraic variables that answers the question, then do the algebra.)*

6. Suppose that she accidentally throws her second boot with the same initial velocity v_0 but at an angle $\theta = 65^\circ$ above the horizontal. Where will it land?

Question 2: a prankster

The students in the next two problems are based on two more of our past PHY211 coaches.

A mischievous SUOC student has climbed on the roof of a snow-covered building and is trying to hit her friend with snowballs as he walks through the Quad. She throws them at an angle of θ above the horizontal at a speed of v_0. The building has a height h. *(In this problem, you will think about how to solve for various things, but not actually do the algebra. As with any problem where some variables are specified in the statement, you can use those variables in your answer – if you were doing the math on this problem, you would have v_0's, θ's, h's, and g's in your answer.)*

1. Draw a cartoon of the problem, making clear your coordinate system and origin, and labelling interesting things.

2. Write expressions for $x(t)$, $y(t)$, $v_x(t)$, and $v_y(t)$, substituting in variables that you know. *(Some will be zero; v_0, $\sin\theta$, $\cos\theta$, h, and g will make an appearance.)*

3. Write sentences in terms of your algebraic variables that allow you to answer the following. You will need to incorporate vector language at times: for instance, you may need to use terms like "the magnitude of the velocity vector" (which will require you to solve for both v_x and v_y.)

   - How much time does it take for the snowballs to hit the Quad?

   - Where do the snowballs land on the Quad?

   - How fast are the snowballs traveling when they hit the Quad?

   - In what direction are they moving when they land on the Quad?

Question 3: retaliation!

He decides to throw a snowball back at her. He's standing a distance d from the side of the building, and throws a snowball at an angle θ above the horizontal at a speed v_0. However, the snowball slips out of his hand when he throws it, and it doesn't go very fast – instead of hitting her on top of the building, it hits the side of the building.

1. Draw a cartoon of the problem, making clear your coordinate system and origin, and labelling interesting things.

2. Write expressions for $x(t)$, $y(t)$, $v_x(t)$, and $v_y(t)$, substituting in variables that you know.

3. Write a sentence in terms of your algebraic variables that will let you figure out how far above the ground the snowball hits the side of the building.

4. Based on your sentence, figure out how far above the ground the snowball hits the building. Your answer should be in terms of v_0, θ, d, and g.

5. He doesn't give up, though, and throws another snowball at her – again at an angle θ above the horizontal. He throws this one harder, and it hits her feet as she stands on the edge of the building. Write a sentence in terms of your algebraic variables that will let you figure out how fast he had to throw it.

6. Now, based on your previous sentence, figure out the initial speed of the second snowball he threw. *(Your answer will have h, g, v_0, d, and θ in it, since those variables are given to you in the problem.)*