Your Name: _____

Teammates: _____

Physics 8, Fall 2023, Worksheet #9.

`http://positron.hep.upenn.edu/p8/files/ws09.pdf`

Upload PDF (smartphone scan or tablet edit) to Canvas shortly after class on Mon, Oct 2, 2023.

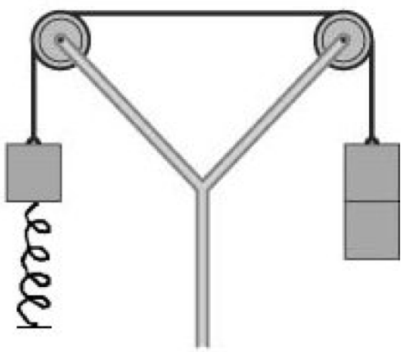
Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

Discuss each problem with your teammates (usually groups of 3), then write up your own solution. Be sure to compare final results with your teammates, as a way to catch mistakes. It can also be very interesting when you and a teammate use different methods to arrive at a result. Do not hesitate to ask for help from other students or from the instructors — but don't just copy down other people's results!

1. Hands-on activity! We have set up four copies of an Atwood machine at tables 9 and 10. The masses m_1 and m_2 are adjustable in 5 gram (0.005 kg) increments. Remember that the key result from the video was that the acceleration of the masses, once released, is $a_x = (m_1 - m_2)g/(m_1 + m_2)$. (You'll derive a variant of this result in problem 3.) Tinker with the Atwood machine yourself and try (a) to see qualitatively how a_x depends on the two masses, and then try (b) to measure quantitatively the acceleration a_x for one combination of masses. See if you can get better agreement here than Bill managed to get in the video! The main goal is simply for you to gain some insight by working with your own hands and eyes, but we'll offer a bonus point if you decide to explain clearly how you checked the prediction for a_x against your own measurement.

2*. You want to hang a potted plant from the ceiling of an elevator that has a maximum acceleration of $3.1\,\mathrm{m/s^2}$. (a) If you hang the plant with fishing line that supports a maximum tension of $54\,\mathrm{N}$ (ie its tensile strength is $54\,\mathrm{N}$), what is the maximum inertia (ie mass) the plant can have if the line is not to break? (b) What combination(s) of slowing down, speeding up, going up, and going down will cause the most tension? (Explain.)

3*. A modified Atwood machine is shown below. Each of the three blocks has the same inertia m. One end of the vertical spring, which has spring constant k, is attached to the single block, and the other end of the spring is fixed to the floor. The positions of the blocks are adjusted until the spring is at its **relaxed** length. The blocks are then released from rest. What is the acceleration of the two blocks on the right after they have fallen a distance D? (Your answer should be a symbolic expression for a_x, expressed in terms of m, g, k, and D. Be sure to indicate what convenion you use for the meaning of the sign of a_x.)



4*. A red 10.0 kg cart is connected to a green 10.0 kg cart by a relaxed spring of spring constant 30.0 N/m. The green cart is resting against another 10.0 kg cart, this one blue. All are on a low-friction track. You push the red cart to the right, in the direction of the green cart, with a constant force of 15.0 N. (a) What is the acceleration of the center-of-mass of the three-cart system? (b) What is the acceleration of each cart the instant you begin to push? (c) What is the acceleration of each cart when the spring is compressed 0.200 m? (d) What is the vector sum of forces (sometimes called "the net force," though not in our textbook) on each cart in part (c)?

More chapter 8 conceptual questions.

5. You are in a stationary elevator, so that the contact force exerted by the floor on you is equal in magnitude to the force of gravity acting on you. When the elevator starts downward, which force changes? What happens to its magnitude?

6. Walking beside a pasture, you and a fellow student see a farmer pulling a mule with a rope and getting nowhere. Your friend says, "The force with which the mule is pulling on the rope has the same magnitude as the force with which the farmer is pulling on the rope, but the two forces point in opposite directions. Because the two forces cancel, the tension in the rope is zero." How do you respond?

7. A delivery person in an elevator is holding a package by a spring-like elastic cord. (Don't ask why.) (a) What happens to the length of the cord when the elevator accelerates upward? Draw the free-body diagram for the package in this case. (b) What happens to the cord's length when the elevator slows to a stop after its ascent? Draw the free-body diagram for the package in this case.

8*. Optional/XC. A tugboat pulls two barges (connected in series, like a train) down a river. The barge connected to the tugboat, carrying coal, has inertia $2.20 \times 10^3\,\mathrm{kg}$. The other barge, carrying pig iron, has inertia $3.30 \times 10^3\,\mathrm{kg}$. The frictional force between the coal barge and the water is $6.50 \times 10^3\,\mathrm{N}$, and that between the pig-iron barge and the water is $9.70 \times 10^3\,\mathrm{N}$. The common acceleration of all three boats is $0.250\,\mathrm{m/s^2}$. Even though the ropes are huge, the gravitational force exerted on them is negligible, as are their inertias. (a) What is the tension in the rope conecting the tugboat to the coal barge? (b) What is the tension in the rope connecting the two barges? (c) Repeat parts (a) and (b) for the case in which the order of the barges is reversed.