Q1 Solutions

Monday, June 27, 2022 8:24 AM

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 **5** correct answers in this section and only the first **5** filled in answers will be graded. There is no partial credit.

1. Horses can move at distinct different speeds based on which pattern their four legs strike the ground. An average horse can **"walk"** at about 32 furlongs per hour and **"trot"** at about double that. If a horse's **"canter"** (also known as a lope) speed is 3 times faster than its ***walking*** speed, how many meters per second does the horse travel at a canter? (hint: 1 furlong = 660 ft, 12 in = 1 ft, 1 in = 2.54 cm)?

   - ☐ (a) 0.04 m/s
   - ☐ (b) 0.83 m/s
   - ☐ (c) 1.7 m/s
   - ☑ (d) 5.4 m/s
   - ☐ (e) 320 m/s

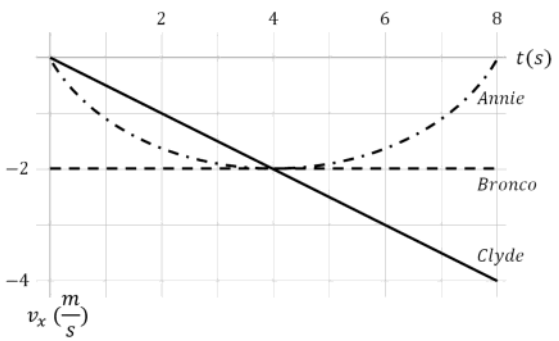
$$\left(32\ \frac{\text{furlongs}}{\text{hr}}\right)\times\left(3\ \frac{\text{canter}}{\text{walk}}\right)\left(\frac{660}{1}\ \frac{\text{ft}}{\text{furlongs}}\right)\left(\frac{1}{12}\ \frac{\text{ft}}{\text{in}}\right)\left(\frac{2.54}{1}\ \frac{\text{cm}}{\text{in}}\right)\left(\frac{1}{100}\ \frac{\text{m}}{\text{cm}}\right)$$
$$\times\left(\frac{1}{60}\ \frac{\text{hr}}{\text{min}}\right)\left(\frac{1}{60}\ \frac{\text{min}}{\text{sec}}\right)=5.36\ \frac{\text{m}}{\text{s}}$$

2. Which of the following quantities are vectors?

   - ☐ (a) Distance a horse can travel in a day.
   - ☑ (b) Velocity of a horse.
   - ☐ (c) Maximum speed of a horse.
   - ☐ (d) Length of a horse from teeth to tail.
   - ☑ (e) Position of a horse relative to its barn.

   .

3. Three young horses (Annie, Bronco, and Clyde) race back to their barn along the x-axis, all arriving at the barn at the same instant in time (t_f = 8 s). Their motions are represented by the lines on the graph. Which of the following statements are true?



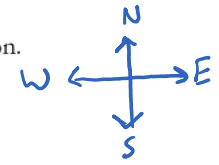
   - ☐ (a) Annie's (instantaneous) top speed is the largest of the three horses.
   - ☑ (b) Clyde and Bronco started the race the same distance away from the barn.
   - ☑ (c) Annie and Bronco both have zero average acceleration between 0 and 8 seconds.
   - ☐ (d) Bronco has an average speed of zero m/s over the 8 seconds.
   - ☐ (e) Annie finishes the race travelling in the positive x direction.

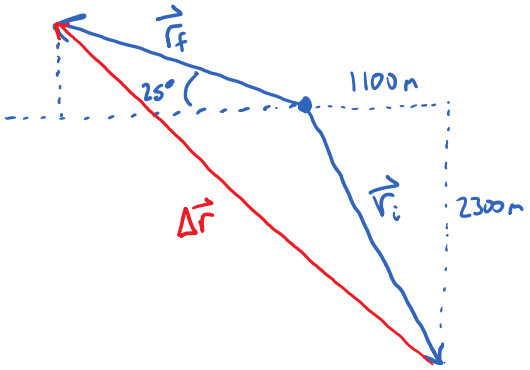
b) Δx = area under curve

c) $a_{avg} = \frac{\Delta v}{\Delta t} = 0$ m/s

4. (9 points) Dasher, the fourth sibling of Annie, Bronco, and Clyde, travels from a location 1100 meters East and 2300 meters South of their barn, to a location 3000 m from the barn at an angle 25 degrees North of West. The trip took 21 minutes.

a) Draw a physical representation for this situation.





$r_{fx} = -|\vec{r}_f| \cos(25°)$

$= -2719\ m$

$r_{fy} = +|\vec{r}_f| \sin(25°)$

$= +1268\ m$

b) What was Dasher's average velocity over this time?

$$\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\vec{r}_f - \vec{r}_i}{\Delta t} = \frac{\langle -2719, 1268\rangle_m - \langle 1100, -2300\rangle m}{(21\ \text{min})\left(\frac{60\ \text{sec}}{1\ \text{min}}\right)}$$

$$\vec{v}_{avg} = \langle -3.03, 2.83\rangle\ m/s$$

c) What was Dasher's average speed over this time?

$$|\vec{v}_{avg}| = \sqrt{(3.03)^2 + (2.83)^2}\ m/s = 4.15\ m/s$$

5. (7 points) Zephyr, the mother of Annie, Bronco, Clyde, and Dasher, starts from rest and accelerates for 416 seconds at a constant rate in the positive x-direction. Zephyr travels a total of 1.911 km during this time.

a) What is Zephyr's final speed?

$\Delta x = 1911$ m

$\Delta t = 416$ sec

k	uk
v_{ix}	v_{fx}
Δx	a
Δt	

① $\Delta x = v_{ix}\Delta t + \frac{1}{2} a_x \Delta t^2$ ✓ ? ✓

② $v_{fx} = v_{ix} + a_x \Delta t$? ? ✓

③ $v_{fx}^2 = v_{ix}^2 + 2 a_x \Delta x$? ? ✓

⇒ use ① to find a_x

then plug into ② to find v_{fx}

① ⇒ $1911\text{m} = \frac{1}{2} a_x (416\text{s})^2$

⇒ $a_x = 0.022\ \text{m/s}^2$

⇒ ② $v_{fx} = v_{ix} + a_x \Delta t$

$v_{fx} = 9.19\ \text{m/s}$

b) Use the known values sensemaking technique to determine if this is a possible top speed for a horse. (A horse's "gallop" speed is about twice that of its "canter" speed) Make sure to compare your expectation for the answer with your found answer.

from problem 1 : canter speed ~ 5.4 m/s

⇒ gallop speed of a horse is ~ 10 m/s

I would expect our answer to be in the ballpark of 10 m/s or less since Zephyr is a horse. We found a $|\vec{v}|$ of 9.2 m/s which is less than 10 m/s. This seems like a reasonable speed for a horse to travel. (though 7 minutes is a long time to "sprint")