Name______________________________

Sept. 28, 2006

Phys 2010, NSCC
Exam #1 — Fall 2006

1.	________________	(12)
2.	________________	(8)
3.	________________	(8)
4.	________________	(10)
5.	________________	(14)
6.	________________	(24)
7.	________________	(14)
MC	________________	(10)
Total	________________	(100)

Multiple Choice

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

1. One square meter is equal to

a) 100 cm^2

b) 1000 cm^2

$\boxed{\textbf{c)}}$ 10000 cm^2

d) 10^6 cm^2

2. If m is a mass and v is a speed, the expression $\frac{1}{3}mv^2$ has units of

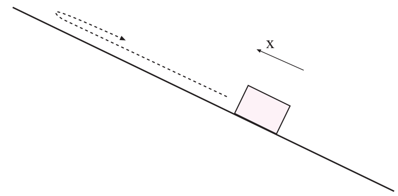
a) $\frac{\text{kg}\cdot\text{m}^3}{\text{s}}$

$\boxed{\textbf{b)}}$ $\frac{\text{kg}\cdot\text{m}^2}{\text{s}^2}$

c) $\frac{\text{m}^2}{\text{s}^2}$

d) $\frac{\text{kg}^2\cdot\text{m}^2}{\text{s}^2}$

3. Suppose the x axis points up the slope of a track. A cart is given a shove; it rolls up the slope and then down. The acceleration of the cart is



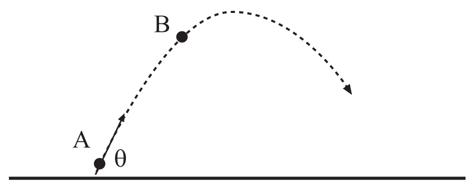
$\boxed{\textbf{a)}}$ Negative on the way up and negative on the way down.

b) Negative on the way up and positive on the way down.

c) Positive on the way up and negative on the way down.

d) Positive on the way up and positive on the way down.

4. Suppose a projectile is fired at some angle θ above the horizontal, as shown here. When we compare the velocity components at point B with those at point A,



a) v_x is smaller and v_y is smaller.

b) v_x is smaller and v_y is the same.

$\boxed{\textbf{c)}}$ v_x is the same and v_y is smaller.

d) v_x and v_y are both the same.

5. If a 2.0 kg object is taken from the earth to the moon,

$\boxed{\textbf{a)}}$ Its mass is the same; its weight will be different.

b) Its weight is the same; its mass will be different.

c) Both mass and weight are the same.

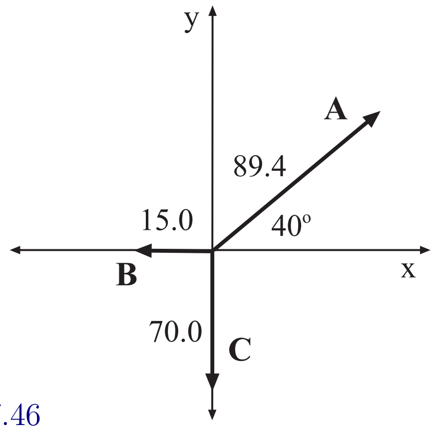
d) The mass and weight are both different.

Problems

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

1. The vector **A** has magnitude 89.4 and is directed at 40.0° from the $+x$ axis. The vector **B** points in the $-x$ direction and has magnitude 15.0. The vector **C** has magnitude 70.0 and points tn the $-y$ direction.

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



The components of the vectors are

$$A_x = A\cos\theta = 89.4\cos 40^\circ = 68.48$$

$$A_y = A\sin\theta = 89.4\sin 40^\circ = 57.46$$

And it is clear that

$$B_x = -15.0 \qquad B_y = 0$$

$$C_x = 0 \qquad C_y = -70$$

Then if $\mathbf{D} = \mathbf{A} + \mathbf{B} + \mathbf{C}$ then

$$D_x = A_x + B_x + C_x = 53.48 \qquad D_y = A_y + B_y + C_y = -12.54$$

This gives

$$D = \sqrt{D_x^2 + D_y^2} = 54.9$$

$$\tan\theta = D_y/D_x = -0.234 \qquad \Longrightarrow \qquad \theta = \tan^{-1}(-0.234) = -13.2^\circ$$

That is the correct answer for θ (the direction of $\mathbf{D}$) since D_x is positive and D_y is negative.

2. The Moon is receding from the Earth at a rate of $3.8\,\frac{\text{cm}}{\text{year}}$.

Express this number in units of $\frac{\text{m}}{\text{s}}$. Use the facts

$$1 \text{ yr} = 365.25 \text{ day} \qquad 1 \text{ day} = 24 \text{ hr}$$

and other well-known facts. (8)

$$\begin{aligned} 3.8\,\tfrac{\text{cm}}{\text{year}} &= (3.8\,\tfrac{\text{cm}}{\text{year}})\left(\frac{1 \text{ m}}{100 \text{ cm}}\right)\left(\frac{1 \text{ yr}}{365.25 \text{ day}}\right)\left(\frac{1 \text{ day}}{24 \text{ hr}}\right)\left(\frac{1 \text{ hr}}{3600 \text{ s}}\right) \\ &= 1.20\times 10^{-9}\,\tfrac{\text{m}}{\text{s}} \end{aligned}$$

3. A record turntable rotates at such a rate that it makes one full revolution every 1.80 s.

What is the speed of a point on the turntable which is 10.0 cm from the center? (You will want to find the circumference of its path; recall $C = 2\pi R$.) (8)

For each turn, the length of the path is

$$C = 2\pi R = 2\pi(10.0 \text{ cm}) = 62.8 \text{ cm}$$

The speed is this length divided by the time for the revolution,

$$v = \frac{C}{T} = \frac{(62.8 \text{ cm})}{(1.80 \text{ s})} = 34.9 \, \frac{\text{cm}}{\text{s}} = 0.349 \frac{\text{m}}{\text{s}}$$

4. A cart travels along a straight line; it initially has a velocity of $2.80\frac{\text{m}}{\text{s}}$. It encounters a rough surface and undergoes a deceleration of magnitude $0.650\frac{\text{m}}{\text{s}^2}$.

a) How far does the cart travel on the rough surface before coming to a halt? (6)

Here we have

$$v_0 = 2.80\frac{\text{m}}{\text{s}} \qquad v = 0 \qquad a = -0.650\frac{\text{m}}{\text{s}^2}$$

Use

$$v^2 = v_0^2 + 2ax$$

and get

$$0 = (2.80\tfrac{\text{m}}{\text{s}})^2 + 2(-0.650\tfrac{\text{m}}{\text{s}^2})x \qquad \Longrightarrow \qquad x = \frac{(2.80\frac{\text{m}}{\text{s}})^2}{2(0.650\frac{\text{m}}{\text{s}^2})} = 6.03 \text{ m}$$

b) How long does it take the cart to come to a halt? (4)

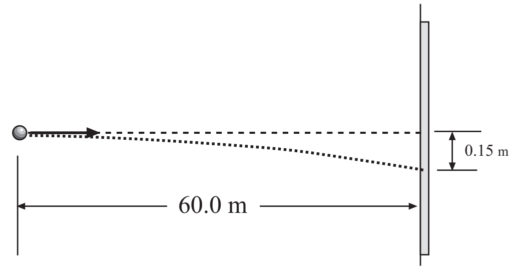
Use

$$a = \frac{v - v_0}{t} \qquad \Longrightarrow \qquad t = \frac{v - v_0}{a}$$

This gives

$$t = \frac{0 - (2.80\frac{\text{m}}{\text{s}})}{(-0.650\frac{\text{m}}{\text{s}^2})} = 4.31 \text{ s}$$

5. A projectile is fired horizontally toward a wall which is at a horizontal distance of 60.0 m. The projectile strikes the wall at a distance 0.150 m below the level at which it was fired.



a) How long was the projectile in flight? (7)

The initial velocity of the projectile has $v_{0y} = 0$ and v_{0x} is unknown.

At impact,

$$y = -0.15\ \mathrm{m} = v_{0y} + \tfrac{1}{2}a_y t^2 = 0 - \tfrac{1}{2}gt^2$$

Solve for t:

$$t^2 = \frac{2(0.15\ \mathrm{m})}{(9.8\frac{\mathrm{m}}{\mathrm{s}^2})} = 0.031\ \mathrm{s}^2 \qquad \Longrightarrow \qquad t = 0.175\ \mathrm{s}$$

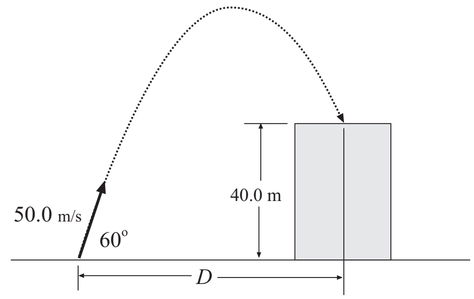
b) What was the initial speed of the projectile? (7)

At impact, $x = 60.0\ \mathrm{m}$, so

$$x = 60.0\ \mathrm{m} = v_{0x}t + \tfrac{1}{2}a_x t^2 = v_{0x}(0.175\ \mathrm{s}) + 0 \qquad \Longrightarrow \qquad v_{0x} = \frac{(60.0\ \mathrm{m})}{(0.175\ \mathrm{s})} = 343\tfrac{\mathrm{m}}{\mathrm{s}}$$

Since v_{0y} is zero, the initial speed of the projectile was $343\frac{\mathrm{m}}{\mathrm{s}}$.

6. A projectile is shot from ground level at an angle of 60° above the horizontal at a speed of $50.0\frac{\text{m}}{\text{s}}$. The projectile lands on the top of a building, 40.0 m above the ground (see picture). (Of course, the projectile is *descending* when it lands.)



a) What are the x and y components of the initial velocity of the projectile? (4)

$$v_{0x} = (50.0\tfrac{\text{m}}{\text{s}})\cos 60^\circ = 25.0\tfrac{\text{m}}{\text{s}}$$

$$v_{0y} = (50.0\tfrac{\text{m}}{\text{s}})\sin 60^\circ = 43.3\tfrac{\text{m}}{\text{s}}$$

b) What was the y component of its velocity when it landed? (Hint: It may be useful to use $v_y^2 = v_{0y}^2 + 2a_y y$ for this.) (8)

Putting numbers into the suggested formula, we get

$$v_y^2 = (43.3\tfrac{\text{m}}{\text{s}})^2 + 2(-9.80\tfrac{\text{m}}{\text{s}^2})(40.0\text{ m}) = 1091\ \tfrac{\text{m}^2}{\text{s}^2}$$

Get v_y by taking the square root, but note that at impact the projectile was moving downward (otherwise it can't land on a $roof$!) so that we get

$$v = -33.0\tfrac{\text{m}}{\text{s}}$$

c) How long was the projectile in flight? (6)

Use

$$a_y = \frac{v_y - v_{0y}}{t} \qquad \Longrightarrow \qquad t = \frac{v_y - v_{0y}}{a_y}$$

which gives

$$t = \frac{-33.0\frac{\text{m}}{\text{s}} - 43.3\frac{\text{m}}{\text{s}}}{(-9.80\frac{\text{m}}{\text{s}^2})} = 7.79\text{ s}$$

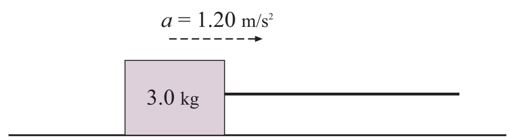
d) What was the horizontal distance (D) travelled by the projectile when it struck the roof of the building? (6)

Since $a_x = 0$,

$$x = v_{0x}t = (25.0\tfrac{\text{m}}{\text{s}})(7.79\text{ s}) = 195\text{ m}$$

7. A 3.0 kg mass is dragged forward over a rough surface by a rope. The tension in the rope is 5.00 N; there is also a force of friction on the block opposite the direction of motion.

The block accelerates forward at a rate of $1.20\frac{\mathrm{m}}{\mathrm{s}^2}$.



a) What is the *total* force on the block? (7)

$$F_{x,\mathrm{net}} = ma_x = (3.00\ \mathrm{kg})(1.20\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 3.60\ \mathrm{N}$$

b) What is the magnitude of the force of friction? (7)

Forces on the block are

$$F_{x,\mathrm{net}} = T - F_{\mathrm{fric}} = 5.00\ \mathrm{N} - F_{\mathrm{fric}} = 3.60\ \mathrm{N}$$

This gives

$$F_{\mathrm{fric}} = 5.00\ \mathrm{N} - 3.60\ \mathrm{N} = 1.40\ \mathrm{N}$$

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

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

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

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

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

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

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