Assignment IV, HONS 157 (Honors Physics I)
Fall 2015
Due 9/18/15 at start of class

As always, please put your answers on separate paper.

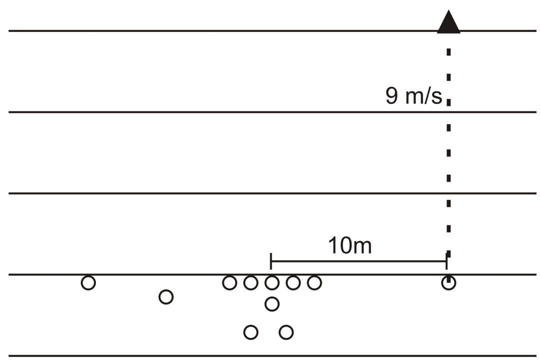
1. Back in 1971, Astronaut Al Shepard hit a golf ball on the surface of the moon. It was awkward for him to hit the ball (with his space-suit on, it is hard to get a decent swing), but he estimated the ball went 200-400 yards anyway. Assume you are able to hit a golf-ball 250 yards on Earth. How far could you hit it under identical conditions on the moon? (g on the moon is about 1.62 meters per second squared).

2. A baseball batter hits a ball that comes off the bat at an angle of 32 degrees. The ball is moving at 43 m/s as it leaves the bat. You may assume the batter hits the ball from ground level.

   a) Assuming no air resistance, how far from the batter would this hit land? Leave your answer in feet. (You'll get an unrealistically large answer; that's because air resistance really isn't totally negligible here).

   b) The center field fence is 420 feet from home plate. The fence is twenty feet tall. Assuming no air resistance, will this baseball clear the fence for a home-run? (Support your answer with calculations.) (This isn't that easy to do).

3. A wide receiver in football runs a "fly" pattern (in other words, he just runs straight ahead after the start of the play). For simplicity, we'll put together a somewhat fake scenario that changes the rules of football just a little bit. First, we'll do everything in meters instead of yards. (That's not too bad – a meter and a yard are only off by about 10%, so you can think of your intuition regarding distances in meters instead of yards without messing up too much). Also, so we don't have to deal with a wide receiver speeding up and then reaching a steady speed, we'll let the wide receiver have a running head start (a la Canadian Football) so that at the moment the play begins, the receiver is running at a speed of 9 meters per second and stays that speed the entire play. At the moment the ball is snapped (the play begins), the wide receiver is exactly 10 meters from the quarterback as shown in the figure (see back of page for figure).



a) If the Quarterback takes a 5 meter drop (retreats 5 meters from where he was given the ball) while the receiver sprints up the field, how far away would the quarterback be from the wide receiver after some time t?

b) Let's say the quarterback throws the football at 22 meters per second from 5 meters behind the line of scrimmage (these are both reasonable numbers). The ball is thrown at an angle 20 degrees above the horizontal. How far from the quarterback will the ball be when it is at the same height that it was at when the quarterback released it?

c) How long will the ball be in the air in part (b)?

d) How many meters past the line of scrimmage (the starting line) will the receiver be when he catches the pass described in part (b)?

e) How long after the snap should the quarterback throw the pass in part (b) so that the receiver can make the catch in stride?

f) How many meters past the line of scrimmage should the receiver be when the pass is thrown?

g) How high did the throw get at its peak?

4. You stand on top of a tower of height 18 m and throw a stone at an angle of $+27°$ with respect to the horizontal at a speed of 14 m/s.

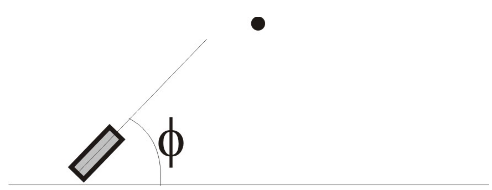
   a) How long does it take for the stone to hit the ground?

   b) At what horizontal distance from the tower does the stone hit the ground?

   c) What is the speed of the stone just before it hits the ground?

   d) Just before the stone hits the ground, what is the angle between the velocity of the stone and the ground?

5. A projectile is fired over a level surface with a speed $v_\circ$ such that it passes through two points both a distance h above the horizontal. (The first time height h is reached is on the projectile's ascent; the second time on its descent).



   a) Show that if the gun is adjusted for maximum range, the horizontal distance the projectile travels between these two points is equal to:

$$\frac{v_\circ}{g}\sqrt{v_\circ^2 - 4gh}$$

   This problem is similar to many in higher level Physics classes, where no numbers at all are given. Your task is to work with the symbols alone to develop an expression like the one above; this expression should work no matter what $v_\circ$ and h are.

   b) Find an expression for the time of flight for the projectile between the points a distance h above the horizontal if the initial launch angle $\phi = \pi/6$. Your answer should be in terms of variables $v_\circ$, h, and g *only*.

(More on back!)

6. Let's say that you are firing a cannon in an attempt to hit a target that is 1400 meters directly East of you. The target and the cannon are on level ground. Your cannon always fires cannonballs with an initial speed of 135 m/s.

   a) Calculate the angle of elevation needed to hit the target. [There are actually two angles; find them both.]

   b) [Extra Credit] Let's make this problem substantially trickier. Let's say that there is a "cross-wind" of 50 m/s directed towards the South. This turns the problem into a truly 3-d scenario, since the cannonball's launch velocity now must have an Eastward, Northward, AND Upward component in order to hit a target directly East of the cannon. (Much like 2-d problems, each of the three components are independent of each other).

      Assume that the crosswind adds a constant 50 (m/s) Southward value to whatever the North-South component of the cannonball velocity would be in the absence of the crosswind. (This isn't too realistic, but it gets us thinking about the right things).

      There are still two different elevation angles that will hit the target. (They may not be the same as what you found in part (a)). Each of these elevation angles will also have a different launch direction (you no longer launch each cannonball straight East; both must be directed a bit Northward as well). You are tasked to find the two different launching strategies that hit the target. (Each "launch strategy" includes an elevation angle (e.g. launch at a 23° angle above the horizontal) as well as a launch direction (e.g. launch at 37° North of East).)

7. Challenge Problem (Extra Credit) (I won't include the solution to this one on the answer key, because I don't want to scare anyone – but if you come visit me after it is due, I will be happy to work this out for you).

   A cannon launches a projectile with initial velocity 175 m/s at an angle of 75° with respect to the horizontal (angle θ on the diagram). However, the area that the cannon is launching to is not level; in fact, the cannon is firing "up-hill" that has a steady grade of 20° with respect to the horizontal (angle ϕ in the diagram). The question is how far "up the hill" does the projectile land?