Homework 3

Due Wednesday, September 25 at 7pm

Reading for this week: Chap. 4.

1. **Theory**: Consider the problem from our worksheet where you were trying to hit your physics professor with a water balloon. Imagine that the professor tries to fire water balloons back at the top of the cliff. Solve all parts of the problem (a)-(f) again, but for the professor's launch and making the appropriate substitutions in the wording. Call the professor's launch angle θ_p and his muzzle speed v_p. Feel free to assume that he fires directly from the ground and that his angle θ_p is large enough that he can hit the cannon at the top of the cliff. Be sure to indicate your choice of coordinates!

A new part (g), check your symbolic answers to parts (d) and (f) using at least one limiting case argument.

Exercises:

2. (a) Is it possible to be accelerating while traveling at constant speed? (b) Is it possible to have zero speed and non-zero acceleration? Is it possible to round a curve with (c) zero acceleration and (d) a constant magnitude of acceleration?

3. A particle undergoes a displacement $\Delta\vec{r} = 2\hat{i} - \hat{j} + 6\hat{k}$, ending with the position vector $\vec{r}_f = 4\hat{j} + 3\,\hat{k}$, in meters. What was the particle's initial position vector?

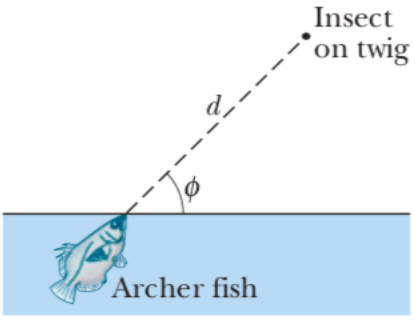
4. A plane flies 483 km east from city A to city B in one hour and then 966 km south from city B to city C in an hour and a half. For the total trip, what are the (a) magnitude and (b) direction of the plane's displacement, the (c) magnitude and (d) direction of its average velocity, and (e) its average speed?

5. A cart is propelled over an xy-plane with acceleration components $a_x = 4$ m/s^2 and $a_y = -2$ m/s^2. Its initial velocity has components $v_{0x} = 5$ m/s and $v_{0y} = 12$ m/s. In unit-vector notation, what is the velocity of the cart when it reaches its greatest y coordinate?

6. The current world-record motorcycle jump is 77 m, set by Jason Renie. Assume that he left the take-off ramp at 12° to the horizontal and that the take-off and landing heights are the same. Neglecting air drag, determine his take-off speed.

7. In a jump spike, a volleyball player slams the ball from overhead and toward the opposite floor. Controlling the angle of the spike is difficult. Suppose a ball is spiked from a height of 2.3 m with an initial speed of 20 m/s at a downward angle of 18°. How much farther on the opposite floor would it have landed if the downward angle were, instead, 8°?

8. Upon spotting an insect on a twig overhanging water, an archer fish squirts water drops at the insect to knock it into the water (see Figure at right). Although the fish sees the insect along a straight-line path at angle ϕ and distance d, a drop must be launched at a different angle θ_0 if its parabolic path is to intersect the insect. If $\phi = 30°$ and $d = 1$ m, what launch angle θ_0 is required for the drop to be at the top of the parabolic path when it reaches the insect?



9. **Problem**: A ball rolls horizontally off the top of a stairway with a speed v_0. The steps have equal tread width and height. Make reasonable estimates for the speed of the ball and the width and height of the tread. Which step does the ball hit first?