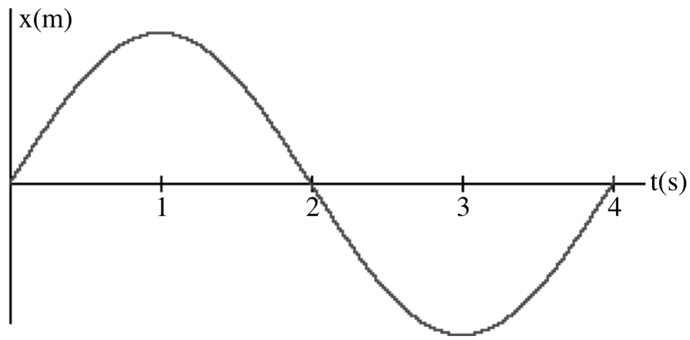
Name:_________________________________

Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied physical principles which are on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. Using the graph of position versus time for an object shown at the right, estimate the time or times when the object



(a)is to the right of the origin,

x>0 from t = 0s to t = 2s.

(b)is to the left of the origin,

x<0 from t = 2s to t = 4s.

(c)is at the origin, x = 0 when t = 0s, 2s, and 4s.

(d)has a positive velocity,

The velocity is the slope. v>0 from t = 0s to t =1s and t = 3s to t = 4s.

(e)has a negative velocity, v<0 from t = 1s to t =3s.

(f)has a velocity of zero, v=0 at t = 1s and t =3s.

(g)has a positive acceleration, The acceleration is the rate at which the slope is changing.

The slope is increasing (a>0) from t = 2s to t = 4s.

(h)has a negative acceleration, The slope is decreasing (a<0) from t = 0s to t = 2s.

(i)has a acceleration of zero. The slope must not be changing (a = 0) in between at t = 2s.

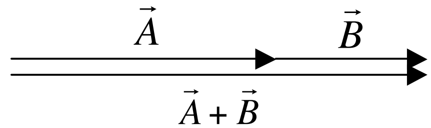
The acceleration is also probably zero at t = 0s and 4s as well.

(j)Find the total displacement of the object.

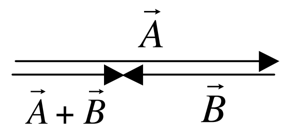
The object winds up where it started so the total displacement must be zero.

2. The vector $\vec{A}$ is 5.00m long and the vector $\vec{B}$ is 3.00m long.
(a)Find the maximum length of $\vec{A}+\vec{B}$ and sketch this situation.
(b)Find the minimum length of $\vec{A}+\vec{B}$ and sketch this situation.
(c)Given that vector $\vec{A}$ is along the x-axis and $\vec{A}+\vec{B}$ is 7.00m long, find the angle that the vector $\vec{B}$ makes with the x-axis.

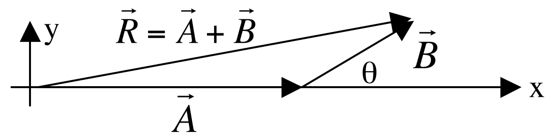
(a)The maximum length is $\left|\vec{A}+\vec{B}\right| = 5+3 \Rightarrow \boxed{\left|\vec{A}+\vec{B}\right| = 8}$.



(b)The minimum length is $\left|\vec{A}+\vec{B}\right| = 5-3 \Rightarrow \boxed{\left|\vec{A}+\vec{B}\right| = 2}$.



(c)From the sketch at the right,
$R_x = A + B\cos\theta$ and $R_y = B\sin\theta$.



Finding the length of R,

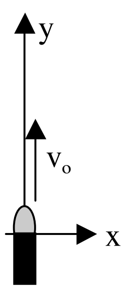
$$R^2 = R_x^2 + R_y^2 = (A + B\cos\theta)^2 + B^2\sin^2\theta$$

$$R^2 = A^2 + 2AB\cos\theta + B^2\cos^2\theta + B^2\sin^2\theta = A^2 + B^2 + 2AB\cos\theta$$

which is really the Law of Cosines. Solving for the angle,

$$\theta = \arccos\left(\tfrac{R^2-A^2-B^2}{2AB}\right) = \arccos\left(\tfrac{7^2-5^2-3^2}{2(5)(3)}\right) = \arccos\left(\tfrac{1}{2}\right) \Rightarrow \boxed{\theta = 60.0^\circ}.$$

3. Water leaving a hose goes straight upward to a maximum height of 1.20m. Find the speed of the water as it leaves the hose.



$y_o = 0$
$y = 1.20m$
$v_o = ?$
$v = 0$
$a = -9.80m/s^2$
$t = ?$

The final speed of the water at the top is zero. Using the kinematic equation without the t,

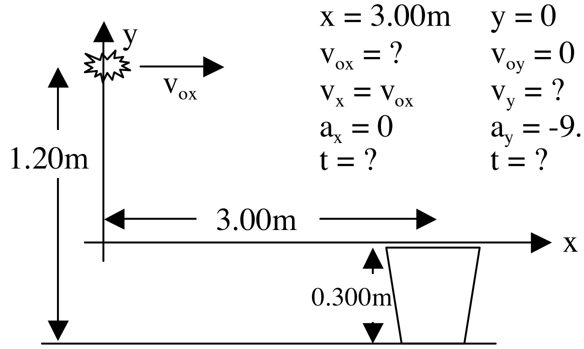
$$v^2 = v_o^2 + 2a(y - y_o) \Rightarrow 0 = v_o^2 + 2ay$$

Solving for the initial speed,

$$v_o = \sqrt{-2ay} = \sqrt{-2(-9.80)(1.20)} \Rightarrow \boxed{v_o = 4.85 m/s}.$$

4. A student works out the solution to a difficult physics problem on a piece of scratch paper. After copying the solution neatly to the page they will turn in they wad the scratch paper up and throw it horizontally into a 30.0cm high wastebasket 3.00m away. Find the speed they should throw it assuming that they release it 1.20m above the ground.

$x_o = 0$	$y_o = 0.900\text{m}$
$x = 3.00\text{m}$	$y = 0$
$v_{ox} = ?$	$v_{oy} = 0$
$v_x = v_{ox}$	$v_y = ?$
$a_x = 0$	$a_y = -9.80\text{m/s}^2$
$t = ?$	$t = ?$



Using the kinematic equation,

$$x = x_o + v_{ox}t + \tfrac{1}{2}a_x t^2 \Rightarrow x = v_{ox}t,$$

and solving for time,

$$t = \frac{x}{v_{ox}}.$$

Use the same kinematic equation along y and insert the equation for time,

$$y = y_o + \tfrac{1}{2}a_y t^2 \Rightarrow y_o = -\tfrac{1}{2}a_y\left(\frac{x}{v_{ox}}\right)^2.$$

Solving for the initial speed,

$$v_{ox} = \sqrt{-\frac{a_y x^2}{2y_o}} = \sqrt{-\frac{(-9.80)(3.00)^2}{2(0.900)}} \Rightarrow \boxed{v_{ox} = 7.00m/s}.$$

5. A television satellite must appear stationary in the sky so that the satellite dish doesn't have to move as it orbits. This means that the satellite completes precisely one orbit each day. The radius of the satellites orbit is $4.22 \text{x} 10^4$km. Find (a)the speed of the satellite and (b)the acceleration of the satellite. (c)Your friend says that the answers to both questions must be zero since the satellite doesn't appear to move. Comment on their statement.

The period of the orbit is, $T = (1\text{day})\left(\frac{24\text{h}}{\text{day}}\right)\left(\frac{3600\text{s}}{\text{h}}\right) = 8.64\text{x}10^4\text{s}$.

(a)The speed of orbit can be found from the definition of speed,

$$v \equiv \frac{\Delta x}{\Delta t} = \frac{2\pi r}{T} = \frac{2\pi(4.22x10^7)}{8.64x10^4} \Rightarrow \boxed{v = 3070m/s}.$$

(b)The centripetal acceleration is,

$$a_c = \frac{v^2}{r} = \frac{(3070)^2}{4.22\text{x}10^7} \Rightarrow \boxed{a_c = 0.223\text{m/s}^2}.$$

(c)The friend is forgetting that they are actually moving in circular motion on the surface of Earth. So, the satellite must be moving to appear motionless. This is the principle of relativity. In addition, your friend is actually accelerating as they go around Earth, so too must the satellite to appear motionless. Alternately, the fact that the velocity vector of the satellite is changing requires that it accelerate.