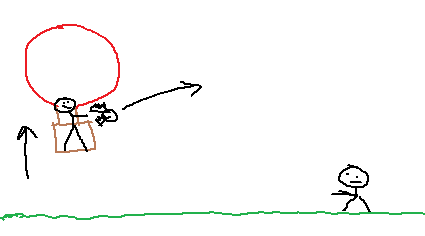
**Homework 5 due 2/15**

**Problem 1.** You’re in a hot-air balloon, accelerating upwards at a rate of 2m/s2. But you left your dog in the car with the windows rolled up. Luckily your friend is on the ground, because he doesn’t like heights, and he’s pretty sure you’re going to run into a power line anyway. So after 10s you throw your keys to him with a speed of 30m/s and horizontally w/r to the balloon.



(a) What is the initial position of the keys (x0, y0), i.e. the position after 10s?

(b) What is the initial velocity of the keys (v0x v0y), i.e. the velocity after 10s, and just after you’ve thrown them. Be careful here ☺.

(c) Write down an equation for x(t) and vx(t).

(d) Write down an equation for y(t) and vy(t).

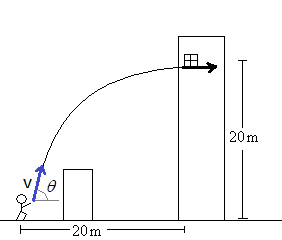
(e) To what maximum height do the keys rise?

(f) When do they hit the ground?

(g) And at what x-position?

(h) What would be the magnitude and direction of its velocity when it hits the ground? (Hint: it’s NOT zero ☺)

**Problem 2.** Your friend, Amelie, is locked in the Bastille for protesting Louis XVI. Fortunately for her, you have the keys. But you can’t get closer than 20m from the tower because of a barricade. And she’s 20m up in the tower. At what angle and speed must you throw the keys in order for them to land in her cell with a horizontal velocity, i.e. at the top of their trajectory?

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(a) Write down an equation for x(t) and vx(t). You don’t know the initial velocity in the x-direction. So you’ll just leave it as a symbol.

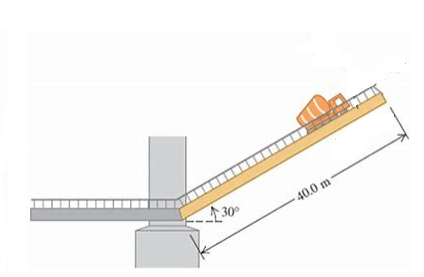
(b) Write down an equation for y(t) and vy(t). You don’t know v0y either, so just leave it as a symbol.

(c) Now take these four equations and plug in what, if anything, you know about the final values: x, y, vx, vy, and solve them for t, v0x, and v0y.

(d) Give the magnitude and direction of the necessary velocity then.

**Problem 3.** What’s the terminal velocity of a penny? Consider that mpenny = 0.003kg, its radius is about 1cm, and its coefficient of aerodynamicity is 0.5, say. The density of air is 1.2kg/m3.

**Problem 4.** You were talking on your cell phone again. Not paying attention, you found yourself headed towards a draw bridge at v = 20m/s. You slam on the brakes (bad move because now your tires are going to skid, meaning that kinetic friction, not static friction, is going to slow you down). Suppose μs = 0.85, and μk = 0.67 (Google). We want to figure out if you’ll go off the bridge or not?



(a) What is your acceleration up the bridge?

(b) Write down equations for vx(t) and x(t).

(c) Now determine when you’ll stop and how far up the bridge you’ll have gone.

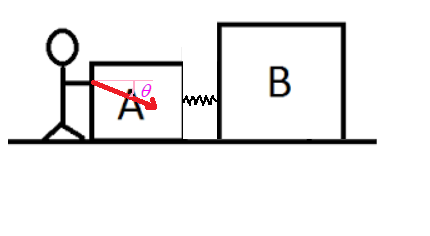
(d) Suppose you put the parking break on immediately when you come to rest. Does it prevent you from sliding back down?

**Problem 5.**  Spoiler Alert! In ‘The Winter Soldier’, Steve Rogers tries to incapacitate Bucky Barnes by throwing his shield at him. But the Winter Soldier just catches it instead. What!? Suppose Bucky has a mass m = 100kg, the shield has a mass of 10kg, that it was thrown at 30m/s (about 67 mph), and that it was caught in the span of about a quarter second (i.e. slowed from 30m/s to 0m/s in that span).

(a) What force must the Winter Soldier have exerted? Convert to pounds too.

(b) Bucky didn’t even slide backwards when he caught it. What again!? What minimum coefficient of friction must there have been between his shoes and the concrete for this to have happened.

**Problem 6.** Your summer job consists of moving crates back and forth, for no good reason, just like the job you’ll have when you graduate. Crate A has mass mA = 10kg, and crate B has mass B = 20kg. You apply a 300N force force at an angle of 20° below the horizontal. The coefficient of friction between the box and floor is μk = 0.5. The spring connecting box A and B has a stiffness k = 200N/m.

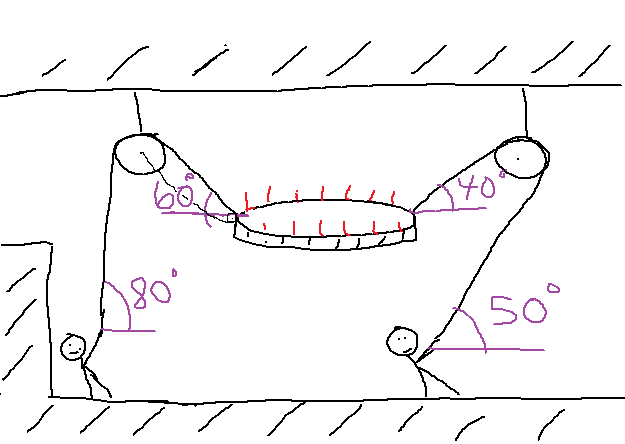


(a) Write down the x and y N2L for block 1. You should solve for the normal force, and have an equation for ax in terms of an unknown Δx (compression of the spring).

(b) Write down the x and y N2L equations for crate B. You should solve for the normal force, and have an expression for the acceleration in terms of the unknown Δx.

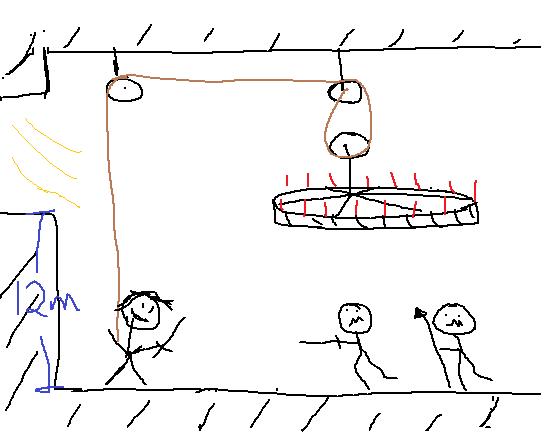
(c) Solve the equations for the acceleration of the boxes, and the compression of the spring.

**Problem 7.**  Suppose you’re helping your mideval friend raise a 150kg chandelier at a constant upwards velocity of 10cm/s. With what forces do you each pull? Note – not all angles matter, and also note that the left pulley is draped over a small pulley-like attachment on the chandelier.



**Problem 8.** You (m = 50kg) finally got your 150kg chandelier installed (and replaced a pulley or two), but now you’re being attacked by scoundrels. So you cut the rope. The chandelier falls on the bad guys, and pulls you up. We want to figure out how long it takes for you to get up to the window.

(a) Calculate your upward acceleration. Pay special attention to the rope attached to the chandelier. And can you see that as our hero goes up, he will have twice the acceleration as the chandelier as it falls (because he’s attached to one rope, but the chandelier is attached to two)?



(b) Write down the equation for your position and get t.

(c) What is the tension in the rope?