PHY 110 Spring 2018 Quiz 3 Solution

1. Suppose you throw a ball horizontally from the top of Watterson Tower (a height of 200 ft) with a speed of 70 ft/s. When the ball hits the ground, how far will it be (horizontally) from the tower?

a) 93 ft b) 168 ft **c) 247 ft** d) 322 ft

Since the ball has no initial vertical velocity, find the time it takes to reach the ground using the y-equation. Use y = 0 at the ground and positive upward.

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

$$0 = 200 + 0 + \frac{1}{2}(-32.2)t^2$$

$$t = 3.5245s$$

Then $x = x_0 + v_{0x}t = 0 + 70(3.5245) = 247\ ft$

2. A golfer, standing on horizontal ground, hits the ball toward an elevated green (10 m above his current position in vertical distance). If the initial launch angle of the ball is 70° above the horizontal and the center of the green is 120 m away (horizontally), what velocity should the golfer give the ball in order to hit the center of the green?

a) 43.5 m/s b) 58.1 m/s c) 66.7 m/s d) 72.4 m/s

Set x = y = 0 at the ball's initial position, with y positive upward and x positive toward the green.

$$x = x_0 + v_{0x}t \quad t = \frac{x - x_0}{v_{0x}} = \frac{120}{v_0\cos(70)} = \frac{350.857}{v_0}$$

$$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

$$10 = 0 + v_0\sin(70)\left(\frac{350.857}{v_0}\right) + \frac{1}{2}(-9.81)\left(\frac{350.857}{v_0}\right)^2$$

$$\frac{9.81}{2}\frac{(350.857)^2}{v_0^2} = \sin(70)(350.857) - 10$$

$$v_0 = 43.459\frac{m}{s}$$

3. An athlete spins a ball on a string in a horizontal circle with constant speed. The string is 1.5 m long, and the athlete causes the ball to make 3 complete circles per second. What centripetal (or radial) acceleration does the ball experience?

a) 272 m/s^2 b) 337 m/s^2 c) 459 m/s^2 **d) 533 m/s^2**

If we consider one complete revolution of the ball's motion, $v = \frac{dist}{time} = \frac{2\pi r}{T} = \frac{2\pi(1.5)}{\frac{1}{3}} = 9\pi \frac{m}{s}$. *Then*

$$a_r = \frac{v^2}{r} = \frac{(9\pi)^2}{1.5} = 532.96 \frac{m}{s^2}$$

4. Suppose the athlete in the previous problem decreases the speed of the ball's motion so that it now makes 1 complete circle per second. (The radius remains unchanged.) By what factor has the radial acceleration of the ball decreased?

a) A factor of 2 b) A factor of 3 c) A factor of 6 **d) A factor of 9**

If the time for one revolution goes up by a factor of 3, the velocity decreases by a factor of 3. But since the acceleration is proportional to v^2*, that becomes a decrease of a factor of* $3^2 = 9$ *in the acceleration.*

5. A plane can fly at 200 mph in still air. The pilot is attempting to land on a north-going runway while a 40 mph wind is blowing from the west. In what direction should the pilot point the nose of the plane?

a) 11.5˚ E of N **b) 11.5˚ W of N** c) 18.9˚ E of N d) 18.9˚ W of N

Let $\hat{i}$ *point East and* $\hat{j}$ *point North. Then the velocity of the wind is 40 mph toward East (*$40\hat{i}$*) and we want the plane's velocity in the fixed (ground) frame to be purely toward the North (*$\hat{j}$ *only).*

$$\vec{v}_{plane\ relative\ to\ ground} = \vec{v}_{plane\ relative\ to\ air} + \vec{v}_{wind}$$
$$v_{PG}\hat{j} = \vec{v}_{PA} + 40\hat{i}$$

It's clear from the x-component of the last equation that $v_{PA,x} = -40$*. This requires that the plane be pointed to the left (West of North) so that* $200\sin\theta = 40$*, or* $\theta = 11.5°$ *W of N.*

The acceleration due to gravity is 9.81 m/s^2 or 32.2 ft/s^2.
For constant acceleration motion in any 1-dimensional direction *x*:

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$
$$v = v_0 + at$$
$$v^2 - v_0^2 = 2a(x - x_0)$$

For uniform circular motion (velocity magnitude *v* and radius *r*), the radial or centripetal acceleration is $a_r = \frac{v^2}{r}$. For constant velocity motion, $v = \frac{dist}{time}$.

For relative motion, $\vec{v}_{relative\ to\ fixed\ frame} = \vec{v}_{relative\ to\ moving\ frame} + \vec{v}_{of\ moving\ frame\ relative\ to\ fixed\ frame}$