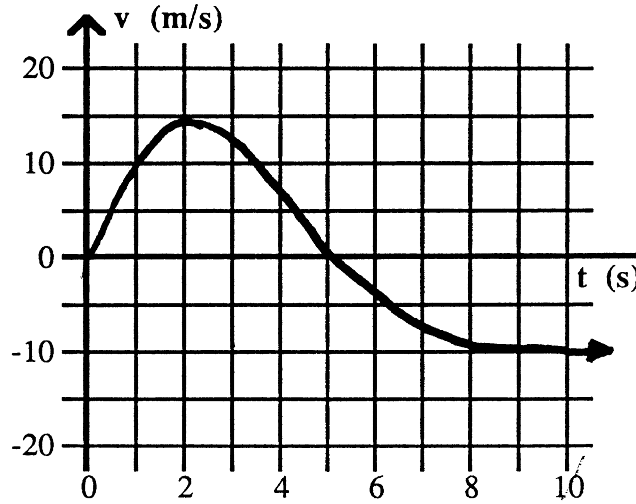
Name:__________________________________

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. The equations you need are on the equation sheet. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. The velocity of an object as a function of time is shown in the graph at the right. Answer the following questions about the object's motion. Be sure to explain your reasoning for full credit.



(a)When is the velocity a maximum?
Reading the graph, the velocity peaks at
$\boxed{t = 2.0s.}$

(b)What is the maximum velocity?
Reading the graph, the peak velocity is
$\boxed{v = 15m/s}$.

(c)When is the velocity zero?
Reading the graph, the velocity is zero at
$\boxed{t = 0s \text{ and at } t = 5.0s.}$

(d)When is the acceleration zero?
According to the definition of acceleration, the acceleration is the slope of the graph so, the acceleration is zero at
$\boxed{t = 2.0s \text{ and from about } t = 8.0s \text{ to } 10s}$.

(e) When is the acceleration a maximum?
The acceleration is maximum when the slope is the largest. This is near $\boxed{t = 0s}$.

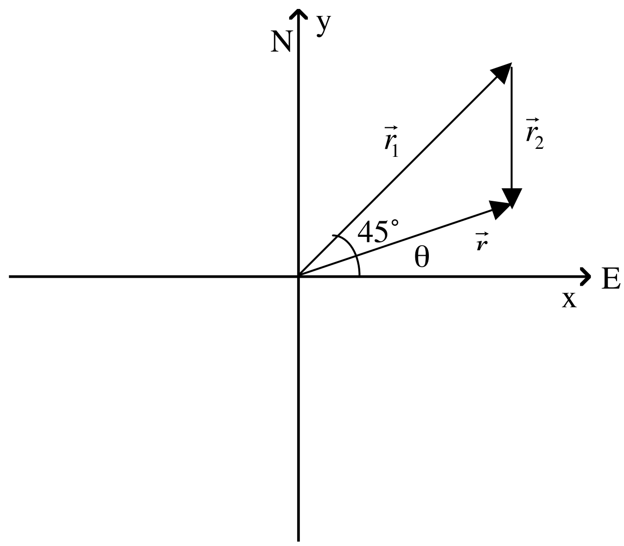
(f)What is the maximum acceleration?
Using the definition of acceleration and applying it near t = 0s,

$$a \equiv \frac{\Delta v}{\Delta t} \approx \frac{10-0}{1-0} \Rightarrow \boxed{a \approx 10 m/s^2}.$$

(g)When is the object the farthest away from its starting point?
According to the definition of velocity, the distance traveled is the area under the curve. The area is the largest when the velocity goes the zero at about $\boxed{t = 5.0s}$.

(h)How can you tell if the object will ever return to its starting point?
The distance traveled is the area under the curve. When the area above the curve from t = 0s to t = 5.0s is equal to the "negative area" from 5.0s onward then the object will be back at its starting point. This probably doesn't happen until after t = 10s.

2. A hiker walks 5.00km northeast, then turns and walks 2.50km due south. (a)Sketch first displacement, the second displacement, and the total displacement on the axes at the right. (b)Find the total distance traveled by the hiker. (c)Find the total displacement of the hiker.



(b)The total distance traveled is just the sum of the magnitudes, $d = r_1 + r_2 = 5.00 + 2.50 \Rightarrow \boxed{d = 7.50km}$.

(c)To add the vectors, break each into components,

$$r_{1x} = r_1 \cos 45° = (5.00)\cos 45° = 3.54km$$
$$r_{1y} = r_1 \sin 45° = (5.00)\sin 45° = 3.54km$$
$$r_{2x} = 0km$$
$$r_{2y} = -2.50km$$

Add the components together,

$$r_x = r_{1x} + r_{2x} = 3.54 + 0 = 3.54km$$
$$r_y = r_{1y} + r_{2y} = 3.54 + (-2.50) = 1.04km$$

Use the Pythagorean Theorem, $r = \sqrt{r_x^2 + r_y^2} = \sqrt{(3.54)^2 + (1.04)^2} \Rightarrow \boxed{r = 3.69km}$.

Use the definition of tangent, $\tan\theta \equiv \frac{r_y}{r_x} \Rightarrow \theta = \arctan\frac{r_y}{r_x} = \arctan\frac{1.04}{3.54} \Rightarrow \boxed{\theta = 16.4°}$.

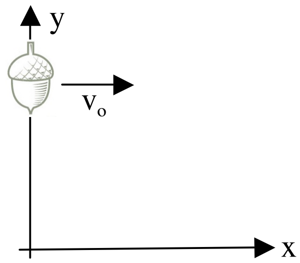
3. At the right is a table showing the acceleration due to gravity on Earth, the moon, and Mars. When astronauts landed on the moon they brought a golf ball. I suspect they will also bring one along when they go to Mars. Imagine identical golf balls thrown upward with identical initial velocities starting at identical heights on Earth, the moon, and Mars. Assume air resistance is negligible. Rank the balls from highest to lowest based upon the maximum height they will reach. You must explain your reasoning in terms of physical principles for full credit.

Body	g (m/s^2)
Earth	9.8
Moon	1.6
Mars	3.7

The definition of acceleration is the rate of change of velocity. Since all three balls start with the same velocity and have a velocity of zero at the maximum height, they all have the same change in velocity. Therefore, the place where the acceleration is the smallest will have the longest time to change the velocity and therefore the most time to rise and the largest maximum height. Therefore, the ranking from highest to lowest is,

$\boxed{\text{Moon>Mars>Earth}}$.

4. A squirrel running along a horizontal limb of an oak tree at 1.50m/s accidentally releases the acorn it was carrying. It strikes the ground 2.00s later. Find (a)the horizontal distance it traveled during the fall and (b)the height from which it was dropped.



$x_o = 0$	$y_o = ?$
$x = ?$	$y = 0$
$v_{ox} = 1.50m/s$	$v_{oy} = 0$
$v_x = v_{ox}$	$v_y = ?$
$a_x = 0$	$a_y = -9.80m/s^2$
$t = 2.00s$	$t = 2.00s$

(a)Using the kinematic equation without the final speed for the x-direction,

$$x = x_o + v_{ox}t + \tfrac{1}{2}a_x t^2 \Rightarrow x = v_{ox}t = (1.50)(2.00) \Rightarrow \boxed{x = 3.00m}.$$

(b)Using the kinematic equation without the final speed for the y-direction,

$$y = y_o + v_{oy}t + \tfrac{1}{2}a_y t^2 \Rightarrow 0 = y_o + 0 + \tfrac{1}{2}a_y t^2 \Rightarrow y_o = -\tfrac{1}{2}a_y t^2.$$

Plugging in the numbers,

$$y_o = -\tfrac{1}{2}(-9.80)(2.00)^2 \Rightarrow \boxed{y_o = 19.6m}.$$

5. The moon orbits Earth every 27.4 days and is $3.84x10^5$ km away. Find (a)the speed and (a)the acceleration of the moon in its orbit.

The radius should be in meters and the period in seconds,
$r = 3.84x10^8m$,

$$T = (27.4d)\left(\frac{24h}{d}\right)\left(\frac{3600s}{h}\right) = 2.37x10^6 s$$

(a)The speed is the distance traveled per time, $v \equiv \frac{\Delta x}{\Delta t} = \frac{2\pi r}{T}$.

Plugging the numbers,

$$v \equiv \frac{\Delta x}{\Delta t} = \frac{2\pi(3.84x10^8)}{2.37x10^6} \Rightarrow \boxed{v \equiv 1020m/s}.$$

(b)The centripetal acceleration is given by, $a_c = \frac{v^2}{r}$.

Plugging the numbers,

$$a_c = \frac{(1020)^2}{3.84x10^8} \Rightarrow \boxed{a_c = 2.70x10^{-3}m/s^2}.$$