Problem Set 1

Instructions:

1. Answer all questions below. Show your work for full credit.
2. The first problems are due at the start of class on 13 Jan 2014
3. The second problems are due at the start of class on 15 Jan 2014
4. The remaining problems are due by the end of the day on 17 Jan 2014
5. You may collaborate, but everyone must turn in their own work.

Daily problems due 13 Jan 2014

1. Here are two vectors:

$$\vec{\mathbf{a}} = 1.0\,\hat{\boldsymbol{\imath}} + 2.0\,\hat{\boldsymbol{\jmath}} \qquad \vec{\mathbf{b}} = 3.0\,\hat{\boldsymbol{\imath}} + 4.0\,\hat{\boldsymbol{\jmath}}$$

Find the following quantities:

a) the magnitude of $\vec{\mathbf{a}}$
b) the angle of $\vec{\mathbf{a}}$ relative to $\vec{\mathbf{b}}$
c) the magnitude and angle of $\vec{\mathbf{a}} + \vec{\mathbf{b}}$
d) the magnitude and angle of $\vec{\mathbf{a}} - \vec{\mathbf{b}}$

2. (a) If the position of a particle is given by $x = 20t - 5t^3$, where x is in meters and t is in seconds, when, if ever, is the particle's velocity zero? (b) When is its acceleration a zero? (c) For what time range (positive or negative) is a negative? (d) Positive? (e) Sketch graphs of $x(t)$, $v(t)$, and $a(t)$.

Daily problem due 15 Jan 2014:

3. A pilot flies horizontally at 1300 km/h, at height $h = 35$ m above initially level ground. However, at time $t = 0$, the pilot begins to fly over ground sloping upward at angle $\theta = 4.3°$. If the pilot does not change the airplane's heading, at what time t does the plane strike the ground?

The problems below are due by the end of the day on 17 Jan 2014.

4. (a) With what speed must a ball be thrown vertically from the ground level to rise to a maximum height of 50 m? **(b)** How long will it be in the air? **(c)** Sketch graphs of y, v, and a versus t for the ball. On the first two graphs, indicate the time at which 50 m is reached.

5. Two seconds after being projected from ground level, a projectile is displaced 40 m horizontally and 53 m vertically above its launch point. What are the horizontal and vertical components of the initial velocity of the projectile?

6. A person standing at the top of a hemispherical rock of radius R kicks a ball (initially at rest on the top of the rock) to give it horizontal velocity $\vec{\mathbf{v}}_\mathbf{i}$ as shown below. What must be its minimum initial speed if the ball is never to hit the rock after it is kicked? Note this is not circular motion.

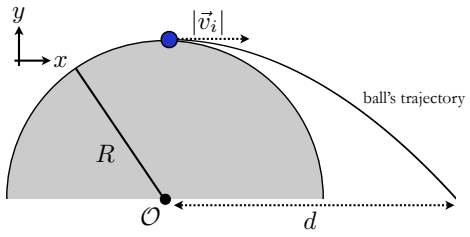

Figure 1: *A ball is kicked off the top of a rock by an unseen person.*

7. Here are three vectors:

$$\vec{\mathbf{d}}_1 = -2.0\,\hat{\boldsymbol{\imath}} + 3.0\,\hat{\boldsymbol{\jmath}} + 2.0\,\hat{\mathbf{k}}$$
$$\vec{\mathbf{d}}_2 = -3.0\,\hat{\boldsymbol{\imath}} - 4.0\,\hat{\boldsymbol{\jmath}} - 2.0\,\hat{\mathbf{k}}$$
$$\vec{\mathbf{d}}_3 = 1.0\,\hat{\boldsymbol{\imath}} + 3.0\,\hat{\boldsymbol{\jmath}} + 5.0\,\hat{\mathbf{k}}$$

What is the result of the following operations?

a) $\vec{\mathbf{d}}_1 \cdot \left(\vec{\mathbf{d}}_2 + \vec{\mathbf{d}}_3\right)$
b) $\vec{\mathbf{d}}_1 \cdot \left(\vec{\mathbf{d}}_2 \times \vec{\mathbf{d}}_3\right)$
c) $\vec{\mathbf{d}}_1 \times \left(\vec{\mathbf{d}}_2 + \vec{\mathbf{d}}_3\right)$

8. A batter hits a baseball coming off of the bat at a 45° angle, making contact a distance 1.22 m above the ground. Over level ground, the batted ball has a range of 107 m. Will the ball clear a 7.32 m tall fence at a distance of 97.5 m? Justify your answer. *Hint: use the range equation to get the velocity, then use the trajectory equation to find the path of the ball.*

9. A ball rolls horizontally off the top of a stairway with a speed of 1.52 m/s. The steps are 20.3 cm high and 20.3 cm wide. Which step does the ball hit first. You may assume that there are many, many stairs.

10. A projectile's launch speed is five times its speed at maximum height. Find the launch angle θ_o.

NAME PROBLEM-SOLVING TEMPLATE

Find / Given:

Sketch:

Relevant equations:

Symbolic solution:

Numeric solution:

Double Check

Dimensions

Order-of-magnitude