Your Name: ______________________

PHY203

Exam #2
Chapters 4-7
Fri., 10/26/18

Solutions

1. A ball is thrown straight down from a cliff with an initial speed of 35.0 m/s at t=0. Take "down" as the positive x-direction and x=0 at the top of the cliff. It takes 2.50 s for the ball to strike the ground. (Among other things), we want to find the height of the cliff. (Ignore the effects of air resistance.)

a. Fill in the following chart for all "known" quantities, taking the initial time and position at the top of the cliff and final time and position just before the ball strikes the ground.

Parameter	Value
x_0	0
x_f	
v_0	+35.0 m/s
v_f	
a	9.81 m/s²
t	2.50 s

6

b. To find the height of the cliff with one equation, which kinematic equation will work best?

A

4

c. Find the height of the cliff.

$x = 0 + 35.0(2.50) + \frac{1}{2} g (2.50)^2$

$= 118\text{ m}$

5

d. Find the velocity and acceleration of the ball just before it hits the ground.

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

$v = 35.0 + 9.81(2.5)$

$= 59.5\text{ m/s}$

5

e. Find the time it takes for the ball to be 50.0 m below the top of the cliff.

$50.0 = 0 + 35.0t + \frac{1}{2} g t^2$

$0 = 4.905t^2 + 35.0t - 50$

$t = \dfrac{-35.0 \pm \sqrt{35.0^2 + 4(50)(4.905)}}{9.81}$

$\approx 1.22\text{ s}$

5

2. Two trains approach each other on parallel tracks. At t=3.50 s the train on the left passes the x=0 position traveling to the right (call that the +x direction) with a constant speed of 12.5 m/s. At t=0 the train on the right is at rest at x=+250 m, and begins to accelerate at a magnitude of 2.50 m/s^2 to the left. The train accelerates for 7.00 s then continues at a constant speed.

a. Using the coordinate system depicted above, write an equation of motion (x vs. t) for the train on the left:

$x_l =$ 0 + 12.5 (t − 3.50) + 0 = 12.5 (t − 3.50) 5

b. Using the coordinate system depicted above, write equations of motion (x vs. t) for the train on the right for t<7.00 s <u>and</u> t≥7.00s:

t<7.00 s $x_r =$ 250 − $\frac{1}{2}$ (2.50) t^2 5

x(7) = 250 − [illegible] = 189

t≥7.00 s $x_r =$ 5

v(7) = (−2.50)(7) = [illegible]

$x_r =$ 189 − 12.5(t − 7)

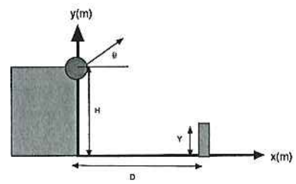
c. Find the time at which the centers of the trains are side-by-side.

12.5 (t − 3.50) = 189 − 12.5 (t − 7) 10

12.5t − 43.8 = 189 − 12.5t + 12[illegible]

20t = 3[illegible]

t = 11.85



3. A cannonball is shot from a cliff of height H = 105 m at a castle wall. The castle wall is Y = 75.0 m high and a horizontal distance of D = 175 m from the cannon. Assume the cannonball just grazes the top of the wall after traveling for 8.50 s.

a. Find the initial velocity of the cannonball and write it in vector notation using the coordinate system above.

x: $175 = V_{0x}(8.50)$ 5

$V_{0x} = 20.6\ m/s$

y: $75 = 105 + V_{0y}(8.50) + \frac{1}{2}(-9.81)(8.50)^2$ 20

10

$V_{0y} = 38.2\ m/s$

$\vec{V_0} = (20.6\hat{i} + 38.2\hat{j})\ m/s$ 5

b. Find the initial speed of the cannonball.

$V_0 = \sqrt{20.6^2 + 38.2^2} = 43.4\ m/s$ 5

c. Find velocity and acceleration of the cannonball at its highest point and write them in vector notation.

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

$\vec{v} = 20.6\hat{i}\ m/s$ 5

d. Find the height of the cannonball at its highest point.

$0 = V_{0y}^2 + 2(-g)\Delta y$

$(38.2)^2 = 2(9.81)\Delta y$ 10

$\Delta y = 74.4\ m$

$H = 74.4\ m + 105\ m = 179\ m$

253

1. A ball is thrown straight down from a cliff with an initial speed of 45.0 m/s at t=0. Take "down" as the positive x-direction and x=0 at the top of the cliff. It takes 3.50 s for the ball to strike the ground. (Among other things), we want to find the height of the cliff. (Ignore the effects of air resistance.)

a. Fill in the following chart for all "known" quantities, taking the initial time and position at the top of the cliff and final time and position just before the ball strikes the ground.

Parameter	Value
x_0	0
x_f	
v_0	45.0 m/s
v_f	
a	9.81 m/s²
t	3.50 s

6

b. To find the height of the cliff with one equation, which kinematic equation will work best?

A

4

c. Find the height of the cliff.

$$x = 0 + 45.0(3.50) + \frac{1}{2}(9.81)(3.50)^2$$

$$= 218\ \text{m}$$

5

d. Find the velocity and acceleration of the ball just before it hits the ground.

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

$$V = 45.0 + 9.81(3.5)$$

$$= 79.3\ \text{m/s}$$

5

e. Find the time it takes for the ball to be 150.0 m below the top of the cliff.

$$150 = 0 + 45.0t + \frac{1}{2}(9.81)t^2$$

$$0 = 4.905t^2 + 45.0t - 150$$

5

$$t = \frac{-45.0 \pm \sqrt{45.0^2 + 4 \cdot 150 \cdot 4.905}}{9.81}$$

$$= 2.60\ \text{s}$$

2. Two trains approach each other on parallel tracks. At t=2.50 s the train on the left passes the x=0 position traveling to the right (call that the +x direction) with a constant speed of 11.5 m/s. At t=0 the train on the right is at rest at x=+250 m, and begins to accelerate at a magnitude of 1.50 m/s^2 to the left. The train accelerates for 8.50 s then continues at a constant speed.

a. Using the coordinate system depicted above, write an equation of motion (x vs. t) for the train on the left:

$x_l =$ $0 + 11.5\,(t-2.50)$ 5

b. Using the coordinate system depicted above, write equations of motion (x vs. t) for the train on the right for t<8.50 s <u>and</u> t≥8.50 s:

t<8.50 s $x_r =$ $250 - \frac{1}{2}(1.50)t^2$ 5

$x(8.50) = 250 - 0.750(8.50)^2$

$= 196$ m

t≥8.50 s $x_r =$

$v(8.50) = -(1.50)\,8.50$ 15

$= -12.8$ m/s

$x_e = 196 - 12.8\,(t-8.50)$

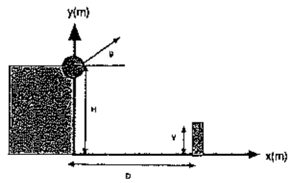
c. Find the time at which the centers of the trains are side-by-side.

$11.5\,(t-2.50) = 196 - 12.8\,(t-8.50)$

$11.5t - 28.8 = 196 - 12.8t + 109$

$24.3t = 334$ 10

$t = 13.79$



3. A cannonball is shot from a cliff of height H = 110 m at a castle wall. The castle wall is Y = 70.0 m high and a horizontal distance of D = 165 m from the cannon. Assume the cannonball just grazes the top of the wall after traveling for 7.50 s.

a. Find the initial velocity of the cannonball and write it in vector notation using the coordinate system above.

x: $165 = v_{0x}(7.50)$ 5

$v_{0x} = 22.0$ m/s

y: $70.0 = 110 + v_{0y}(7.50) - \frac{1}{2}g(7.50)^2$ 10

$v_{0y} = 31.5$ m/s

$\vec{v}_0 = (22.0\,\hat{i} + 31.5\,\hat{j})$ m/s 5

b. Find the initial speed of the cannonball.

$v_0 = \sqrt{22.0^2 + 31.5^2} = 38.4$ m/s 5

c. Find velocity and acceleration of the cannonball at its highest point and write them in vector notation. $\vec{a} = -9.81\,\hat{j}$ m/s^2 always

$\vec{v} = 22.0\,\hat{i}$ m/s 5

d. Find the height of the cannonball at its highest point.

$0 = 31.5^2 - 2g(\Delta y)$ 10

$\Delta y = 50.5$ m

$H = 50.5 + 110 = 161$ m