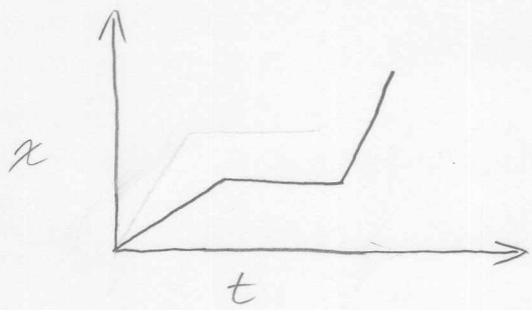
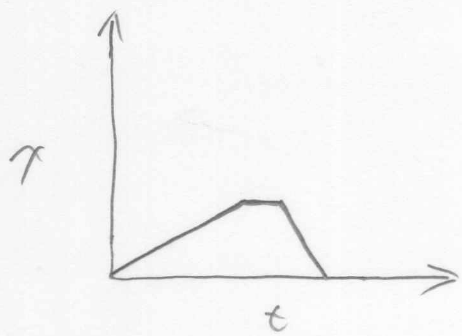
1D Kinematics

1. Sketch position vs. time graphs for the following situations. You should label your axes, but you don't need to include numbers.

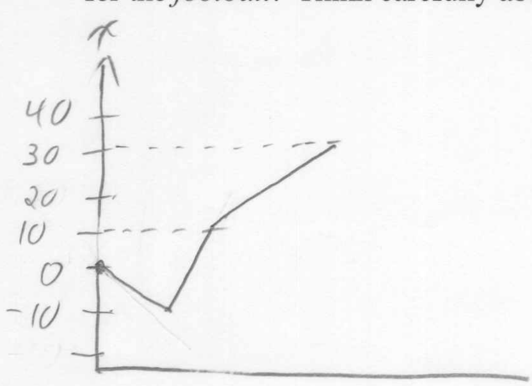
(a) A student walks to the bus stop, waits for the bus, then rides to campus. Assume that all the motion is along a straight street.



(b) A student walks slowly from home to the bus stop, realizes he forgot his paper that is due, and *quickly* walks home to get it.



(c) The quarterback drops back 10 yards from the line of scrimmage, then throws a pass 20 yards to the receiver, who catches it and sprints 20 yards to the goal. Draw your graph for the *football*. Think carefully about what the slopes of the lines should be.



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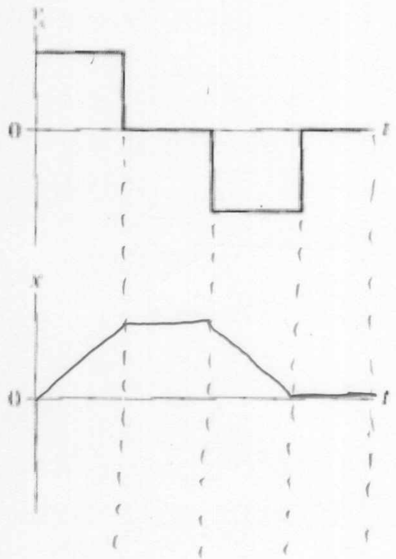
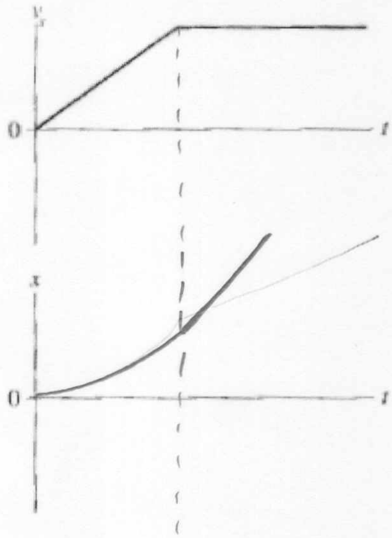
2. Below are four velocity vs. time graphs. For each, draw the corresponding position vs. time graph.

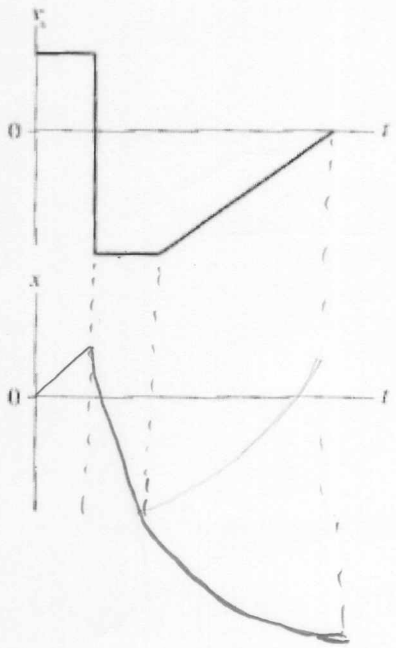
a.



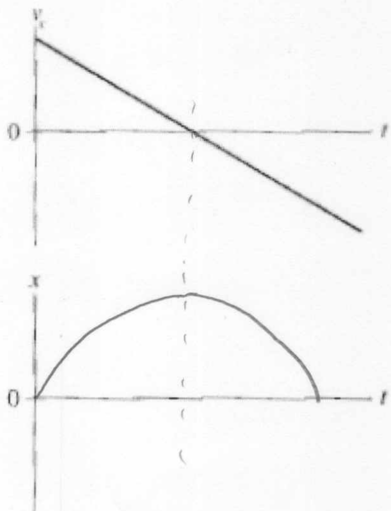
b.



c.



d.



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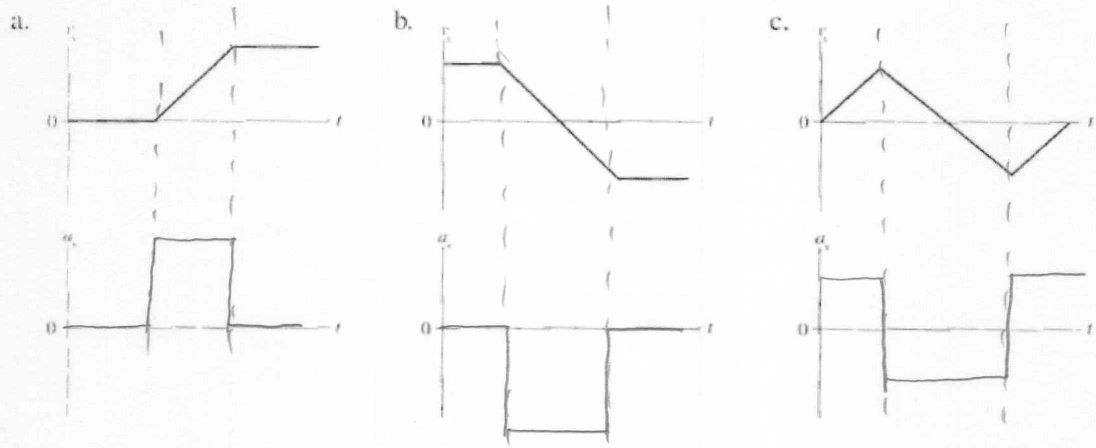
3. For each velocity vs. time graph below, draw the corresponding acceleration vs. time graph.



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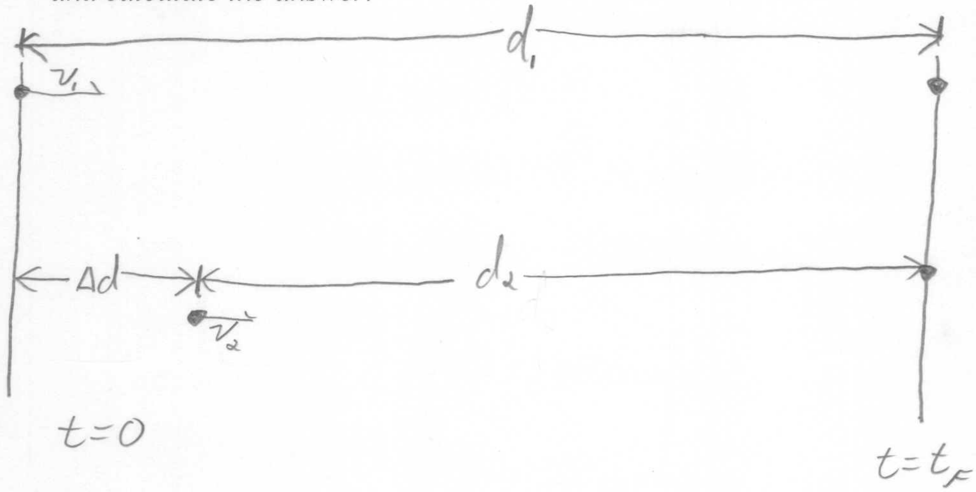
4. I can run at 90 m/s, 20% faster than my little brother (we're super heroes). We are running a 100m dash. How much of a head start (distance) should I give him so that we cross the finish line at the same time?

Make a sketch of the situation. Define a coordinate system and all of the relevant variables. Derive the ***analytical*** *solution (no numbers!). Finally, plug in the numbers and calculate the answer.*



Given:

$v_1 = 90\,m/s$

$P = 0.2$

$d_1 = 100\,m$

Want: $\underline{\Delta d}$

$\Delta d = d_1 - \underline{d_2} \leftarrow$ Find d_2

Displacement: $x = \frac{1}{2}at^2 + v_{0x}t + x_0$

$d_2 = v_2 t_F$

$d_1 = v_1 t_F$

$\Rightarrow \frac{d_2}{d_1} = \frac{v_2}{v_1} \Rightarrow d_2 = d_1 \frac{v_2}{v_1}$

$$\boxed{v_1 = v_2(1+P)}$$

$$\Delta d = d_1 - \frac{v_2}{v_1} d_1$$

$$\Delta d = d_1\left(1 - \frac{v_2}{v_1}\right) = d_1\left(1 - \frac{v_2}{v_2(1+P)}\right) = d_1\left(\frac{P}{1+P}\right)$$

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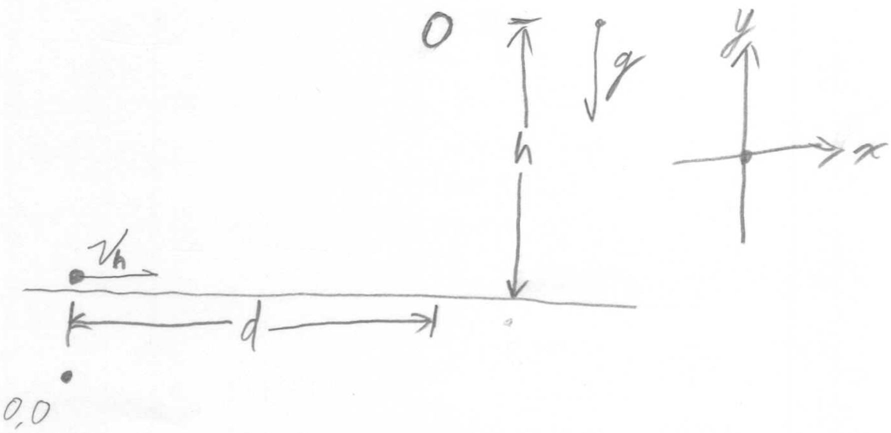
5. A daring ranch hand sitting on a tree limb wishes to drop vertically onto a horse galloping under the tree. The constant speed of the horse is 10.0 m/s, and the distance from the limb to the level of the saddle is 3.00 m.

   What must be the horizontal distance between the saddle and the limb when the ranch hand makes his move?

   Make a sketch of the situation. Define a coordinate system and all of the relevant variables. Derive the ***analytical*** *solution (no numbers!). Finally, plug in the numbers and calculate the answer.*



$x = \frac{1}{2}at^2 + v_{0x} + x_0$

Cowboy

$0 = -\frac{1}{2}gt^2 + h$

$t = \left(\frac{2h}{g}\right)^{1/2}$

horse

$d = v_h t \Rightarrow t = \frac{d}{v_h}$

$d = v_h \left(\frac{2h}{g}\right)^{1/2}$

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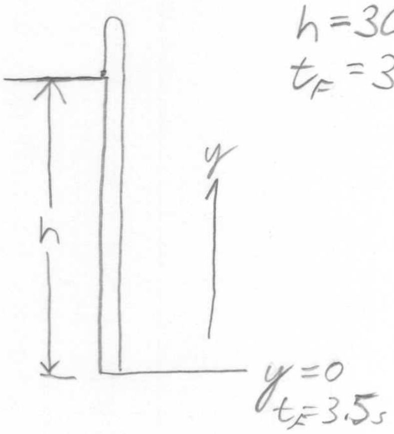
6. Wile E. Coyote is standing on the edge of a cliff throwing dynamite. The cliff is 30.0 m high, and Wile E. throws the dynamite straight up in the air. The dynamite falls past the edge of the cliff and hits the ground 3.50 s after it was thrown.

(a) What was the dynamite's initial velocity?

$$x(t) = x_0 + v_0 t + \tfrac{1}{2}at^2$$

$h = 30.0\,m$

$t_F = 3.50\,s$



$$0 = h + v_0 t_F - \tfrac{1}{2}g t_F^2$$

$$\boxed{v_0 = \frac{1}{t_F}\left(\tfrac{1}{2}g t_F^2 - h\right)}$$

$$v_0 = \frac{1}{3.50\,s}\left(\tfrac{1}{2}(9.8\,m/s^2)(3.50\,s)^2 - 30.0\,m\right)$$

$$\boxed{v_0 = 8.58\ m/s}$$

(b) Emboldened by his first throw, Wile E. decides to light the next stick and repeat his throw (same trajectory), this time trying to hit Roadrunner. The dynamite explodes 1.60 seconds after The Coyote throws it. Is he toast?

Now that we know v_0 we can solve for y at $t = 1.60\,s$:

$t_B = 1.60\,s$

$$\boxed{y(t_B) = h + v_0 t_B - \tfrac{1}{2}g t_B^2}$$

$$y = 30.0\,m + (8.58\,m/s)(1.60\,s) - \tfrac{1}{2}(9.8\,m/s^2)(1.60\,s)^2$$

$$\boxed{y = 31.2\ m}$$

Boom at 1.2 m above the cliff edge. Bummer! right in the chest.