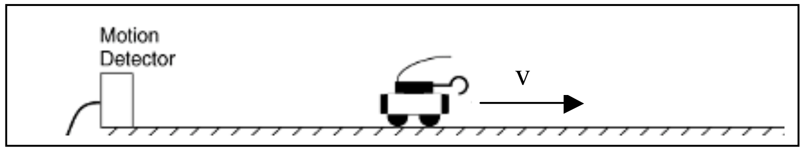
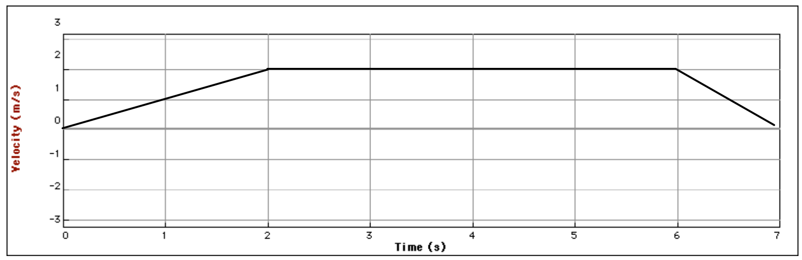
Name:____

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. A 350g cart initially at rest is given a push to the right along a level track beginning at t = 0s. The motion sensor plots the velocity as a function of time as shown in the graph at the right. Answer the following questions. Be sure to explain your answers for full credit.





(a)How much time elapses while the cart being pushed? How do you know?
The cart is being pushed for $\boxed{2s}$ because the cart is speeding up during the first two seconds according to the graph.

(b)How far does the cart travel while being pushed? How do you know?
According to the definition of velocity, distance traveled is the area under the velocity vs. time graph.

$$\bar{v} \equiv \frac{\Delta x}{\Delta t} \Rightarrow \Delta x = \bar{v}\Delta t = \tfrac{1}{2}(1.5)(2.0) \Rightarrow \boxed{\Delta x = 1.5m}.$$

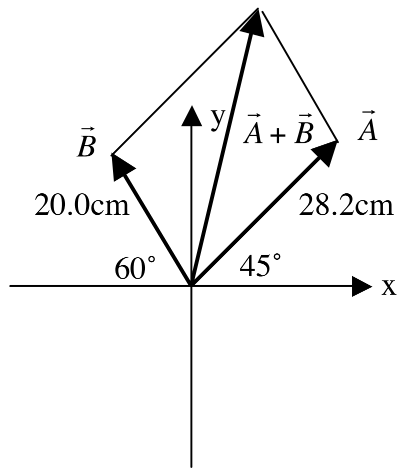
Note that you could also use 2m/s for the final speed depending on how you read the graph.

(c)What is the acceleration of the cart travel while being pushed? How do you know?
According to the definition of acceleration, velocity is the slope of the velocity vs. time graph.

$$\bar{a} \equiv \frac{\Delta v}{\Delta t} = \frac{1.5-0}{2.0-0} \Rightarrow \boxed{\bar{a} = 0.75m/s^2}.$$

Again, you could also use 2m/s for the final speed.

(d)Describe the motion of the cart travel after the push is complete.
From 2s to 6s, the cart coasts along at 1.5m/s.
From 6s to 7s, the cart slows and comes to rest.



2. For the two vectors shown at the right find (a) $\vec{A}+\vec{B}$ in unit vector form, (b)the magnitude and direction of $\vec{A}+\vec{B}$, (c) $\vec{A}\bullet\vec{B}$ and (d) $\vec{A}\times\vec{B}$. (e)Show $\vec{A}+\vec{B}$ at the right.

Break the vectors into components:

$A_x = 28.2\cos 45° = 19.9cm \qquad A_y = 28.2\sin 45° = 19.9cm$

$B_x = -20.0\cos 60° = -10.0cm \quad B_y = 20.0\sin 60° = 17.3cm$

(a) $\vec{A}+\vec{B} = (19.9\hat{i} + 19.9\hat{j}) + (-10.0\hat{i} + 17.3\hat{j}) \Rightarrow$

$\vec{A}+\vec{B} = (19.9 - 10.0)\hat{i} + (19.9 + 17.3)\hat{j} \Rightarrow \boxed{\vec{A}+\vec{B} = 9.9\hat{i} + 37.2\hat{j}}$

(b)Using the Pythagorean Theorem, $\left|\vec{A}+\vec{B}\right| = \sqrt{9.9^2 + 37.2^2} \Rightarrow \boxed{\left|\vec{A}+\vec{B}\right| = 38.5cm}$.

Using the definition of the tangent, $\theta = \arctan\dfrac{37.2}{9.9} \Rightarrow \boxed{\theta = 75.1°}$.

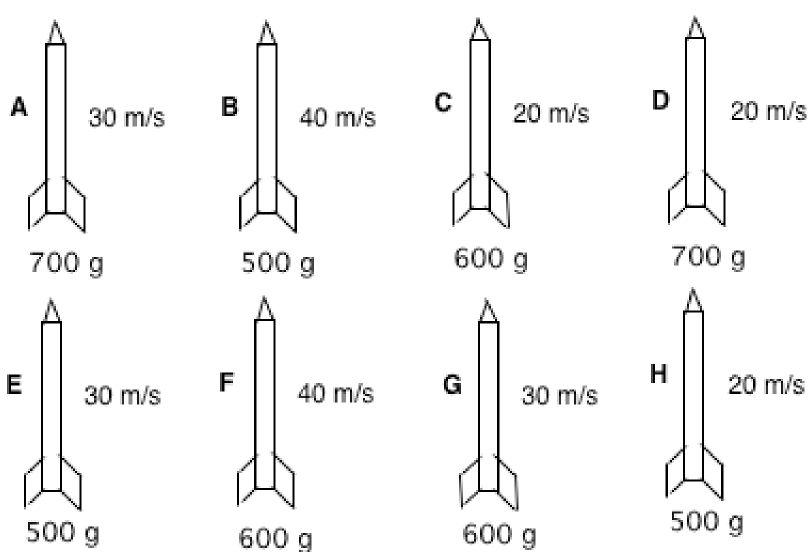
(c)Using the definition of the dot product,

$\vec{A}\bullet\vec{B} \equiv A_xB_x + A_yB_y = (19.9)(-10.0) + (19.9)(17.3) \Rightarrow \boxed{\vec{A}\bullet\vec{B} = 145cm^2}$.

(d)Using the definition of the cross product and noting that only the z-component exists,

$\vec{A}\times\vec{B} \equiv \left[A_xB_y - A_yB_x\right]\hat{k} = \left[(19.9)(17.3) - (19.9)(-10.0)\right]\hat{k} \Rightarrow \boxed{\vec{A}\times\vec{B} = 543\hat{k}cm^2}$.

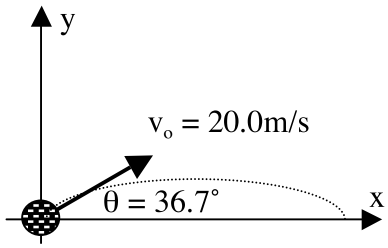
3. The eight figures below depict eight model rockets that have just had their engines turned off. All of the rockets are aimed straight up, but their speeds differ. All of the rockets are the same size and shape, but their masses differ. The specific mass and speed for each rocket is given in each figure. (In this situation, we are going to ignore any effect air resistance may have on the rockets.) At the instant when the engines are turned off, the rockets are all at the same height. Rank these model rockets, from greatest to least, on the basis of the maximum height they will reach. You must carefully explain your reasoning for full credit.



Since the Rule of Falling Bodies states that the motion is independent of the mass, only the initial velocity determines the maximum height.

$\boxed{\text{B=F>A=E=G>C=D=H}}$

4. A football is kicked at an angle of 36.9° above horizontal with a speed of 20.0m/s. Assuming no air resistance, find (a)the time it is in the air and (b)the distance is travels before hitting the ground.



$x_o = 0$	$y_o = 0$
$x = ?$	$y = 0$
$v_{ox} = v_o\cos\theta = 16.0\text{m/s}$	$v_{oy} = v_o\sin\theta = 12.0\text{m/s}$
$v_v = v_{ox} = 16.0\text{m/s}$	$v_y = ?$
$a_x = 0$	$a_y = -g = -9.80\text{m/s}^2$
$t = ?$	$t = ?$

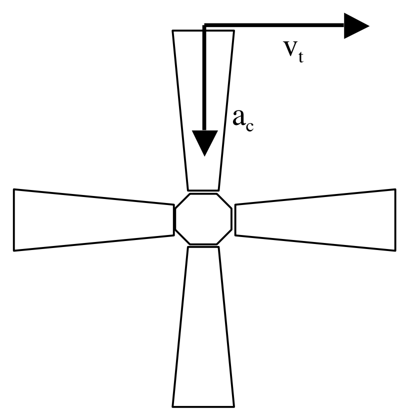
(a)Using the kinematic equation,

$$y = y_o + v_{oy}t + \tfrac{1}{2}a_y t^2 \Rightarrow 0 = v_{oy}t + \tfrac{1}{2}a_y t^2 \Rightarrow t = \frac{-2v_{oy}}{a_y} \Rightarrow t = \frac{-2(12.0)}{-9.80} \Rightarrow \boxed{t = 2.45s}.$$

(b)Using the kinematic equation,

$$x = x_o + v_{ox}t + \tfrac{1}{2}a_x t^2 \Rightarrow x = 0 + v_{ox}t + 0 \Rightarrow x = (16.0)(2.45) \Rightarrow \boxed{x = 39.2m}.$$

5. The 45.0cm long blades of a ceiling fan rotate at a constant rate of 180rpm. Find the linear speed of the tip of the blades and (b)the linear acceleration of the tip of the blades. (c)Describe the direction of the linear speed and acceleration.



(a)The distance around one rotation is the circumference,

$$\Delta x = 2\pi r = 2\pi(0.450m) = 2.83m.$$

The time for a rotation can be found from the rate,

$$\Delta t = \left(\frac{\text{min}}{180}\right)\left(\frac{60s}{\text{min}}\right) = 0.333s.$$

Using the definition of speed,

$$v = \frac{\Delta x}{\Delta t} = \frac{2.83}{0.333} \Rightarrow \boxed{v_t = 8.48m/s}.$$

(b)Using the centripetal acceleration,

$$a_c = \frac{v_t^2}{r} = \frac{(8.48)^2}{0.450} \Rightarrow \boxed{a_c = 160m/s^2}.$$

(c)The velocity is tangential and the acceleration is radial (toward the center) as shown at the right.