

Your Name: \_\_\_\_\_

**PHY203  
Exam #1  
Chapters 1-3  
Fri., 2/17/17**

1 \_\_\_\_\_ (out of 30)

2 \_\_\_\_\_ (out of 35)

3 \_\_\_\_\_ (out of 35)

Total \_\_\_\_\_

- Show work
- Use correct SI units
- Use scientific notation
- All answers with 3 significant figures
- use  $g = 9.81 \text{ m/s}^2$

*Solutions*

1. At  $t=0$  an object is at a position of  $x = -12.5$  m and  $y = +7.50$  m with a velocity of  $+6.50$  m/s in the x-direction and a constant acceleration of  $-4.50$  m/s<sup>2</sup> in the y-direction.

a. Write the position, velocity, and acceleration at  $t=0$  in vector notation.

$$\vec{r}_0 = (-12.5\hat{i} + 7.50\hat{j}) \text{ m} \quad 2$$

$$\vec{v}_0 = 6.50\hat{i} \text{ m/s} \quad 2$$

$$\vec{a} = -4.50\hat{j} \text{ m/s}^2 \quad 2$$

b. Find the position, velocity, and acceleration in vector notation at  $t=5.50$  s.

$$\vec{a} = \text{same} = -4.50\hat{j} \text{ m/s}^2 \quad 5$$

$$\begin{aligned} \vec{v} &= \vec{v}_0 + \vec{a}t = 6.50\hat{i} - 4.50\hat{j}(5.50) \quad 5 \\ &= (6.50\hat{i} - 24.8\hat{j}) \text{ m/s} \end{aligned}$$

$$\begin{aligned} \vec{r} &= \vec{r}_0 + \vec{v}_0t + \frac{1}{2}\vec{a}t^2 \\ &= (-12.5\hat{i} + 7.50\hat{j}) + (6.50\hat{i})(5.50) + \frac{1}{2}(-4.50\hat{j})(5.50)^2 \\ &= (+23.2\hat{i} - 60.6\hat{j}) \text{ m} \quad 10 \end{aligned}$$

c. Find the speed (magnitude of the velocity) at this time.

$$\begin{aligned} v &= \sqrt{6.50^2 + (-24.8)^2} \quad 4 \\ &= 25.6 \text{ m/s} \end{aligned}$$

2. Two trains are running on parallel tracks. Train A is at rest at a position of  $x=0$  at  $t=0$  with a constant acceleration of  $2.50 \text{ m/s}^2$  in the  $+x$ -direction. Train B is at a position of  $x= -15.0 \text{ m}$  at  $t=0$  with a constant speed in the  $+x$ -direction of  $10.5 \text{ m/s}$ .

a. Write the equation for the position of train A as a function of time.

$$x_A = \frac{1}{2} (2.50) t^2 = 1.25 t^2 \quad 10$$

b. Write the equation for the position of train B as a function of time.

$$x_B = -15.0 + 10.5 t \quad 10$$

c. Find the time(s) at which the trains are side-by-side.

$$1.25 t^2 = -15.0 + 10.5 t$$

$$1.25 t^2 - 10.5 t + 15.0 = 0 \quad 10$$

$$t = \frac{10.5 \pm \sqrt{10.5^2 - 4(1.25)(15.0)}}{2.50}$$

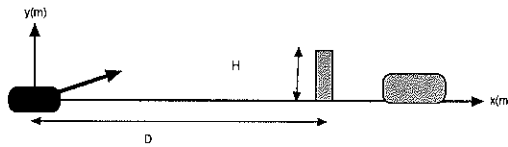
$$= \frac{10.5 \pm 3.94}{2.50} = 1.82 \text{ s}, 6.57 \text{ s}$$

d. Find the speed(s) of train A when the trains are side-by-side.

$$v = v_0 + a t = 2.50 t$$

$$v = 2.50 (1.82 \text{ or } 6.57) \quad 5$$

$$= 4.55 \text{ m/s or } 16.4 \text{ m/s}$$



3. A cannonball is shot from ground level at a castle wall. The initial velocity of the ball is 45.0 m/s at an angle of  $35.0^\circ$  with respect to the horizontal direction. The castle wall has height  $H$  and horizontal distance  $D = 150$  m from the cannon.
- a. Write the initial velocity of the cannonball in vector notation using the coordinate system above.

$$\vec{v}_0 = v_0 \cos \theta \hat{i} + v_0 \sin \theta \hat{j} \quad 4$$

$$= (45.0) \cos 35.0^\circ \hat{i} + 45.0 \sin 35.0^\circ \hat{j}$$

- b. Find the height of the cannonball at its highest point.  $= (36.9 \hat{i} + 25.8 \hat{j}) \text{ m/s}$

$$0 = v_{0y}^2 + 2a \Delta y$$

$$\Delta y = H = \frac{25.8^2}{2 \cdot 9.81} = 33.9 \text{ m} \quad 6$$

Assume the cannonball just grazes the top of the wall (but not at its highest point).

- c. Find the time it takes the ball to reach the wall.

$$150 = v_{0x} t$$

$$t = 150 / 36.9 = 4.07 \text{ s} \quad 5$$

- d. Find the height of the castle wall.

$$y = y_0 + v_{y0} t + \frac{1}{2} a_y t^2$$

$$= 0 + 25.8(4.07) + \frac{1}{2}(-9.81)(4.07)^2 = 10$$

$$= 24.0 \text{ m}$$

- e. Find the time it takes it ball to hit the top of a building behind the wall that has a height of 15.0 m.

$$15.0 = 0 + 25.8 t + \frac{1}{2}(-9.81) t^2$$

$$4.905 t^2 - 25.8 t + 15.0 = 0 \quad 10$$

$$t = \frac{25.8 \pm \sqrt{25.8^2 - 4(4.905)(15.0)}}{2(4.905)}$$

$$= 4.59 \text{ s} \quad \text{other } t \text{ doesn't make sense}$$