University of Alabama
Department of Physics and Astronomy

PH 105 LeClair Summer 2015

Week 1 Homework

Instructions:

1. There are problems assigned for each day of class.
2. The following class, you will turn in the one problem the instructor requests.
3. Only the chosen problem for the day is graded.
4. Please follow the homework template provided.
5. You may collaborate, but everyone must turn in their own work.

Problems for 26 May (due 27 May)

1. Water is poured into a container that has a leak. The mass m of the water is as a function of time t is

$$m = 5.00t^{0.8} - 3.00t + 20.00$$

with $t \geqslant 0$, m in grams, and t in seconds. At what time is the water mass greatest?

2. **(a)** Find the separation vector $\Delta\vec{r} = \vec{r} - \vec{r}'$ between the vectors $\vec{r}' = (3, 4, 5)$ and $\vec{r} = (7, 2, 17)$. **(b)** Determine its magnitude, and **(c)** construct the corresponding unit vector.

3. Here are two vectors:

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

Find the following quantities:

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

Problems for 27 May (due 28 May)

4. If the acceleration as a function of time is known to be $a(t) = \alpha t$, and if $x = v = 0$ at $t = 0$, what is the position versus time $x(t)$?

5. You are driving a car that has a maximum acceleration of a. The magnitude of the maximum deceleration is also a. What is the maximum distance you can travel in a time T, assuming you begin and end at rest?

6. An object starts from rest at the origin at time $t = -T$ and accelerates with constant acceleration a. A second object starts from rest at the origin at time $t = 0$ and accelerates with the same a. How far apart are they at time t? Explain the meaning of the two terms in your answer.

7. A ball is dropped from rest at height h. Directly below on the ground, a second ball is simultaneously thrown upward with speed v_0. **(a)** If the two balls collide at the moment the second ball is instantaneously at rest, what is the height of the collision? **(b)** What is the relative speed of the balls when they collide? Ignore air resistance.

8. You throw a ball upward. After half of the time to the highest point, the ball has covered what fraction of its maximum height? Ignore air resistance.

Problems for 28 May (due 29 May)

9. Two balls are thrown with the same speed v_o from the top of a cliff. The angles of their initial velocities are θ above and below the horizontal (i.e., one is thrown downward at θ below the horizontal, one is thrown upward at the same angle). How much farther along the ground does the top ball hit compared to the bottom ball? *Hint: The two trajectories have a part in common. Not much calculation is necessary.*

10. A ball is thrown with speed v at angle θ with respect to horizontal ground. At the highest point in the motion, the strength of gravity is somehow magically doubled. What is the total horizontal distance traveled by the ball?

11. **(a)** You wish to throw a ball to a friend who is a distance $2d$ away, and you want the ball to just barely clear a wall of height h that is located halfway to your friend. At what angle θ should you throw the ball? **(b)** What initial speed v_o is required? What value of h (in terms of d) yields the minimum v_o? What is the value of θ in this minimum case?

12. A person throws a ball with speed v_o at a 45° angle and hits a given target. How much quicker does the ball get to the target if the person instead throws the ball with the same speed, but at an angle that makes the trajectory consist of two identical bumps? (Assume unrealistically that there is no loss in speed at the bounce.)

13. 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 $\theta = 4.3^\circ$. If the pilot does not change the airplane's heading, at what time t does the plane strike the ground?

Problems for 29 May (due 1 June)

14. 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?

15. 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.

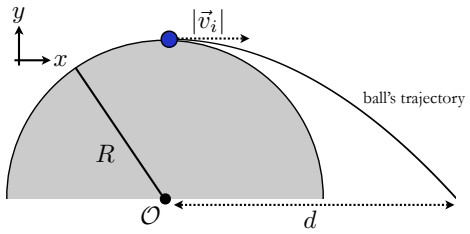

Figure 1: *A ball is kicked off the top of a rock by an unseen person.*

16. A ball is thrown horizontally with speed v from the floor at the top of some stairs. The width and height of each step are both equal to l. **(a)** What should v be so that the ball barely clears the corner of the step that is N steps down? **(b)** How far along the next step (from its base) does the ball hit? **(c)**

17. A boy whirls a stone in a horizontal circle of radius 1.5 m and at height 2.0 m above ground level. The string breaks, and the stone flies off horizontally and strikes the ground after traveling a horizontal distance of 10 m. What is the magnitude of the centripetal acceleration of the stone during the circular motion?

18. A typical front-loading washing machine might have a radius of 0.3 m and a spin cycle of 1000 revolutions per minute. What is the acceleration of a point on the surface of the drum at this spin rate? How many g's is this equivalent to?