

Your Name: _____

**PHY203
Exam #1
Chapters 1-3
Fri., 2/14/20**

Solutions

Exam1S20

1. A ball is thrown straight up from a cliff with an initial speed of 35.0 m/s at $t=0$. Take "up" as the positive x-direction and $x=0$ at the base of the cliff. It takes 9.50 s for the ball to strike the ground, assuming it just grazes the side of the cliff on the way down. (Ignore the effects of air resistance.)

a. Find the height of the cliff. 10

kin equation A:

$$0 = H + 35.0(9.50) - \frac{1}{2}g(9.50)^2$$

$$H = 110 \text{ m}$$

b. Find the velocity and acceleration (magnitude and sign) of the ball just before it hits the ground. 10

$$a = -9.81 \text{ m/s}^2$$

kin. eq. B:

$$v = 35.0 - g(9.50)$$

$$= -58.2 \text{ m/s}$$

c. Assuming a cliff height of 100 m (not the answer from part a.), find the times it takes for the ball to be at an x position of 130 m (2 answers). 10

$$130 = 100 + 35.0t - \frac{1}{2}gt^2$$

$$4.905t^2 - 35.0t + 30.0 = 0$$

$$t = \frac{35.0 \pm \sqrt{(35.0)^2 - 4 \cdot 4.905 \cdot 30}}{9.81}$$

$$= 0.999 \text{ s}, 6.118 \text{ s}$$

2. Two trains are traveling to the right (+x direction) on parallel tracks. At a time of $t=0$ train A passes the $x=0$ point traveling in the +x direction with a constant speed of 17.0 m/s. At $t=5.00$ s train B which was at rest at $x=-180$ m starts traveling with a constant acceleration of 6.00 m/s² in the +x direction.

a. Write an equation of motion (x vs. t) for train A: 5

$$x_A = 17.0 t$$

b. Write an equation of motion (x vs. t) for train B: 15

$$x_B = -180 + \frac{1}{2}(6.00)(t-5)^2$$

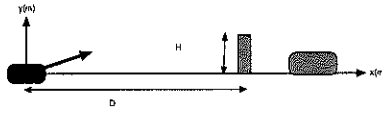
c. Find the time at which the centers of the trains are side-by-side. 10

$$\begin{aligned} 17.0 t &= -180 + 3(t^2 - 10t + 25) \\ &= -180 + 3t^2 - 30t + 75 \end{aligned}$$

$$3t^2 - 17.0t - 105 = 0$$

$$t = \frac{47.0 \pm \sqrt{47.0^2 + 4 \cdot 3 \cdot 105}}{6}$$

$$= 17.6 \text{ s}$$



3. A cannonball is launched at a castle wall. The wall is $H = 45.0$ m high and is at a distance of $D = 250$ m from the cannon. After traveling for 1.75 s, the cannonball just grazes the top of the wall. (Not at the highest point.)

a. Find the initial velocity of the cannonball in vector notation. **20**

$$x: 250 = v_{0x}(1.75)$$

$$v_{0x} = 143 \text{ m/s}$$

$$y: 45.0 = 0 + v_{0y}(1.75) - \frac{1}{2}g(1.75)^2$$

$$v_{0y} = 34.3 \text{ m/s}$$

$$\vec{v} = (143\hat{i} + 34.3\hat{j}) \text{ m/s}$$

b. If the cannonball did not hit the castle wall, find the velocity, acceleration, and position of the cannonball at its highest point, all in vector notation. **20**

$$\vec{a} = -9.81\hat{j} \text{ m/s}^2$$

$$\vec{v} = 143\hat{i} \text{ m/s}$$

$$t: 0 = 34.3 - gt, t = 3.50 \text{ s}$$

$$x: x = (143)(3.50) = 500 \text{ m}$$

$$y: y = 0 + 34.3(3.50) - \frac{1}{2}g(3.50)^2$$

$$= 60.0 \text{ m}$$

$$\vec{r} = (500\hat{i} + 60.0\hat{j}) \text{ m}$$

Exam1S20alt

1. A ball is thrown straight up from a cliff with an initial speed of 45.0 m/s at $t=0$. Take "up" as the positive x-direction and $x=0$ at the base of the cliff. It takes 12.0 s for the ball to strike the ground, assuming it just grazes the side of the cliff on the way down. (Ignore the effects of air resistance.)

a. Find the height of the cliff. 10

kin. eq. A!

$$0 = H + 45.0(12.0) - \frac{1}{2}g(12.0)^2$$

$$H = 166 \text{ m}$$

b. Find the velocity and acceleration (magnitude and sign) of the ball just before it hits the ground. 10

$$a = -9.81 \text{ m/s}^2$$

kin. eq. B!

$$v = 45.0 - g(12.0)$$

$$= -72.7 \text{ m/s}$$

c. Assuming a cliff height of 100 m (not the answer from part a.), find the times it takes for the ball to be at an x position of 140 m (2 answers). 10

$$140 = 100 + 45.0t - \frac{1}{2}gt^2$$

$$4.905t^2 - 45.0t + 20.0 = 0$$

$$t = \frac{45.0 \pm \sqrt{45.0^2 - 4 \cdot 4.905 \cdot 20}}{9.81}$$

$$= 0.9999, 8.18 \text{ s}$$

2. Two trains are traveling to the right (+x direction) on parallel tracks. At a time of $t=0$ train A passes the $x=0$ point traveling in the +x direction with a constant speed of 16.5 m/s. At $t=4.00$ s train B which was at rest at $x=-160$ m starts traveling with a constant acceleration of 4.00 m/s^2 in the +x direction.

a. Write an equation of motion (x vs. t) for train A: 5

$$x_A = 16.5t$$

b. Write an equation of motion (x vs. t) for train B: 15

$$x_B = -160 + \frac{1}{2} (4.00) (t - 4.00)^2$$

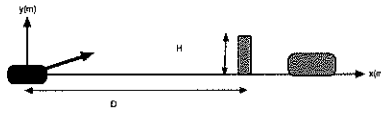
c. Find the time at which the centers of the trains are side-by-side. 10

$$\begin{aligned} 16.5t &= -160 + 2(t^2 - 8t + 16) \\ &= -160 + 2t^2 - 16t + 32 \end{aligned}$$

$$2t^2 - 32.5t - 128 = 0$$

$$t = \frac{32.5 \pm \sqrt{32.5^2 + 4 \cdot 2 \cdot 128}}{4}$$

$$= 19.5 \text{ s}$$



3. A cannonball is launched at a castle wall. The wall is $H = 55.0$ m high and is at a distance of $D = 300$ m from the cannon. After traveling for 2.50 s, the cannonball just grazes the top of the wall. (Not at the highest point.)

a. Find the initial velocity of the cannonball in vector notation. **20**

$$x: 300 = v_{0x} (2.50)$$

$$v_{0x} = 120 \text{ m/s}$$

$$y: 55.0 = 0 + v_{0y} (2.50) - \frac{1}{2} g (2.50)^2$$

$$v_{0y} = 34.3 \text{ m/s}$$

$$\vec{v} = (120\hat{i} + 34.3\hat{j}) \text{ m/s}$$

b. If the cannonball did not hit the castle wall, find the velocity, acceleration, and position of the cannonball at its highest point, all in vector notation. **20**

$$\vec{a} = -9.81\hat{j} \text{ m/s}^2$$

$$\vec{v} = 120\hat{i} \text{ m/s}$$

$$t: 0 = 34.3 - g t, t = 3.50 \text{ s}$$

$$x: x = (120) (3.50) = 420 \text{ m}$$

$$y: y = 0 + 34.3 (3.50) - \frac{1}{2} g (3.50)^2$$

$$= 60.0 \text{ m}$$

$$\vec{r} = (420\hat{i} + 60.0\hat{j}) \text{ m}$$