**Name**______________________________

Sept. 27, 2007

**Phys 2010, NSCC**
**Exam #1 — Fall 2007**

| | | |
|---|---|---|
| **1.** | ________________ | (10) |
| **2.** | ________________ | (12) |
| **3.** | ________________ | (10) |
| **4.** | ________________ | (10) |
| **5.** | ________________ | (11) |
| **6.** | ________________ | (16) |
| **7.** | ________________ | (12) |
| **8.** | ________________ | (9) |
| **MC** | ________________ | (10) |
| **Total** | ________________ | (100) |

## Multiple Choice

*Choose the best answer from among the four! (2) each.*

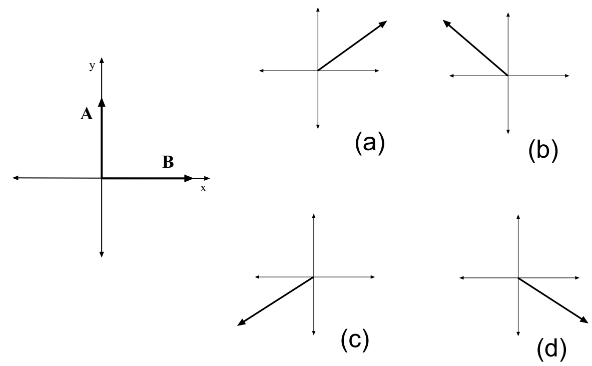
**1.** One square kilometer (1 $\text{km}^2$) is equal to

- **a)** $10^3\ \text{m}^2$
- **b)** $10^4\ \text{m}^2$
- $\boxed{\textbf{c)}}$ $10^6\ \text{m}^2$
- **d)** $10^8\ \text{m}^2$

**2.** If $m$ is a mass, $r$ is a distance and $a$ is an acceleration, the expression $mra$ has units of

- $\boxed{\textbf{a)}}$ $\frac{\text{kg}\cdot\text{m}^2}{\text{s}^2}$
- **b)** $\frac{\text{kg}\cdot\text{m}}{\text{s}^3}$
- **c)** $\frac{\text{kg}\cdot\text{m}^2}{\text{s}^3}$
- **d)** $\frac{\text{kg}\cdot\text{m}^3}{\text{s}}$

**3.** The vectors **A** and **B** are shown in the first picture at shown at the right. Which of the choices best represents the vector **A** − **B** ?




- **a)**
- $\boxed{\textbf{b)}}$
- **c)**
- **d)**

**4.** Suppose we drop an object and in a time $T$ it falls a distance $H$. How far does it fall in a time $3T$ after it is released?

- **a)** $3H$
- $\boxed{\textbf{b)}}$ $9H$
- **c)** $12H$
- **d)** None of the above.

**5.** When a projectile is fired straight upward, at the top of its path

- **a)** Its acceleration is zero.
- **b)** Its acceleration has magnitude $4.9\frac{\text{m}}{\text{s}^2}$.
- $\boxed{\textbf{c)}}$ Its acceleration has magnitude $9.8\frac{\text{m}}{\text{s}^2}$.
- **d)** Its acceleration has magnitude $19.6\frac{\text{m}}{\text{s}^2}$.

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## Problems

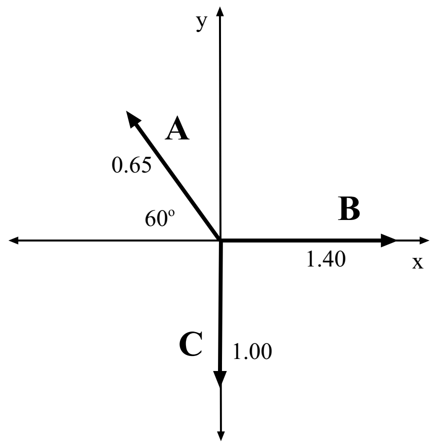
*Show your work and include the correct units with your answers!*

**1.** Convert $2.5\,\frac{\text{cm}^3}{\text{s}}$ to units of $\frac{\text{m}^3}{\text{hour}}$ (10)

$$2.5\,\frac{\text{cm}^3}{\text{s}} = (2.5\,\frac{\text{cm}^3}{\text{s}})\left(\frac{1\text{ m}}{100\text{ cm}}\right)^3\left(\frac{3600\text{ s}}{1\text{ hour}}\right) = 9.0\times10^{-3}\,\frac{\text{m}^3}{\text{hour}}$$

**2.** Vector **A** has magnitude 0.65 and points at 60° above the $-x$ axis. Vector **B** has magnitude 1.40 and points in the $+x$ direction. Vector **C** has magnitude 1.00 and points in the $-y$ direction.

Find the magnitude and direction of the sum of the three vectors. (12)




The $x, y$ components of the three vectors are

$$A_x = -0.65\cos 60^\circ = -0.325 \qquad A_y = 0.65\sin 60^\circ = 0.563$$

and

$$B_x = 1.40 \qquad B_y = 0 \qquad \text{and} \qquad C_x = 0 \qquad C_y = -1.00$$

The components of the sum of the three vectors (vector $\mathbf{R}$) are

$$R_x = A_x + B_x + C_x = 1.075 \qquad R_y = A_y + B_y + C_y = -0.437$$

The magnitude of the sum is

$$R = \sqrt{R_x^2 + R_y^2} = 1.16$$

and the direction of $\mathbf{R}$ is given by

$$\tan\theta = \frac{(-0.437)}{(1.075)} = -0.407 \qquad \Longrightarrow \qquad \theta = -22.1^\circ$$

which needs no fixing since $\mathbf{R}$ does point in that direction.

**3.** Starting from rest a car travels in a straight line and travels a distance of 202 m in 15.0 s. During this time the car has constant acceleration.

**a)** Find the acceleration of the car. (6)

Use the $x$ equation of motion, with $v_0 = 0$; at $t = 15.0\ \mathrm{s}$, $x = 202\ \mathrm{m}$:

$$x = 0 + \tfrac{1}{2}at^2 \qquad \Longrightarrow \qquad 202\ \mathrm{m} = \tfrac{1}{2}a(15.0\ \mathrm{s})^2$$

Solve for $a$:

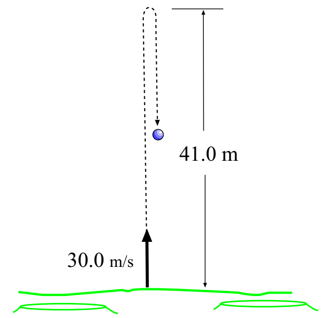
$$a = \frac{2(202\ \mathrm{m})}{(15.0\ \mathrm{s})^2} = 1.80\tfrac{\mathrm{m}}{\mathrm{s}^2}$$

**b)** What was the speed of the car at the end of the 15.0 s? (4)

Find $v$ at $t = 15.0\ \mathrm{s}$:

$$v = v_0 + at = (1.80\tfrac{\mathrm{m}}{\mathrm{s}^2})(15.0\ \mathrm{s}) = 26.9\tfrac{\mathrm{m}}{\mathrm{s}}$$

**4.** On a strange planet an object is fired upward at a speed of $30.0\frac{\text{m}}{\text{s}}$. It attains a maximum height of 41.0 m.




**a)** Find the value of $g$ on this planet. (6)

From the launch to maximum height $y = 41.0\ \text{m}$, $v_0 = 30.0\frac{\text{m}}{\text{s}}$, $v = 0$ and $a = -g$. Use:

$$v^2 = v_0^2 + 2ay \qquad \Longrightarrow \qquad 0 = (30.0\tfrac{\text{m}}{\text{s}})^2 + 2(-g)(41.0\ \text{m})$$

Solve for $g$:

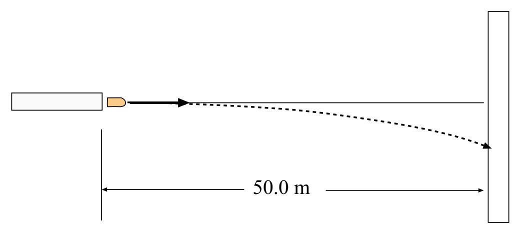
$$g = \frac{(30.0\frac{\text{m}}{\text{s}})^2}{2(41.0\ \text{m})} = 11.0\frac{\text{m}}{\text{s}^2}$$

**b)** How long did it take the object to reach maximum height? (4)

Find the time at which $v = 0$:

$$v = 0 = v_0 + at = 30.0\tfrac{\text{m}}{\text{s}} + (-11.0\tfrac{\text{m}}{\text{s}^2})t \qquad \Longrightarrow \qquad t = 2.7\ \text{s}$$

**5.** A gun is fired horizontally toward a target which is 50.0 m away. When the bullet strikes the target, it hits at a point which is 10.0 cm below the point at which the gun was aimed.




**a)** How long was the bullet in flight? (6)

The initial velocity has only an $x$ component. The acceleration is $a_x = 0$, $a_y = -9.8\frac{\text{m}}{\text{s}^2}$. At impact, $y = -0.10\ \text{m}$; the $y$ equation gives the time of flight of the bullet:

$$y = -0.10\ \text{m} = 0 + \tfrac{1}{2}(-9.8\tfrac{\text{m}}{\text{s}^2})t^2 \qquad \Longrightarrow \qquad t = 0.143\ \text{s}$$

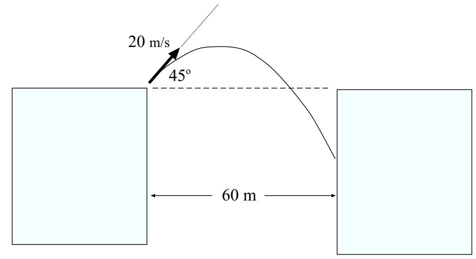
**b)** What was the initial speed of the bullet? (5)

Use the fact that at $t = 0.143\ \text{s}$, $x = 50.0\ \text{m}$, so

$$x = 50.0\ \text{m} = v_{0x}t + 0 = v_{0x}(0.143\ \text{s}) \qquad \Longrightarrow \qquad v_{0x} = 350\tfrac{\text{m}}{\text{s}}$$

The initial speed of the bullet is $\boxed{350\frac{\text{m}}{\text{s}}}$.

**6.** Two tall buildings have exactly the same height and are separated by a horizontal distance of 60.0 m. From the top of one the buildings a projectile is fired toward the other at a speed of $20.0\frac{\mathrm{m}}{\mathrm{s}}$ and an angle of 45° above the horizontal. (See figure.)




**a)** What are the $x$ and $y$ components of the initial velocity of the object? (4)

$$v_{0x} = 20.0\tfrac{\mathrm{m}}{\mathrm{s}}\cos 45^\circ = 14.1\tfrac{\mathrm{m}}{\mathrm{s}} \qquad v_{0y} = 20.0\tfrac{\mathrm{m}}{\mathrm{s}}\sin 45^\circ = 14.1\tfrac{\mathrm{m}}{\mathrm{s}}$$

**b)** How long does it take the object to hit the second building? (Hint: Use the $x$ equation of motion.) (6)

It hits the second building when $x = 60.0\ \mathrm{m}$. Use the $x$ equation of motion,

$$x = 60.0\ \mathrm{m} = v_{0x}t + 0 = (14.1\tfrac{\mathrm{m}}{\mathrm{s}})t \qquad \Longrightarrow \qquad t = 4.24\ \mathrm{s}$$

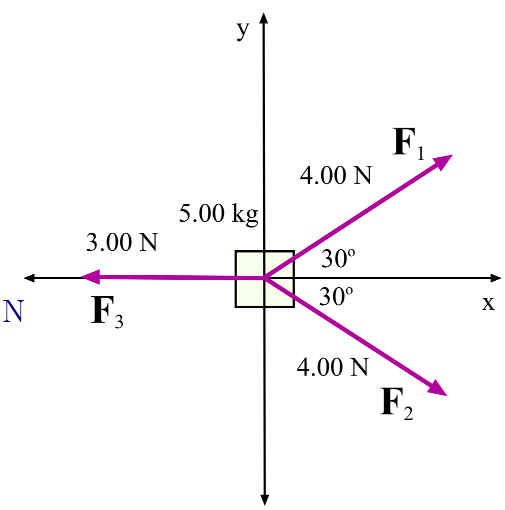
**c)** How far below the top of the second building does the object strike? (6)

Find the value of $y$ at $t = 4.24\ \mathrm{s}$. Get:

$$y = v_{0y}t + \tfrac{1}{2}at^2 = (14.1\tfrac{\mathrm{m}}{\mathrm{s}})(4.24\ \mathrm{s}) + \tfrac{1}{2}(-9.80\tfrac{\mathrm{m}}{\mathrm{s}^2})(4.24\ \mathrm{s})^2 = -28.3\ \mathrm{m}$$

This tells us that the object hit the second building $\boxed{28.3\ \mathrm{m}}$ below its top.

**7.** Three forces act on a 5.00 kg mass as shown here. The forces all act in the same plane; two 4.00 N forces act at $\pm 30^\circ$ and a 3.00 N force acts in the $-x$ direction.




**a)** What is the magnitude and direction of the net force on the mass? (8)

Add the forces. The sum of the $x$ components is

$$\sum F_x = -3.00\ \mathrm{N} + 4.00\ \mathrm{N}\cos 30^\circ + 4.00\ \mathrm{N}\cos 30^\circ = +3.93\ \mathrm{N}$$

The sum of the $y$ components is (obviously?) zero:

$$\sum F_y = 4.00\ \mathrm{N}\sin 30^\circ - 4.00\ \mathrm{N}\sin 30^\circ = 0$$

So the net force points in the $+x$ direction with a magnitude of $3.93\ \mathrm{N}$.

**b)** What is the acceleration of the mass? (4)

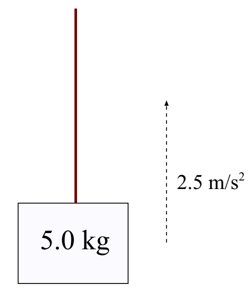
From $F_x = ma_x$,

$$a_x = \frac{F_x}{m} = \frac{3.93\ \mathrm{N}}{5.00\ \mathrm{kg}} = 0.786\tfrac{\mathrm{m}}{\mathrm{s}^2}$$

and there is no acceleration in the $y$ direction.

**8.** A string attached to a 5.0 kg mass pulls the mass straight up such that the acceleration of the mass is $2.5\frac{\mathrm{m}}{\mathrm{s}^2}$ upward.

Find the tension in the string. (9)




The forces on the mass are the string tension $T$ pointing upward and the force of gravity $mg$ pointing downward. The acceleration is $2.5\frac{\mathrm{m}}{\mathrm{s}^2}$ upward. Newton's second law gives

$$T - mg = ma \qquad \Longrightarrow \qquad T = mg + ma = m(g+a) = (5.0\ \mathrm{kg})(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2} + 2.50\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 61.5\ \mathrm{N}$$

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**You must show all your work and include the right units with your answers!**

$$A_x = A\cos\theta \qquad A_y = A\sin\theta \qquad A = \sqrt{A_x^2 + A_y^2} \qquad \tan\theta = A_y/A_x$$

$$v_x = v_{0x} + a_x t \qquad x = v_{0x}t + \tfrac{1}{2}a_x t^2 \qquad v_x^2 = v_{0x}^2 + 2a_x x \qquad x = \tfrac{1}{2}(v_{0x} + v_x)t$$

$$v_y = v_{0y} + a_y t \qquad y = v_{0y}t + \tfrac{1}{2}a_y t^2 \qquad v_y^2 = v_{0y}^2 + 2a_y y \qquad y = \tfrac{1}{2}(v_{0y} + v_y)t$$

$$g = 9.80\tfrac{\mathrm{m}}{\mathrm{s}^2} \qquad R = \frac{2v_0^2 \sin\theta\cos\theta}{g} \qquad \mathbf{F}_{\mathrm{net}} = m\mathbf{a} \qquad \text{Weight} = mg$$

$$F = G\frac{m_1 m_2}{r^2} \qquad G = 6.67\times 10^{-11}\,\frac{\mathrm{N\cdot m^2}}{\mathrm{kg}^2}$$

$$\text{If} \quad ax^2 + bx + c = 0 \quad \text{then} \quad x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}\,.$$