1. a) Introduce them after having set up the equation to solve for acceleration. Use the variable V_0 for 120 km/hr to represent the initial velocity, and the variable t for 50 ms to represent the time it took to decelerate from 120 km/hr to a stop.

b) $V(t) = V_0 + at$

At the time $t=0$, the driver is moving with velocity 120 km/hr (the moment of the crash).

c) What is the value of $\underline{a}$ such that $\underline{V}$ is equal to zero at time $\underline{50ms}$.

d) $V = V_0 + at$

$V - V_0 = at \rightarrow a = \frac{V-V_0}{t}$

e) We found that $a = \frac{V-V_0}{t}$ and we know that $V=0$, $V_0 = 120 \frac{km}{hr}$, $t = 50 ms$

We want all our units to match so we convert into meters and seconds.

$$V_0 = 120 \frac{\cancel{km}}{\cancel{hr}} \cdot \frac{1000 m}{1 \cancel{km}} \cdot \frac{1 \cancel{hr}}{3600 s} = 33.3 \frac{m}{s}$$

$$t = 50 \cancel{ms} \cdot \frac{1 s}{1000 \cancel{ms}} = 0.05 s$$

Now we substitute:

$$a = \frac{V-V_0}{t} = \frac{0 - 33.3 \, m/s}{0.05 s} = -666 \, m/s^2.$$

f) The minus sign for the acceleration signifies that the velocity was getting smaller as time passed; the person was slowing down.

2.

$$\frac{666 \, \cancel{m/s^2}}{9.8 \, \cancel{m/s^2}} = 68 \text{ times greater}$$

This is not surprising since the acceleration gained from abruptly stopping from a very high velocity to a dead stop has to be very large.

3. We can infer information about the variables needed from the question. First, since the bucket simply falls off the ledge, the initial velocity of the bucket is 0. Second, the time it took for the bucket to fall was 14 seconds, and since the bucket is in free fall, we know that $a = 9.8 \, m/s^2$ (depending on the coordinate system choice, this could have a minus in front).

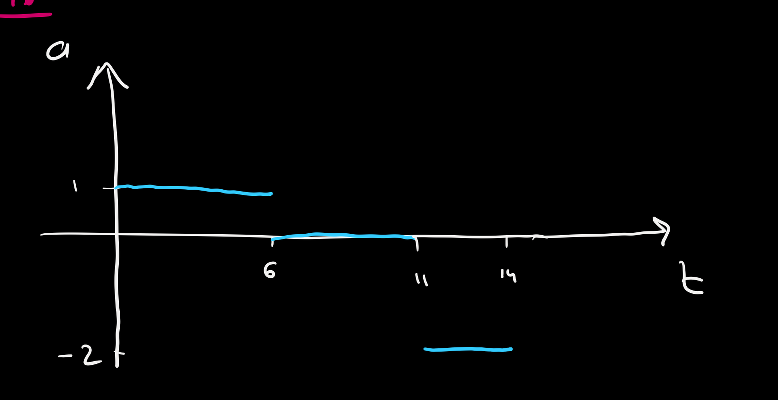
a) We want to find the distance that the bucket travelled.

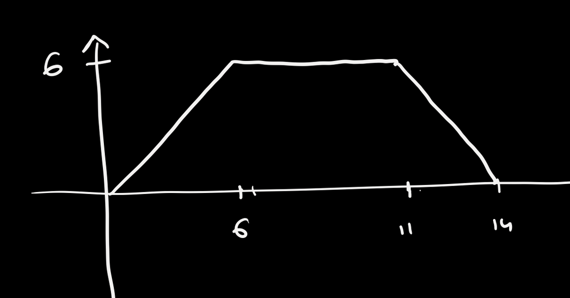
$$X = X_0 + V_0 t + \frac{1}{2}at^2 \quad \text{where } X_0 = 0,\ V_0 = 0,\ t = 14s,\ a = 9.8 \, m/s^2$$

$$X = \frac{1}{2}(9.8 \, m/s^2)(14s)^2 = 960 m$$

b) I chose the coordinate system in such a way that the down direction was positive, thus I kept the acceleration due to gravity to be positive. If I had chosen down to be negative, then a would be $-9.8 \, m/s^2$ and we'd find $X = -960 m$ which would tell us that the bucket moved downwards.

4.





b) Since the acceleration changes, we break down the problem into three parts.

Part 1: $a = 1 \, m/s^2$, $V_0 = 0$, $X_0 = 0$, $t = 6s$

$$X = X_0 + V_0 t + \frac{1}{2}at^2 = \frac{1}{2}(1 \, m/s^2)(6s)^2 = 18 m$$

Part 2: $a = 0$, $X_0 = 18m$, $V_0 = 6 \, m/s$, $t = 5s$

$$X = X_0 + V_0 t + \frac{1}{2}at^2 = 18m + 6 \, m/s \cdot 5s = 48 m$$

Part 3: $a = -2 \, m/s^2$, $V_0 = 6 \, m/s$, $t = ?$, $V = 0$, $X_0 = 48m$

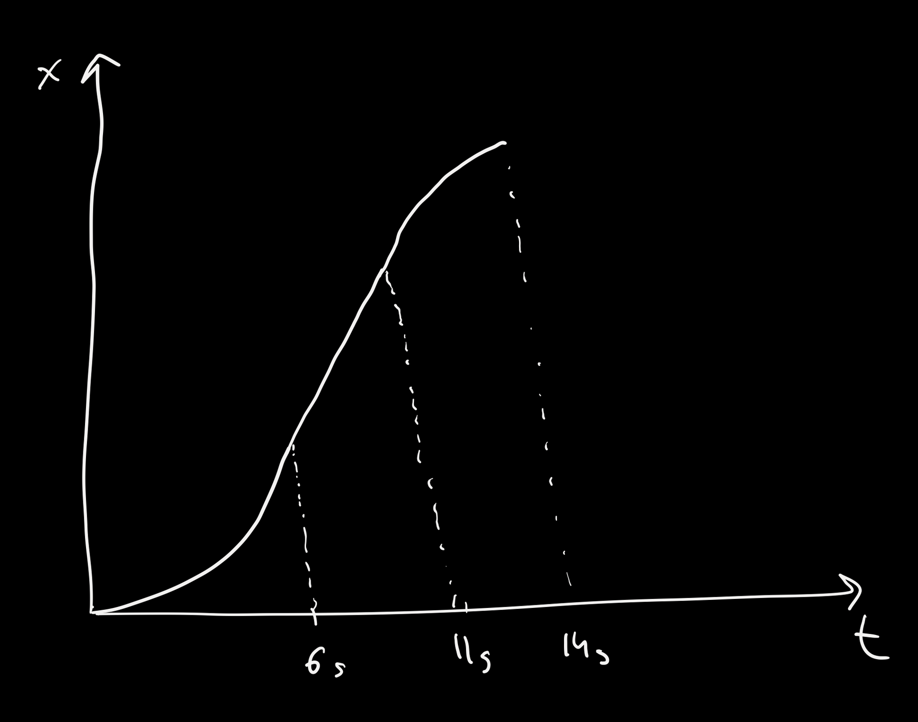
$$V = V_0 + at \rightarrow t = \frac{V - V_0}{a} = \frac{0 - 6 \, m/s}{(-2 \, m/s)} = 3s \quad \rightarrow t = 3s$$

$$X = X_0 + V_0 t + \frac{1}{2}at^2 = 48m + (6 \, m/s \cdot 3s) + \left(\frac{1}{2}(-2 \, m/s^2)(3s)^2\right)$$

$$X = 48m + 18m - 9m = 57m$$

Total distance travelled is 57m.

Note: We could've taken $X_0 = 0$ for all three parts, and in the end add the distances you find for each part to find the total distance.



The first part of the graph is a concave up parabola since a is positive; the second part (after 6s) is a straight line since $a = 0$ and the third part is a concave down parabola since a is negative from 11s to 14s.

5. First, let's write down what information we can gather about our variables from the question.

The distance from the place where the car brakes to the roadrunner is 30m, so $X = 30m$.

We can take $X_0 = 0$.

$$V_0 = 110 \, \cancel{km}/\cancel{hr} \cdot \frac{1000m}{1 \cancel{km}} \cdot \frac{1 \cancel{hr}}{3600s} = 30.5 \, m/s.$$

$a = -9 \, m/s^2$ (negative since she's decelerating)

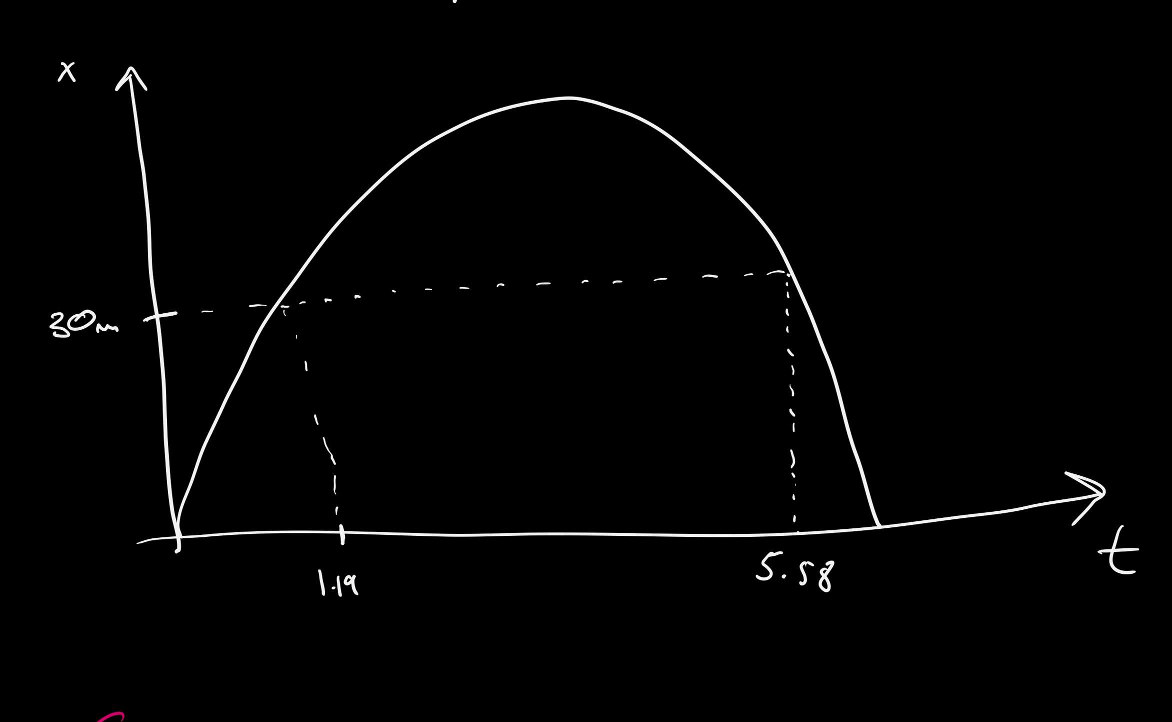
a) $X = \cancel{X_0}^{\,0} + V_0 t + \frac{1}{2}at^2 \rightarrow \frac{1}{2}at^2 + V_0 t - X = 0$ after rearranging

$$\underbrace{-4.5}_{A} t^2 + \underbrace{30.5}_{B} t \underbrace{- 30}_{C} = 0$$

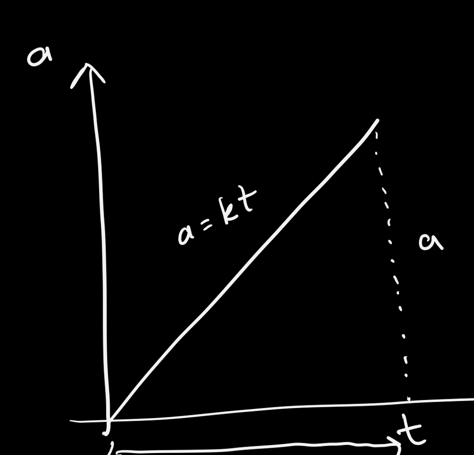
$$t = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A} = \frac{-30.5 \pm \sqrt{(30.5)^2 - 4(-4.9)(-30)}}{2(-4.9)}$$

We get two solutions: $t = 1.19s$ or $t = 5.58s$

b) The solution $t = 1.19s$ is the correct one. The second solution tells you at what time you would hit $X = 30m$ again if you keep the same acceleration of $a = -9 \, m/s^2$. But in the case of a car braking, that acceleration would become zero after reaching a stop



6. a) Since a has dimensions of length per time squared, then k has to have dimensions of length per time cubed. Units could be meters per second cubed.



Area of this triangle is $\frac{1}{2}at = \frac{1}{2}(kt)t = \frac{1}{2}kt^2$

Remember, velocity is the area under the curve of the velocity vs. time graph (the integral of a with respect to time), thus:

$$V = \frac{1}{2}kt^2 + V_0$$

Next, position is the area under the curve of the velocity vs. time graph.

Using the fact that the area under a curve ct^n is $\frac{1}{n+1}ct^{n+1}$, then

$$X = V_0 t + \frac{1}{6}kt^3 + X_0.$$

As you can see, if acceleration is different, the kinematics equations we've been using do not work; you obtain new "kinematics equations."

7. Since we don't care about the numbers you obtain in this problem since it's an approximation, here's the way I would do it.

I'd first find out the area of the SU quad, and I would search how much snow falls on average in Syracuse every year. Using the area of the quad, and multiplying that by the amount of snowfall gives me the volume of snow fall in the quad per year.

Once I have the volume, I can use the definition of density to find the mass of that snow.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \rightarrow \text{Mass} = \text{Density} \cdot \text{Volume}.$$

You can find the density of snow online and find the mass that way.