Physics 2010 (Schroeder) Name ______________________
spring 2004

Problem Set 3

(due Thursday, Jan. 29)

1. Find the x and y components of the vector $\vec{A}$ shown below, given that $|\vec{A}| = 2.4$ meters and $\phi = 34°$. (The figure is not to scale, so use formulas instead of graphical methods.)

2. A certain velocity vector $\vec{v}$ has components $v_x = 42$ m/s and $v_y = -64$ m/s. Sketch this vector (along with a set of coordinate axes for reference), and find its magnitude and direction. Be sure to describe the direction unambiguously.

3. Just as a sequence of English words may or may not be a grammatically correct sentence, an arrangement of mathematical symbols may or may not be potentially meaningful. Some of the following equations are meaningful (whether or not they are true), while others are meaningless—there is no clear way to interpret what they are trying to say. Determine which ones are meaningless, and for each, explain in a sentence what the problem is. (Any symbol with an arrow represents a vector, while any symbol without an arrow represents a scalar. Symbols with subscripts represent the components of corresponding vectors. Pay no attention to what the symbols might actually stand for, or to whether the intended statements are true!)

$$\vec{a} = \frac{|\vec{v}|^2}{R} \qquad \vec{F} = m\vec{a} \qquad F_x = ma_y \qquad m = \frac{\vec{F}}{\vec{a}} \qquad \Delta x = \frac{1}{2}\vec{g}t^2$$

4. Draw a large "strobe diagram" of a car braking to a stop on a straight section of road. Alongside the dots, draw the car's velocity vectors at various points. Then graphically subtract two of these velocity vectors to determine the direction of the car's acceleration vector.

5. Draw a large "strobe diagram" of the motion of a car, as viewed from above, as it rounds a curve to the left and simultaneously brakes to a stop. Alongside the dots, draw the car's velocity vectors at a few different points. Then use these velocity vectors to determine the approximate direction of the car's acceleration vector.

6. A ball is suspended from a string to make a simple pendulum. Draw a large "strobe diagram" of the motion of the pendulum swinging back and forth. Draw arrows near the dots to represent the velocity vectors of the ball at various points. Then use these velocity vectors to determine the approximate direction of the ball's acceleration vector at various points, including the top of the swing, the bottom of the arc, and at least one intermediate point (as the ball is on its way down).

7. A baseball is thrown with an initial velocity of $v_x = 10$ m/s, $v_y = 15$ m/s (where x is a horizontal direction and y is upward). Air resistance is negligible. When the baseball reaches the top of its trajectory, what are its velocity and acceleration vectors?

8. A baseball leaves a pitcher's hand horizontally at a speed of 100 miles per hour. The distance to the batter is 60 ft. (a) How long does it take for the ball to travel the first 30 ft horizontally?

The second 30 ft? (b) How far does the ball fall vertically during the first 30 ft of its horizontal travel? (c) During the second 30 ft? (d) Why aren't the answers to (b) and (c) equal? (You may ignore air resistance.)

9. Abel Knaebble, professional stunt-man and amateur physicist, wants to jump the Grand Canyon with his new super-streamlined motorcycle (which is completely immune to the effects of air-resistance). He simply plans to ride his motorcycle horizontally off the north rim, fast enough to land safely on the south rim, which is 320 meters lower. The width of the canyon at the point of his jump is 8 km, the depth of the canyon is 1.6 km, and the mass of the fully loaded cycle (including Abel himself) is 330 kg. How fast does he need to ride in order to make the jump? (You may wish to use the Constant Acceleration Problem Worksheet.)

10. An eagle is flying horizontally at a speed of 3.0 m/s when the fish in its talons wiggles loose and falls into the lake, 5.0 m below. Find the velocity of the fish (magnitude and direction) when it hits the water. (You may wish to use the worksheet.)

11. A football player kicks a successful field goal from a distance of 37 m (40 yards) from the goalpost. The ball just clears the crossbar, 3.1 m (10 ft) above the ground. Assuming that the ball is kicked at an initial angle of 40° above the horizontal, what is its initial speed? (You may wish to use the worksheet.)

12. A ship sets sail from Rotterdam, The Netherlands, heading due north at 7.0 m/s relative to the water. The local ocean current is 1.5 m/s in a direction 40° north of east. What is the velocity (magnitude and direction) of the ship relative to the earth?

Study Guide

You should understand the fundamental vector operations of addition, subtraction, and scalar multiplication. You should be able to find the magnitude and direction of a vector from its components, or vice-versa.

You should know and understand the fundamental definitions:

$$\vec{v} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\vec{r}_f - \vec{r}_i}{t_f - t_i} \qquad \text{(definition of velocity)}$$

$$\vec{a} = \frac{\Delta\vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i} \qquad \text{(definition of acceleration)}$$

For any type of motion, you should be able to correctly describe (or draw) the velocity and acceleration vectors. In particular, you should understand why the acceleration vector of a curving object points inward toward the center of the curve.

If the acceleration vector is constant (in both magnitude and direction), then

$$v_x = v_{x0} + a_x t; \qquad x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2 \qquad \text{(and similarly for } y,\ z\text{).}$$

You needn't memorize these equations, but you should know when and how to use them correctly.

For a freely flying projectile, $\vec{a}$ points straight down and has magnitude $g = 9.8$ m/s^2.

You should be able to combine velocity vectors to determine relative velocities, as described in Section 3.5.