Exam 1 Solutions

1. **B** - Using \( v_f^2 = v_o^2 + 2a\Delta y \) you get \( v_f = \sqrt{2g\Delta y} \) \( V_f = 188 \text{ m/s} \)

2. **A** - use \( \Delta y = v_o t + \frac{1}{2} at^2 \) \( t = 19.2 \text{ s} \)

3. **A** - Distance traveled is equal to the total distance traveled or 3 \( \frac{1}{2} \) times the circumference of the circle. Displacement is the distance from where you started to where you ended, or the diameter of the track.

4. **B** - \( \text{speed}_{av} = \frac{\text{distance}}{\text{time}} \)
   
   Distance = 3.5 * circumference
   
   Time = time(first 2 laps) + time(last 1.5 laps)

   \[
   \text{time(first 2 laps)} = \frac{2 \ast \text{diameter} \ast \pi}{v_1}
   \]

   \[
   \text{time(last 1.5 laps)} = \frac{1.5 \ast \text{diameter} \ast \pi}{v_2}
   \]

   \[\text{speed}_{av} = 2.14 \text{ m/s}\]

5. **D G** - The object is always moving to the right at a constant velocity because the slope of the line is constant. Since velocity is constant, acceleration is 0. Also only passes through the origin once because crosses the x-axis once.

6. **A F H I** - At the beginning it is moving to the left because its position is decreasing with time and then moves to the right because its position increases with time. The object’s velocity (slope) is first to the left, and decreasing, then to the right and increasing so it always has a positive acceleration (check: \( x(t) \) has the upward curvature. Crosses the x-axis twice, so passes through the origin twice. Stops once for one instant when it changes from moving to the left to the right.

7. **B** – Decreasing your velocity (slowing down) implies a negative acceleration – backwards in this case

8. **C** – We discussed this in class: equal speeds at equal heights. You can also see it using \( v_f^2 = v_o^2 + 2a\Delta y \) since \( \Delta y = 0 \) (starts and ends at same height) we get
   
   \( v_f^2 = v_o^2 \) so \( v_f = \pm \sqrt{v_o^2} \) and we take the negative root because it is falling down.

9. **C** – Easiest way is the idea of relative velocities: you are 50 m ahead when your brother starts, and he catches up with a relative speed of 12-5 = 7 m/s. So \( t = 50m/(7m/s) \)

Or you can do it formally: \( \Delta x_{you} = \Delta x_{brother} \)
\[ \Delta x_{\text{you}} = v_{\text{you}} (10 + t) \quad \text{because your brother leaves seconds after you pass him, or} \]

it could be \[ \Delta x_{\text{you}} = 50 + v_{\text{you}} t . \]

\[ \Delta x_{\text{brother}} = v_{\text{horse}} t . \] Solve for \( t \).

\( t = 7.14 \text{ s} \)

10. E – Using vector addition you get

Adding components:

\[ R_x = 0 + 57 \cos(27) + 0 \]

\[ R_y = 33 + 57 \sin(27) - 13 \]

\[ R = \sqrt{R_x^2 + R_y^2} \]

\[ R = 68.4 \text{ m} \]

11. D – \( \theta = \tan^{-1}\left( \frac{R_y}{R_x} \right) \quad \theta = 42.1^\circ \)

12. C – constant speed means no acceleration

13. A We have:

Thus \( \theta = \tan^{-1}\left( \frac{100}{300} \right) \quad \theta = 18.4^\circ \)

14. G We have to add the opposite of the wind’s velocity to the ground velocity he wants to cancel the wind (he has to point a bit into the wind). Adding components:

so:

\[ V_{\text{air}} = 265 \text{ km/hr} \]

15. D – use \( v_f^2 = v_o^2 + 2a\Delta y \)

\[ a = -7.2 \times 10^6 \text{ m/s}^2 \]
16. C – they will all be the same because the determining factor as to how long each cannon ball will be in the air is y-component of the initial velocity and if that part is always the same they will all go the same height, and take the same time to fall.

Using \( \Delta y = v_y t + \frac{1}{2} at^2 \), we get \( 0 = v_{oy} t - \frac{1}{2} gt^2 \) or \( t = \frac{2v_{oy}}{g} \) so with all the same initial y velocities, the time will always be the same.

17. E – acceleration due to gravity is always a constant 9.80 m/s\(^2\), down, for objects in free-fall.

18. C – since acceleration is a constant -9.80 m/s\(^2\), the v(t) graph will have a constant slope of 9.80 m/s\(^2\). It also has to stop and turn around, which rules out A and D.

19. F – We have this:

\[ \begin{align*}
20 \text{ m/s} \\
\begin{array}{c}
35^\circ \\
\end{array}
\end{align*} \]

So: \( v_x = 20 \cos(35) \)

\[ V_x = 16.4 \text{ m/s} \]

20. E - You can use \( \Delta y = v_{oy} t - \frac{1}{2} gt^2 \), and solve the quadratic equation for t. You get two times, the time if it is caught on the way up (0.58s), or the time if it is caught coming down (1.76s).

Or, you can use: \( v_{fy}^2 = v_{oy}^2 - 2g\Delta y \) we get \( v_{fy} = \pm 5.8 \text{ m/s} \)

We take the negative root because the ball is on its way down from the top of its arc

Thus using
\[ v_{fy} = v_{oy} - gt \]

\[ -5.8 = 20 \sin 35 - gt \]

we get \( t = 1.76 \text{ s} \).

Then since the time in the vertical motion is the same as the motion in the horizontal motion we use this found time to find \( \Delta x \) using \( \Delta x = v_{ox} t = 16.4 \times 1.67 = 28.9 \text{ m} \)

\[ \Delta x = 28.9 \text{ m} \]