Pre-Lab 6:
Due: 11/5

Print your full LAST name: ________________________________

Print your full first name: ________________________________

Print your Lab TA’s name: ________________________________

What is your Lab TA’s box # (located outside of Wngr 234)? __________

Print your Lab SECTION # here: ------------------>

Sign your name (full signature): ________________________________

Print today’s date: ________________________________
Pre-Lab 6:

Before you can do this lab, you will need to read all of chapters 4-5 in the textbook. Then complete these questions, and turn them into your lab TA box by 11/5

1. If the acceleration of a body is zero, then are no forces acting on it? Explain.

2. What is the weight of a 58-kg astronaut
   a. on Earth?
   b. on the Moon \((g = 1.7 \text{ m/s}^2)\)
   c. on Mars \((g = 3.7 \text{ m/s}^2)\)
   d. in outer space traveling with a constant velocity.

3. A 750-N force acts in a northwesterly direction. A second 750-N force must be exerted in what direction so that the resultant of the two forces points westward?

4. According to a simplified model of the mammalian heart, at each pulse, approximately 20-g of blood is accelerated from 0.25 m/s to 0.35 m/s during a period of 0.10 s. What is the magnitude of the force exerted by the heart muscle?
5. Define the following terms:
   a. normal force
   
   b. kinetic friction force
   
   c. static friction force

6. In pushing a heavy box across the floor, is the force needed to start the box moving usually greater than, less than, or the same as the force needed to keep it moving?

7. How do you think the force of friction is related to the weight of the box? Explain.

8. Cross-country skiers prefer their skis to have a large coefficient of static friction but a small coefficient of kinetic friction. Explain why. (Think of skiing uphill and downhill.)

9. An ice skater, of mass $m$, is given a push on a frozen lake. After the push, he has an initial speed of 2 m/s. Assuming the only horizontal force that acts on him is a slight frictional force between the blades of the skates and the ice. Draw a free body diagram showing the horizontal and vertical forces. Identify those forces.
Lab 6: Forces and Acceleration

Station A: The Tension in a String

Consider the above arrangement of masses and a force probe. What is the reading that you would expect on the force probe?

(A) Zero  (B) mg  (C) 2mg

Explain your answer.

Check your prediction:

1. Attach a string to both ends of the Force Sensor that is connected to channel 1. Zero out the sensor at this time. Then connect a mass, m (about 200 g, more if needed) to each string, using the same amount of mass on each side. Holding the Force Sensor horizontally, drape the strings over the pulleys, so that the string and the Force Sensor are horizontal and the masses hang vertically as shown.

How does the force probe reading from the computer compare to your prediction?

Identify two action/reaction force pairs. Indicate the object exerting the force, the object experiencing the force, and the magnitude and the direction of the force.
2. Repeat the above experiment—same masses hanging—but with two force probes (facing each other), as provided at your station. What's the reading on each force probe? Explain your answer.

Again, identify two action/reaction force pairs. Indicate the object exerting the force, the object experiencing the force, and the magnitude and the direction of the force.

Is there a way to for one force sensor to pull on the other without the other pulling back? If so, describe it.

When a bug spatters on your windshield, which is greater: the force of the bug on the windshield, or the force of the windshield on the bug? Explain.

When you pull on a wagon, the wagon pulls back with an equal but oppositely directed force. Why, then, does the wagon begin to move?
Station B: Pulling Carts with Strings

Suppose you have carts A and B sliding along on a frictionless horizontal surface. The carts are connected to each other via a string, and some force pulls on another string that is connected to object A. The mass of A is twice the mass of B.

\[ \text{Diagram:} \quad \begin{array}{c}
\text{B} \\
\text{A}
\end{array} \quad \]

Draw a free-body diagram for cart A and another for cart B. Label each force with its type, the body exerting the force, and the body on which it is exerted.

For each force exerted on A, describe the type of force, the object exerting the force, the object upon which the force is exerted, and whether it’s a contact or a noncontact force.

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For each force exerted on B, describe the type of force, the object exerting the force, the object upon which the force is exerted, and whether it is a contact or a noncontact force.

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Consider two forces: the tension force $T_1$ on object A by the string on the right and the tension force $T_2$ on object B by the string that connects the two objects. Suppose in a certain experiment that $T_1 = 6 \text{ N}$. What is the value of $T_2$?

(A) 6 N  (B) 12 N  (C) 2 N  (D) 4 N  (E) 3 N

Explain why you chose this answer.

In general, what is the relationship between the magnitudes of $T_1$ and $T_2$?

1. Set up the experiment with two carts on the frictionless track. Connect two Dual Range Force Sensors to Channels 1 and 2 on the LabPro. Open the Lab 7B file from the Lab 7-8 folder on the desktop. Attach the Force Sensor to each dynamics cart so that they measure the horizontal tensions in the two strings. Add mass to cart A so that the total mass of cart A (including the force probe) is twice the total mass of cart B (including the force probe).

2. Hang the string to the left of A over the pulley and attach a weight. Let the weight fall and the carts slide briefly, and note the readings on the two force probes. Does the relationship between the tensions agree with your prediction?


4. Repeat the measurement with a different amount of weight hanging from the pulley. Do the tensions still agree with your prediction?
Now suppose the tension $T_1$ in the string is pulling to the right on object B (as shown here) with a value of 6 N. What is the tension $T_2$ exerted on object A by the string connecting the two objects?

(A) 6 N  (B) 12 N  (C) 2 N  (D) 4 N  (E) 3 N

Explain why you chose this answer.

In general, what is the relationship between $T_1$ and $T_2$?

Test your prediction:

5. Reverse the positions of the two objects so that the string looped over the pulley is now pulling on object B, as in the scheme arrangement shown above.

6. Place the mass on the hanger and let the carts slide as the mass drops. Describe the results of your experiment.

What is the net horizontal force on object A? On object B? Explain your answers.
Station C: Sliding Blocks

How does friction behave? Specifically, how does static friction behave—that force you need to overcome to get an object to slide across a surface? You’re going to use this sort of setup to find out:

First, measure the mass of the wooden block (by itself) and record.

| Mass of block | kg |

1. Connect the Force Sensor to Channel 1 of the LabPro

2. Open the Lab 7 folder on your desktop. Open file Lab 7C. Set the range switch on the Force Sensor to 50 N. One graph will appear on the screen. The vertical axis will have force scaled from 0 to 20 Newtons. The horizontal axis has time scaled from 0 to 5 seconds.

3. One end of a string should be connected to the Force Sensor and the other end to the wooden block. Place a total of 1 kg mass on top of the block, fastened so the masses cannot shift.

4. Practice pulling the block and masses with the Force Sensor using this straight-line motion: Slowly and gently pull horizontally with a small force. Very gradually, taking one full second, increase the force until the block starts to slide, and then keep the block moving at a constant speed for another second.

5. Hold the Force Sensor in position, ready to pull the block, but with no tension in the string. Click Zero at the top of the graph to set the Force Sensor to zero.

6. Click ______ to begin collecting data. Pull the block as before, taking care to increase the force, gradually, taking one full second to get the block moving. Repeat the process as needed until you have a graph that reflects the desired motion, including pulling the block at constant speed once it begins moving.

7. Sketch the graph here and label the portions corresponding to the block at rest, the time when the block just started to move, and the time when the block was moving at a roughly constant speed.

Look at the data and estimate the force that is necessary to get the block moving.
This is the maximum static friction force the surface can exert on the block. But is the force of static friction always the same? Explain the pattern of force you see before the block started to move.

8. Repeat steps 5-6 above, after adding another 500 g of mass onto the block. Again, look at the data and estimate the force that was necessary to get the block moving:

9. Use the results of steps 7 and 8 to estimate the coefficient of static friction between the block and the surface (and show your work here):

10. What if you let gravity do the pulling—instead of you—by gradually tilting the surface until the block starts to slide? You should be able to use your knowledge of the coefficient of static friction to predict how much you can tilt the surface before the block starts to slide. Start with a complete free-body diagram of the situation at the moment when the block would start to slip down the inclined surface. Label all forces and angles!

11. Use your diagram above to write an equation of static equilibrium at the moment just before slippage.

12. Now use that equation to show that when the block breaks free and starts to move, the coefficient of friction is equal to the tangent of the incline angle.

13. Now test this! Remove all the extra mass from the block and gradually tilt up the surface until the block slips. Measure that angle! (Were you close?)