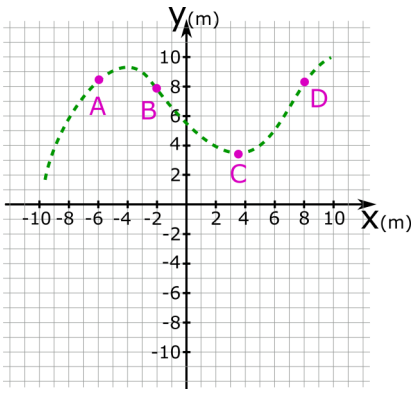
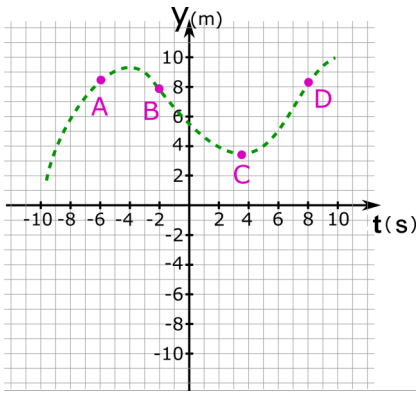
1. (9 points) Below are two figures representing the motion of two different scary objects, a zombie and a ghost. One of the plots represents the zombie traveling at constant speed in a 2-D plane. The other plot represents the ghost traveling along a straight line. Answer the following questions using a combination of words, figures, math, or any other way to communicate your understanding.

(a) Which graph goes with which scary object?





The plot on the left shows position vs. position, so it must represent something moving in 2 dimensions. It must be the Zombie.

The plot on the right shows position vs. time, so it goes with ghost traveling on the y-direction.

(b) Are the zombie and the ghost undergoing the same motion? Explain?

No, one of them is traveling in 2-D and the other 1-D. The zombie is traveling at a constant speed while the ghost's speed varies. They also have different accelerations.

Rubric

Part (a) - 1 points

Part (b) - 3 points
1 pt - identifying they are not the same motion
2 pt - explaining some differences

Part (c) - 3 points
1.5 pt - zombie's velocity, both magnitude and direction
1.5 pt - ghost's velocity, both magnitude and direction

Part (d) - 2 points
1 pt - zombie's acceleration from changing directions
1 pt - ghost has acceleration from changing directions and magnitude

(c) Describe the velocity of both the zombie and the ghost at point A and compare any similarities and/or differences.

The zombie's velocity has both positive x and y components. It's direction is changing but not its magnitude.

The ghost's velocity is in the positive y-direction. It's direction is not changing but it's magnitude is getting smaller.

(d) Acceleration can be caused by either changing speed or the direction of motion. Describe the acceleration of both the zombie and the ghost at point C and compare any similarities and/or differences. If they are accelerating, state whether it is due to changing speed, or direction of motion, or both?

The zombie's speed is constant but its direction of motion is changing from down and the right before point C, to up and to the right after point C. This means it is accelerating (in the upward(ish) direction) due to changing directions.

The ghost's velocity right before point C is in the negative y-direction and right after in the positive y-direction. This indicates the ghost is turning around with a positive acceleration. You can also see that the slope of the position vs. time plot is changing before and after point C, meaning the magnitude of the velocity, or the speed is changing. The acceleration is due to both changing speed and direction.

For questions 2 through 5 **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.

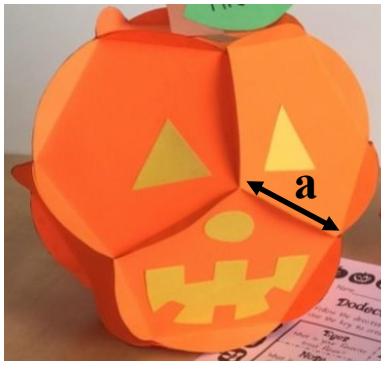
2. A ghost is confined to move only along the x-axis (it is haunting only the x-axis). At time t = 0 the ghost is at location x = 0 and is slowing down. Which of the following statements must be true?

□ (a) The x-component of the ghost's velocity is positive
□ (b) The x-component of the ghost's velocity is negative
x (c) The x-component of the ghost's acceleration is a non-zero value
□ (d) The x-component of the ghost's acceleration is negative
x (e) The x-component of the ghost's velocity is a non-zero value
x (f) The x-components of the ghost's velocity and acceleration have opposite signs

3. You are driving your car directly south, away from the zombie apocalypse. Which of the following actions could result in your car accelerating in the northwestern direction?

□ (a) Turning towards the east and pressing on the gas.
□ (b) Turning towards the west and pressing on the gas.
□ (c) Continuing straight while pressing on the gas.
□ (d) Continuing straight while pressing on the brakes.
□ (e) Turning towards the east and pressing on the brakes.
x (f) Turning towards the west and pressing on the brakes.

4. Consider the dodecahedron Jack-O-Lantern of side length **a**. Which of the following equations could represent the surface area of this dodecahedron?



□ (a) $3a\sqrt{10}$

x (b) $3a^2\sqrt{25+10\sqrt{5}}$

□ (c) $3\sqrt{5a^3}+2\sqrt{a}$

□ (d) $3a^3\sqrt{3-25a}$

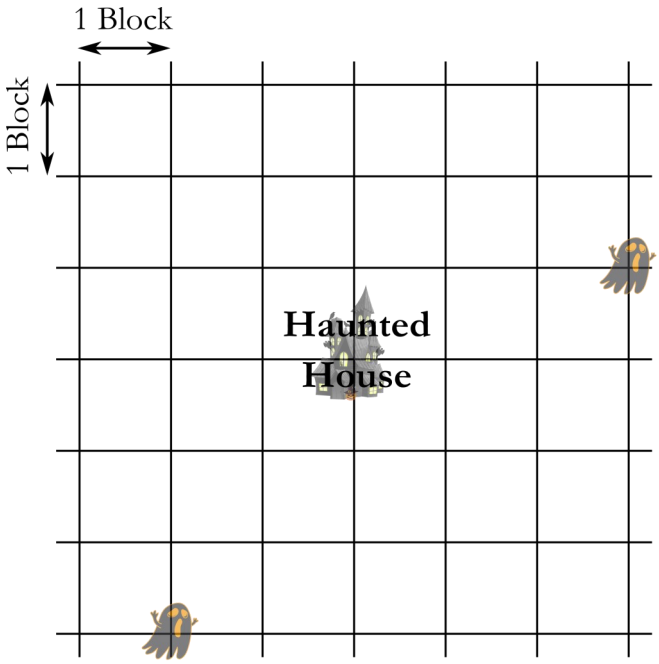
□ (e) $3a\sqrt{5}-25a^2$

5. Which vector(s) must point in the same direction as average velocity?

□ (a) Initial position.
□ (b) Final position.
x (c) Change in position.
□ (d) Change in velocity.
□ (e) Average acceleration.

6. (8 points) A spooky ghost is spotted initially < 3 , 1 > blocks from a haunted house. After 50 seconds later, the spooky ghost was spotted < -2 , - 3 > blocks away from the same haunted house. A standard coordinate system was used with the haunted house at the origin to determine the initial and final positions of the ghost; use the same coordinate system for all parts of this problem. Note that 1 block = 76.2 meters.

(a) Sketch the initial position vector, final position vector, and change in position vector on the provided grid.



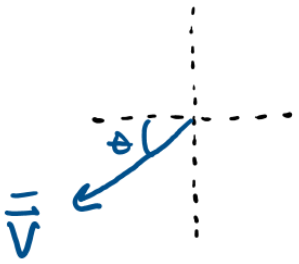
(b) What is the average velocity of this ghost in component form with SI units (meters, seconds, kg, Newtons, etc).

$$\vec{V} = \frac{\Delta \vec{r}}{\Delta t} = \frac{\vec{r}_f - \vec{r}_i}{\Delta t} = \frac{1}{50s} \langle -2-3, -3-1 \rangle \text{Blocks}$$

$$\vec{V} = \frac{\langle -5, -4 \rangle}{50} \frac{\text{Blocks}}{s}$$

$$\vec{V} = \langle -7.62, -6.10 \rangle \text{ m/s}$$

(c) What is the magnitude and direction of the average velocity of this ghost?



$$|\vec{V}| = \sqrt{\bar{V}_x^2 + \bar{V}_y^2} = 9.76 \text{ m/s}$$

$$\tan\theta = \frac{|\bar{V}_y|}{|\bar{V}_x|} \Rightarrow \theta = 38.7^\circ$$

(d) Can we determine the direction of the average acceleration of this ghost? If so, what is it? If not, explain.

No. Average acceleration is change in velocity divided by change in time. We would need to know the instantaneous initial and final velocities to calculate the average acceleration.

Question 6 Rubric

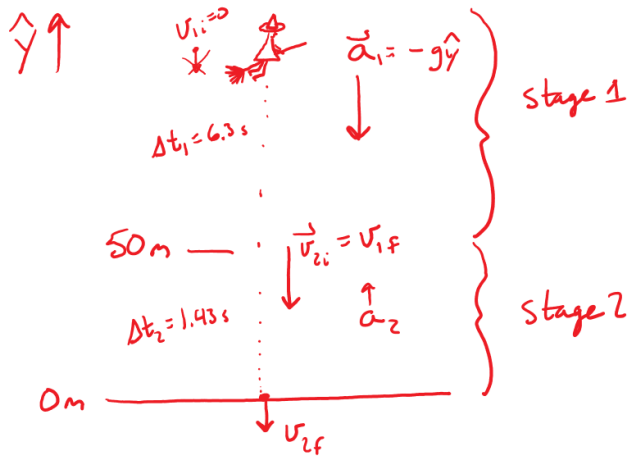
Question part	Points	Description
Part a	0.5 pt	For correct initial position vector
Part a	0.5 pt	For correct final position vector
Part a	0.5 pt	For correct change in position vector
Part b	0.5 pt	For correct unit conversion of displacement from block to meters. **.OR.** Average velocity from blocks/s to m/s.
Part b	0.5 pt	For definition of average velocity
Part b	0.5 pt	For using consistent values of their change in position vector.
Part b	0.5 pt	For correct answer.
Part c	1.0 pt	Uses correct definition of magnitude of a vector.
Part c	1.0	Uses physical representation to identify components and angle of vector.
Part c	0.5 pt	Uses trig to find angle.
Part c	0.5 pt	Correct answer.
Part d	1.5 pts	High Level Application: Correct answer, no, identifying that instantaneous velocities are not known.
Part d	1.0 pts	Mid Level Application: Correct answer, no, but not clear about velocities. **.OR.** Incorrect answer, yes, but assumes information about instantaneous velocities.
Part d	0.5 pts	Low Level Application: Incorrect answer, yes, with no consideration of instantaneous velocities or no explanation at all. **.OR.** Correct answer with no explanation.

7. (12 points) Woozy from her battle with the Heffalumps, a witch and her broom, initially at rest in the air, free-fall straight down towards the Earth (no magic is involved here!) for 6.3 seconds. When she is 50 meters above the ground, her broom's automatic safety mechanism gives her a constant upwards acceleration. Unfortunately, her broom is not calibrated correctly, and after 1.43 seconds, she and her broom hit the ground with a non-zero velocity. Note: please use the back of this sheet if needed. Make sure to label your solution with the parts (a), (b), and (c).

(a) What is the magnitude of the upwards acceleration the witch has due to the broom's safety mechanism?

(b) With what speed does she hit the ground?

(c) Are the signs of your answers to questions (a) and (b) as you would expect them to be? Why or why not? Explain. (This is sign sensemaking!)



(a) stage 1 $\Rightarrow v_{1f} = v_{1i} + a_1 \Delta t_1$

$v_{1f} = 0 - (9.8\ m/s^2)(6.3\,s)$

$v_{1f} = -61.74\ m/s$

stage 2 $\Rightarrow$

k	uk
v_{2i}	v_{2f}
Δt_2	a_2
Δy_2	

$\Delta y_2 = v_{2i}\Delta t_2 + \frac{1}{2} a_2 \Delta t_2^2$

$\Rightarrow \Delta y_2 - v_{2i}\Delta t_2 = \frac{1}{2} a_2 \Delta t_2^2$

$\Rightarrow a_2 = \frac{2(\Delta y_2 - v_{2i}\Delta t_2)}{\Delta t_2^2}$

$a_2 = \frac{2(-50m - (-61.74)(1.43))}{(1.43)^2}$

$\boxed{a_2 = +37.4\ m/s^2}$

(b) $v_{2f} = v_{2i} + a_2 \Delta t_2$

$\Rightarrow v_{2f} = (-61.74\ m/s) + (37.4\ m/s^2)(1.43\,s)$

$\Rightarrow \vec{v}_{2f} = -8.19\ m/s\ \hat{y}$

$\Rightarrow \boxed{|\vec{v}_{2f}| = 8.19\ m/s}$

(c) sign of $|a_2|$ is positive b/c magnitude, but in addition $\vec{a}_2$ is expected to point ↑ & we found a_2 was in the $+\hat{y}$ direction! $\Rightarrow$ ✓

sign of $|v_{2f}|$ was + b/c speed is a magnitude but $\vec{v}_{2f}$ is expected to be negative since impacting ground, we found v_{2f} is in $-\hat{y}$ direction $\Rightarrow$ ✓

Rubric

(a)
Problem setup - 4 pts
- picture
- 2 stages
- knowns, unknowns

Finding acceleration - 2 pts

(b)
2 pts
Final answers - 1 pt

(c)
Sensemaking - 3 pts