Problem Set 3
Due: See website for due date

Chapter 5: Force and Motion—I
Exercises & Problems: 5, 16, 25, 51, 53, 57, 66, 80

Question A
While driving your car, you are rear-ended. How does a car headrest help to guard against whiplash? Your explanation should show pictures, forces and Newton’s laws to explain your reasoning.

Question B
When a string barely strong enough lifts a heavy weight, it can lift the weight by a steady pull; but if you jerk the string, it will break. Your explanation should show pictures, forces and Newton's laws to explain your reasoning.

Question C
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 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?

Question D
Draw free-body diagrams (FBD) for each situation. Make sure the lengths of the force vectors are appropriate to the magnitudes of the forces and use short concise sentences to explain how you obtained the magnitudes.

a. A small car is pushing a large truck. They are speeding up. Draw FBDs for the car and the truck. Is the net force acting on the truck larger, smaller or the same as the net force acting on the car?

b. You are carrying your 3-year niece on your shoulders in an elevator cabin that is moving upwards with constant velocity. Then the elevator starts decelerating. Draw FBDs for the elevator cabin, your niece, and yourself of both situations (constant velocity and decelerating). What changes occurred? In other words, what happens to the magnitudes of the forces?

Question E
I am sitting in my car (not moving) at a red light and I see an incoming car that's going to hit me from behind. Would I personally be safer if I (i) put on the brakes on or (ii) put the car in neutral? Assume there's no possibility of being hit by another car and the car crashing into me is going at a good speed.

Problem 5.5
Three astronauts, propelled by jet backpacks, push and guide a 120 kg asteroid toward a processing dock, exerting the forces shown in Fig. 5-32, with $F_1 = 32 \text{ N}$, $F_2 = 55 \text{ N}$, $F_3 = 41 \text{ N}$, $\theta_1 = 30^\circ$, and $\theta_3 = 60^\circ$. What is the asteroid's acceleration (a) in unit-vector notation and as (b) a magnitude and (c) a direction relative to the positive direction of the x axis?

Problem 5.16
Some insects can walk below a thin rod (such as a twig) by hanging from it. Suppose that such an insect has mass m and hangs from a horizontal rod as
shown in Fig. 5-37, with angle $\theta = 40^\circ$. Its six legs are all under the same tension, and the leg sections nearest the body are horizontal. (a) What is the ratio of the tension in each tibia (forepart of a leg) to the insect’s weight? (b) If the insect straightens out its legs somewhat, does the tension in each tibia increase, decrease, or stay the same?

**Problem 5.25**
Sunjamming. A “sun yacht” is a spacecraft with a large sail that is pushed by sunlight. Although such a push is tiny in everyday circumstances, it can be large enough to send the spacecraft outward from the Sun on a cost-free but slow trip. Suppose that the spacecraft has a mass of 900 kg and receives a push of 20 N. (a) What is the magnitude of the resulting acceleration? If the craft starts from rest, (b) how far will it travel in 1 day and (c) how fast will it then be moving?

**Problem 5.51**
The figure shows two blocks connected by a cord (of negligible mass) that passes over a frictionless pulley (also of negligible mass). The arrangement is known as Atwood’s machine. One block has mass $m_1 = 1.30$ kg; the other has mass $m_2 = 2.80$ kg. What are (a) the magnitude of the blocks’ acceleration and (b) the tension in the cord?

**Problem 5.53**
Three connected blocks are pulled to the right on a horizontal frictionless table by a force of magnitude $T_3 = 65.0$ N. If $m_1 = 12.0$ kg, $m_2 = 24.0$ kg, and $m_3 = 31.0$ kg, calculate (a) the magnitude of the system’s acceleration, (b) the tension $T_1$, and (c) the tension $T_2$.

**Problem 5.57**
A block of mass $m_1 = 3.70$ kg on a frictionless plane inclined at $30.0^\circ$ is connected by a cord over a massless, frictionless pulley to a second block of mass $m_2 = 2.30$ kg. What are (a) the magnitude of the acceleration of each block, (b) the direction of the acceleration of the hanging block, and (c) the tension in the cord?

**Problem 5.66**
The figure shows a section of a cable-car system. The maximum permissible mass of each car with occupants is 2800 kg. The cars, riding on a support cable, are pulled by a second cable attached to the support tower on each car. Assume that the cables are taut and inclined at angle $\theta = 35^\circ$. What is the difference in tension between adjacent sections of pull cable if the cars are at the maximum permissible mass and are being accelerated up the incline at 0.81 m/s$^2$?

**Problem 5.80**
An 80 kg person is parachuting and experiencing a downward acceleration of 2.5 m/s$^2$. The mass of the parachute is 5.0 kg. (a) What is the upward force on the open parachute from the air? (b) What is the downward force on the parachute from the person?