Quizbit 3 | Solution

Friday, October 14, 2022 11:46 AM

Individual Quizbit 3

PH201, Fall 2022

You are encouraged to discuss these questions with others, but those conversations need to be only in words. Please do not write down steps for others, draw pictures, show math steps, or consult online resources. Any work shown here should be your own thoughts and not copied from any source. You will be graded on the clarity of how well you communicate your steps and reasoning, not on absolute correctness. Hand write your solutions (paper or tablet) and turn your work into Gradescope.

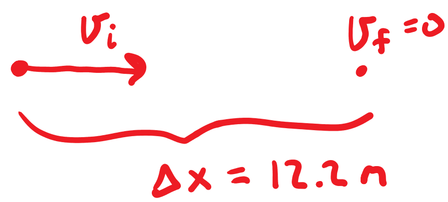
Problem Statement | Nessie, the wonder-dog, is sprinting at a constant speed in a straight line, chasing a ball. As she catches the ball, she changes her acceleration to a constant non-zero value in order to slow down. It takes her 12.2 meters and 2.745 seconds to come to a stop.

(a) What was Nessie's speed, measured in inches per second, before she caught the ball? (Hint: there are 2.54 cm in an inch)

(b) Is this a reasonable speed for a dog? Use *order of magnitude* sensemaking to compare the expected order of magnitude for Nessie's speed with the answer you found.

(c) Using any combination of diagrams, words, etc, describe a situation in which Nessie would simultaneously (i.e. at the same moment in time) have an increasing speed and a decreasing magnitude of acceleration.

a)



K	UK
Δt	v_i ?
Δx	a
v_f	

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$ (1)

$v_f = v_i + a \Delta t$ (2)

$v_f^2 = v_i^2 + 2 a \Delta x$ (3)

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

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

(1) $\Rightarrow$ $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$

$\Delta x = v_i \Delta t + \frac{1}{2}\left(-\frac{v_i}{\Delta t}\right) \Delta t^2$

$\Delta x = v_i \Delta t - \frac{1}{2} v_i \Delta t$

$\Rightarrow$ $v_i = \frac{2 \Delta x}{\Delta t}$

$v_i = 8.89\ m/s$

$= 350\ in/s$

b) Dogs run roughly as fast as humans, & humans can run 100 m in 10 seconds, so a speed on the order of magnitude of 10 m/s would make sense for a dog.

We found a speed of ~10 m/s

(8.89 is on the order of 10 m/s)

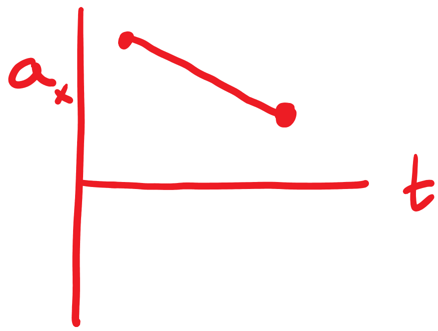
⇒ reasonable!

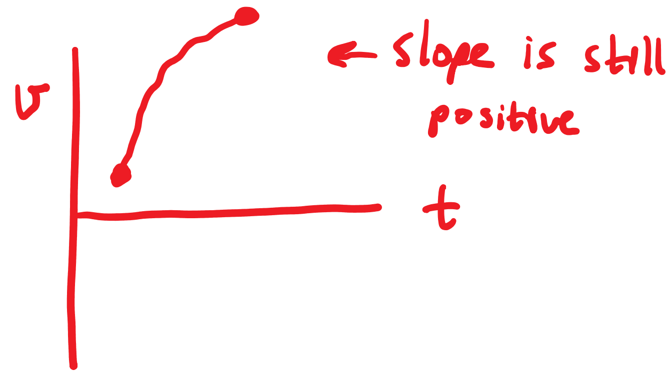
c) • increasing speed ⇒ velocity and acceleration are in the same direction

• decreasing acceleration ⇒ acceleration is getting smaller.

These conditions will be satisfied if Nessie were running in the $+\hat{x}$ direction, with acceleration that is also in the $+\hat{x}$ direction, but that acceleration is changing from $+4\ m/s^2$

but that acceleration is changing from +4 m/s² to +2 m/s²





Group Quizbit 3

PH201, Fall 2022

You will be working with your group to create a single solution for these questions. You are encouraged to think about the questions beforehand, and discussing with your classmates is encouraged, but do not bring a solution to your group's working session. You are working to develop a shared solution, with the input and problem solving skills of all your group members. You will be graded on both the clarity of how well you communicate your steps and reasoning, and on absolute correctness.

Problem Statement | Nessie, the wonder-dog, is sprinting at a constant 10.0 m/s in a straight line. After passing point A, she slows to a stop with a constant acceleration of 1.79 m/s^2, and then with a different constant acceleration, she sprints back to point A in 4.5 seconds.

Useful Equations

$\Delta x = v_i\, \Delta t + \frac{1}{2}\, a\, \Delta t^2$

$v_f = v_i + a\, \Delta t$

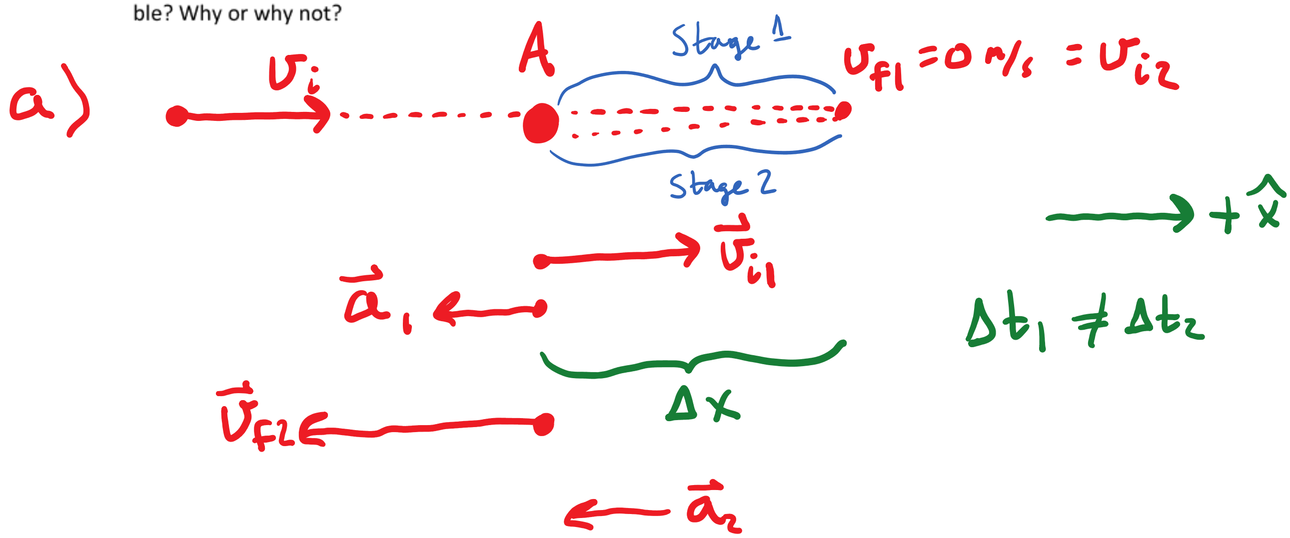
$v_f^2 = v_i^2 + 2\, a\, \Delta x$

(a) Draw a physical representation of the situation. Include: all relevant information, a coordinate system, and labels for vectors and other quantities.

(b) What is Nessie's speed as she crosses point A for the second time?

(c) Using the *related quantities* sensemaking technique, compare Nessie's velocities as she passes point A the first and the second time to each other. Does this comparison lead you to believe your answer to part (b) might be reasonable? Why or why not?

a)



b)

Stage 1

K	UK
v_{i1}	Δt_1
v_{f1}	Δx
a_1	

Stage 2

K	UK
v_{i2}	Δx
Δt_2	v_{f2}
	a_2

Need more knowns for stage 2

$\Rightarrow$ We need to find Δx from stage 1

(1) $\Delta x = v_{i1} \Delta t_1 + \frac{1}{2} a_1 \Delta t_1$
? ✓ ? ✓ ?

(2) $v_{f1} = v_{i1} + a_1 \Delta t_1$
✓ ✓ ✓ ?

(3) $v_{f1}^2 = v_{i1}^2 + 2 a_1 \Delta x$
✓ ✓ ✓ ?

(3) $\Rightarrow$ $\cancel{v_{f1}^2}^{0} = v_{i1}^2 + 2 a_1 \Delta x$

$\Rightarrow \frac{-v_{i1}^2}{2a_1} = \Delta x$

Stage 2

(1) $\Delta x = v_{i2} \Delta t_2 + \frac{1}{2} a_2 \Delta t_2^2$
✓ ✓ ✓ ? ✓

(2) $v_{f2} = v_{i2} + a_2 \Delta t_2$
? ✓ ? ✓

(3) $v_{f2}^2 = v_{i2}^2 + 2 a_2 \Delta x$
? ✓ ? ✓

(1) $\Rightarrow \frac{-v_{i1}^2}{2a_1} = \cancel{v_{i2}}^{0} \Delta t + \frac{1}{2} a_2 \Delta t_2^2$

$\Rightarrow a_2 = -\frac{v_{i1}^2}{a_1 \Delta t_2^2}$

(2) $\Rightarrow v_{f2} = \cancel{v_{i2}}^{0} - \frac{v_{i1}^2 \Delta t_2}{a_1 \Delta t_2^2}$

$\Rightarrow v_{f2} = -\frac{v_{i1}^2}{a_1 \Delta t_2}$

$v_{f2} = 12.4$ m/s

c) $v_{i1} = 10$ m/s

$v_{f2} = 12.4$ m/s

these velocities are fairly similar

$\Rightarrow$ inspires confidence that our answer

$\Rightarrow$ inspires confidence that our answer of 12.4 m/s could be correct.

additionally, we could find $|\vec{a}_2| = \left| \frac{v_{i1}^2}{a_1 \Delta t_2^2} \right|$

$\Rightarrow |\vec{a}_2| = 2.76 \, m/s^2$, which is greater than $|\vec{a}_1|$ $\Rightarrow$ we would expect a larger $|\vec{v}_f|$ after travelling the same distance.