Homework 2, due Thursday, 25 February, before class

This homework set is specifically designed to prepare you for Quiz 1, held on 25 February. All of the problems here touch on ideas that you may need for the quiz.

1. During the siege of Constantinople that led to its conquest by the Ottomans in 1453, the Hungarian engineer Orban built a set of bombards (primitive cannon) to throw enormous stones at the city to breach its walls. The largest of these could throw a 300 kg stone a distance $x_f = 2$ km. Assume that the stone was launched at an angle of $\theta = 45°$ above the horizontal; in the absence of air resistance, this gives the largest range.

   (a) What speed did the stone have to be launched at to achieve this range?

   (b) How long was the ball in the air?

   (c) How fast was the ball traveling at the apex of its flight?

   (d) Orban's cannon was 8m long. What was the average acceleration of the stone as it was launched down the bore of the cannon? *Hint: Note that during its movement down the bore of the cannon, it accelerated from $v = 0$ to the velocity you found as your solution to the first part of this problem.*

2. Our head TA, Mario Olivares, has an adorable dog named Teddy.

   Suppose Mario throws a ball out into the lake for Teddy to catch. It lands $d = 6$ meters out into the water. Teddy is standing on a flat platform 2 meters above the water. Wanting to get his ball back, he runs down the platform and flies out over the water, landing on top of his ball. Suppose that Teddy runs straight off the platform, so that he is moving horizontally when he leaves the ground.

   (a) How fast was Teddy moving when he left the platform?

   (b) How fast was Teddy moving when he landed in the water?

   (c) In what direction was Teddy moving when he splashed into the lake? (Give your answer in a physically meaningful way: "X degrees below the horizontal" or similar.

3. A previous head TA, Lindsey DeMarchi, had a very athletic black cat named Kiki who liked to jump and swat at things. One day I watched Kiki jump straight up and swat at the peep-hole in her door, 150 cm off the floor. This means that Kiki can push herself off the ground with enough velocity to reach a height of 150 cm. *(Note that this velocity is a property of Kiki herself; no matter where we take Kiki, this velocity is the same.*

   (a) With what velocity must Kiki leave the ground in order to jump 150 cm high?

   (b) How long will she be in the air before she lands?

4. Suppose that Lindsey now takes Kiki to an elevator, accelerating upward at $\alpha = 2\,\mathrm{m/s^2}$. Kiki jumps up and tries to swat at one of the elevator buttons. This elevator button is 135 cm above the floor of the elevator.

   (a) If Kiki jumps as high as she can, will she be able to push the button? How far above the elevator floor will she make it?

   (b) How long will Kiki be in the air?

   Hint: Think very carefully about your coordinate system, and all of the consequences of the accelerating elevator. You may need the quadratic formula for this problem. If you are still stuck, draw position vs. time graphs for both Kiki and the elevator button the wall she is trying to push.

5. A hiker is standing on the top of a mountain with a slope of 45 degrees. They kick a rock horizontally off of the top of the mountain at an initial speed v_0; it sails through the air until it lands lower on the slope.

   (a) Think very carefully about how you can describe "The rock lands back on the slope" in mathematical terms. It will help to draw a picture, as always.

   (b) Where on the slope does the rock land?