Physics 2010 (Schroeder) Name _____
spring 2004

Problem Set 4

(due Friday, Feb. 6)

1. For each of the following objects, draw a qualitatively correct force (or "free-body") 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) A box sitting at rest on an inclined ramp.

   (b) A car braking to a stop as it travels in a straight line on a horizontal road.

   (c) An unpowered roller coaster car at the very top of a "loop-de-loop", where the car is exactly upside-down.

2. If an object is at rest (for more than an instant), can there still be a force acting on it? Explain.

3. A hockey puck is sliding eastward on frictionless ice. With a single swing of your stick, you want to make the puck turn a 90° angle to the south, 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.)

4. Calculate your weight in newtons and your mass in kilograms.

5. 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.

6. 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.

7. 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 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 m/s^2. What is the mass of this object?

8. Suppose that a frisbee (mass 175 g) while flying horizontally through the air, is acted upon by two forces: gravity and a horizontal (backward) air resistance force of 0.2 N. Find the magnitude and direction of the frisbee's acceleration vector.

9. A person (mass 55 kg) is in an elevator traveling upward. The person is standing on a bathroom scale that reads 420 N. What is the magnitude and direction of the elevator's acceleration? (Hint: The reading on the scale is a measure of the force exerted on the person by the scale. Analyze the person's motion with respect to an inertial frame of reference. You may wish to use the worksheet.)

10. A 12 kg armadillo is suspended from the middle of a rope, as two people pull the ends of the rope trying to keep it horizontal. What force must each of them exert if the

angle of the rope is to be no more than 10° from horizontal (on either side of the point where the armadillo is hanging)? Can they reduce the angle to 0°? Explain. (Hint: Consider the armidillo and whatever attaches it to the rope to be a single object, and analyze the forces acting on this object. You may wish to use the worksheet.)

11. While tending bar (to earn money to pay your tuition for this course), you casually slide a mug of beer along the bar to a customer 5.0 meters away. Because of friction (and your expertise at giving the mug the right initial speed), the beer mug comes to rest right in front of the customer, as desired. Suppose the coefficient of kinetic friction between the mug and the slick countertop is 0.12. With what initial speed did you slide the mug? (Hint: Use the Constrained Motion Problem worksheet to determine the mug's acceleration, then use the Constant Acceleration worksheet to determine the initial speed.)

12. A box (mass 14 kg) sits in the back of a pickup truck (mass 2800 kg) waiting at a stoplight. When the light turns green, the driver of the pickup drives forward with an acceleration of magnitude 5.0 m/s^2. If the coefficient of static friction between the box and the truck bed is 0.40, will the box stay on the truck? (Hint: Remember that Newton's laws apply only with respect to a reference frame that is not accelerating. You may wish to use the worksheet.)

Study Guide

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

Law of inertia (Newton's first law)

Reference frame

Inertial reference frame

Mass

Force

Newton's second law: $\sum F_x = ma_x$, $\sum F_y = ma_y$, $\sum F_z = ma_z$.

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

Long-range forces (gravity, electrostatic, magnetic)

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

Friction forces: $|\vec{F}_{\text{slipping}}| = \mu_k |\vec{F}_N|$; $|\vec{F}_{\text{gripping}}| \leq \mu_s |\vec{F}_N|$

Force diagrams

Agent of a force

You should also be able to solve "constrained-motion problems", such as problems 9 through 12 on this problem set.