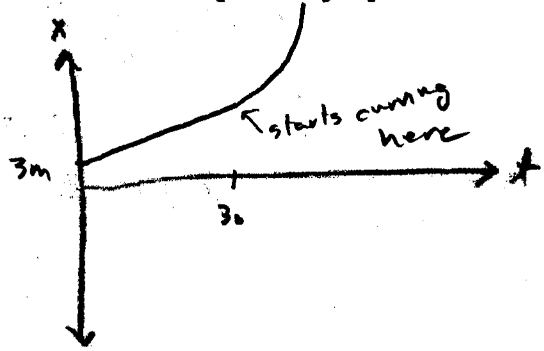
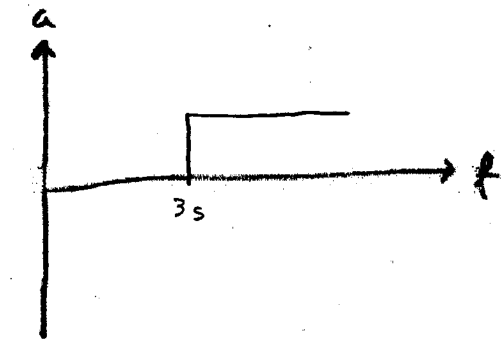
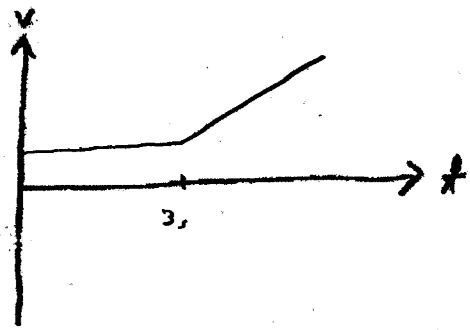
1-2. For the following motions, draw x vs. t, v vs. t, and a vs. t graphs. For all motions, use the convention that right is positive and left is negative.

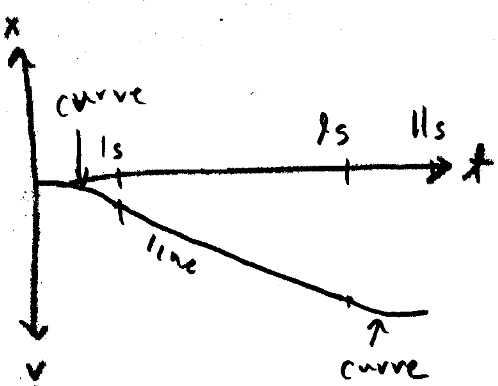
1. A car moving at constant speed to the right passes x=3m at time 0. It continues to move at a constant speed for for 3 seconds. At t=3s, the car starts speeding up with constant acceleration.

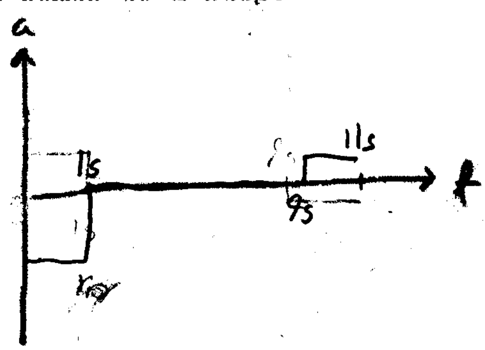


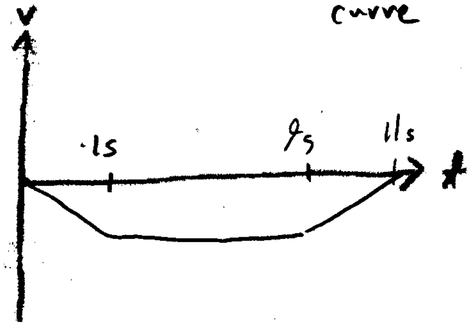




2. Starting from rest, a sprinter accelerates at a constant rate for 1 second, running to the left. She then moves at constant speed for 8 seconds, when she passes the finish line. Finally, she slows down with constant acceleration for two seconds, and comes to a stop.

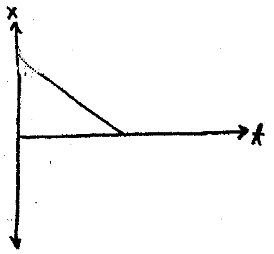




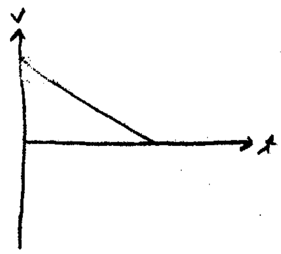


3. Describe, using words, the motions described by the graphs below. Assume the the object moving is a car, and that east is defined to be the +x direction.

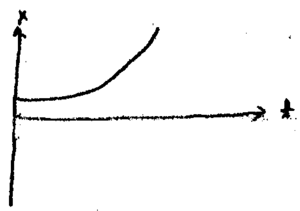
a)



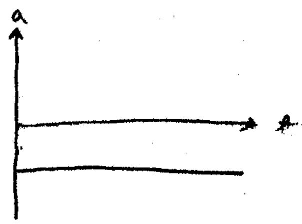
b)



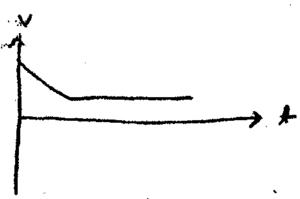
c)



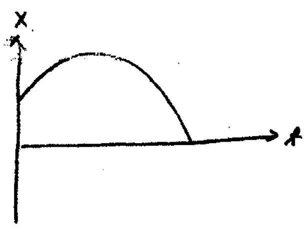
d)



e)



f)



a) The car moves left with constant speed,

b) The car starts off moving to the right, and slows to a stop with constant acceleration

c) The car starts at rest and accelerates w/ constant acceleration to the right

d) The car accelerates w/ constant acceleration in the negative direction. It could be speeding up towards the left or it could have started travelling to the right, in which case it would be slowing down.

e) A car moving to the right slows a bit, then continues at a constant speed

f) A car starts moving to the right, slows to a stop, and then accelerates to the left. All this occurs with constant acceleration

Standard Problems 2. Complex 1D kinematics w/ constant accel. intervals

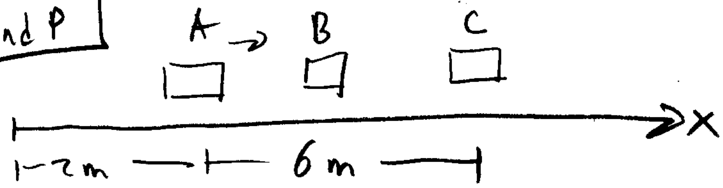
Introductory problem.

$$v_B = v_A + a_{AB}\Delta t_{AB} \qquad x_B = x_A + v_A\Delta t_{AB} + \frac{a_{AB}}{2}\Delta t_{AB}{}^2$$

$$v_B^2 = v_A^2 + 2a_{AB}\Delta x_{AB} \qquad x_B = x_A + \left(\frac{v_A+v_B}{2}\right)\Delta t_{AB}$$

A toy train is pushed forward and released at x= 2.0 m with a speed of 2.0 m/s. It rolls at a steady speed for 2.0 s, then one wheel begins to stick. The train comes to a stop 6.0m from the point at which it was released. What is the train's acceleration after its wheel begins to stick?

O and P



$x_A = 2\text{ m}$ $\quad a_{AB} = 0$ $\quad \Delta t_{AB} = 2\text{ s}$

$x_C = 8\text{ m}$ $\quad a_{BC} = ?$

$V_A = V_B = 2\text{ m/s}$

$V_C = 0$

$\Delta x_{AC} = 6\text{ m}$

Approach: Analyze AB and BC to ~~find~~ relate a_{BC} to known Δx_{AC}

Solve: Analyze AB first: $x_B = x_A + V_A(\Delta t_{AB})$

$$= 2\text{m} + \left(2\tfrac{\text{m}}{\text{s}}\right)(2\text{s}) = 6\text{ m}$$

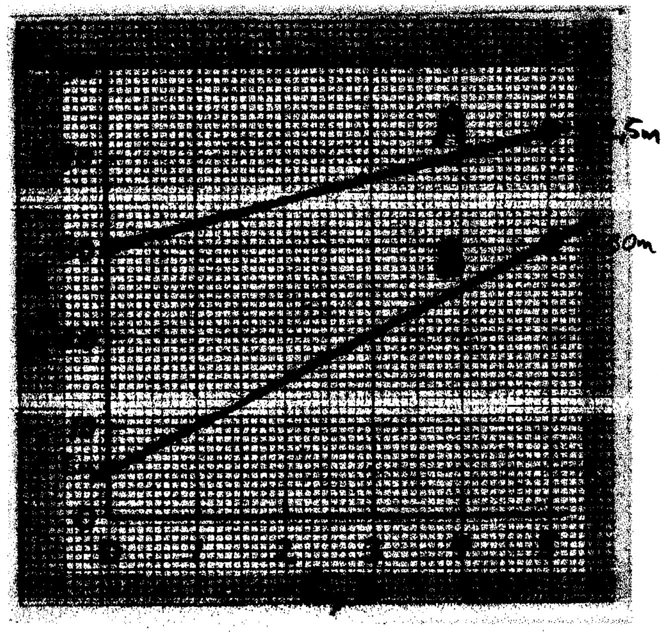
Now analyze BC: $V_C^2 = V_B^2 + 2a_{BC}\Delta x_{BC}$

$\Delta x_{BC} = 8\text{m} - 6\text{m} = 2\text{m}$

$$\Rightarrow a_{BC} = \frac{V_C^2 - V_B^2}{2\Delta x_{BC}} = \frac{0 - (2\text{ m/s})^2}{2(2\text{ m})} = -1\text{ m/s}^2$$

Reflect: the setup was a bit confusing: I initially misread and thought $x_C = 6\text{ m}$. Reading the problem carefully is important!

4. The graph at the right shows the *position vs. time* plots for two cars, car A and car B.

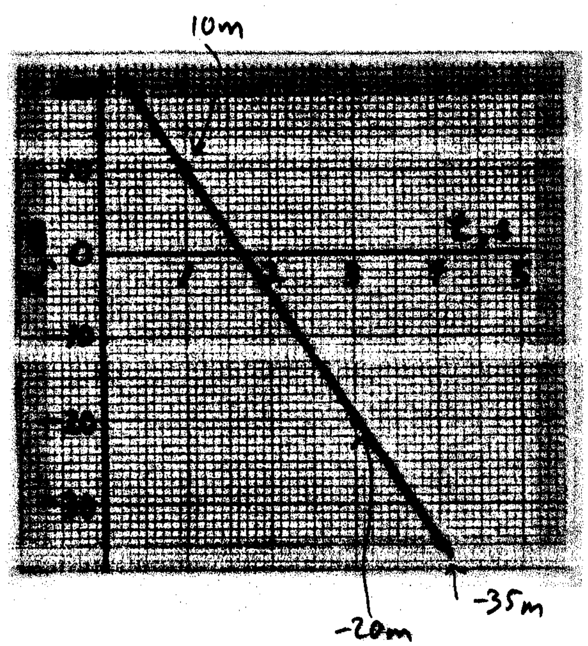


Find the velocities of both cars.

$V = \text{slope } A = \frac{42.5m - 30m}{5s - 0s} = 2.5\ m/s$

$V = \text{slope } B = \frac{30m - 5m}{5s - 0s} = 5m/s$

5. A portion of the *position vs. time* plot for an object moving along the x-axis is shown on the graph at the right.



a) What is the *instantaneous velocity* of the object at

t = 3 seconds?

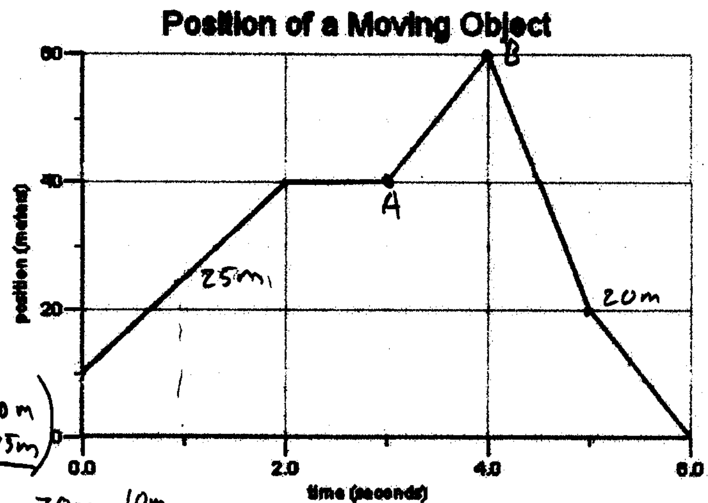
$V = \bar{V} = \text{slope} = \frac{-20m - 10m}{3s - 1s} = -15\ m/s$

b) What is the *displacement* of the object between

t = 1 and t = 4 seconds?

$\Delta X = -35m - 10m = -45m$

6. The *position vs. time* plot for an object moving along the x-axis is shown on the graph at the right.



a) For which *time intervals*, if any, is the object moving to the *left*? from $t=4$ to $t=6$

b) What is the *position* of the object at t = 1 second and at t = 5 seconds? $x = 20m$

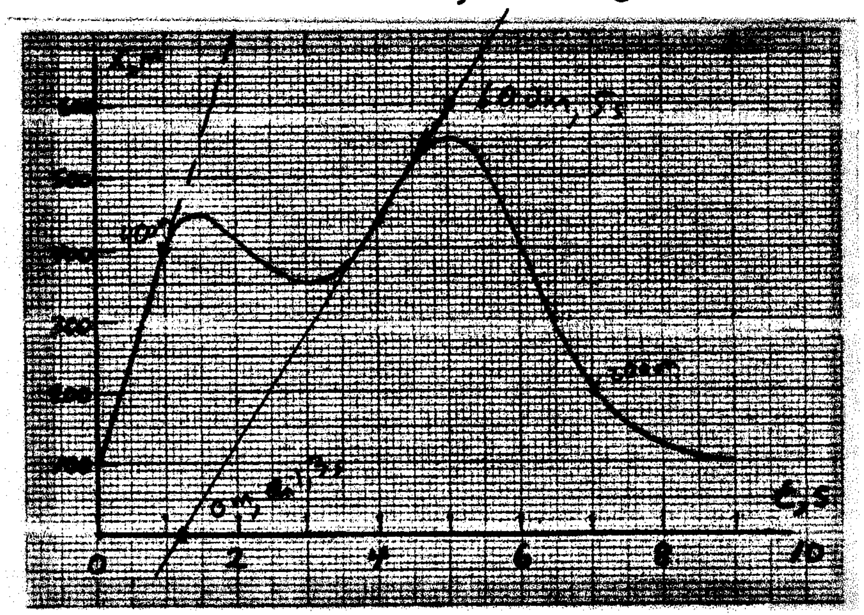
c) What is the *displacement* of the object between t = 1 and t = 5 seconds?
$\Delta x = 20m - 25m = -5m$

Omitted d) What *distance* did the object travel between t = 1 and t = 5 seconds? It went from 25m to 60m and then back to 20m. This is 35+40=75m

e) What is the *average velocity* of the object between t = 0 and t = 5 seconds? $\bar{v} = \frac{\Delta x}{\Delta t} = \frac{20m - 10m}{5s - 0s} = 2m/s$

f) What is the *instantaneous velocity* of the object at t = 2.5 seconds and at t = 3.5 seconds?
2.5s: the slope is flat: $v = 0$
3.5s: the slope is that of the line AB shown: $v = \bar{v} = \frac{60m - 40m}{4s - 3s} = \frac{20m}{s}$

7. The graph at the right shows the *position vs. time* plot for a high-speed object moving along the x-axis.



a) What is the *initial position* ~~and the initial speed~~ of the object? $X_0 = 100m$.

Omitted b) What *total distance* did the object move in the time interval from t = 3 to t = 8 seconds?

c) At what time or times, if any, is the *instantaneous velocity* of the object equal to zero.
$t = 1.5s, 3.0s, 5.0s$, and $9.0s$

d) What is the *displacement* of the object between t = 1 and t = 7 seconds? $\Delta x = 200m - 400m = -200m$

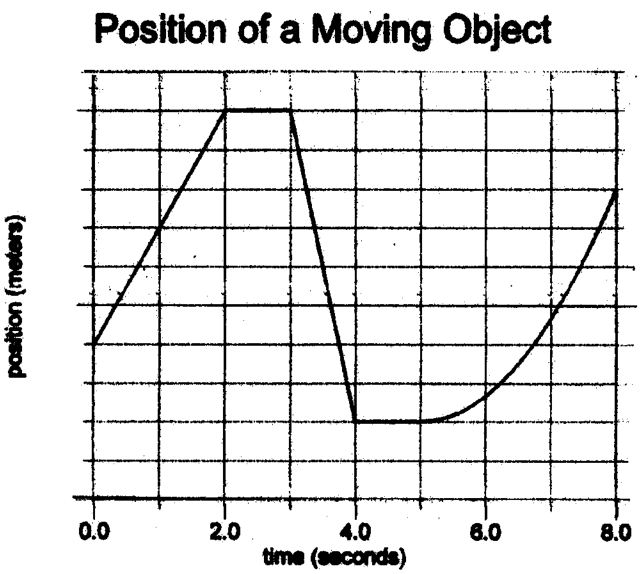
e) Estimate the *average velocity* of the object between t = 0 and t = 1 seconds. $\bar{v} = \frac{400m - 100m}{1s} = \frac{300m}{s}$

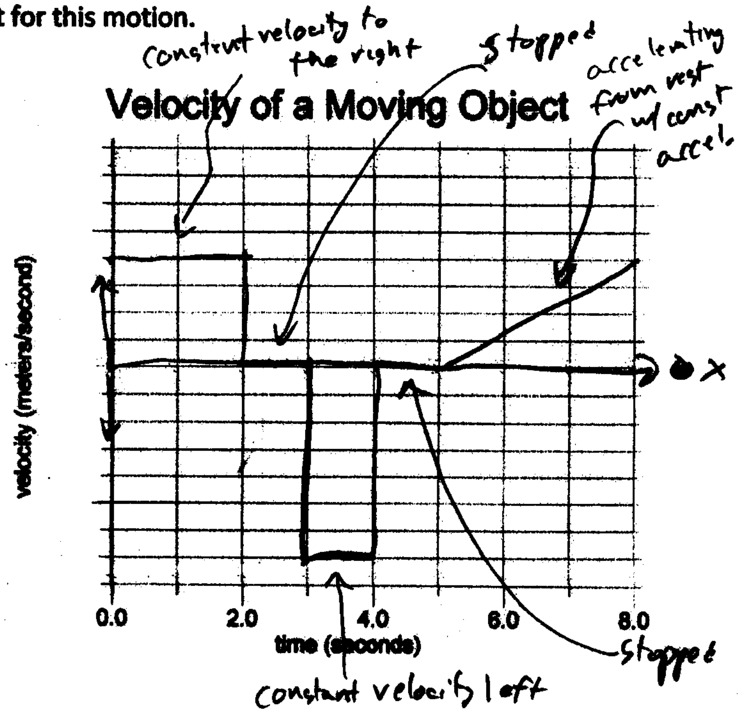
f) Estimate the *average velocity* of the object between t = 1 and t = 7 seconds. $\bar{v} = \frac{\Delta x}{\Delta t} = \frac{-200m}{7s - 1s} = \frac{-200m}{6s} = -33.3\frac{m}{s}$

g) Estimate the instantaneous *velocity* at t = 1 second. This is the same as the slope of the line from 0s to 1s, so that's 300m/s

h) Estimate the instantaneous *velocity* at t = 4 seconds.
slope of tangent line is
$v = \frac{600m - 0m}{5s - 1.3s} = 162 m/s$

8. The graph on the left below shows a *position vs. time* plot for the motion of a moving object. On the graph at the right, sketch the *velocity vs. time* plot for this motion.





9. Show at the left below is the *position-time* graph for a moving object. On the velocity-time graph sketch the *velocity plot* for this motion.