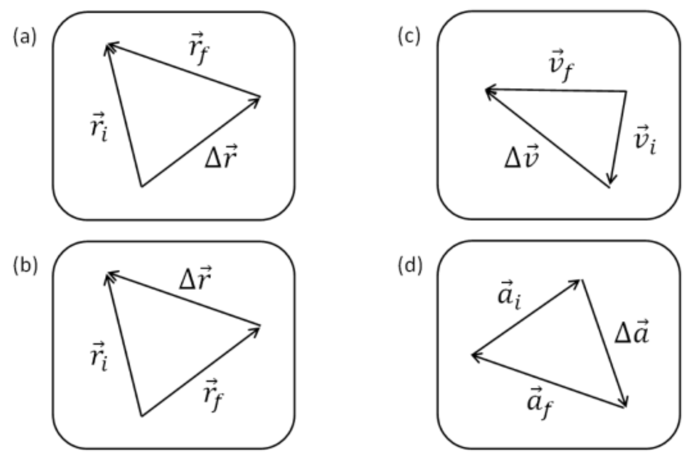
# PH201 U2023 Midterm 1 Solutions

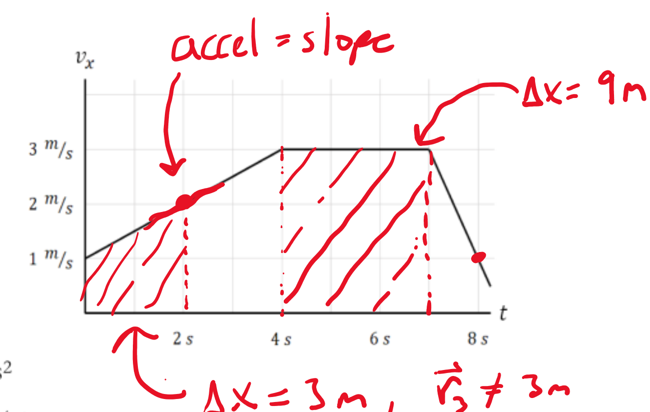
For questions 1 and 2 **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **5** correct answers in this section and only the first **5** filled in answers will be graded. There is no partial credit.

1. Which of the following diagrams shows appropriate relationships between the "initial", "final", and "change in" vectors?

   ☐ (a)
   ☐ (b)
   ☑ (c)
   ☐ (d)



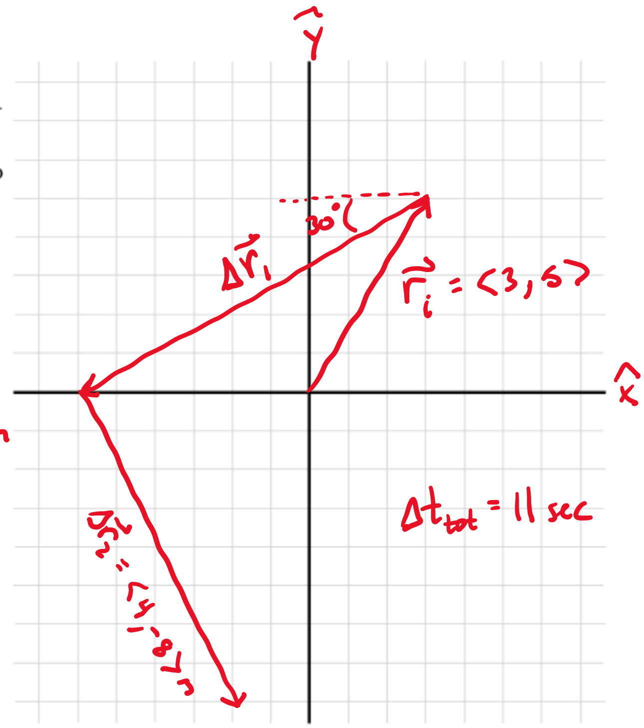

2. Stewart the stallion travels along the x-axis according to the diagram. Which of the following statements **must be** true regarding Stewart's motion?



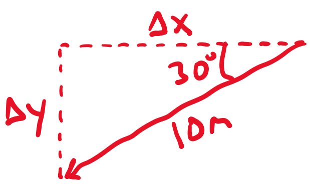

   ☑ (a) Stewart's velocity at t = 4 s is 3 m/s
   ☐ (b) Stewart's position at t = 2 s is 3 m
   ☐ (c) Stewart's position at t = 2 s is 2 m
   ☐ (d) Stewart's acceleration at t = 2 s is 2 m/s$^2$
   ☑ (e) Stewart's acceleration at t = 2 s is 0.5 m/s$^2$
   ☑ (f) The magnitude of Stewart's velocity is smaller at t = 8 s than it is at t = 2 s
   ☐ (g) The magnitude of Stewart's acceleration is smaller at t = 8 s than it is at t = 2 s
   ☐ (h) The magnitude of Stewart's position is smaller at t = 8 s than it is at t = 2 s
   ☑ (i) The change in Stewart's position between t = 4 s and t = 7 s is 9 m

3. (9 points) Measured relative to your boat, using a standard coordinate system, Alexander the Alligator is initially spotted at a position of $\mathbf{r_i} = < 3 , 5 >$ **m**. He disappears under water and travels a displacement, $\mathbf{\Delta r_1}$ **= 10 m** in a direction **30° from the –x axis towards the –y axis**, resurfacing **3 s** later. Over the next **8 seconds**, he then travels a second displacement of $\mathbf{\Delta r_2} = < 4 , -8 >$ **m** before disappearing forever.

(a) Draw a physical representation of this situation. Include the relevant given information that will help you solve part (b) and (c). The displacements do not need to be exact, but should be in appropriate directions and scaled approximately.




(b) What are the x and y components of Alexander's first displacement vector, $\mathbf{\Delta r_1}$?




$\cos(30°) = \frac{\Delta x}{10m}$

$\Delta x = -8.66m$

$\sin(30°) = \frac{\Delta y}{10m}$

$\Delta y = -5m$

(c) What was Alexander's average velocity between his initial and final positions?

$\vec{r}_i = <3, 5> m$

$\Delta\vec{r}_1 = <-8.66, -5> m$

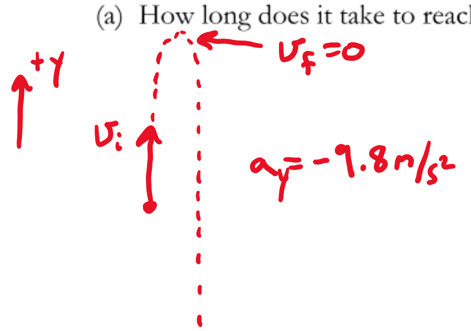
$\Delta\vec{r}_2 = <4, -8> m$

$\Delta\vec{r}_{tot} = <-4.66, -13> m$

$\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t} = \frac{<-4.66, -13> m}{11 s} = <-0.424, -1.18> m/s$

4. (9 points) Standing on a bridge on Earth, you reach out and toss a stone directly upwards with an initial speed of **25 m/s** such that it travels up, reaches a certain height above the release point, then falls down past the bridge and hits the water below.

(a) How long does it take to reach the top of its motion?




$v_{yf} = v_{yi} + a_y \Delta t$

$0 = +25\,m/s - 9.8\,m/s^2\,\Delta t$

$\Rightarrow \Delta t = 2.55\,s$

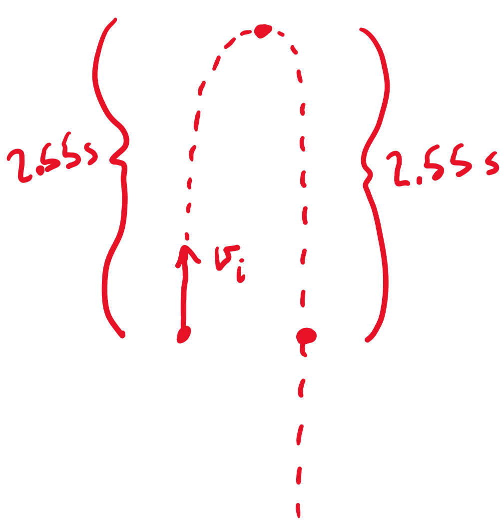
(b) What is the location of the stone at **t = 5.5 seconds** after you release it? (relative to the release point)

$\Delta y = v_{iy}\Delta t + \frac{1}{2} a_y \Delta t^2$

$\Delta y = (25\,m/s)(5.5\,s) + \frac{1}{2}(-9.8\,m/s^2)(5.5\,s)^2$

$\Delta y = -10.7\,m \Rightarrow$ 10.7 m below release point

(c) Using your answer to part (a) and the given time of **t = 5.5 seconds** for part (b), explain using any combination of words, diagrams, etc. whether the sign (+ or - ) of your answer to part (b) is what you expected using ***related quantities*** and ***sign*** sensemaking.




It takes the stone 2.55 seconds to reach the top of its flight ⇒ it will take 2.55 seconds to come back down to the release point ⇒ 5.1 seconds.

Since 5.5 s > 5.1 s, I expect the stone to have fallen past the release point, which means the sign of (b) will be negative. This expectation matches what we find!