PHY 140Y - FOUNDATIONS OF PHYSICS
2001-2002
Problem Set #1

HANDED OUT: Friday, September 21, 2001 (in class).

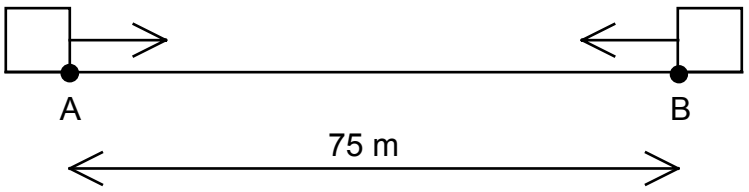
DUE: **5:00 PM, Thursday, October 4, 2001** in the appropriate box, labeled by tutorial group, in the basement at the bottom of the stairs leading down from MP202.

LATE PENALTY: 5 marks/day (which also applies to weekend days!) until 1:00 PM, Monday, October 8, after which it will not be accepted as solutions will then be available in tutorials and on the WWW.

NOTES: Answer all questions. A selected subset (3-4) will be marked out of 100%. Marks will be given for workings and units, as well as for final answers.

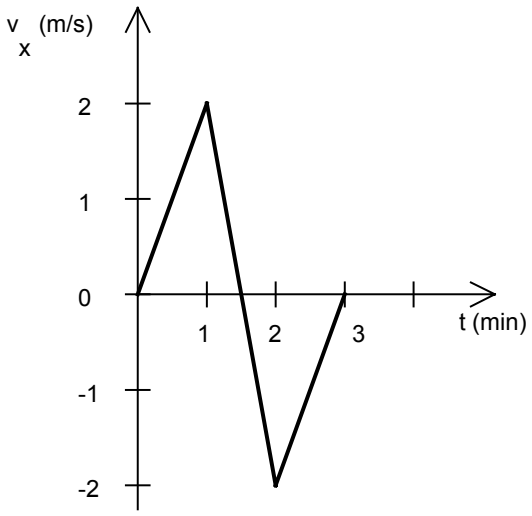
QUESTIONS:

1. One car starts out from point A with initial velocity 10.0 m/s to the right but is decelerating at the rate of 2.0 m/s^2. A second car starts out from rest at point B (75 m from A) and accelerates towards A at 4.0 m/s^2.
   (a) When do the two cars collide?
   (b) Where are the two cars when they collide?
   (c) How fast is each car going when they collide?



2. A water balloon is thrown straight up and reaches its maximum height after 2.00 s. Sketch the situation and introduce an appropriate coordinate system to answer the following questions.
   (a) What is the acceleration of the balloon after it leaves the hand and is rising?
   (b) What is the acceleration of the balloon as it is falling?
   (c) What is the acceleration of the balloon at the instant it is motionless at it maximum height?
   (d) What was the initial velocity component of the balloon?
   (e) How high did the balloon rise above the point of its release?

3. The x-component of the velocity of a garbage barge is indicated in the graph shown below.
(a) What is the average acceleration of the barge during the time interval between 0 min and 1.0 min on the clock? What is the instantaneous acceleration of the barge when t = 0.5 min?
(b) What is the average acceleration of the barge during the time interval between 1.0 min and 2.0 min on the clock? What is the instantaneous acceleration of the barge when t = 1.5 min?
(c) What is the average acceleration of the barge during the time interval between 2.0 min and 3.0 min on the clock? What is the instantaneous acceleration of the barge when t = 2.5 min?
(d) Explain what is happening to the barge in descriptive English.
(e) Sketch a graph of the position x of barge as a function of time consistent with and as complete as the information provided allows. Assume that the barge initially is at the Cartesian origin.



4. A ball is tossed vertically upward with a speed of 25.0 m/s.
(a) Indicate an appropriate coordinate system for analyzing its motion.
(b) What is its maximum altitude above the point from which it was thrown?
(c) How long does it take to return to the point of release?
(d) Make a graph of the acceleration component a_x of the particle versus time, indicating appropriate numerical values along the axes.
(e) Make a graph of the velocity component v_x of the particle versus time, indicating appropriate numerical values along the axes.
(f) Make a graph of the position vector component x as a function of time, indicating appropriate numerical values along the axes.

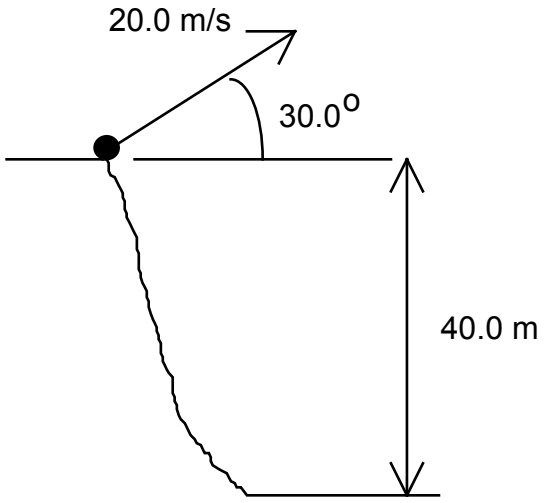
5. When a ball bounces from the floor, the ratio of the speed at the instant just after the bounce to the speed at the instant just before the bounce is called the coefficient of restitution, ε, of the ball.
(a) Show that if a ball, initially at rest, is dropped from a height h_o and rebounds to a height h_1, then the coefficient of restitution is

$$\varepsilon = \sqrt{h_1/h_o}\ .$$

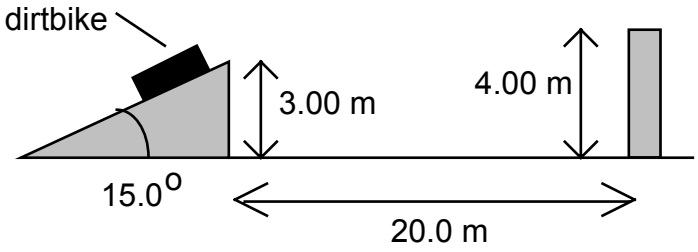
(b) The height of rebound is difficult to measure precisely. An alternative way of determining the coefficient of restitution is to drop a ball from height h_o and measure the total time T from its release to the instant of its third impact with the floor. Show that the coefficient of restitution is related to T by

$$T = \sqrt{2h_o/g}\left(1 + 2\varepsilon + 2\varepsilon^2\right).$$

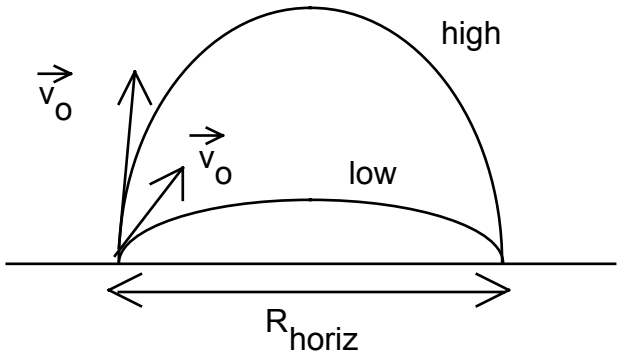
6. A soccer ball is kicked off a cliff at a speed of 20.0 m/s as indicated in the figure below.
(a) In a sketch, indicate a choice for a coordinate system to analyze the problem.
(b) Give equations for the initial x and y components of position, velocity, and acceleration. Also give equations for the x and y components of position and velocity as functions of time.
(c) Determine the time of flight of the ball.
(d) Determine where the ball hits the ground the first time.



7. A dirt biker races up a 15.0° incline at a constant speed of 120. km/hr. The end of the ramp is 3.00 m off the ground as indicated in the figure below. A 4.00 m high obstacle is located 20.0 m from the base of the ramp.
(a) Indicate an appropriate coordinate system to attack the problem.
(b) Will the daredevil clear the obstacle? If so, where will she land?



8. A projectile is launched at speed v_o towards a target located a distance R_{horiz} away over level terrain as indicated in the figure below.
(a) Show that there are *two* possible launch angles, hence that there is a high trajectory and a low trajectory, *except* when the launch angle is 45° for maximum horizontal range, in which case the two launch angles are identical to each other. The two launch angles are symmetrical about the 45° angle.
(b) If R_{horiz} = 100. m and v_o = 40.0 m/s, find the two possible angles for launch.
(c) Which launch angle is a quarterback on a football team likely to use?



9. A particle is moving at constant speed 10.0 m/s in circles of various radii.
(a) Make a graph of the magnitude of the centripetal acceleration of the particle versus the radius of the circle for radii between r = 0 m and 100 m.
(b) At what radius is the magnitude of the centripetal acceleration of the particle equal to the magnitude of the local acceleration due to gravity (g = 9.81 m/s^2)? What is the angular speed ω of the particle with speed 10.0 m/s at this radius?

10. A particle is moving in a circle of radius 5.00 m.
(a) Make a graph of the magnitude of the centripetal acceleration versus the speed of the particle for speeds ranging between 0 m/s and 10.0 m/s. What is the slope of the graph when v = 0 m/s?
(b) Make a corresponding graph of the magnitude of the centripetal acceleration versus the angular speed ω of the particle for the same speeds indicated in part (a). What is the slope of this graph when ω = 0 rad/s?