Your Name: ____________________________

Teammates: ____

Physics 8, Fall 2021, Worksheet #8.

`http://positron.hep.upenn.edu/p8/files/ws08.pdf`

Upload PDF (smartphone scan or tablet edit) to Canvas shortly after class on Wed, Sep 29, 2021.

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, from Melina, or from Bill.

Questions 3–8 are short-answer conceptual questions, not calculations. Once you spend some time discussing them, they should be very quick to write up.

1. You are climbing a rope straight up toward the ceiling. (a) What are the magnitude and direction of the force you must exert on the rope in order to accelerate upward at $1.05\,\mathrm{m/s^2}$, assuming your inertia (mass) is $65.0\,\mathrm{kg}$? (b) If the maximum tension the rope can support (aka its tensile strength) is $1035\,\mathrm{N}$, what is the maximum inertia (mass) the rope can support at this acceleration? Assume that the inertia (mass) of the rope is so small that the gravitational force on the rope itself can be ignored. [An ideal rope has negligible mass, does not stretch at all, and exerts a force of the same magnitude on whatever is connected to each of its two ends — a rope or cable basically just transmits a force from each end to the other. The magnitude of that force is called the **tension** in the rope.]

2. A 1700 kg truck and a 950 kg car are parked with their rear bumpers nearly touching each other in a level parking lot. Both vehicles have their brakes off so that they are free to roll. A woman sitting on the rear bumper of the truck exerts a constant horizontal force on the rear bumper of the car with her feet, and the car accelerates east at $1.5\,\mathrm{m/s^2}$. (a) What are the magnitude and acceleration of the center of mass of the car+truck system? (You can consider the woman to be part of the truck that she sits on, and consider her mass to be included in the stated mass of the truck. So think of the truck directly pushing on the car, or think of the woman as a massless spring placed between car and truck.) (b) What are the forces (magnitude and direction) exerted on each vehicle by the woman? [For this part, just consider the woman to be a intermediary, of negligible mass, who transmits the force between the car and the truck.] (c) What are the magnitude and direction of the acceleration of the truck? Ignore any friction between tires and parking lot surface.

(Chapter 8 conceptual questions. These questions require no calculations. Just think about them and write your answer as either (a) a sentence, or (b) a few words and a quick drawing — whichever is more appropriate for the problem. Very short answers are fine, as long as your reasoning is clear. You will probably learn a lot by discussing these questions with other students. To make grading easier, please try to make these answers as clear and succinct as possible.)

3. A worker pushes boxes in a factory. In each case decide which force has the greater magnitude — the force exerted by the worker on the box or the force exerted by the box on the worker. (a) The box is heavy and does not move no matter how hard she pushes. (b) Some contents are removed, and now when pushed the box slides across the floor at constant speed. (c) The worker pushes harder, and the box accelerates.

4. A pitcher has thrown a fastball toward home plate. (a) When the ball is halfway to the plate [ie about 10 meters away from both the pitcher and the catcher], does the ball still feel the pitcher's push? [In other words, is the pitcher still exerting a force on the ball?] Explain your answer. (b) What forces does the ball feel, if any, when it is halfway to home plate?

5. You push on a refrigerator, but it does not move. Explain how this can be. [One thing it helps to know about friction, which we will quantify in ch10: when a box is sitting at rest on the floor, if you give the box a gentle horizontal push, friction (exerted by the floor) will push on the box in the opposite direction, to prevent the box from starting to move. But there is a maximum value to the frictional force that the floor can exert on the box (which we'll quantify in ch10). If the required frictional force to prevent the box from sliding becomes too large, then friction will "lose its grip" and the magnitude of the frictional force will take on a smaller value while the box is sliding — that is, smaller than the maximum value at which friction "loses its grip."]

6. You push on a crate, and it starts to move but you don't. Draw a free-body diagram for you and one for the crate. Then use the diagrams and Newton's third law of motion to explain why the crate moves but you don't. [It may help to imagine that you are wearing rubber-soled shoes, while the bottom of the crate is wood or cardboard.]

7. When you are standing motionless on the ground, your feet are exerting a force on Earth. Why doesn't Earth move away from you?

8. The design strength of the couplings used in connecting railroad cars is determined by the maximum tension or compression that any coupling in a given train will likely feel. [Note: compression is similar to tension, but if a rope or a cable or a spring or a bar or a rod (or etc) is in tension, then its two ends are being pulled apart. If a spring or a bar or a rod is in compression, then its two ends are being pushed together. A rope or cable cannot support compression, only tension.] Assume that friction between the track and the railcars can be neglected (but of course friction between the track and the locomotive cannot be neglected). (a) If a locomotive is pulling three cars and speeding up, in which coupling is the force greatest? (b) Is this force a tension force or a compression force? (c) If the locomotive is slowing the three-car train down, which coupler feels the greatest force? (d) Is this force a tension force or a compression force? [Assume that the railcars are in neutral and have no brakes. Only the locomotive has brakes.]