Name: Solutions

Wednesday, October 25, 2023

ID: ______________________________

Physics 201

Midterm 1

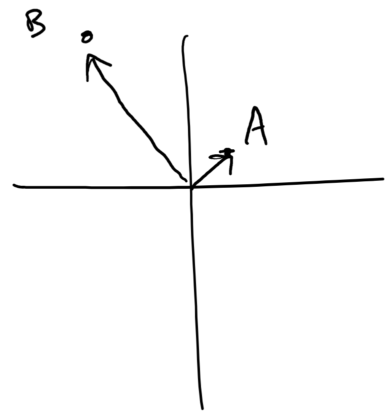
10/25/2023

Collaboration is not allowed. Allowed on your desk are: ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating graphing scientific calculator, a page of scratch paper, writing utensils, and the exam. You will have 60 minutes to complete this exam.

For questions 1 through 3 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **6** correct answers in this section and only the first **6** filled in answers will be graded. There is no partial credit.

1. Compare the position vectors A = < 1, 1 > m and B = < -3, 4 > m. Which of the following statements must be true?

   ☑ (a) Vector B has a larger magnitude
   □ (b) Vector A has a larger magnitude.
   □ (c) If A is the initial position and B is the final position, the displacement is 5 m.
   □ (d) If A is the initial position and B is the final position, we should add A to B to find the change in position vector.
   ☑ (e) if A is the initial position and B is the final position, we should subtract A from B to find the change in position vector.



2. Which of the following are vector quantities?

   ☑ (a) velocity
   □ (b) speed
   ☑ (c) displacement
   □ (d) magnitude of acceleration
   □ (e) magnitude of magnetic moment

3. A Newton (N) is a measurement of force, and has dimensions of mass * acceleration. Work is a measurement of energy and has dimensions of force * distance. Which of the following quantities have dimensions of velocity?

   □ (a) Force / mass
   □ (b) Work per force
   ☑ (c) (Force * time) / mass
   ☑ (d) Work / (mass * velocity)
   □ (e) (Force * mass) / work

(a) $\frac{ma}{m}$

(b) $\frac{Nd}{ma} = \frac{\cancel{ma}d}{\cancel{ma}}$

(c) $\frac{\cancel{m}at}{\cancel{m}} = \frac{L}{t^{\cancel{2}}}\cancel{t}$

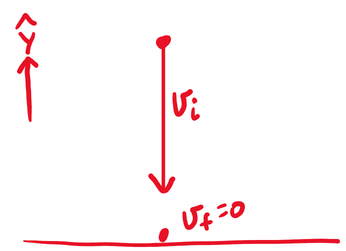
(d) $\frac{Nd}{m\,L/t} = \frac{\cancel{m}ad}{\cancel{m}d/t} = at$

(e) $\frac{\cancel{m}am}{\cancel{m}ad}$

$N = [m][a]$, $W = [N][d]$

4. (8 points) Benny the Beaver is testing his XElon rocket which is capable of landing on its own after launching. The rocket launches straight upwards, accelerating vertically, then turns off it's engines. As the rocket falls vertically back towards earth, it gains speed. At a specific time, the rocket is measured to be travelling downwards at a speed of **55.0 m/s**. At that instant, the rocket begins its landing procedure. The rocket engines turn on again, stopping the free fall and providing a constant acceleration. This constant acceleration continues until, at a time **12.0 seconds** later, the rocket lands gently and precisely on the ground, reaching zero velocity at the instant it makes contact. *Note: the acceleration is what brings the velocity to zero, not the collision with the ground (we will learn to analyze collisions in week 7 of this course).*

(a) In which direction is the acceleration of the rocket during the 12.0 seconds? Explain briefly. *(Please assume a standard coordinate system for this problem)*



$\Rightarrow \Delta\vec{v} = \vec{v}_f - \vec{v}_i$ points upwards $\Rightarrow \vec{a} = \frac{\Delta\vec{v}}{\Delta t}$ also points upwards or $+\hat{y}$

(b) What was the height of the rocket above the ground when it was measured to be travelling downwards at 55 m/s?

K	UK
Δt	Δy
v_f	a
v_i	

what was the height $\Rightarrow$ we want Δy

$\Rightarrow$

1. $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$ (? ✓ ✓ ? ✓)
2. $v_f = v_i + a \Delta t$ (✓ ✓ ? ✓)
3. $v_f^2 = v_i^2 + 2 a \Delta y$ (✓ ✓ ? ?)

$\Rightarrow$ use 2 to find a, then plug into 1 or 3 to get Δy

2 $\Rightarrow$ $\cancel{v_f}^{\,0} = v_i + a \Delta t$

$a \Delta t = -v_i$

$a = \frac{-v_i}{\Delta t}$

3 $\cancel{v_f^2}^{\,0} = v_i^2 + 2 a \Delta y$

$0 = v_i^2 + 2\left(\frac{-v_i}{\Delta t}\right) \Delta y$

$2\left(\frac{-v_i}{\Delta t}\right) \Delta y = -v_i^2$

height $= 330\,m \Leftarrow \Delta y = \frac{v_i \Delta t}{2} = -330\,m$

5. (8 points) Assume a standard coordinate system for this question. Pally the platypus is lounging in the lagoon. She then decides to make the **2.3 minute** swim to the Palapa Palace, located at **< 410, 270 > m**. The Palapa Palace is **20 degrees West of North** from the lagoon and Pally swims in a straight line with an average speed of **1.5 m/s**.

$\vec{r}_i$ Δt θ $\vec{r}_f$ $|\vec{v}_{avg}|$

(a) What distance does Pally swim in 2.3 minutes?

$$|\vec{v}_{avg}| = \frac{|\Delta\vec{r}|}{\Delta t}$$

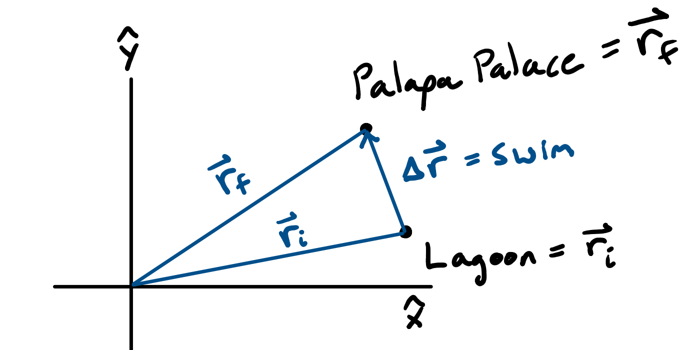
Speed; distance

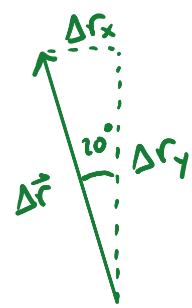
$$(2.3\ \text{min})\left(\frac{60}{1}\ \frac{\text{sec}}{\text{min}}\right) = 138\ \text{seconds}$$

$$\Rightarrow |\Delta\vec{r}| = |\vec{v}_{avg}|\,\Delta t$$

$$|\Delta\vec{r}| = (1.5\ \text{m/s})(138\ \text{s}) = 207\ \text{m} = \text{distance}$$

(b) What is the position vector of the lagoon?
(Give your answer in cartesian form: < x, y > m).





$$\sin\theta = \frac{\Delta r_x}{|\Delta\vec{r}|}$$

$$\cos\theta = \frac{\Delta r_y}{|\Delta\vec{r}|}$$

$$\Rightarrow \Delta\vec{r} = \langle -70.8, +195 \rangle\ \text{m}$$

$\vec{r}_f = \langle 410, 270 \rangle$ m

$\Delta\vec{r} = \langle -70.8, 195 \rangle$ m

$\vec{r}_i = ?$

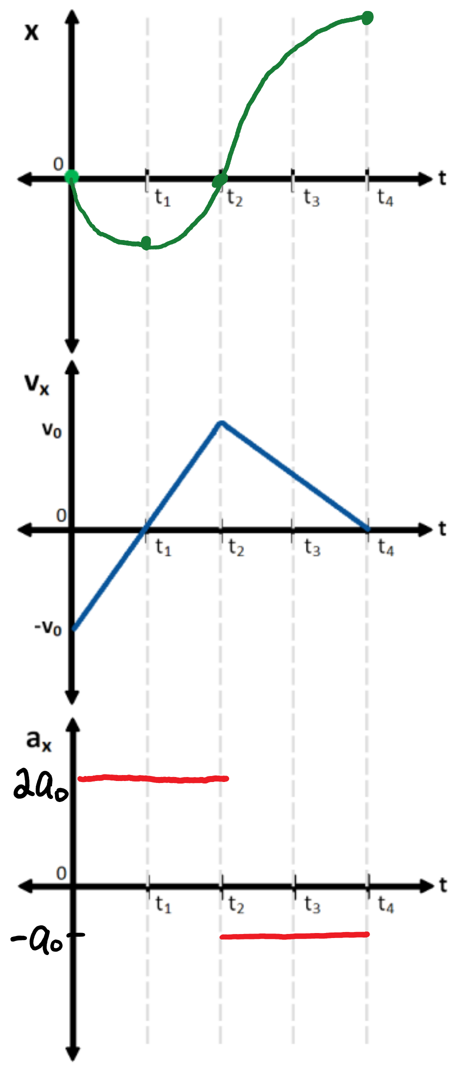
$$\overset{\checkmark}{\Delta\vec{r}} = \overset{\checkmark}{\vec{r}_f} - \overset{?}{\vec{r}_i}$$

$$\Rightarrow \vec{r}_i = \vec{r}_f - \Delta\vec{r}$$

$$\Rightarrow \vec{r}_i = \langle 410, 270 \rangle\ \text{m} - \langle -70.8, 195 \rangle\ \text{m}$$

$$\vec{r}_i = \langle 481, 75 \rangle\ \text{m}$$

6. (10 points) During the apocalypse (or Halloween) you find a zombie with a particularly unique affliction. They can only walk along a straight line - in the positive or negative direction - while searching for human brains (which is all the time). By approaching perpendicular to their movement you are easily able place a wireless velocity tracker on them. The data from your first tracking is plotted in the figure.



(a) In the provided acceleration vs time graph, sketch a plot of the acceleration of the zombie during the entire time the velocity is plotted.

(b) How many times larger is the magnitude of the acceleration during the time period **t = 0** to $\mathbf{t_2}$ than the magnitude of the acceleration during the time period $\mathbf{t_2 - t_4}$?

$$\bar{a} = \frac{\Delta V}{\Delta t}, \quad a_{0\text{-}2} = \frac{2V_0}{t_2 - 0}, \quad a_{2\text{-}4} = -\frac{V_0}{t_4 - t_2} \quad \Big\} \; |a_{0\text{-}2}| = 2|a_{2\text{-}4}|$$

factor of $\boxed{2}$

(c) In the provided position vs time graph, sketch a plot of the position of the of the zombie from time **t = 0** to $\mathbf{t_4}$. Assume the zombie starts at **x = 0**.

(d) Does the zombie end up in a positive or negative position? Explain your reasoning using any combination of words, diagrams, algebra, etc.

Area under the velocity curve equals displacement. From 0 - t_1 this is negative displacement and then from t_1 to t_2 it has the same positive displacement, returning back to the to the origin at t_2. From t_2 to t_4 it's all positive displacement, meaning it ends up in the positive position.

Rubric:

3 pts - part (a): slope, constant positive and negative, relative magnitudes
2 pts - part (b): slope magnitudes, factor of 2
3 pts - part (c): area, negative then positive, zero slope at t_1, zero displacement at t_2, zero slope at t_4
2 pts - part (d): positive vs negative area, ends positive