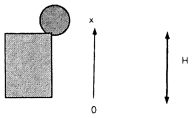
Your Name: _____

PHY203
Exam #1
Chapters 1-4
~~??????~~
Fri, Sept. 27, 2024

Solutions

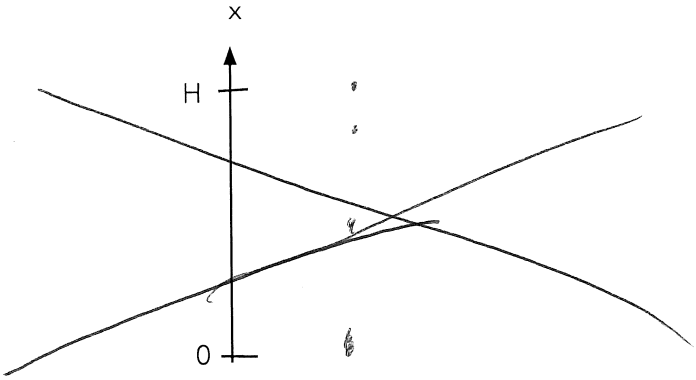
F2P

Exam1S24~~Makeup~~



1. A ball is thrown straight down from the top of a cliff of height H with an initial speed of 15.0 m/s. It takes 5.50 s for the ball to hit the ground. We want to find the height of the cliff, among other things. (Ignore air resistance.)

a. Produce a motion diagram of the ball: **5**



b. Fill out the table of known quantities for the ball: **5**

Parameter	Known Value
x_0	H
x_f	0
v_0	$-15.0\ m/s$
v_f	
a	$-9.81\ m/s^2$
t	5.50 s

c. Find the height of the cliff. **5**

$$A: \quad 0 = H - 15.0(5.50) - \frac{1}{2}(9.81)(5.50)^2$$

$$H = 231\ m$$

d. Find the distance the ball traveled between the 3rd and 4th seconds the ball was in the air. **10**

$$x_3 = 231 - 15.0(3) - \frac{1}{2}9(3)^2$$

$$= 142\ m$$

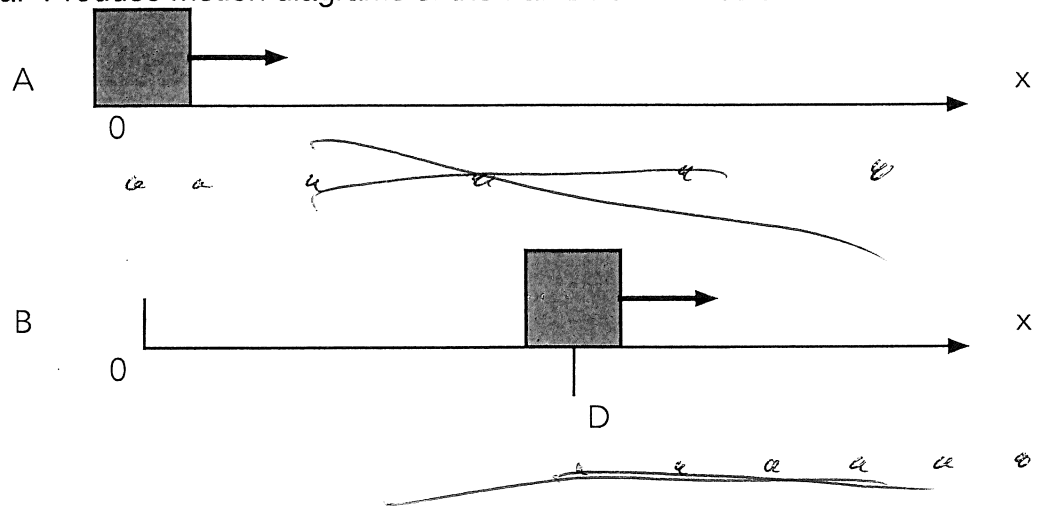
$$x_4 = 231 - 15.0(4) - \frac{1}{2}9(4)^2$$

$$= 92.5\ m$$

$$\Delta x = 142 - 92.5 = 49.5\ m$$

2. Two trains are traveling in the same direction on parallel tracks. At t=0, train A is at rest at x =0 and starts to accelerate to the right with a magnitude of 2.50 m/s^2. At t=0, train B passes the position D = 150 traveling with a constant speed of 30.0 m/s. We want to find the time that the trains are side-by-side.

a. Produce motion diagrams of the trains from t=0 below each sketch: **5**



b. Fill out the tables of known quantities for the two trains: **5**

Train A:

Parameter	Known Value
x_0	0
x_f	
v_0	0
v_f	
a	2.50 m/s^2
t	

Train B:

Parameter	Known Value
x_0	150 m
x_f	
v_0	30.0 m/s
v_f	30.0 m/s
a	0
t	

c. Write the equation for the position of train A as a function of time: **5**

$x_A = 0 + 0 + \frac{1}{2}(2.50)t^2 = 1.25t^2$

d. Write the equation for the position of train B as a function of time: **10**

$x_B = 150 + 30.0t$

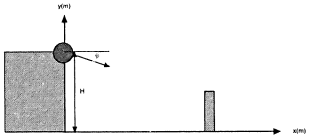
e. Find the time the trains are side-by-side. **10**

$1.25t^2 = 150 + 30t$

$1.25t^2 - 30t - 150 = 0$

$t = \frac{30 \pm \sqrt{30^2 + 4(1.25)(150)}}{2.50}$

$= 28.2\,s$



3. A cannonball is shot from a cliff of height H at a castle wall, as shown above. The initial vertical component of velocity of the ball is 40.5 m/s in magnitude. The ball takes 3.50 s to just graze the top of the castle wall before continuing on to hit the ground. The castle wall has a height of 85.0 m and is a horizontal distance D=150m from the base of the cliff. Ignore air resistance.

a. Fill out the tables of known values. (Take the "final" position as when the ball grazes the top of the wall.) **5**

Parameter	Known Value
x_0	0
x_f	150 m
v_{x0}	
v_{xf}	
a_x	0
t	3.50 s

Parameter	Known Value
y_0	H
y_f	85.0 m
v_{y0}	−40.5 m/s
v_{yf}	
a_y	$-9.81\ m/s^2$
t	3.50 s

b. Find the initial velocity of the cannonball and write it in vector notation using the coordinate system above. **15**

$$x: \quad 150 = 0 + v_{0x}(3.50)$$

$$v_{0x} = 42.9\ m/s$$

$$\vec{v_0} = (42.9\,\hat{i} - 40.5\,\hat{j})\ m/s$$

c. Find the height of the ~~castle wall~~ cliff. **5**

$$y: A: \quad 85 = H - 40.5(3.50) - \frac{1}{2}(9.81)(3.50)^2$$

$$H = 287\ m$$

d. Find the velocity and acceleration of the cannonball in vector notation just before it hits the ground. **15**

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

$$y: C: \quad v_y^2 = v_{0y}^2 + 2a\Delta y$$

$$v_y^2 = 40.5^2 + 2(-9.81)(-287)$$

$$v_y = -85.3\ m/s$$

$$\vec{v} = (42.9\,\hat{i} - 85.3\,\hat{j})\ m/s$$

(or y: A: $0 = 287 - 40.5 - \frac{1}{2}gt^2$, $t = 4.57\ s$; $v = -40.5 - 4.57g = -85.3$)

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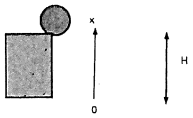
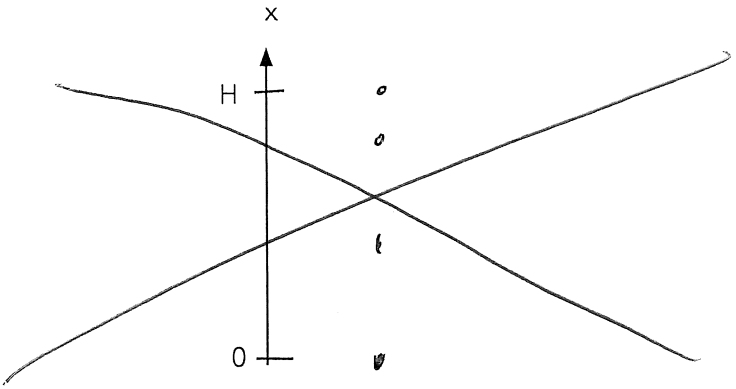


1. A ball is thrown straight down from the top of a cliff of height H with an initial speed of 17.0 m/s. It takes 6.50 s for the ball to hit the ground. We want to find the height of the cliff, among other things. (Ignore air resistance.)

a. Produce a motion diagram of the ball: **5**



b. Fill out the table of known quantities for the ball: **5**

Parameter	Known Value
x_0	H
x_f	0
v_0	-17.0 m/s
v_f	
a	-9.81 m/s^2
t	6.50 s

c. Find the height of the cliff. **5**

$$A: \quad 0 = H - 17.0(6.50) - \frac{1}{2} g (6.50)^2$$

$$H = 318 \text{ m}$$

d. Find the distance the ball traveled between the 3rd and 4th seconds the ball was in the air. **10**

$$x(3) = 318 - 17.0(3.00) - \frac{1}{2} g (3.00)^2$$

$$= 223 \text{ m}$$

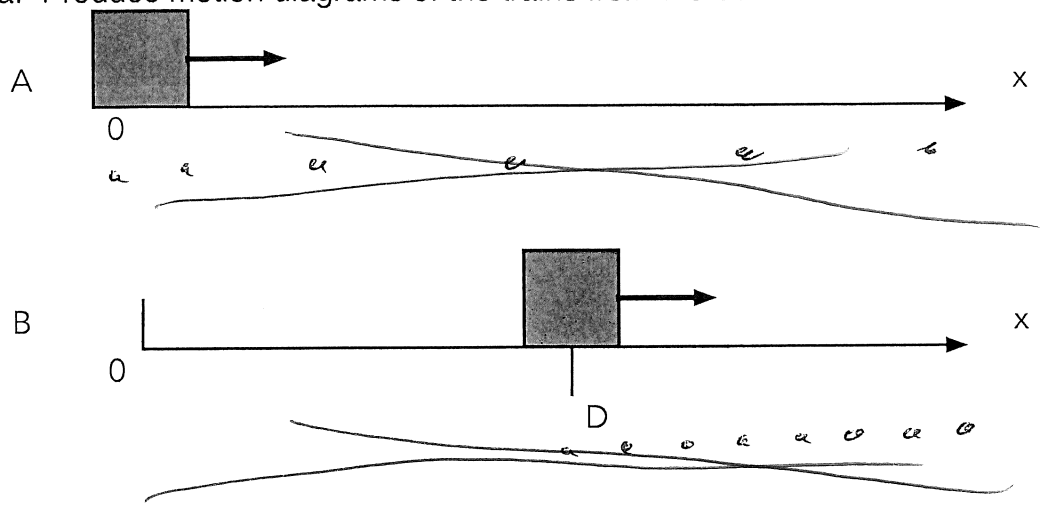
$$x(4) = 318 - 17.0(4.00) - \frac{1}{2} g (4.00)^2$$

$$= 172 \text{ m}$$

$$\Delta x = 223 - 172 = 51.5 \text{ m}$$

2. Two trains are traveling in the same direction on parallel tracks. At t=0, train A is at rest at x =0 and starts to accelerate to the right with a magnitude of 2.00 m/s^2. At t=0, train B passes the position D = 170 traveling with a constant speed of 25.0 m/s. We want to find the time that the trains are side-by-side.

a. Produce motion diagrams of the trains from t=0 below each sketch: **5**



b. Fill out the tables of known quantities for the two trains: **5**

Train A:

Parameter	Known Value
x_0	0
x_f	
v_0	0
v_f	
a	2.00 m/s^2
t	

Train B:

Parameter	Known Value
x_0	170 m
x_f	
v_0	25.0 m/s
v_f	25.0 m/s
a	0
t	

c. Write the equation for the position of train A as a function of time: **5**

$x_A = \frac{1}{2}(2.00)t^2 = t^2$

d. Write the equation for the position of train B as a function of time: **10**

$x_B = 170 + 25.0t$

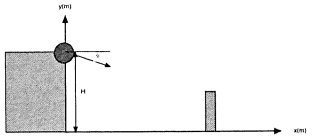
e. Find the time the trains are side-by-side. **10**

$t^2 = 170 + 25.0t$

$t^2 - 25.0t - 170 = 0$

$t = \frac{25.0 \pm \sqrt{25.0^2 + 4 \cdot 170}}{2}$

$= 30.6\text{s}$



3. A cannonball is shot from a cliff of height H at a castle wall, as shown above. The initial vertical component of velocity of the ball is 45.5 m/s in magnitude. The ball takes 3.00 s to just graze the top of the castle wall before continuing on to hit the ground. The castle wall has a height of 95.0 m and is a horizontal distance D=180m from the base of the cliff. Ignore air resistance.

a. Fill out the tables of known values. (Take the "final" position as when the ball grazes the top of the wall.) **5**

Parameter	Known Value
x_0	0
x_f	180 m
v_{x0}	
v_{xf}	
a_x	0
t	3.00 s

Parameter	Known Value
y_0	H
y_f	95.0 m
v_{y0}	−45.5 m/s
v_{yf}	
a_y	$-9.81\ m/s^2$
t	3.00 s

b. Find the initial velocity of the cannonball and write it in vector notation using the coordinate system above. **15**

x: $180 = 0 + v_{x0}(3.00)$, $v_{x0} = 60.0\ m/s$

$\vec{v}_0 = (60.0\hat{i} - 45.5\hat{j})\ m/s$

c. Find the height of the ~~castle wall~~ cliff. **5**

y: A: $95 = H - 45.5(3.00) - \frac{1}{2}g(3.00)^2$

$H = 276\ m$

d. Find the velocity and acceleration of the cannonball in vector notation just before it hits the ground. **15**

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

y: C: $v_f^2 = 45.5^2 + 2(-g)(-276)$

$v_f = -86.5\ m/s$

$\vec{v} = (60.0\hat{i} - 86.5\hat{j})\ m/s$