Homework #3
due Feb. 17

1. A ship is pointing due east and has a speed relative to the water of 35 km/hr. The current at the position of the ship is flowing at a rate of 5 m/s at an angle of 45° south of east. The shore is 17 km away and due east.

   (a) What direction does the boat captain have to point his ship in order to go due east? Assume that the ship’s speed is constant.

   (b) How long will it take the ship to reach the shore if the boat is headed due east?

2. For the following questions, make the same assumptions as in the monkey and hunter problem: perfect aim, no air resistance, and point-like bullets.

   (a) Two gunfighters on a hill aim their guns directly at each other. If guns are fired simultaneously, do the bullets hit in midair? Does it matter whether the guns shoot the bullets with the same initial velocity?

   (b) Two hunters aim their guns directly at the same point in space. If guns are fired simultaneously, do the bullets hit in midair? Does it matter whether the guns shoot the bullets with the same initial velocity?

3. A particle moves with constant speed in a circle of radius $R$ centered on the origin in the $x$–$y$ plane. The particle’s position vector as a function of time is given by

   $$\vec{r}(t) = R\cos(\omega t)\hat{i} + R\sin(\omega t)\hat{j}.$$ 

   (a) Show that the formula describes motion in a circle of radius $R$ by showing that the distance to the origin is equal to $R$ at all times.

   (b) Find the velocity vector as a function of time for this motion. Show that the speed is independent of time. Give a formula for the speed in terms of $R$ and $\omega$.

   (c) Find the acceleration vector as a function of time for this motion. Show that the magnitude of the acceleration is constant, and that the acceleration is perpendicular to the velocity.

   (d) On a diagram, show the position, velocity, and acceleration at $t = 0$.

4. A catapult is capable of launching a large stone at a fixed angle of 30° above the horizontal at a speed of 30 m/s.

   (a) It is desired to launch the stone over a castle wall that is 5 m high. What is the maximum distance that the catapult can be from the wall such that the stone makes it over the wall?
(b) What is the range of the catapult if it is placed on a slope of 12° and fired uphill? What if it is fired downhill?

5. A toy tank has a gun that is pointing at a fixed angle of 45° above the horizontal. The gun can fire a ball with an initial speed (relative to the gun) of 9 m/s. The tank is moving forward at a speed of 2 m/s on horizontal ground.

(a) What angle above the horizontal is the ball going just after it leaves the gun? Hint: It’s not 45°!

(b) Does the ball go farther or not as far compared to the situation where the toy tank is at rest? How much farther or not as far?

Study Problems

Chapter 3, Problems 47, 62, 64, 67, 70, 79, 98, 119, 120