

**Problem Set 4**  
(due Thursday, Jan. 27)

- For each of the following objects, draw a qualitatively correct force diagram, being sure that the net force points in the direction of the acceleration (if any). For each force, list the type of force (e.g., tension, gravity) and the agent of the force (i.e., the nearby object that exerts the force).
  - A box sitting at rest on an inclined ramp.
  - A car braking to a stop as it travels in a straight line on a horizontal road.
  - An unpowered roller coaster car at the very top of a “loop-de-loop”, where the car is exactly upside-down.
- If an object is at rest (for more than an instant), can there still be a force acting on it? Explain.
- A hockey puck is sliding on frictionless ice. With a single swing of your stick, you want to make the puck turn a  $90^\circ$  angle without changing speed. In what direction should you aim your swing? (Please draw a picture showing the path of the puck and the direction of the swing, and explain carefully.)
- Calculate your weight in newtons and your mass in kilograms.
- If gold were sold by weight, would you rather buy it in Denver or in Death Valley? What if it were sold by mass? Explain carefully.
- The force of gravity is twice as great on a 20-N rock as on a 10-N rock. Why doesn't the 20-N rock accelerate more rapidly when dropped? Explain carefully.
- A standard kilogram mass (rolling on small frictionless wheels) is pulled horizontally with a standard spring scale, and is found to accelerate at a rate of  $5.0 \text{ m/s}^2$ . (a) What is the force exerted by the spring scale? (b) Suppose that an unknown mass is pulled with this same force, and found to accelerate at a rate of  $2.0 \text{ m/s}^2$ . What is the mass of this object?
- An elevator in a skyscraper takes 4 seconds to accelerate from rest to its cruising speed of 10 m/s, and another 4 seconds to come to a stop. A 60-kg passenger boards the elevator on the ground floor. What is the passenger's apparent weight (a) before the elevator starts moving? (b) while the elevator is speeding up? (c) while the elevator is moving at cruising speed? and (d) while the elevator is slowing down? Draw a qualitatively accurate force diagram for the passenger in each of these four situations.
- A crate is sitting in the middle of the bed of a pickup truck, stopped at a red light, on a horizontal road. After the light turns green, the truck accelerates and the crate remains in the middle of the truck bed, without slipping. Draw a qualitatively accurate force diagram for the crate, indicating the type and agent of each force. Also indicate the direction of the truck's motion on your diagram.

10. Imagine that you are trying to carry a cabinet through a tight corridor, but that there is no good place to hold the cabinet—so you simply place a hand against each side and press inward with your palms on the vertical surfaces, hoping there will be enough friction to keep the cabinet from slipping downward. Suppose that you exert an inward (horizontal) force of 300 N with each hand, but the coefficient of slipping friction between your sweaty hands and the sides of the cabinet is only 0.4. Unfortunately, this isn't sufficient and the cabinet begins slipping. (a) Draw a qualitatively accurate force diagram for the cabinet, indicating the type and agent of each force. (b) What is the magnitude of the friction force exerted by each of your hands on the cabinet? (c) After pausing to dry off your hands, you try the same procedure again. Now the coefficient of gripping friction between your hands and the sides of the cabinet is 0.7. You successfully lift the cabinet and it doesn't slip! What can you conclude about the magnitude of the friction forces, and the weight of the cabinet?

## Study Guide

You should be able to define and explain the following concepts, in your own words:

Reference frame

Inertial reference frame

Newton's first law

Mass

Force

Newton's second law:  $\sum \vec{F} = m\vec{a}$

Contact forces (compression, tension, friction, drag, thrust, "normal")

Long-range forces (gravity, electrostatic, magnetic)

Agent of a force

Weight = gravitational force (magnitude =  $mg$ , where  $g = 9.8 \text{ N/kg}$ )

Apparent weight

Coefficient of friction (slipping, gripping, rolling)

Force diagrams

You should also be able to draw accurate force diagrams for objects subject to various types of forces, correctly identifying the type and agent of each force.