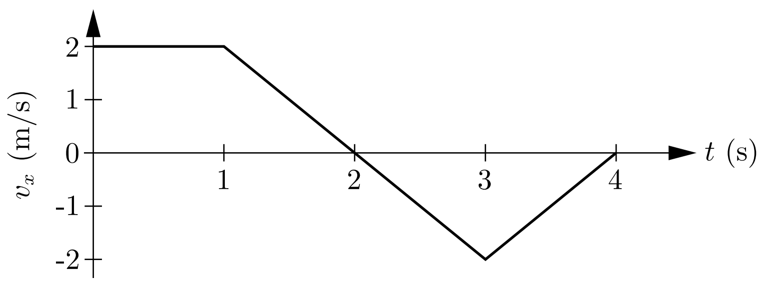
Physics 2010 (Schroeder) Name ____________________
spring 2004

Problem Set 2

(due Friday, Jan. 23)

1. Precise measurements show that North America and Europe are moving apart at a velocity of about 3 centimeters per year. The current average width of the Atlantic Ocean is roughly 5000 km. Use this information to make a rough estimate of how long ago Europe and North America first began to split apart.

2. Shown below is a graph of velocity vs. time for an object moving in one dimension. Use this graph to answer each of the following questions, being sure to show your work or explain your reasoning in each case.



   (a) At what time(s) is the object moving in the $+x$ direction?

   (b) At what time(s) is the *speed* of the object increasing?

   (c) What is the acceleration of the object at $t = 2$ s?

   (d) If the object is at $x = 0$ at $t = 0$, where is it at $t = 2$ s?

   (e) What is the object's net displacement over the entire time interval shown?

   (f) Carefully draw a graph of acceleration vs. time for this motion.

   (g) Carefully draw a graph of position vs. time for this motion.

3. A train is initially at rest at $x = 0$. It then starts moving in the $+x$ direction, gradually speeding up until it reaches its "cruising speed". After it has been at cruising speed for a while, someone hits the emergency brake, rapidly bringing the train to a stop. Sketch qualitatively accurate graphs of position, velocity, and acceleration vs. time for the motion of the train. Place your graphs vertically one above the other, so that corresponding times match up on the three graphs.

4. In the previous problem set you drew graphs of position and velocity for a bouncing ball. Draw the velocity graph again, then underneath it, draw a graph of acceleration vs. time for this motion.

5. (a) Give an example in which the velocity of an object is zero while the acceleration is not. (b) Give an example in which the velocity of an object is negative but its acceleration is positive.

6. On December 10, 1954, Dr. John Paul Stapp rode a rocket sled to a speed of 632 mi/h, enduring extreme accelerations. He went from rest to his top speed in 5.0 s, and brought jarringly back to rest in only 1.4 s! Calculate his average accelerations during these two time intervals. Express your answers in m/s, and also as multiples of g.

7. Raindrops fall to earth from a cloud 1700 m above earth's surface. If they were not slowed by air resistance, how fast would the drops be moving when they struck the ground? Would it be safe to walk outside during a rainstorm? (Hint: Use the Constant Acceleration Problem Worksheet.)

8. A jumbo jet must reach a speed of 360 km/hr (225 mph) on the runway for takeoff. The length of the runway is 1.8 km. What is the minimum (constant) acceleration needed? (Hint: Use the worksheet.)

9. A basketball player jumps straight upward to reach the ball. At what initial velocity must the player jump, in order to rise 1.25 meters? (Hint: Use the worksheet, and pretend that the player is a pointlike particle.)

10. A car is driven 50 km east, then north 30 km north, then 25 km in a direction 30° north of east. Draw a vector diagram showing these motions, then graphically determine the total displacement (magnitude and direction) of the car from its starting point.

11. Vector $\vec{a}$ has a magnitude of 5.0 units and is directed east. Vector $\vec{b}$ is directed 35° west of north and has a magnitude of 4.0 units. Use a ruler and a protractor to construct accurate vector diagrams showing $\vec{a}+\vec{b}$ and $\vec{b}-\vec{a}$. Measure the magnitude and direction of the resulting vector in each case. (Please use the "tail-to-tail" method of vector subtraction, as presented in class.)

Study Guide

You should understand the basic definitions of velocity and acceleration in one dimension:

$$v_x = \frac{\Delta x}{\Delta t}, \qquad a_x = \frac{\Delta v_x}{\Delta t}.$$

You should be able to draw and interpret graphs of x, v_x, and a_x for any type of one-dimensional motion.

If the acceleration of an object is contant, then you can use the following equations to describe and predict the motion for all time:

$$v_x = v_{x0} + a_x \cdot t, \qquad\qquad x = x_0 + v_{x0} \cdot t + \frac{1}{2} a_x t^2.$$

Because these equations apply only in a restricted class of problems, you need not memorize them; I will provide them when necessary on quizzes and tests. Be sure not to use these equations unless the acceleration is (at least approximately) constant!

The acceleration of any freely flying object near earth's surface, neglecting air resistance, is straight down and has magnitude

$$g = 9.8 \text{ m/s}^2.$$

You should memorize this number.

You should understand what a vector is, and be able to add and subtract vectors graphically.