Assignment V, PHYS 111 (General Physics I)
Fall 2016
Due 9/23/16 at start of class

As always, please put your clearly written answers on separate paper.

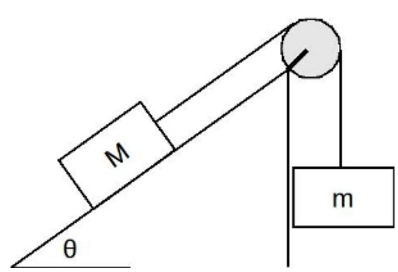
1. A 4.00 kg mass moves under the simultaneous influence of the following three (constant) forces:

$$\vec{F}_1 = (3.00\text{ N})\hat{\imath} - (6.00\text{ N})\hat{\jmath}$$
$$\vec{F}_2 = (-6.00\text{ N})\hat{\imath} + (10.00\text{ N})\hat{\jmath} + (2.00\text{ N})\hat{k}$$
$$\vec{F}_3 = (-40.00\text{ N})\hat{k}$$

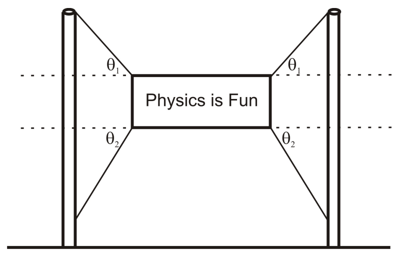
The mass starts at position $\vec{r}_i = (-2.00\text{ m})\hat{\imath} + (3.00\text{ m})\hat{k}$ and with initial velocity $\vec{v}_i = (-2.00\text{ m/s})\hat{\imath} + (4.00\text{ m/s})\hat{\jmath}$.

a) Find the (constant) values of a_x, a_y, and a_z for the mass.
b) Develop expressions for $v_x(t)$, $v_y(t)$, and $v_z(t)$. (Make sure this makes sense given what you know for $\vec{v}$ at $t = 0$).
c) Develop an expression for the position as a function of time [$x(t)$, $y(t)$, and $z(t)$]. (Make sure this makes sense given what you know for $\vec{r}$ at $t = 0$).
d) Find the velocity of the mass at $t = 5$ s.
e) Find the displacement between $t = 3$ s and $t = 7$ s.
f) Find the average velocity between $t = 3$ s and $t = 7$ s

2. A triangular wedge of elevation angle supports a mass M. Connected to mass M via a (massless) string is a second mass m that hangs freely from a frictionless pulley as shown. The wedge is firmly attached to the Earth (it can't move) and the wedge/mass interface is assumed to be frictionless. $\theta = 48°$. Assume the hypotenuse of the wedge has a total length of 10 meters, and that the large mass M starts at the very top of the wedge with an initial velocity of 3 m/s down the slope of the incline. If $M = 3.00$ kg, what is the minimum mass m that would prevent the 3.00 kg block from reaching the bottom of the wedge? (Assume that the string is sufficiently long so that m stays below the pulley no matter what).



3. A sign of mass m is held up by four (massless) wires connected to sturdy poles as shown below. The top two wires make an angle of θ_1 above the horizontal at their attachment point with the sign. The bottom two wires make an angle of θ_2 below the horizontal at their attachment point with the sign.



a) Draw a free-body diagram for the sign.

b) Assume that the bottom two wires are cut. Find the tension in each of the top two wires. (You'll have to leave your answer in terms of m, g, and θ_1.

c) Instead of cutting the bottom two wires, assume that the wire in the upper-right and the lower-left are cut (so that the only two remaining wires are in the upper-left and the lower-right). Draw a new free-body diagram for the sign. [In reality, cutting these cords will cause the sign to rotate. Ignore this. Assume the sign is very small – basically a point mass – so that cutting the two wires in question don't change the geometrical alignment of the sign].

d) If the wire in the upper-right and the lower-left are cut, show that the tension in the upper-left wire is equal to:

$$T = \frac{mg\cos\theta_2}{\sin(\theta_1 - \theta_2)}$$

Note! You cannot solve a problem like this by merely plugging in the proposed solution and showing that it works! Such a method will not earn credit. Rather, you need to actually go forward and come up with what the tension should be in terms of m, g, θ_1, and θ_2 by starting with the free-body diagram you already drew and then apply Newton's second law. From there, you may have to manipulate it a bit to get the form shown. I merely give you the answer so you can know in advance if you did it right or not.

e) The above solution gives you a pretty crazy answer when $\theta_2 > \theta_1$; you get a negative tension. What does this physically mean?

4. A flat box of mass 37 kg sits on a fairly smooth surface. The box-surface interface has $\mu_k = 0.1$ and $\mu_s = 0.3$. A force F is applied that is directed 32 degrees below the horizontal. (Someone pushes the box with a horizontal and downward component).

a) What is the minimum magnitude of the applied force required to start this box moving?

b) You wish to accelerate the box at 2 m/s^2 (still by pushing at a vector directed 32 degrees below the horizontal). What is the magnitude of the force should you apply?

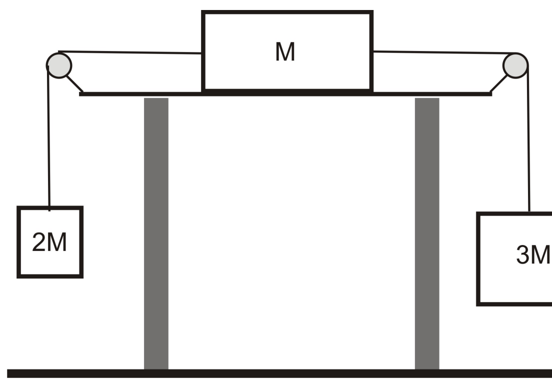
5. A flat, frictionless table has a mass M resting on top of it. Connected to each side of this mass are two massless, inextensible strings. Going over frictionless pulleys, the strings are attached to hanging masses $2M$ (on the left) and $3M$ (on the right) as shown.

   a) Draw free body diagrams for each of the 3 masses.

   b) Solve for the acceleration of the system, as well as both string tensions.

   c) Assume that the table is actually not frictionless. Redraw your free-body diagram for the mass on the table.

   d) Let us continue to say that the table-block interface has friction. Under this constraint, the acceleration of all three masses ends up being 0.5 m/s^2. What is the coefficient of kinetic friction between the table and the block? (I'm looking for an actual number here).



6. A car is traveling at 20 m/s down a hill with a 12 degree grade. (In other words, the car is driving down an inclined plane with angle of elevation 12 degrees). Suddenly, the car realizes that another car is stopped 30 meters ahead (on the same inclined plane). Immediately, the driver slams on their brakes – causing the brakes to lock up and slide against the pavement. Assuming the coefficient of kinetic friction between the car tires and the road is 0.6, how fast is the car moving when the two cars collide?