ABRHS PHYSICS (H) NAME: KEY

~Test 2: *Vectors, Circles & Relative(s)*

2013

Equations and Constants:

$\bar{v} = \frac{\Delta x}{\Delta t}$ $v = \frac{dx}{dt}$ $\bar{a} = \frac{\Delta v}{\Delta t}$ $a = \frac{dv}{dt}$ $\bar{v} = \frac{1}{2}(v_i + v_f)$ $|g| = 10\ m/s^2$

$x = \frac{1}{2}at^2 + v_i t + x_i$ $v = at + v_i$ $v_f^2 = v_i^2 + 2a\Delta x$ $a_c = \frac{v^2}{r}$

Focus

Multiple Choice: *Choose the letter of the best answer. 3 points each.*

Questions 1 and 2 refer to the following:
The position of an object (in SI units) is given by $\mathbf{r} = (4t^2 - 10t)\mathbf{i} + (3t - 9)\mathbf{j}$.

$\frac{36-30}{2} = (6\hat{i} + 10\hat{j}) - (0 - 9)$

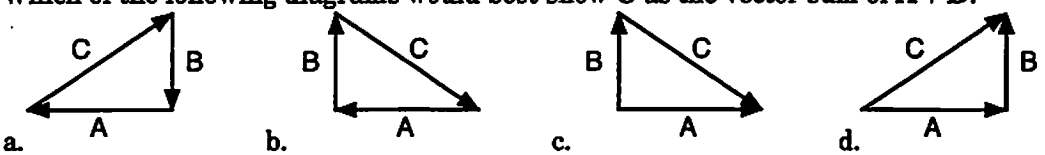
$\frac{6\hat{i} + 9\hat{j}}{3}$

1. C What is the initial velocity of the object?
   a. 0i + 3j m/s. b. 0i – 9j m/s. c. –10i + 3j m/s. d. 8i – 10j m/s.

2. A What was the average velocity for the first 3 seconds?
   a. 2i + 3j m/s. b. 6i + 9j m/s. c. 6i + 3j m/s. d. 2i – 3j m/s.

3. E The earth rotates on its axis once a day. Acton is at a latitude of 42°. In which direction are we accelerating because of the rotation of the earth?
   a. We aren't rotating at all because the earth can't move or we would feel it moving, so there is no acceleration.
   b. The earth is rotating, but because it is a constant rate there is no acceleration.
   c. To the center of the earth.
   d. Because we are rotating to the East, it is 42° E of N
   e. Well it is hard to describe: Look North, and then the acceleration is directed down at an angle of 48° below the horizon.

4. D Which of the following diagrams would best show **C** as the vector sum of **A** + **B**?



a. b. c. d.
   e. None of the above are correct.

5. A The acceleration of an object is given by the expression $\mathbf{a} = (4t)\mathbf{i} + (-7)\mathbf{j}$. Which of the following could be an expression that gives the velocity of the object?
   a. $(2t^2)\mathbf{i} + (-7t)\mathbf{j}$. b. $(4t^2)\mathbf{i} + (-7t)\mathbf{j}$. c. $(4t^2)\mathbf{i} + (-7)\mathbf{j}$. d. $(2t^2)\mathbf{i} + (-7)\mathbf{j}$.

Questions 6 to 8 refer to the following vectors:
$\mathbf{A} = 7\mathbf{i} + 12\mathbf{j} - 4\mathbf{k}$ $\mathbf{B} = -5\mathbf{i} + 3\mathbf{j} + 2\mathbf{k}$ $\mathbf{C} = 4\mathbf{i} - 5\mathbf{j}$

-5 3
+12 -15
$7\hat{i} + 12\hat{j} + 2\hat{k}$

6. D Which of the following would be in the opposite direction of vector A?
   a. 7i – 12j + 4k. b. 24i – 8j + 14k. c. 7i + 12j + 4k. d. –14i – 24j + 8k.
   e. None of the above are correct.

7. E What is B + 3C?
   a. 7i – 9j + 6k. b. 7i – 9j + 2k. c. –15i + 9j + 6k. d. 7i –9j – k.
   e. None of the above are correct.

$7\hat{i} - 12\hat{j} + 2\hat{k}$

-15 3
+12 -15
$7\hat{i} - 12\hat{j} + 2\hat{k}$

8. C What is A – B?
   a. 2i + 15j – 2k. b. 12i – 15j + 6k. c. 12i + 9j – 6k. d. –12i – 9j – 2k.
   e. None of the above are correct.

$12\hat{i} + 9\hat{j} - 6\hat{k}$

a

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9. A Imagine it is a lovely day, and you are driving down a twisty, curvy road with a constant speed. Which of the following must be true?
   a. Your acceleration will always be perpendicular to your direction of travel.
   b. You have to have a constant, non-zero acceleration.
   c. Your acceleration could be in any direction at any time.
   d. You can't be accelerating at all.

10. D What was one of the big points of studying relative motion?
   a. There is no such thing as absolute rest.
   b. Velocities are always measured relative to something else.
   c. One can't tell if you have a constant velocity or not.
   d. All of those are good points.
   e. None of the above.

11. A You watch a friend sitting in the back of a truck drive by to the right with a speed of 15 m/s. You see her throw a tennis ball with a velocity of $-5\mathbf{i} + 10\mathbf{j}$ m/s. What was the velocity of the tennis ball according to your friend?
   a. $-20\mathbf{i} + 10\mathbf{j}$ m/s. b. $-25\mathbf{i} + 10\mathbf{j}$ m/s. c. $-10\mathbf{i} - 10\mathbf{j}$ m/s. d. $10\mathbf{i} + 10\mathbf{j}$ m/s.
   e. None of the above are correct.

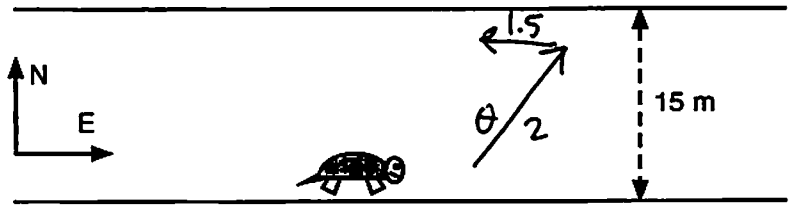
Questions 12 and 13 refer to the following:
Will and Horace are riding a Merry-go-Round which is rotating at 10 rpm. Will is at a radius of 4 meters, and Horace is at a radius of 2 meters.

12. D How fast is Will traveling?
   a. 23.9 m/s. b. 1.0 m/s. c. 0.67 m/s. d. 4.2 m/s.
   e. None of the above are correct.

$\left(\frac{10\ rev}{min}\right)\left(\frac{1\ min}{60\ s}\right)\left(\frac{2\pi 4\ m}{1\ rev}\right)$

13. B How does Horace's acceleration compare to Will's?
   a. They have the same acceleration.
   b. Horace has half the acceleration of Will.
   c. Horace has twice the acceleration of Will.
   d. Will's acceleration is $\sqrt{2}$ times that of Horace.
   e. Will's acceleration is 4 times that of Horace.

Questions 14 and 15 refer to the following:
A turtle is trying to cross a river that is 15 m wide. The river flows with a speed of 1.5 m/s, due West. The turtle always has a water speed of 2 m/s.



$\sin\theta = \frac{1.5}{2}$

$\theta = 48.6°$

14. C In what direction should the turtle point so that the turtle goes directly across the river?
   a. 36.9° E of N. b. 41.4° E of N. c. 48.6° E of N. d. 53.1° E of N.
   e. due North.

15. C What is the least amount of time the turtle could take to the cross the river?
   a. 6 seconds. b. 3.75 seconds. c. 7.5 seconds. d. 10 seconds.
   e. None of the above are correct.

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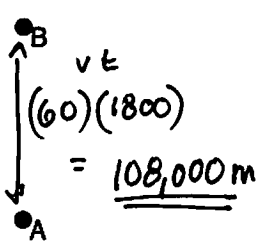
Problem Solving: *Show all work. 12 points each.*

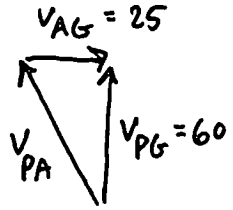
16. A plane is flying in a strong wind. The velocity of the wind is 25 m/s due East. The plane has a velocity with respect to the ground of 60 m/s due north (from A to B in the diagram.) After 1/2 hour, the plane turns due East, and flies for another 1/2 hour (to point C.) The plane had a constant speed relative to the air the whole time. What is the total displacement of the plane?



$v\,t$

$(60)(1800)$

$= 108{,}000\ m$



$V_{PA} = \sqrt{25^2 + 60^2}$

$V_{PA} = 65\ m/s$

So

$\vec{65} + \vec{25} = 90\ m/s$

$d = v\,t$

$= (90)(1800)$

$= 162{,}000\ m$

$\tan\theta = \frac{108}{162} = .67$

$\theta = 33.7°$

$\Delta\vec{r} = 162{,}000\,\hat{i} + 108{,}000\,\hat{j}$ or $195{,}000 \angle 33.7°$ N of E

17. A cat is running around in circles for some reason. It starts at the origin, and has an initial velocity of 4i – 4j m/s. 11 seconds later, its velocity is – 4i – 4j m/s. The cat did not make a complete circle in that time.

a. Where is the center of the circle the cat is making? (There are actually two correct answers - you only have to give me one of them.)

v_i & v_f are 90° apart. ∴ Cat has made $\frac{1}{4}$ turn

$v = \sqrt{4^2 + 4^2}$

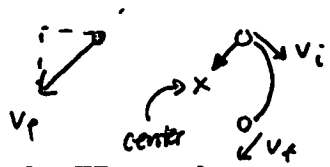
$v = 5.66\ m/s$

$v = \frac{d}{t}$

$5.66 = \frac{\frac{1}{4}(2\pi r)}{11}$

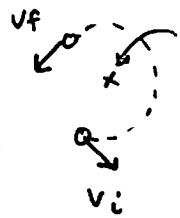
$r = 39.6\ m$

Since a_c is ⊥ to v & directed to center, the vectors is



b. Why are there two correct answers for part a? (*Only 3 points. Don't write an essay.*)

Because cat could have made 3/4 turn, so the radius would be smaller and



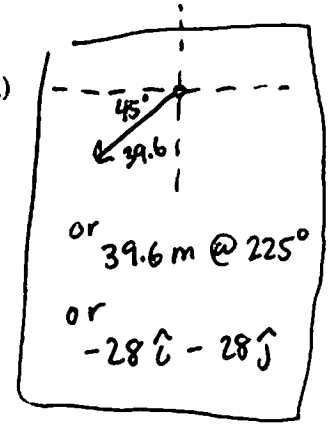
So $5.66 = \frac{\frac{3}{4}(2\pi r)}{11}$

$r = 13.2\ m$

So $13.2 \angle 45°$ m

or $9.34\,\hat{i} + 9.34\,\hat{j}$

OR



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18. A particle has a constant acceleration of 5i + 7j m/s². At t = 0, its velocity is 4i m/s. After it has traveled horizontally 8 m, what is its velocity? Give your answer as a magnitude and a direction.

$\vec{a} = 5\hat{i} + 7\hat{j}$

$\vec{v}_i = 4\hat{i} + 0\hat{j}$

$\Delta x = 8$

$\vec{r} = \frac{1}{2}(5\hat{i} + 7\hat{j})t^2 + (4\hat{i})t$

$= 2.5t^2\hat{i} + 3.5t^2\hat{j} + 4t\hat{j}$

$\vec{r} = (2.5t^2 + 4t)\hat{i} + (3.5t^2)\hat{j}$

so Δx corresponds to $\hat{i}$

$8 = 2.5t^2 + 4t$

$0 = 2.5t^2 + 4t - 8$

$t = \frac{-4 \pm \sqrt{16 - 4(2.5)(-8)}}{2(2.5)}$

$t = \frac{-4 \pm 9.8}{5}$ + root.

$t = 1.16$ s

can't mix & match scalars & vectors!

You don't know anything about Δy!

Quad. Eqn.

$v_f^2 = v_i^2 + 2a\Delta x$

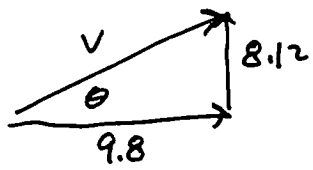
$|a| - b$

So $\vec{v} = \frac{d\vec{r}}{dt}$

$\vec{v} = (5t + 4)\hat{i} + (7t)\hat{j}$

$\vec{v} = [5(1.16) + 4]\hat{i} + [7(1.16)]\hat{j}$

$\vec{v} = 9.8\hat{i} + 8.12\hat{j}$



$\tan\theta = \frac{8.12}{9.80} = .83$

$\theta = 39.6°$

$v^2 = (8.12)^2 + (9.8)^2$

$v = 12.7$

So $\vec{v} = 12.7$ m/s @ 39.6°