Physics 2A Spring 2020
Discussion 3

TA: Jiashu Han

Wednesday, April 15, 2020

1. **Warm-ups**[1]

   (a) You throw a rock horizontally from the edge of a cliff 30 m high. Which equation(s) will tell us its total speed when it lands? (assume down is positive)

   A. $v_x(t) = v_x(0)$

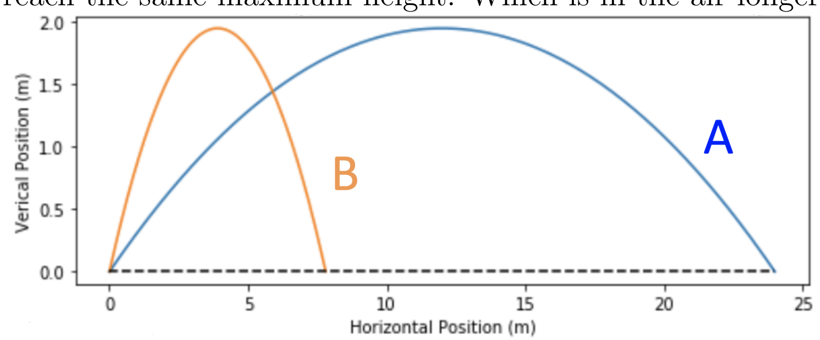
   B. $v_y(t) = v_y(0) + gt$

   C. $v_y^2(t) = v_y^2(0) + 2g\Delta y$

   D. $v = \sqrt{v_x^2 + v_y^2}$

   Solution: In order to find the total speed, we need both the horizontal and vertical velocities. The only incorrect equation here is B, and we need all of the other three equations.

   (b) Two balls are kicked into the air and follow the trajectories shown. Both reach the same maximum height. Which is in the air longer?



   A. Ball A

   B. Ball B

   C. Same amount of time

   D. Cannot determine from the plot

   Solution: The time they spend in the air is constrained by the motion in the vertical direction. It's easier to consider half of the trajectory (from top to bottom). Since Δy, $v_{y,top}$ and a_y are all the same for the two balls, the amount of time they spend in the air is the same.

[1]From Prof. Burgasser's TPS worksheet

2. **Ballistic motion** An electron is launched from the ground with speed 1 m/s at an angle 60° above the horizontal. A uniform electric field is pointing upward everywhere which gives the electron a constant, downward acceleration. Assume the electron's mass is small so gravitational acceleration can be neglected. If the electron lands at 3 m from its launch point, what is the magnitude of the acceleration due to the electric field?

   A. 0.3 m/s^2

   B. 0.6 m/s^2

   C. 0.9 m/s^2

   D. 1.2 m/s^2

   E. 1.5 m/s^2

   Solution: First we break up the initial velocity into x and y components: $v_x = 1\cos 60°$ m/s $= 0.5$ m/s, $v_y = 1\sin 60°$ m/s $= \frac{\sqrt{3}}{2}$ m/s. The time it takes for the electron to land is $t = \Delta x / v_x = 6$ s. Now we use $\Delta y = v_y(0)t + \frac{1}{2}at^2 = 0$ m to solve for a. $a = -2v_y/t = -\sqrt{3}/6$ m/s^2 $= -0.3$ m/s^2.

3. **Uniform circular motion**[2]
   A fairground ride spins its occupants inside a flying saucer-shaped container. The horizontal circular path the riders follow has an 8.00-m radius.

   (a) At how many revolutions per minute are the riders subjected to a centripetal acceleration equal to that of gravity?

   A. 5.3

   B. 8.0

   C. 9.8

   D. 10.6

   E. 15.9

   Solution: The centripetal (radial) acceleration is $a = v^2/r = r\omega^2 = 9.8$ m/s^2. $\omega = \sqrt{(9.8 \text{ m/s}^2)/(8.00 \text{ m})} = 1.1$ rad/s. Each revolution is 2π rad, so this is equal to 10.6 revolutions per minute.

   (b) If the beam connecting a rider and the center of rotation suddenly snaps, what is the velocity at which the rider will travel?

   A. 1.1 m/s

   B. 2.2 m/s

[2] OpenStax *University Physics*. Chapter 4 problem 63

C. 4.4 m/s

D. 6.6 m/s

E. 8.8 m/s

Solution: It will be the tangential velocity: $v = \omega r = 8.8$ m/s.

4. **Relative motion**[3]

A seagull can fly at a velocity of 9.00 m/s in still air.

(a) If it takes the bird 20.0 min to travel 6.00 km straight into an oncoming wind, what is the velocity of the wind?

Solution: The seagull's still air velocity is $v_s = 9.00$ m/s. The combined velocity $v_c = v_s + v_w = 6.00$ km/20.0 min $= 5$ m/s, so $v_w = -4.00$ m/s.

(b) If the bird turns around by 120°, how long will it take the bird to fly another 6.00 km?

Solution: Now the wind blows in a direction 60° from the direction of the seagull, so the combined velocity along the direction of the wind is $v_{c,\|} = v_w + v_s \cos 60° = 8.5$ m/s. The velocity perpendicular to the direction of the wind is $v_{c,\perp} = v_s \sin 60° = 7.8$ m/s. The combined velocity has a magnitude of $|v_c| = \sqrt{v_{c,\|}^2 + v_{c,\perp}^2} = 11.5$ m/s, so $\Delta t = 6.00$ km/11.5 m/s $= 520$ s, or 8 min 40 s.

5. **Forces**[4]

Two ropes are attached to a tree, and forces of $\mathbf{F}_1 = 2.0\hat{\mathbf{x}} + 4.0\hat{\mathbf{y}}$ N and $\mathbf{F}_2 = 3.0\hat{\mathbf{x}} + 6.0\hat{\mathbf{y}}$ N are applied. The forces are coplanar (in the same plane).

(a) What is the resultant (net force) of these two force vectors?

Solution: $\mathbf{F} = \mathbf{F}_1 + \mathbf{F}_2 = (2.0\hat{\mathbf{x}} + 4.0\hat{\mathbf{y}})\text{ N} + (3.0\hat{\mathbf{x}} + 6.0\hat{\mathbf{y}})\text{ N} = (5.0\hat{\mathbf{x}} + 10.0\hat{\mathbf{y}})\text{ N}$

(b) Find the magnitude and direction of this net force.

Solution: $|\mathbf{F}| = \sqrt{(5.0\hat{\mathbf{x}})^2 + (10.0\hat{\mathbf{y}})^2}\text{ N} = \sqrt{125}\text{ N} = 11$ N. The direction is $\arctan(F_y/F_x) = \arctan 2 = 1.1$ rad, or 63°, counterclockwise from $\hat{\mathbf{x}}$.

[3] OpenStax *University Physics*. Chapter 4 problem 73

[4] OpenStax *University Physics*. Chapter 5 problem 19