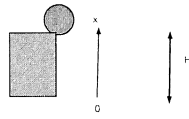


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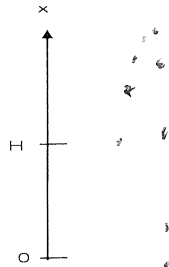
**PHY203**  
**Exam #1**  
**Chapters 1-4**  
**Fri., Feb. 16, 2024**

Solutions



1. A ball is thrown straight up from the top of a cliff of height  $H=55.0$  m with an initial speed of  $v_0$ . It takes  $6.00$  s for the ball to hit the ground. We want to find the initial speed. (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
$x_0$	55.0 m
$x_f$	0
$v_0$	
$v_f$	
$a$	$-9.81 \text{ m/s}^2$
$t$	6.00 s

c. Find the initial speed of the ball. 10

$$A: \quad 0 = 55.0 + v_0(6.00) - \frac{1}{2}g(6.00)^2$$

$$v_0 = 20.3 \text{ m/s}$$

d. Find the velocity and acceleration of the ball just before it hits the ground (magnitudes and signs). 10

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

$$B: \quad v = 20.3 - g(6.00)$$

$$= -38.6 \text{ m/s}$$



2. Two trains approach each other on parallel tracks. At  $t=0$  the train on the left passes the  $x=0$  position with a constant speed of  $24.5 \text{ m/s}$ . At  $t=0$ , the train on the right passes the  $x=250 \text{ m}$  position with a speed of  $19.0 \text{ m/s}$  and starts to accelerate towards train A with a magnitude of  $2.50 \text{ m/s}^2$ .

a. Produce motion diagrams of the trains: 5



Train A:



Train B:



b. Fill out the tables of known quantities for the two trains. Take the final position when the trains are side-by-side: 5

Train A	
Parameter	Known Value
$x_0$	0
$x_f$	
$v_{x0}$	$24.5 \text{ m/s}$
$v_{xf}$	$24.5 \text{ m/s}$
$a_x$	0

Train B	
Parameter	Known Value
$x_0$	$250 \text{ m}$
$x_f$	
$v_{x0}$	$-19.0 \text{ m/s}$
$v_{xf}$	
$a_x$	$-2.50 \text{ m/s}^2$

c. Using the coordinate system depicted above, write an equation of motion ( $x$  vs.  $t$ ) for the train on the left: 5

$$x_l = 24.5t$$

d. Using the coordinate system depicted above, write an equation of motion ( $x$  vs.  $t$ ) for the train on the right: 10

$$x_r = 250 - 19.0t - \frac{1}{2}(2.50)t^2$$

c. Find the time at which the centers of the trains are side-by-side. 5

$$24.5 = 250 - 19.0t - 1.25t^2$$

$$1.25t^2 + 43.5t - 250 = 0$$

$$t = \frac{-43.5 \pm \sqrt{43.5^2 + 4(1.25)(250)}}{2(1.25)}$$

$$= 5.02 \text{ s}$$



3. A cannonball is shot from ground level at a castle wall. The castle wall is  $Y = 55.0$  m high and a horizontal distance  $D = 205$  m from the cannon. The initial horizontal component of velocity of the ball is  $85.0$  m/s in magnitude. Take  $y = 0$  at ground level. Assume the ball just grazes the top of the wall on the way up.

a. On the figure above, plot the trajectory of the cannonball. **5**

b. Fill out the tables of known values. Take the final position as when the cannonball grazes the castle wall. **5**

Parameter	Known Value
$x_0$	0
$x_f$	205 m
$v_{x0}$	85.0 m/s
$v_{xf}$	85.0 m/s
$a_x$	0

Parameter	Known Value
$y_0$	0
$y_f$	55.0 m
$v_{y0}$	
$v_{yf}$	
$a_y$	$-9.81 \text{ m/s}^2$

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

$$x: \quad 205 = v_{0x} t = 85.0 t, \quad t = 2.41 \text{ s}$$

$$y: \quad 55.0 = 0 + v_{0y} (2.41) - \frac{1}{2} g (2.41)^2$$

$$v_{0y} = 34.7 \text{ m/s}$$

$$\vec{v}_0 = (85.0\hat{i} + 34.7\hat{j}) \text{ m/s}$$

d. Find the velocity, acceleration, and position of the cannonball at its highest point and write them in vector notation. **15**

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

$$\vec{v} = 85.0\hat{i} \text{ m/s}$$

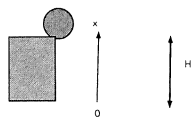
$$y: \quad 0 = 34.7 - g t, \quad t = 3.53 \text{ s}$$

$$x = 85.0 t = 300 \text{ m}$$

$$y: \quad 0 = (34.7)^2 - 2g \Delta y$$

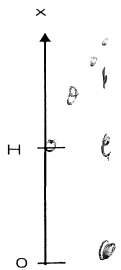
$$\Delta y = 61.2 \text{ m}$$

$$\vec{r} = (300\hat{i} + 61.2\hat{j}) \text{ m}$$



1. A ball is thrown straight up from the top of a cliff of height  $H=65.0$  m with an initial speed of  $v_0$ . It takes  $5.00$  s for the ball to hit the ground. We want to find the initial speed. (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
$x_0$	$65.0$ m
$x_f$	$0$
$v_0$	
$v_f$	
$a$	$-9.81$ m/s <sup>2</sup>
$t$	$5.00$ s

c. Find the initial speed of the ball. 10

$$A: \quad 0 = 65.0 + v_0(5.00) - \frac{1}{2}g(5.00)^2$$

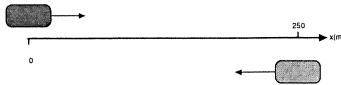
$$v_0 = 11.5 \text{ m/s}$$

d. Find the velocity and acceleration of the ball just before it hits the ground (magnitudes and signs). 10

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

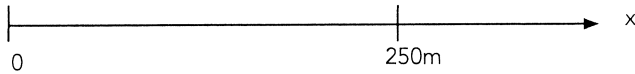
$$v = v_0 + at = 11.5 - g(5.00)$$

$$= -37.5 \text{ m/s}$$

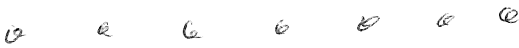


2. Two trains approach each other on parallel tracks. At  $t=0$  the train on the left passes the  $x=0$  position with a constant speed of  $27.0 \text{ m/s}$ . At  $t=0$ , the train on the right passes the  $x=250 \text{ m}$  position traveling to the left with a speed of  $16.5 \text{ m/s}$  and starts to accelerate towards train A with a magnitude of  $3.00 \text{ m/s}^2$ .

a. Produce motion diagrams of the trains: **5**



Train A:



Train B:



b. Fill out the tables of known quantities for the two trains. Take the final position when the trains are side-by-side: **5**

Train A	
Parameter	Known Value
$x_0$	0
$x_f$	
$v_{x0}$	$27.0 \text{ m/s}$
$v_{xf}$	$27.0 \text{ m/s}$
$a_x$	0

Train B	
Parameter	Known Value
$x_0$	250
$x_f$	
$v_{x0}$	$-16.5 \text{ m/s}$
$v_{xf}$	
$a_x$	$-3.00 \text{ m/s}^2$

c. Using the coordinate system depicted above, write an equation of motion ( $x$  vs.  $t$ ) for the train on the left: **5**

$$x_l = 27.0t$$

d. Using the coordinate system depicted above, write an equation of motion ( $x$  vs.  $t$ ) for the train on the right: **10**

$$x_r = 250 - 16.5t - \frac{1}{2}(3.00)t^2 = 250 - 16.5t - 1.50t^2$$

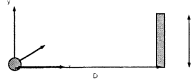
e. Find the time at which the centers of the trains are side-by-side. **5**

$$27.0t = 250 - 16.5t - 1.50t^2$$

$$1.50t^2 + 43.5t - 250 = 0$$

$$t = \frac{-43.5 \pm \sqrt{43.5^2 + 4 \cdot 1.50 \cdot 250}}{2 \cdot 1.50}$$

$$= 4.91 \text{ s}$$



3. A cannonball is shot from ground level at a castle wall. The castle wall is  $Y = 135$  m high and a horizontal distance  $D = 220$  m from the cannon. The initial horizontal component of velocity of the ball is  $75.0$  m/s in magnitude. Take  $y = 0$  at ground level. Assume the ball just grazes the top of the wall on the way up.

a. On the figure above, plot the trajectory of the cannonball. **5**

b. Fill out the tables of known values. Take the final position as when the cannonball grazes the castle wall. **5**

Parameter	Known Value
$x_0$	0
$x_f$	220 m
$v_{x0}$	75.0 m/s
$v_{xf}$	75.0 m/s
$a_x$	0

Parameter	Known Value
$y_0$	0
$y_f$	135 m
$v_{y0}$	
$v_{yf}$	
$a_y$	$-9.81 \text{ m/s}^2$

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

$$x^0: 220 = 75.0 t, \quad t = 2.93 \text{ s}$$

$$y^0: 135 = 0 + v_{0y}(2.93) - \frac{1}{2}g(2.93)^2$$

$$v_{0y} = 60.4 \text{ m/s}$$

$$\vec{v}_0 = (75.0 \hat{i} + 60.4 \hat{j}) \text{ m/s}$$

d. Find the velocity, acceleration, and position of the cannonball at its highest point and write them in vector notation. **15**

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

$$\vec{v} = 75.0 \hat{i} \text{ m/s}$$

$$y^0: 0 = 60.4 - g t, \quad t = 6.16 \text{ s}$$

$$0 = 60.4^2 - 2g \Delta y, \quad \Delta y = 186 \text{ m}$$

$$x^0: x = 75.0(6.16) = 462 \text{ m}$$

$$\vec{r} = (462 \hat{i} + 186 \hat{j}) \text{ m}$$