Physics 2210 (Schroeder) Name _____
spring 2006

Problem Set 5

(due Wednesday, September 24)

1. 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.)

2. 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.)

3. A pig slides down a certain 35° incline in twice the time it would take to slide down a frictionless incline with the same lenghth and angle. What is the coefficient of sliding friction between the pig and the inclined surface? (Hint: First use your knowledge of motion under constant acceleration to determine the acceleration of the pig. Then draw a force diagram and use Newton's laws to determine the coefficient of friction.)

4. You are riding in a railroad car on a level track when for amusement you decide to hang a 1.5-kg rock from the ceiling by a string. At a certain moment you notice that the rock hangs motionless at an angle of 10° from the vertical, toward the front of the train. From this information, what can you determine about the motion of the train? (Hint: analyze the problem from the viewpoint of an *inertial* reference frame, namely the earth.)

5. In a popular amusement park ride, you stand with your back against the wall inside a cylinder of radius 2.5 meters. The cylinder then begins to turn, eventually reaching a speed at which it turns once every 1.5 seconds. At this point the floor drops away, but you feel pressed against the wall by an unseen (and nonexistent!) force. Draw a diagram of all the *actual* forces acting on your body, then apply Newton's second law to determine whether you will fall. Assume that the coefficient of gripping friction between your clothing and the wall is 0.4.

6. A stuntman drives a car over the top of a hill, the cross section of which can be approximated by a circular arc of radius 250 m. What is the greatest speed at which he can drive without the car leaving the road at the top of the hill? (Be sure to justify your answer with a full explanation, not just a calculation.)

7. A banked circular highway curve is designed for traffic moving at 30 mph. (So at this speed, no friction is necessary to keep a car on the road.) The radius of the curve is

150 m. But you're in a hurry, so you try to take the curve at 55 mph. Unfortunately, the road surface is wet, so the coefficient of friction between your tires and the road is only 0.20. Will you crash?

In each of the next three problems, draw a qualitatively accurate force diagram for each object involved, and list all pairs of forces that are equal according to Newton's *third* law.

8. You jump off the ground. (Draw diagrams for both you and the earth during the time when you are still in contact with the ground, accelerating upward.)

9. A little box sits on top of a bigger box sitting on an incline. Both are at rest. (Draw diagrams for both boxes.)

10. A person hangs from a helicopter by a rope as the helicopter begins to accelerate upward. (Draw diagrams for the person, the helicopter, and the rope.)

11. A bowling ball crashes head-on into a bowling pin at the end of the lane. Obviously the ball exerts a force on the pin. Does the pin also exert a force on the ball? If so, which of these two forces is greater in magnitude? Explain fully.

12. A mule is asked to pull a plow. The mule resists, explaining "If I tug on the plow, Newton's third law asserts that the plow will tug on me with an equal and opposite force. Since these forces cancel each other out, it is obvious that we're not going to go anywhere. Therefore, there is no point in even trying." Carefully explain the error in the mule's reasoning, and draw force diagrams for the mule and the plow showing how it is possible for both to accelerate.

Study Guide

You should be able to solve constrained motion problems for a single object at rest, or undergoing linear or circular motion. In solving these problems, you should be able to draw qualitatively accurate force diagrams, correctly identifying all forces (type, direction, agent). You should be able to apply Newton's second law in component form, and use what you already know about kinematics and vectors to solve for unknown quantities. You should be able to answer yes/no questions by solving for an appropriate quantity and making a comparison.

You should also understand Newton's third law. In particular, you should be able to correctly identify pairs of forces that are related by the third law.