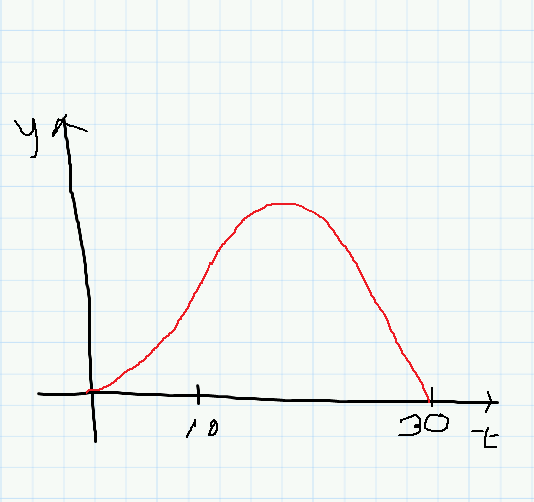
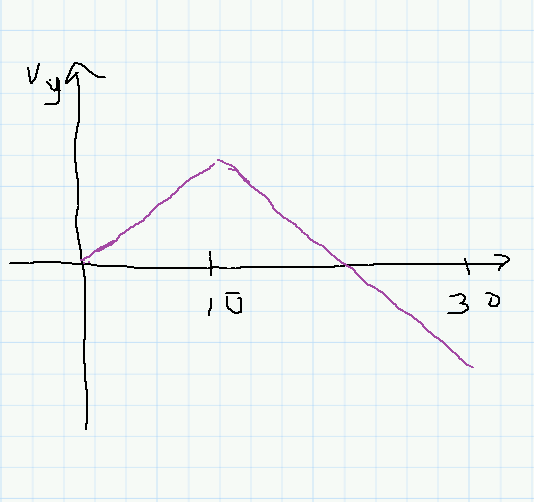
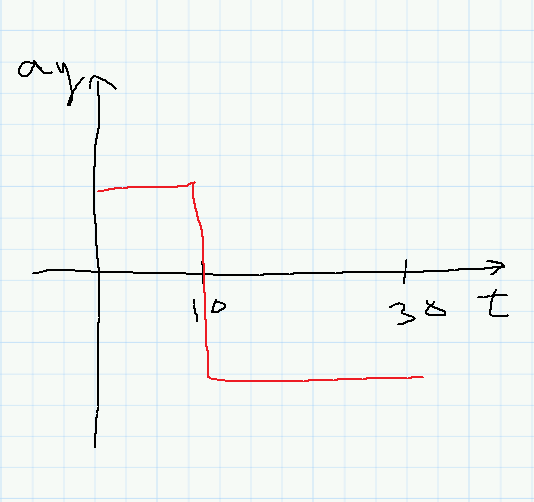
**Homework Assignment 1 Solutions**

**Problem 1.** A model rocket accelerates upward at a constant rate for 10s. Thereupon, its engines shut off, and it coasts in free fall with a constant downward acceleration until it hits the ground at t = 30s. Draw rough y vs. t, vy vs. t, and ay vs. t graphs of this situation. You don’t need any numbers on the graph (except for t = 10s, 30s) – just the correct shapes.

**Problem 2**. Say (or well, indicate) whether you’re speeding up or slowing down in the following scenarios.

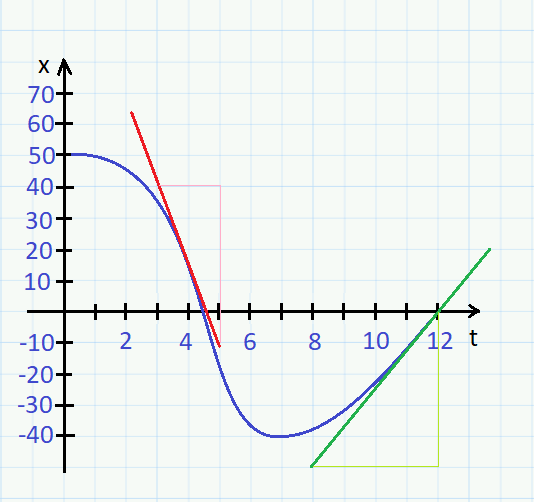
(a) Your’re driving to the right with positive acceleration. Speeding up.

(b) You’re driving to the left with positive acceleration. Slowing down.

(c) You’re driving to the left with negative acceleration. Speeding up.

(d) You’re driving to the right with negative acceleration. Slowing down.

**Problem 2.** Rochelle the roach is munching on the chocolate chip you dropped on the kitchen floor 5 days ago. When you turn the lights on, Rochelle scrambles back and forth in a manner described by the following x vs. t graph (t is measured in s, and x in cm) .



(a) When is she moving to the left? When is she moving to the right?

Wherever slops is negative: (0s, 6s) Wherever slope is positive: (6s, 12s)

(b) When is she speeding up? When is she slowing down?

Wherever graph is getting steeper: (0s, 4.5s), (7s, 12s) Wherever graph is getting shallower: (4.5s, 7s)

(c) What is her displacement between t = 2s and t = 6s? What is her average velocity during this same time interval? Δx = -35cm – 45cm = -80cm. Average velocity is vave. = Δx/Δt = -80cm/4s = -20cm/s.

(d) What is her displacement between t = 6s and t = 10s? What is her average velocity during this time interval? Δx = -20cm – (-35cm) = 15cm. Average velocity is vave = Δx/Δt = 15cm/4s = 3.75cm/s.

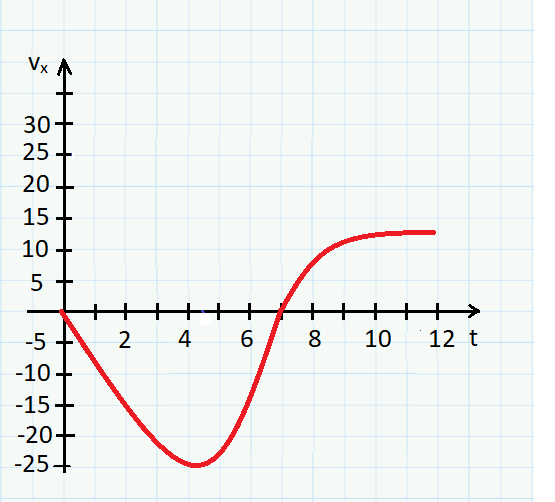
(e) Estimate her velocity at t = 4s. And show the lines you’re using for this estimate.

Instantaneous velocity is slope of red line, is vx = -50cm/2s = -25cm/s.

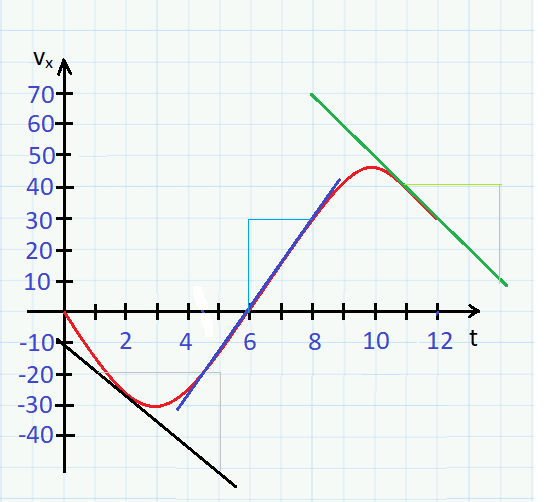
(f) Estimate her velocity at t = 12s. And show the line you’re using for this estimate.

Instantaneous velocity is slope of green line, is vx = 50cm/4s = 12.5cm/s.

(g) Draw a rough vx vs. t curve in the graph below.



**Problem 3.** While your friend, Fred, is driving along the road, you pay attention to the speedometer (newer car models have negative speedometers), and make the following plot from memory (vx is measured in mph, and t is in s).



(a) When is he moving to the left? When is he moving to the right?

Moving to left when vx < 0: (0s,6s) Moving to right when vx > 0: )6s,12s)

(b) When is he speeding up? When is he slowing down?

Speeding up when |vx| increasing: (0s,3s), (6s,10s) Slowing down when |vx| decreasing: (3s,6s),

(10s,12s)

(c) What is his average acceleration (in m/s2) between t = 0s and t = 3s?

Average acceleration is aave. = Δv/Δt = (-30mph-0mph)/3s = -10mph/s = -4.4m/s2 (using conversion 1m/s = 2.25mph).

(d) What is his average acceleration (in m/s2) between t = 0s and t = 9s?

Average acceleration is aave. = Δv/Δt = (40mph-0mph)/9s = 4.4mph/s = 2m/s2 (using conversion 1m/s = 2.25mph).

(e) Estimate his acceleration (in m/s2) at t = 2s. Show the line you’re using for this purpose.

Using black line, we have a = slope = -30mph/4s = -7.5mph/s = -3.33m/s2.

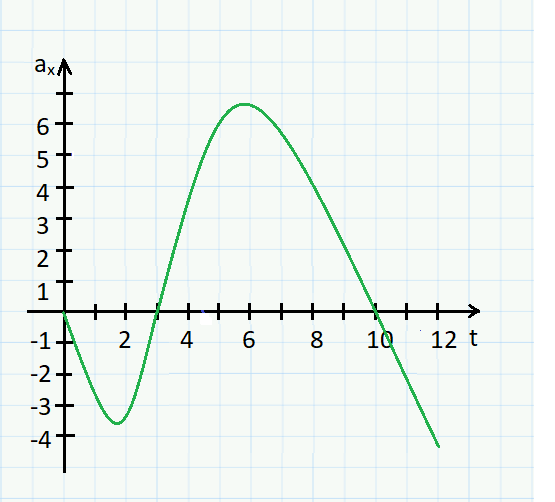
(f) Estimate his acceleration (in m/s2) at t = 6s, and show the line you’re using.

Using blue line, we have a = slope = 30mph/2s = 15mph/s = 6.7m/s2.

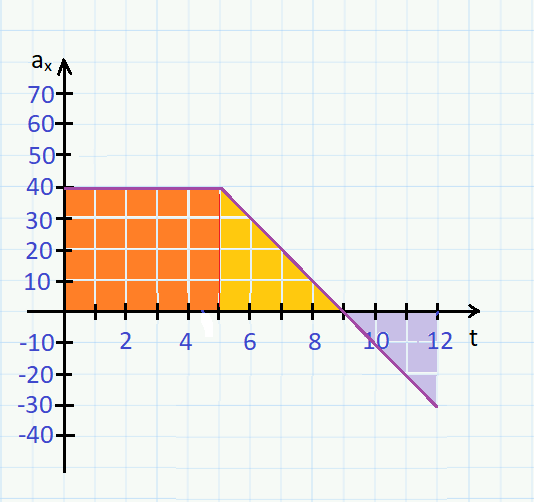
(g) Estimate his acceleration (in m/s2) at t = 12s and show the line.

Using green line, a = slope = -30mph/3s = -10mph/s = -4.4m/s2.

(h) Draw a rough ax (in m/s2) vs. t curve in the graph below.



**Problem 4.** An aerial drone has a built in accelerometer, which measures its acceleration of course. It starts off from rest and accelerates as follows (in m/s2).



(a) When is it moving up? When is it moving down (tricky….)?

Always (0s,12s). See (e) for validation. Nevah.

(b) When is it speeding up? When is it slowing down?

(0s,9s) (9s,12s)

But this is because it started from rest. It’s not always case that a > 0 → speeding up, and a < 0 → slowing down.

(c) What is its velocity at t = 5s?

vx = v0x + ∫06axdt = 0 + orange area = 0 + (40m/s2)∙(5s) = 200m/s.

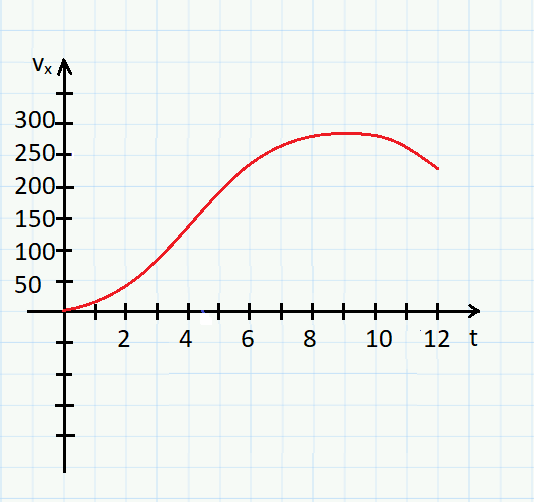
(d) What is its velocity at t = 9s?

vx = v0x + ∫09axdt = 0 + orange area + yellow area = 0 + [(40m/s2)∙(5s) + (1/2)(40m/s2)∙(4s)] = 280m/s.

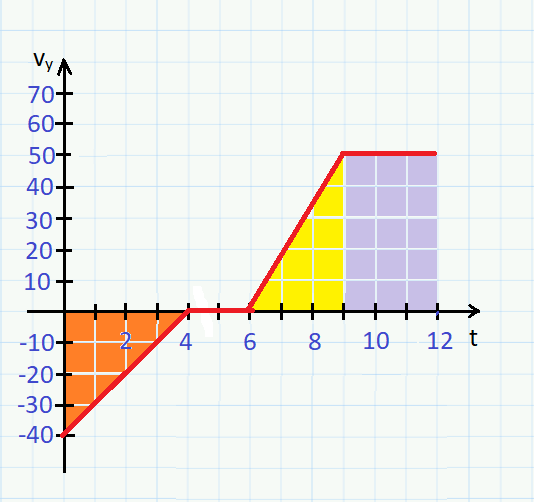
(e) What is its velocity at t = 12s?

vx = v0x + ∫012axdt = 0 + orange area + yellow area + purple area = 0 + [(40m/s2)∙(5s) + (1/2)(40m/s2)∙(4s) + (1/2)(-30m/s)∙(3s)] = 235m/s.

(f) Draw a rough vx vs. t graph below.



**Problem 5**. Now the drone is released at height y = 100m, and proceeds to execute the following vy vs. t graph.



(a) What is its height at t = 4s?

y = y0 + ∫04vydt = 100m + orange area = 100m + (1/2)(-40m/s)∙(4s) = 20m.

(b) What is its height at t = 6s?

y = y0 + ∫06vydt = 100m + orange area + nada = 100m + [(1/2)(-40m/s)∙(4s) + 0] = 20m.

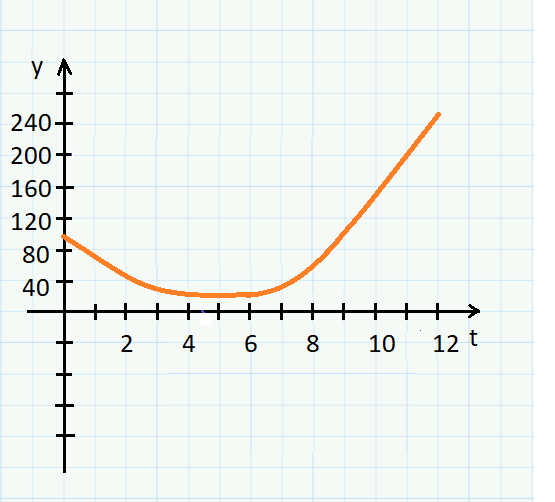
(c) What is its height at t = 9s?

y = y0 + ∫09vydt = 100m + orange area + nada + yellow area = 100m + [(1/2)(-40m/s)∙(4s) + 0 + (1/2)(50m/s)∙(3s)] = 95m.

(d) What is its height at t = 12s?

y = y0 + ∫012vydt = 100m + orange area + nada + yellow area + purple area = 100m + [(1/2)(-40m/s)∙(4s) + 0 + (1/2)(50m/s)∙(3s) + (50m/s)(3s)] = 245m.

(e) Draw a rough y vs. t graph below, por favor.



**Problem 6.** You’re driving your car at 30m/s you see a red light and apply the brakes, giving yourself an acceleration of -8m/s2. (a) Taking your present position to be 0m, write down an expression for x(t) and vx(t). (b) What is your position at t = 2s? What is your velocity at t = 2s? (c) When do you stop? (d) How far have you traveled by then?

(a) Well,



(b) So,



(c) You’ll stop when



(d) You’ll have traveled,



**Problem 7**. Consider a similar scenario. You’re doing 30m/s when you see the red light. You apply the brakes, slowing down at the rate of 5m/s2 for 4s. But then the light turns green and so you step on the accelerator, speeding back up to 30m/s in 6s. (a) Write down an expression for x(t) and v(t) during the first 4s. (b) Write down an expression for x(t) and v(t) for the last 6s. (c) How far have you traveled in those 10s?

(a) So



(b) But then at the end of the 4s, your position will be x(4) = 30(4) – 2.5∙42 = 80m. And your velocity will be: vx(4) = 30 – 5(4) = 10m/s. These will constitute your initial position and velocity for the next segment of motion. Moreover, your acceleration during this next segment will be a = Δvx/Δt = (30m/s – 10m/s)/6s = 3.33m/s2. And so we have:



(c) The distance you’ve traveled in those 10s, will just be your position when t = 10s. This is (using the second expression for x(t))

We would plug t = 4s into our expression above, as this is how long has elapsed since the initial position of x = 80. So



**Problem 8.** You’re minding your business, doing 25m/s when suddenly a suicidal dear jumps out in front of you, 50m away. You slam on the breaks. (a) How long will it take to come to rest in those 50m? (b) What acceleration is necessary to bring you to rest in those 50m?

We can write your position and velocity as:



Now by the time x = 50, we must have vx = 0. Let’s fill these into our two equations:



Now plug the second equation into the first one and solve for t:



And then solve for ax, using the second equation:



**Problem 9.** You’re trying out for the football team. The 40m dash time trials are up. You run it in 4.7s, with a constant acceleration. What was your finishing spped?

Your position and velocity equations are:



Now we have that at the final time t = 4.7s, x = 40m. So plug these into our two equations:



With the first equation we can solve for ax:



Plugging this into the second equation:



**Problem 10.** You’re a midevil knight in a jousting tournament. You’re at position x = 0m, and your opponent is at x = 50m. The referee strikes the gong and you (on your horse) begin to gallop at a constant acceleration of 4m/s2, but your helmet comes loose. Your opponent accelerates towards you at 2m/s2, but since he’s a knight in training, was allowed a head start and so has an initial speed of 5m/s. (a) How long do you have to fix your helmet? (b) And at what coordinate will you two meet? (c) and what will be your speeds?

(a) Yall’s position is given by:



Setting your positions equal, we have:



(b) And you’ll be at position:



(c) Your speed will be:



And his speed will be:

