NYU Physics I—Problem Set 3

Due Thursday 2017 September 28 at the beginning of lecture.

Problem 1: Re-do the "block on a plane" problem we did in class, but now using vector components. Make the x direction point down the plane, and make the y direction point perpendicular to the plane, and solve for the x and y components of gravity, the normal force, and the block's acceleration (that is, three vectors, and two components per vector).

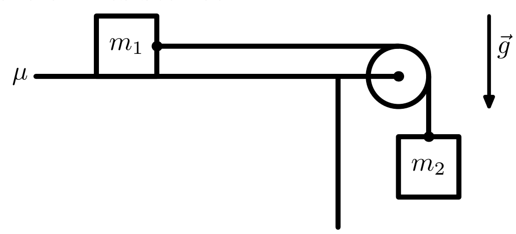
Problem 2: In a 200-m race, the winner crosses the halfway mark (ie, 100 m) at $t_{1/2} = 10.12$ s and the finish line at $t_\mathrm{f} = 19.32$ s. If you make a kinematic model of the runner's behavior as (i) constant acceleration a from rest for the period $0 < t < t_a$ followed by (ii) constant speed $v = a\,t_a$ during the period $t_a < t < t_\mathrm{f}$, what are a and t_a?

Hint: Draw a graph of $v(t)$ before you start writing equations.

Hint: Once you have a graph, consider the question: is t_a going to be before or after $t_{1/2}$? Make a quantitative argument.

Hint: You can solve this problem with geometry and the graph; no need to do calculus!

Problem 3: In the system shown below, the strings are massless and inextensible and the pulley is massless and frictionless. There is a small frictional force $F_\mathrm{f} = \mu\,N$ between block m_1 and the table, but when released from rest, block m_2 falls. Ignore air resistance!



(a) Draw complete free-body diagrams for both masses, and for the pulley.

(b) What is the acceleration $\vec{a}$ (magnitude and direction) of mass m_1? Give your answer in terms of quantities shown in the diagram.

(c) Why did we treat the strings as massless? How did that help us?

Problem 4: Imagine a package of mass M sitting on the floor of an elevator that is accelerating upwards at acceleration a. The acceleration due to gravity is g.

(a) Draw the free-body diagram for the package.

(b) What is the magnitude N of the normal force on the package?

(c) Answer those same two questions again, but with the elevator accelerating *downwards* at acceleration a.

(d) Answer those same two questions again, but with the elevator accelerating downwards at acceleration g (that is, at the gravitational acceleration).

(e) In lecture Prof Hogg did a stunt with a coffee cup and a quarter. Draw the free-body diagram for the quarter when it was at the top of the arc (that is, when it was directly overhead).

Extra Problem (will not be graded for credit): In what sense were the astronauts in the Space Station weightless? Is there no gravity acting? Look up the altitude at which the Space Station orbited and ask yourself: How much weaker is the gravitational force at that altitude? (The relevant distance is the distance from the Space Station to the center of the Earth.)

Also, why didn't the quarter fall out of the cup?