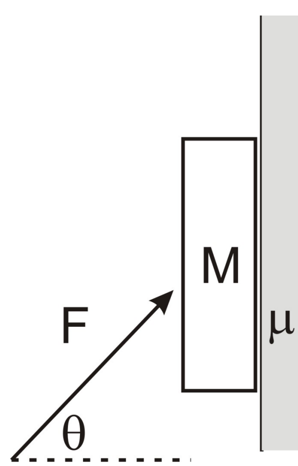
Assignment V, PHYS 101 (Introductory Physics I)
Fall 2020
Due via pdf upload to OAKS prior to Thursday, September 24th at 9:25 AM

General instructions:
For this, and all other homework assignments, please turn in your solutions with all supporting work; answers without supporting work will not earn credit. You do not need to upload the sheet with the questions on it, but please clearly number your problems and circle or box your final answers. I encourage you to collaborate with classmates to discuss how to approach a particular question, but the mathematical steps to generate your final answer on your submitted work should be your own. If I see the same simple mistake on multiple homework assignments, I will take off more points for that error than I normally would. Please include *words* in your answers. When you get answer keys back from me, you'll see that there are explanations, ideas, commentary, and thought processes included – not just a set of equations one after another. Finally, please ensure that all numerical answers have units. As always, if you have questions feel free to email me or send me a DM in the slack.

1. You want to hold a book of mass M up against a wall (see illustration below). Assume that the wall-book interface is frictionless. Thus, to merely "hold" it against the wall, the vector sum of the forces on the book must be zero.

   a) There are 3 forces on the book. What are they?
   b) Carefully draw a free body diagram for the book. Make sure your vectors are approximately the correct lengths.
   c) If $M = 1.5$ kg, what is the weight of the book?
   d) If $M = 2$ kg and $F = 30$ N, what would θ be to hold the book stationary?
   e) Assume that the book has a mass of 3 kg, you apply a force of 40 N, and $\theta = 60°$. What is the acceleration of the book? (Acceleration can be a scalar or a vector; here I'm looking for the vector, so give me magnitude and completely unambiguous direction!)



2. Watch the video at the following link: https://www.youtube.com/watch?v=4ovhEkSIqV0. This shows a so-called "Atwood Machine" in operation. (You will be doing a lab like this later this semester).

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

   b) What should the acceleration of the heavier mass have been? (You should figure this out from computation and the measurements given in the video before the demonstration starts, *not* from the final experimentally measured times.)

   c) What was the final velocity of the heavier mass right before it hit the table? (You should figure this out from computation and the measurements given in the video, *not* from the big clock and the distance of 1 meter – if you do that, you'll end up with the *average* velocity which is not what I'm asking for.

   d) Based on the analysis you've done above, let's pretend we have a similar Atwood machine, but this time the heavier mass is 1.352 kg and the lighter mass is 1.350 kg and the height of the system is 15.0 meters. How long would it take the heavy mass to make its way to the bottom?

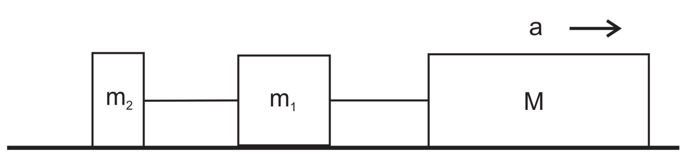
3. Three masses accelerate to the right as shown below. The rightmost mass has mass 5.5kg, and the other two masses are $m_1 = 4.1$kg and $m_2 = 3.7$kg as shown. The three masses are connected by ropes of negligible mass. The masses slide on a friction-less surface. The rightmost mass accelerates with constant acceleration $a = 1.3$ m/s^2. The entire force causing this motion is not shown, but acts directly on mass M only. (The other masses accelerate because they are pulled by M). Determine:

   a) The magnitude of the force applied to M to make this system accelerate as specified.

   b) The tension in the rope between M and m_1.

   c) The tension in the rope between m_1 and m_2.

   d) The net force on m_1.



4. A triangular wedge of elevation angle supports a mass $M = 18.3$ kg. Connected to the mass M via a (massless) string is a second mass $m = 15$ kg 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.

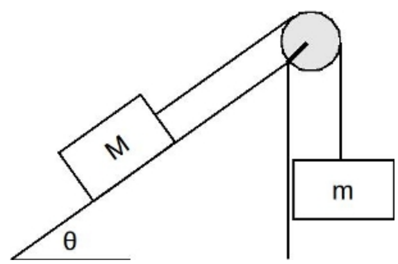
   a) Draw a free body diagram for mass M

   b) Draw a free body diagram for mass m

   c) Use a coordinate system where x describes the position of the large mass M with $x = 0$ being when the mass is at the top of the incline and $x = +10$ m when the mass is at the bottom of the incline. In this coordinate system and with the masses as described above, determine the acceleration of mass M. (It should be in the positive or negative x direction).

   d) Assume mass M starts at $x = 0$ with an initial velocity of $+3.2$ m/s using the coordinates defined in part (c) above. Find the velocity of mass M 2.2 seconds after the system starts.

   e) Assume mass m starts on the ground when mass M is at $x = 0$. How far is the bottom of mass m off of the ground after 2.2 seconds? As in part (d), assume that mass M is starting at $x = 0$ with an initial velocity of $+3.2$ m/s using the coordinates defined in part (c).



5. A flat, frictionless table has a mass $M = 4.0$ kg 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 $2M$ (aka 8.0 kg) (on the left) and $3M$ (aka 12.0 kg) (on the right) as shown.

a) Draw free body diagrams for each of the 3 masses.
b) Solve for the acceleration of the mass on the table.
c) What is the tension in the string on the left?
d) What is the tension in the string on the right?