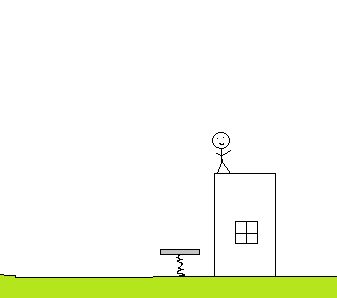
**Homework 4 Solutions Due 2/27**

**Problem 1**. Suppose you (mass m = 70kg) step off an 5m tall platform, onto 2m tall spring (k = 2000N/m). Starting time from when you hit the spring…



(a) What will be new equilibrium position about which you oscillate? This would be the position (y = 0 at ground level) at which the forces on you (spring and gravity) balance.

Equilibrium is where forces balance. So



(b) And what will be your period of oscillation?

Period is



(c) What will be the lowest point you reach? Energy conservation?

We can get this via energy conservation:



(d) What will be the highest point you reach?

We can use energy conservation again. We basically get the same equation as before, we just choose the other root:



(e) So what will be the amplitude of your oscillation about the equilibrium point?

Amplitude is just the distance between the equilibrium and either of the top or bottom – should be the same either way.



(f) What is your speed as you pass through the equilibrium point (not of the spring alone, which is at y = 2, but ‘your’ equilibrium point from part a)?

Energy conservation again….



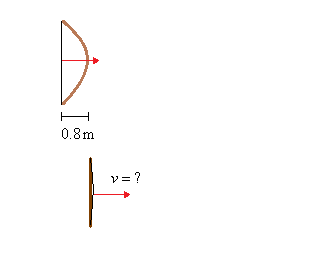
(g) what will be your acceleration at the top of your oscillation? Would you stay on the spring, if you weren’t, say, velcroed on?

The top, y = 3.13m, is above the rest length of the spring, y = 2m, and so the spring will be pulling downwards. So your acceleration would be:



No you wouldn’t stay on the spring, as gravity can only give you an acceleration of g = -9.8m/s2, whereas the maximum acceleration the spring together with gravity would attempt to impart, is much greater than this.

**Problem 2.** Say we have an arrow, which has a mass of approximately 100 grams. Then we put it on a bow, and pull it back with an ever increasing force (because bow acts like a spring) until we’ve stretched it to a displacement of 80cm, via force F = 500N.



(a) What is the ‘spring constant’ of the bow?

This would be:



(b) How much spring potential energy does the arrow possess?

This is:



(c) How fast will the arrow be going once it’s cleared the bow?

Energy conservation:

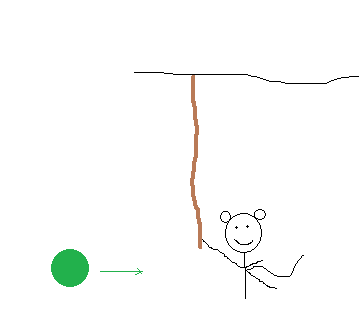
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(d) How long does it take for the arrow to be released? Consider how this relates to a ‘period’.

The time to release would constitute a quarter of a period. And this would be:



**Problem 3.** A monkey (m = 10kg) hangs on a vine (can treat as a uniform board with mass m = 6kg) of length ℓ = 5m. You throw a watermellon (m = 3kg) horizontally at speed v = 18m/s, which the monkey catches. Remember the formula for center of mass ℓcm = (m1y1center + m2y2center + … + mnyncenter)/(m1 + m2 + …. + mn).



(a) What will be the monkey’s period of oscillation? Don’t think too hard – just hard enough.

So the formula for the period is:



Now



And the center of mass would be:



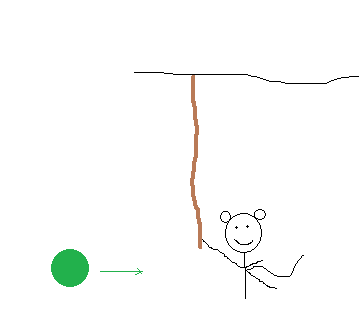
So,



(b) What would be the period if the speed of the watermelon were doubled?

Same ☺. v plays no role (mostly).

**Problem 4.** A monkey (m = 10kg) hangs on a massless vine of length ℓ = 5m. You throw a watermellon (m = 3kg) horizontally at speed v = 18m/s, which the monkey catches. Supposing the catch happens instantaneously….



(a) What will be the monkey’s initial velocity after catching the watermelon? \*Hint: gotta use conservation of something here!

So conservation of angular momentum would say:



From which we may get v0 = ω0ℓ = (0.83)(5) = 4.16m/s. Could also do conservation of linear momentum, in this case,

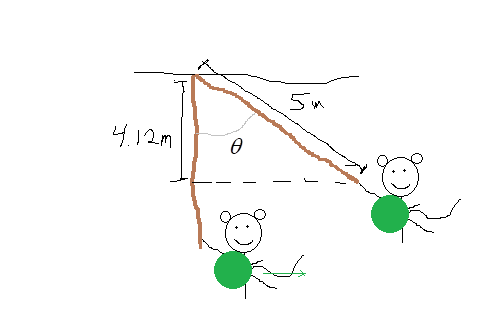


(b) What maximum angle will the monkey reach?

Must. Use. Energy conservation. And I’m going to treat y = 0 as being at the pivot point. So then,



And this corresponds to an angle of:





(c) When will the monkey reach this spot? Consider how it relates to a period.

Period of oscillation comes from ω,



And going from nadir to apex constitutes a quarter of a period. So this would take,

