ABRHS PHYSICS (H)

NAME: KEY

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

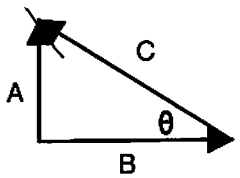
2011 (online) 82 total

Equations and Constants:

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

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

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



1. C or D Three vectors are shown in the diagram above. Which of the following expressions would match the diagram?
   a. **A + B = C.** b. **A + C = B.** c. **C + B = A.** d. **A − B = C.** e. **C − B = A.**

Questions 2 and 3 refer to the following vectors:

$\vec{A} = 5\hat{i} - 3\hat{j} + 4\hat{k}$ $\quad \vec{B} = -4\hat{i} - 2\hat{j} + 3\hat{k}$ $\quad \vec{C} = 4\hat{i} + 5\hat{j} - 3\hat{k}$

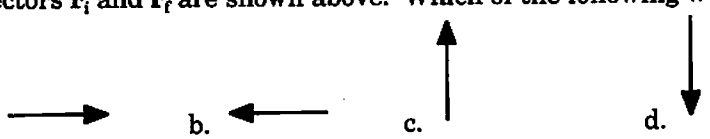
2. A What is **B − A**?
   a. $-9\hat{i} + \hat{j} - \hat{k}$ b. $-9\hat{i} - 5\hat{j} + 7\hat{k}$ c. $-\hat{i} - 5\hat{j} + 7\hat{k}$ d. $\hat{i} + \hat{j} - \hat{k}$

3. B Which two vectors have the same magnitude?
   a. **A & B.** b. **A & C.** c. **B & C.** d. none, they are all different.

4. E The initial velocity of an object is **2i + 3j** m/s. It undergoes a constant acceleration of **–i + 2j** m/s² for 4 seconds. What is its final velocity?
   a. **i + 5j** m/s b. **3i + j** m/s c. **7i + 14j** m/s d. **–6i – 5j** m/s e. **–2i + 11j** m/s

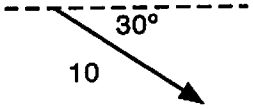
5. B If a moving object has an acceleration that is always perpendicular to its velocity, what must be happening?
   a. It must always be slowing down.
   b. It must have a constant speed.
   c. Its path must be a parabola.
   d. It must slow down, stop and then speed up in the opposite direction.
   e. What? It is clearly impossible for this situation to exist.

6. A Vectors $\mathbf{r}_i$ and $\mathbf{r}_f$ are shown above. Which of the following would best represent $\Delta\mathbf{r}$?



a. b. c. d. e. none of these.

7. A What is the vector in unit-vector notation for the vector shown in the diagram to the right?



   a. **8.7i – 5j.** b. **8.7i + 5j.** c. **5i + 8.7j.**
   d. **1.5i – 9.9j .** e. **1.5i – 9.9j.**

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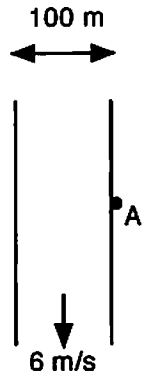
Questions 8 to 10 refer to the following:
Charlie is riding a Ferris Wheel of radius 7 meters. He is moving with a constant speed of 3 m/s.

8. B What is the magnitude of his acceleration when he is at his lowest point?
a. 16.3 m/s². b. 1.3 m/s². c. 0.8 m/s². d. 8.7 m/s². e. 6.3 m/s².

9. C When he is at the lowest point on the ride, which of the following vectors best represent his acceleration?
a. ←. b. →. c. ↑. d. ↓. e. none of these.

10. B With how many "rpm"s is he rotating?
a. 0.068 rpm. b. 4.09 rpm. c. 14.7 rpm. d. 43.9 rpm. e. 180 rpm.

Questions 11 to 13 refer to the following:
A river is 100 m wide and has a current that is flowing at 6 m/s. A duck has a water speed of 8 m/s.



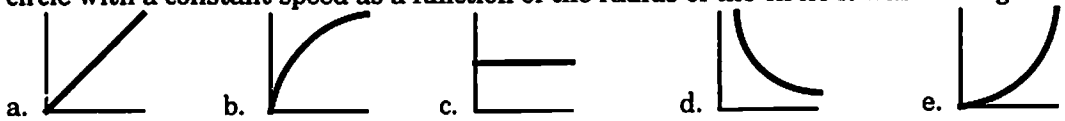
$\leftarrow 8t = 100$

11. B What would be the minimum time the duck needs to cross the river?
a. 16.7 s. b. 12.5 s. c. 10.0 s. d. 7.14 s.

12. D What would be the fastest possible speed of the duck with respect to the ground?
a. 5.3 m/s. b. 8 m/s. c. 10 m/s. d. 14 m/s.

13. A If the duck had a water velocity directed due west, what would be the velocity of the duck with respect to the ground?
a. –8i – 6j m/s. b. 8i + 6j m/s. c. 8i – 10j m/s. d. -10i – 8j m/s.

14. D Which of the following would best represent the acceleration of an object traveling in a circle with a constant speed as a function of the radius of the circle it was moving in?



Problem Solving: *Show all work. 10 points each.*

15. The position in meters as a function of time in seconds for an object is given by

$$\vec{r} = (-t^3 + t^2 + 5)\hat{i} + (-5t^2 + 15t)\hat{j}$$

What is the average velocity of the object for the first 4 seconds?

$$\bar{v} = \frac{\Delta \vec{r}}{\Delta t} = \frac{\left[(-4^3 + 4^2 + 5)\hat{i} + (-5(4)^2 + 15(4))\hat{j}\right] - \left[5\hat{i} + 0\hat{j}\right]}{4}$$

$$= \frac{(-43\hat{i} - 20\hat{j}) - (5\hat{i} + 0\hat{j})}{4} = \frac{-48\hat{i} - 20\hat{j}}{4}$$

$$\vec{v} = -12\hat{i} - 5\hat{j} \text{ m/s}$$

-6 if v(4)

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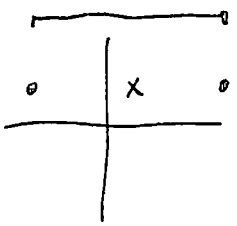
16. Some students do a lab recording the postion of an object that is rotating with a constant speed. They notice that at one time, the position of the object is -4i + 2j. Then 3.5 seconds later the, object has made exactly half a rotation and the postion is 6i + 2j. In unit-vector notation, what is the acceleration of the object when it is at the second position?



$2r = 4+6$

$r = 5$

So center $= 5\hat{i} + 2\hat{j}$

$\hat{j}$ -2
$\hat{i}$ -1
$\vec{r}$ -5

$$v = \frac{2\pi r}{T} = \frac{2\pi(5)}{2\cdot(3.5)} = \frac{10\pi}{7}$$

$v = 4.49$ m/s

$$a_c = \frac{v^2}{r} = \frac{(4.49)^2}{5}$$

$a_c = 4.03$ m/s²

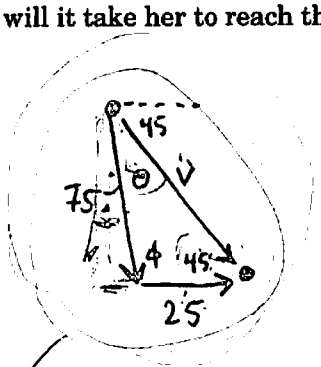
So $\vec{a} = -4.03\,\hat{i} + 0\,\hat{j}$

17. A plane is flying with an airpseed of 75 km/h. The pilot wants to go straight to an airport that is 300 km SE of her current position. Ground Control reports that there is a constant wind velocity of 25 km/h E. She orients the plane in such a way that she flies directly to the airport. How long will it take her to reach the airport?

$V = V_{PA} + V_{AG}$

So $300 = (90.6)\,t$

$t = 3.31$ hours



Correct = 5 pts.

or $75^2 = 25^2 + v^2 - 2(25)v\cos 45$

$5000 = v^2 - 35.4\,v$

$0 = v^2 - 35.4\,v - 5000$

$$v = \frac{35.4 \pm \sqrt{(35.4)^2 - 4(1)(-5000)}}{2(1)}$$

$$v = \frac{35.4 \pm 146}{2} = 90.6$$

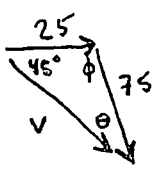
$v = 90.6$

$$\frac{\sin 45}{75} = \frac{\sin\theta}{25}$$

$\theta = 13.63°$ → So $\phi = 180 - 13.6 - 45 = 121.4°$

So $\frac{\sin 121.4}{V} = \frac{\sin 45}{75}$

or



18. The earth has a radius of 6400 km. How long would one day be if the earth rotated so fast that the centripetal acceleration of someone standing on the equator was equal to 9.8 m/s²? (Also, in this situation, what would be the centripetal acceleration for someone at the North Pole?)

So $r = 6.4 \times 10^6$ m

$$9.8 = \frac{v^2}{r}$$

$$v^2 = (9.8)(6.4 \times 10^6)$$

$v = 7920$ m/s

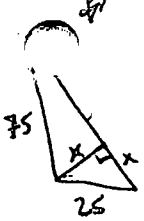
$$v = \frac{2\pi r}{T}$$

$$T = \frac{2\pi r}{v}$$

$T = 5078$ sec.

$(= 1.41$ hr $= 84.6$ min$)$

(North Pole = 3)



@ North Pole, $v = 0$, so $a_c = 0$!