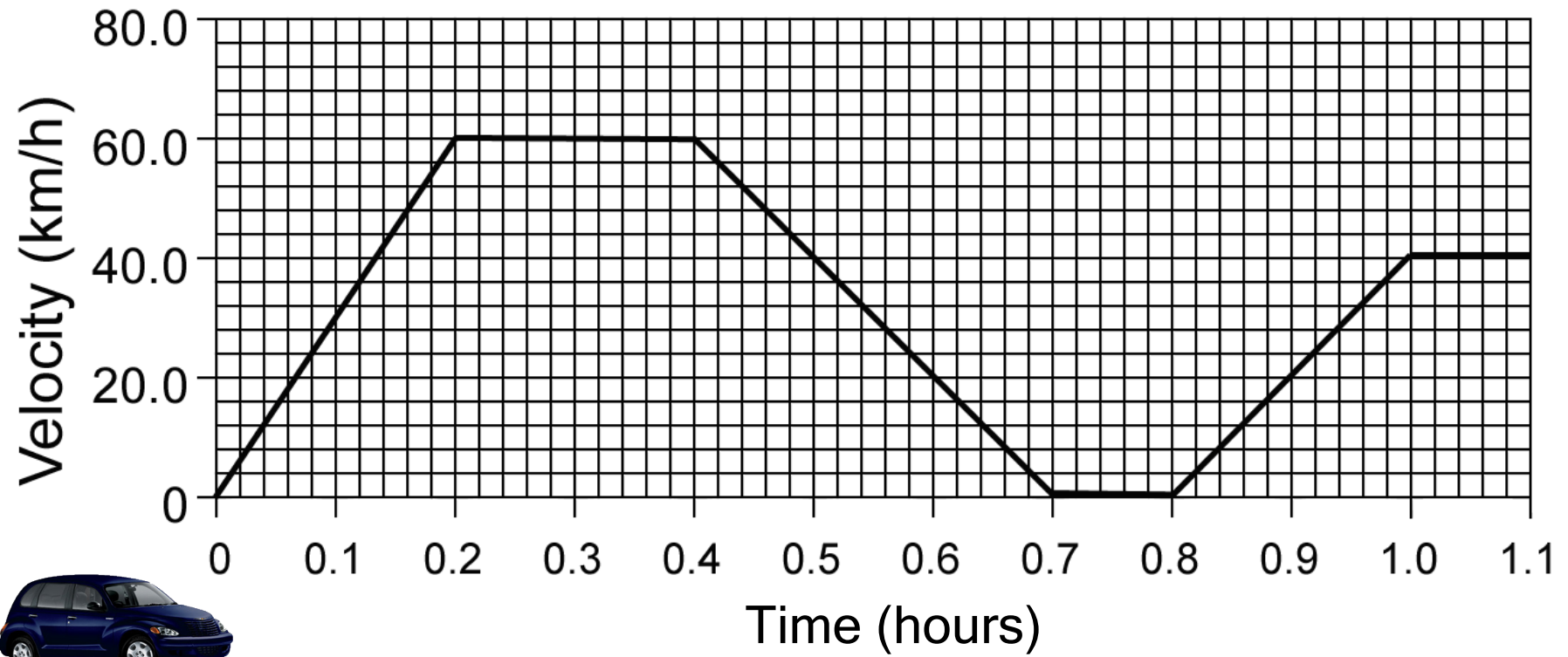


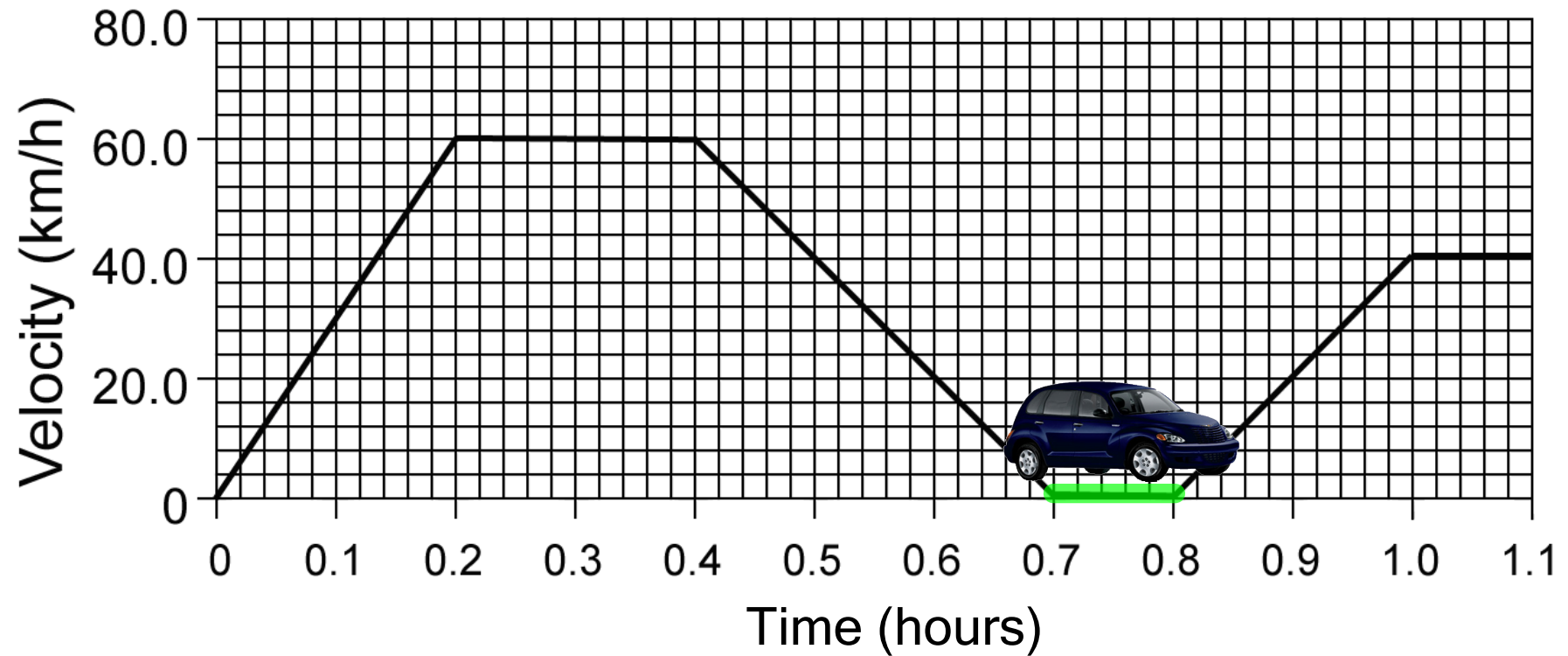
1. Above is a velocity-time graph of a moving car. Answer the following questions using the graph.

- \_\_\_\_\_ a. At what time was the car stopped?
- \_\_\_\_\_ b. At what time did the car have the greatest velocity?
- \_\_\_\_\_ c. What was the greatest velocity?
- \_\_\_\_\_ d. At what time(s) was the car accelerating?
- \_\_\_\_\_ e. How fast was the car going at 1.0h?
- \_\_\_\_\_ f. What is the acceleration at 0.9 h?



**a. At what time was the car stopped?**

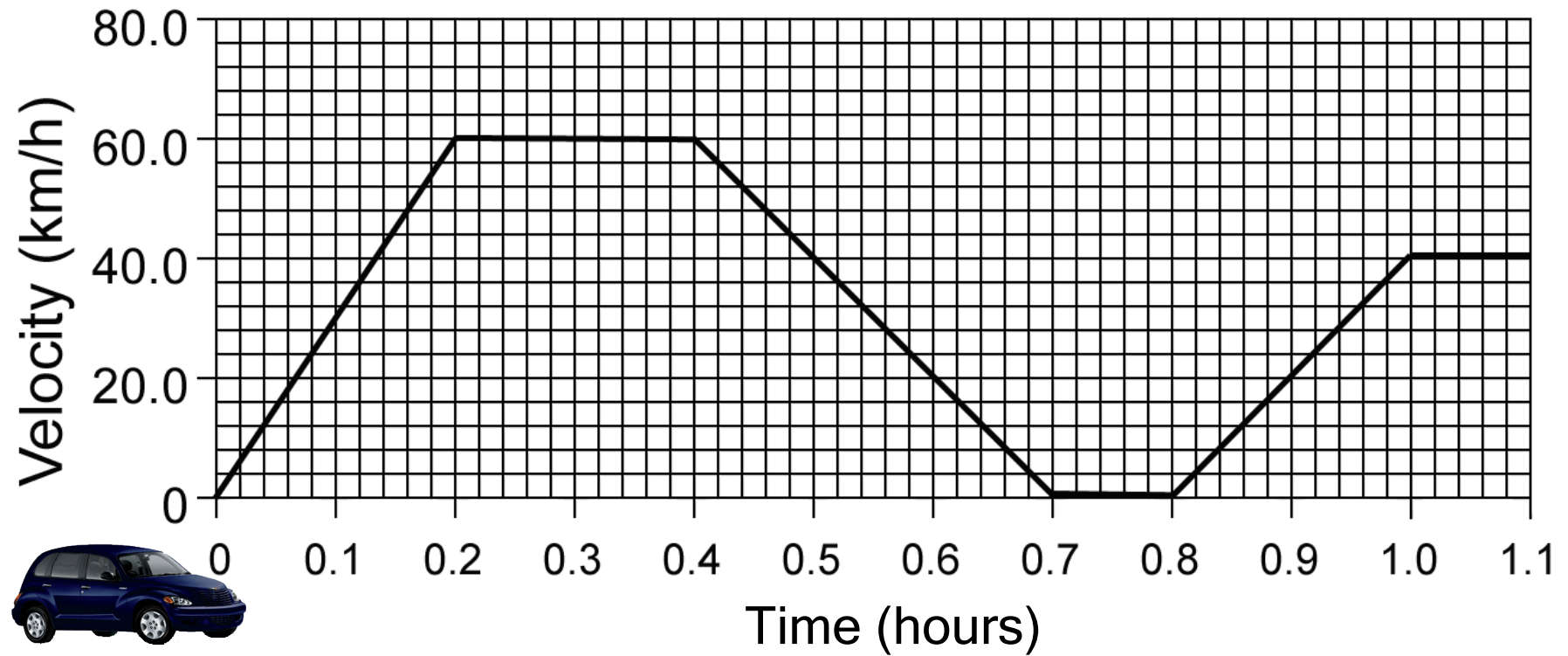
\_\_\_\_\_



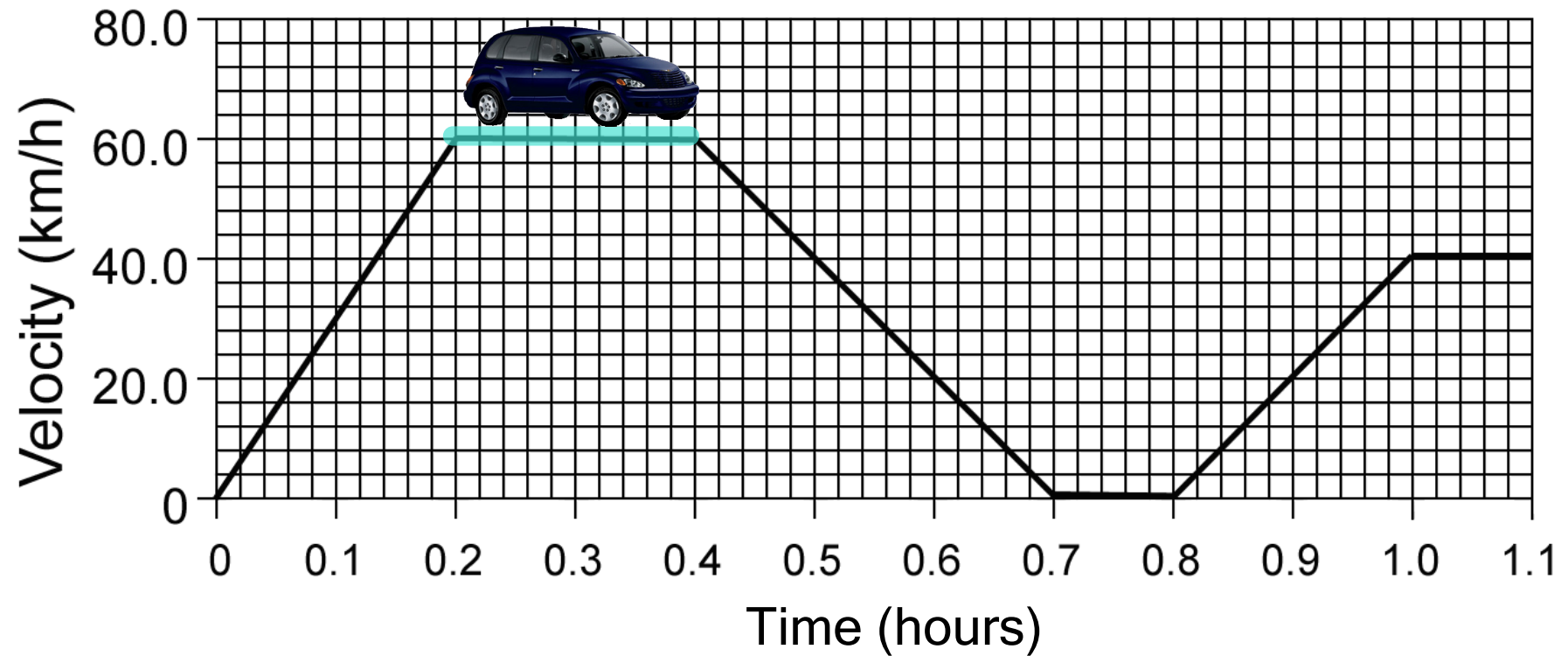
**0.7-0.8 hours**

**a. At what time was the car stopped? ★**

**We look to the graph to where velocity = 0 km/h. This is indicated by the green line. This velocity occurs between time 0.7-0.8 hours.**

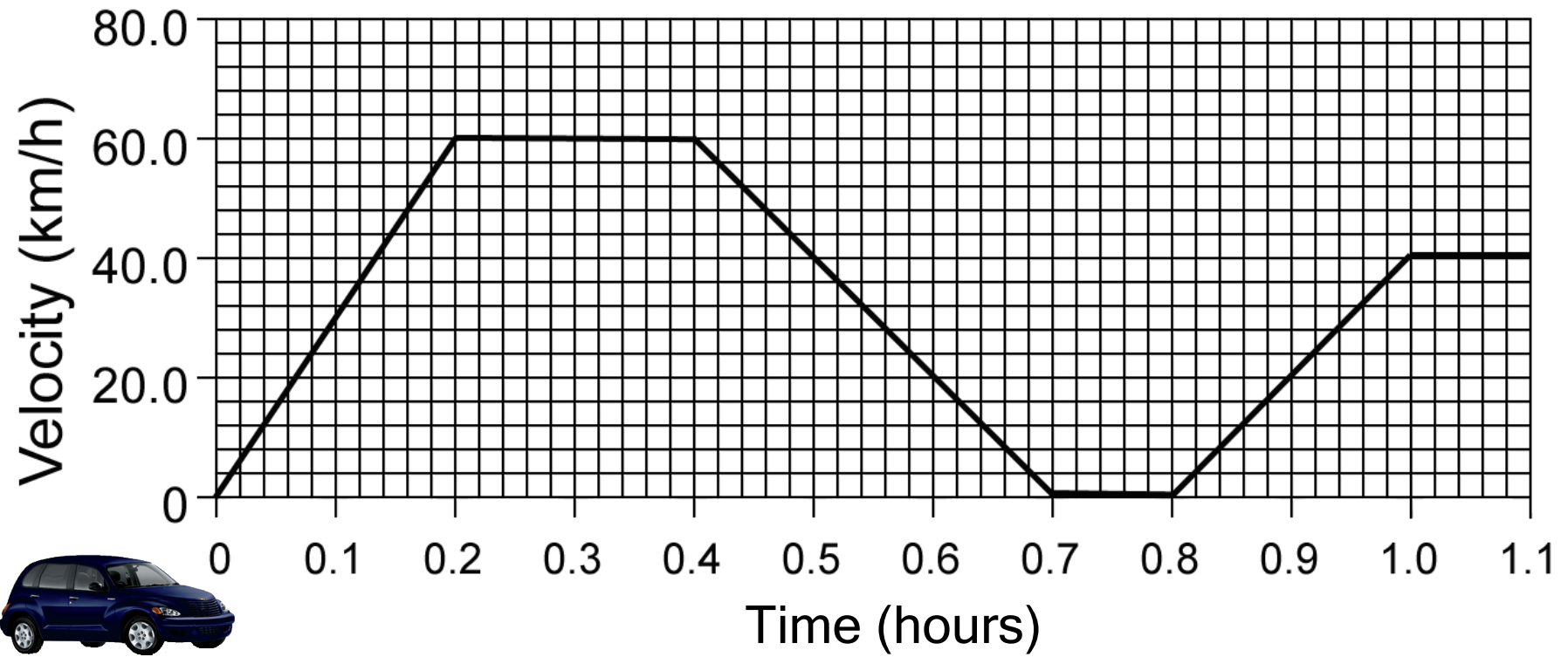


**b. At what time did the car have the greatest velocity?**



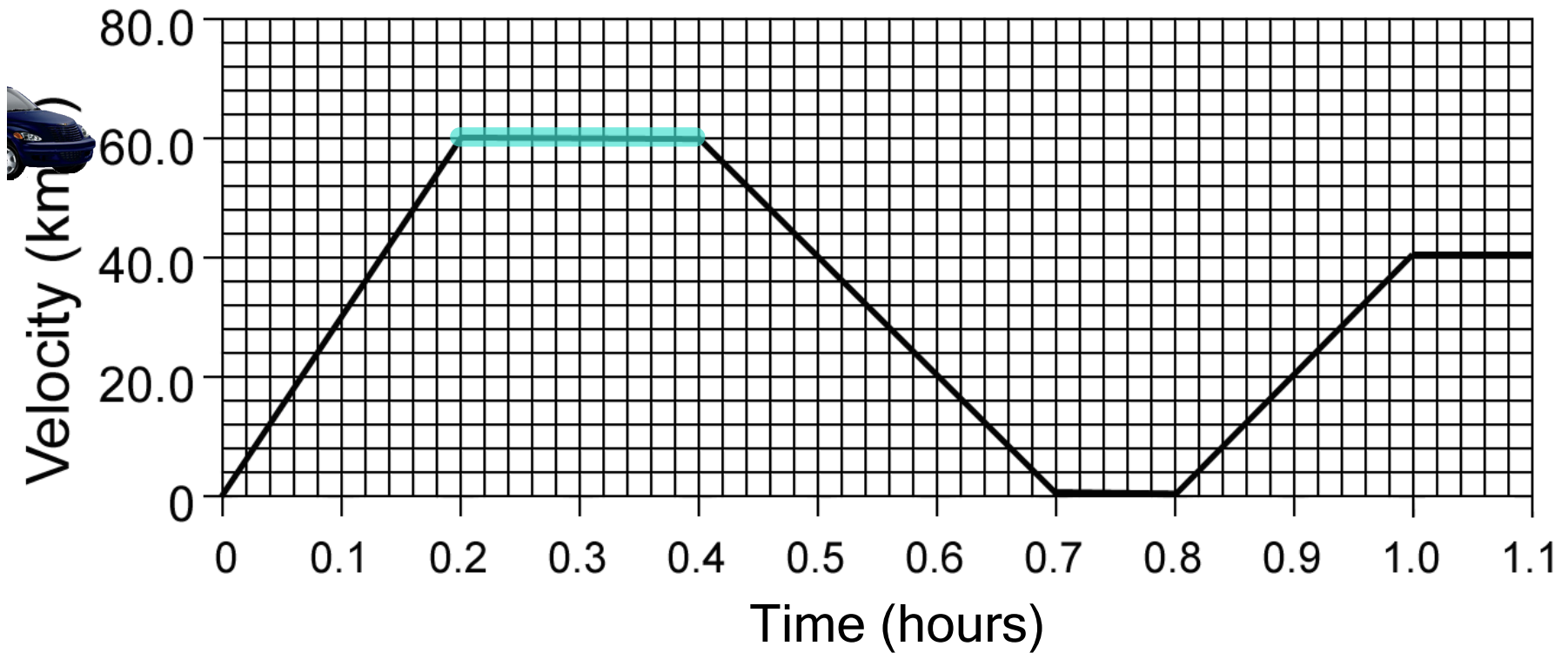
0.2-0.4 hours b. At what time did the car have the greatest velocity? ★

We look to the graph to find the highest vertical point. This range is indicated by the blue line. In this case the highest point occurs in the range of 0.2-0.4 hours.



**c. What was the greatest velocity?**

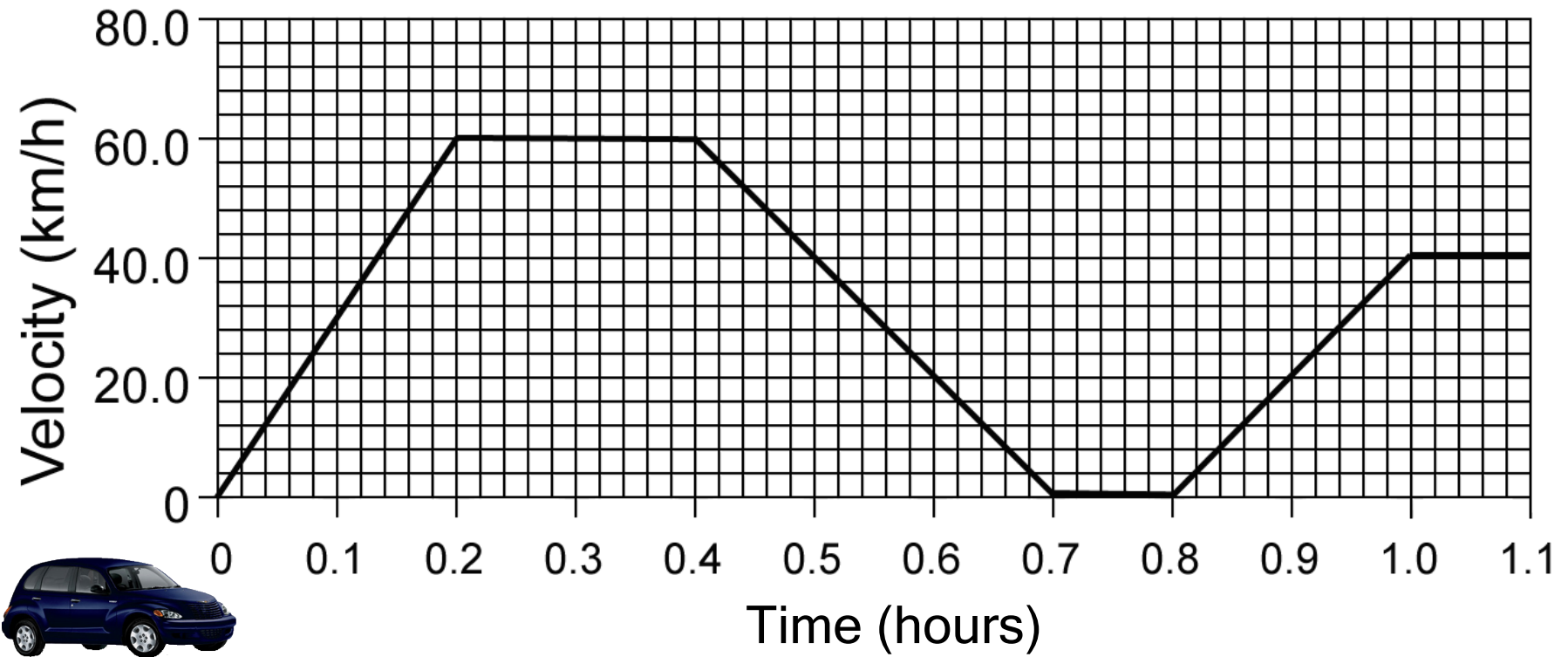
\_\_\_\_\_



**60.0 km/h**

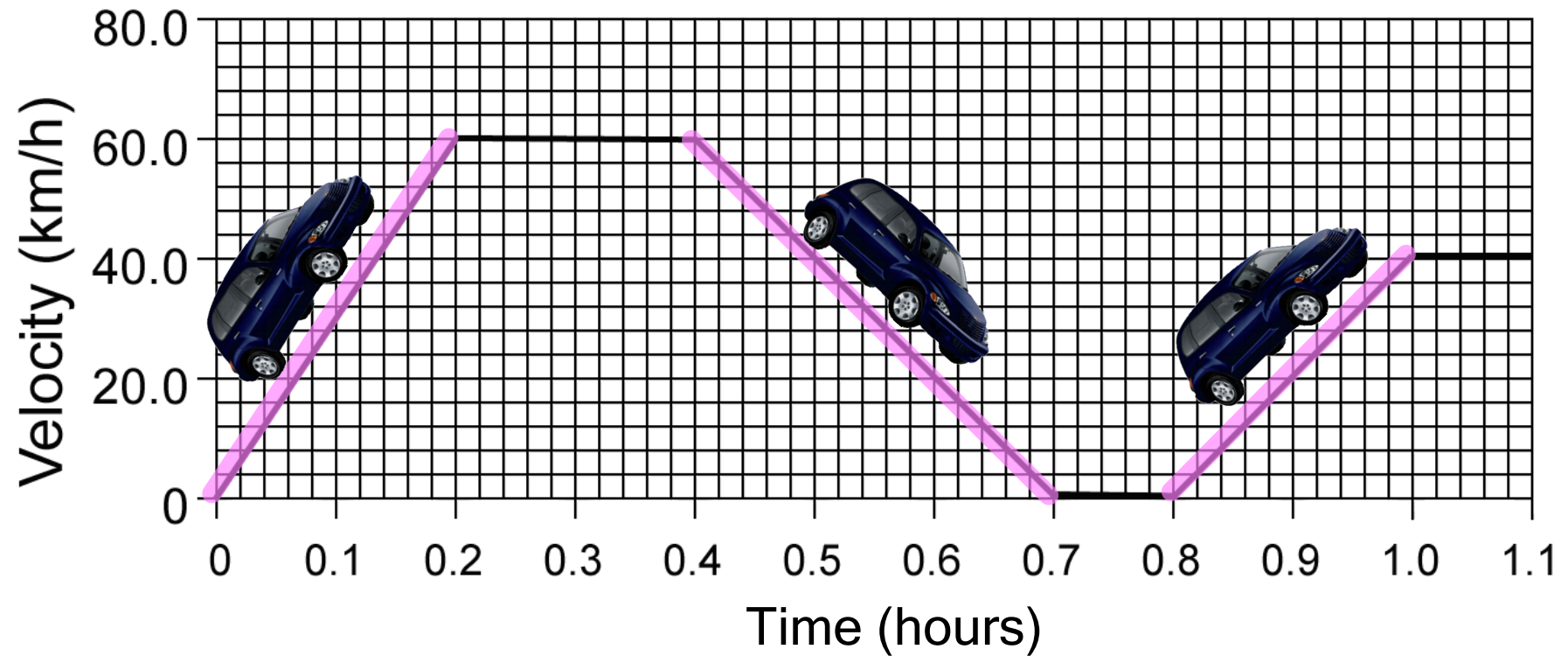
c. What was the greatest velocity? ★

**We use the vertical axis, which measures velocity to find that the greatest velocity was 60.0 km/hr.**



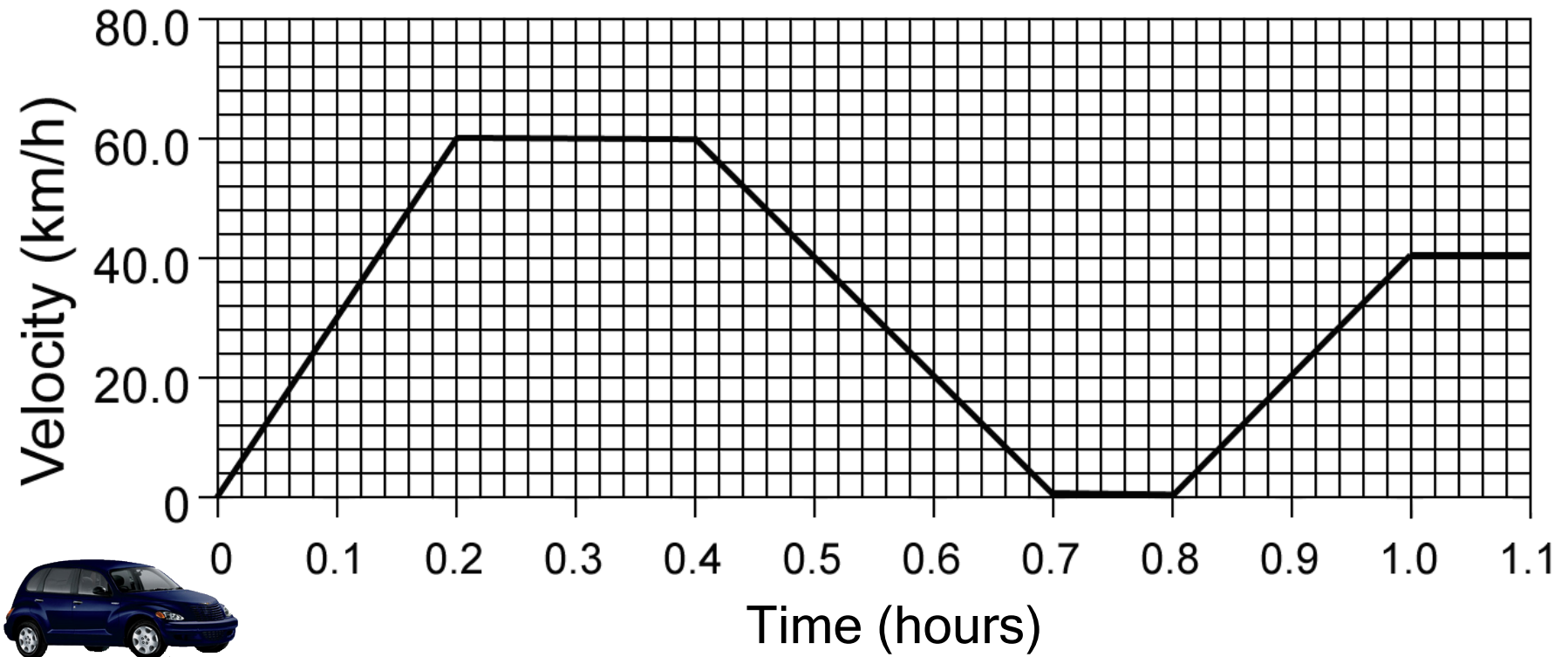
\_\_\_\_\_ d. At what time(s) was the car accelerating?



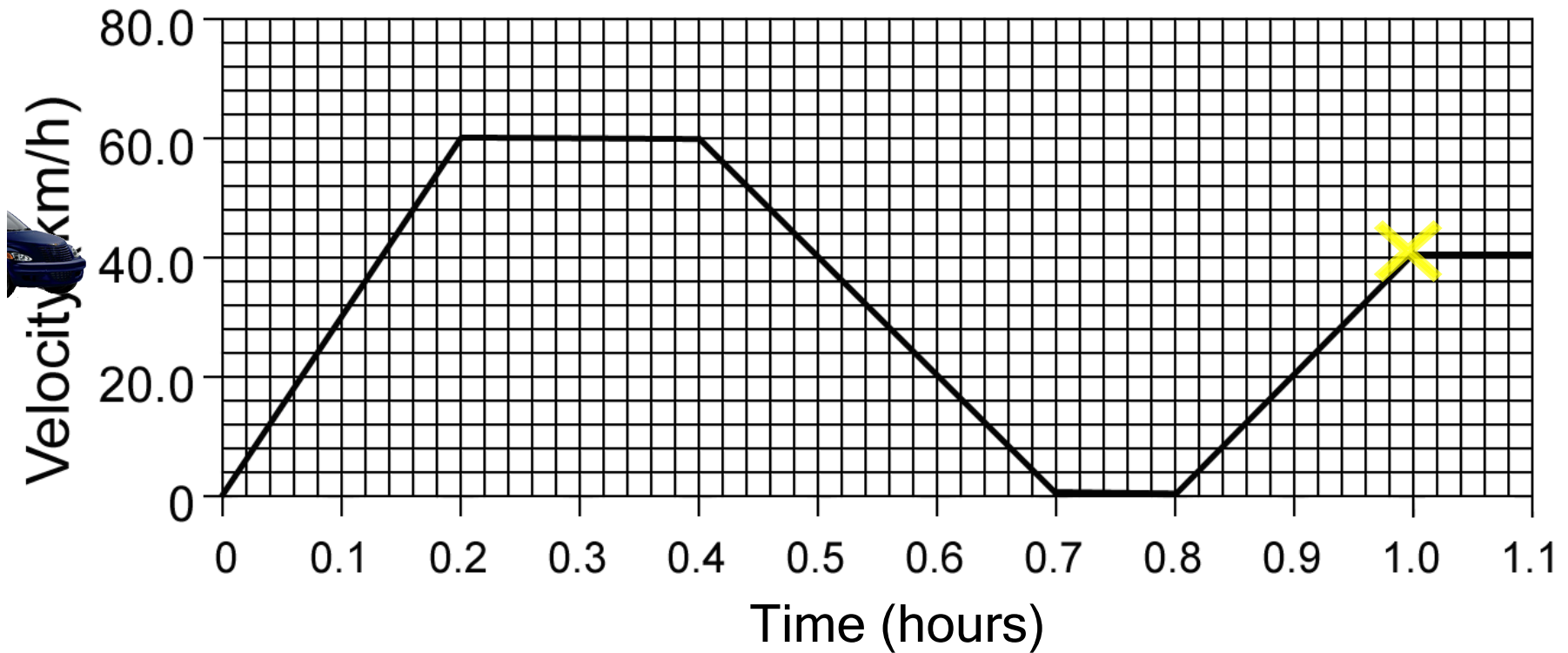


0-0.2h, 0.4-0.7h, 0.8-1.0h d. At what time(s) was the car accelerating? ★

- Acceleration means change in velocity, so we look to the graph to find where the slope does not equal zero.
- Remember, in physics class, acceleration can mean both positive acceleration, or negative acceleration (deceleration), so we also must count the interval of 0.4-0.7 hours.



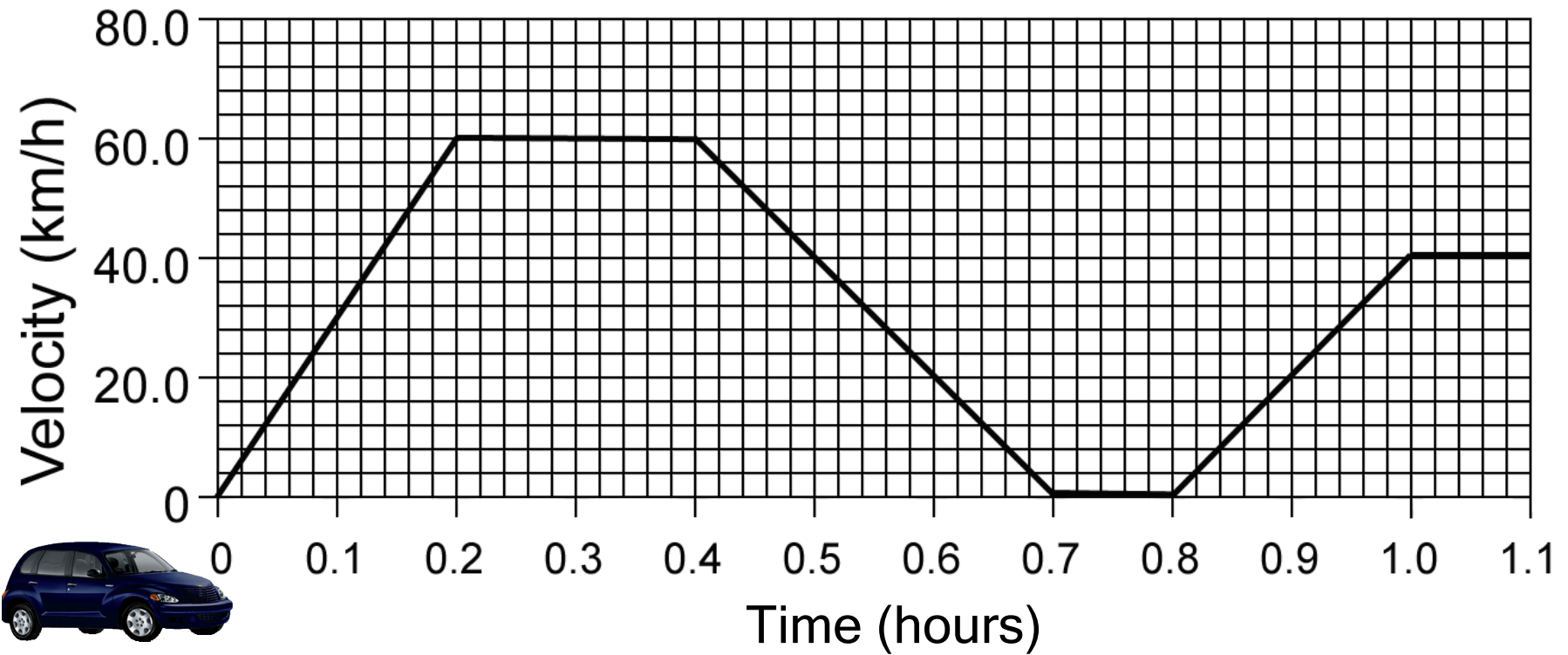
\_\_\_\_\_ e. How fast was the car going at 1.0h?



**40.0 km/h**

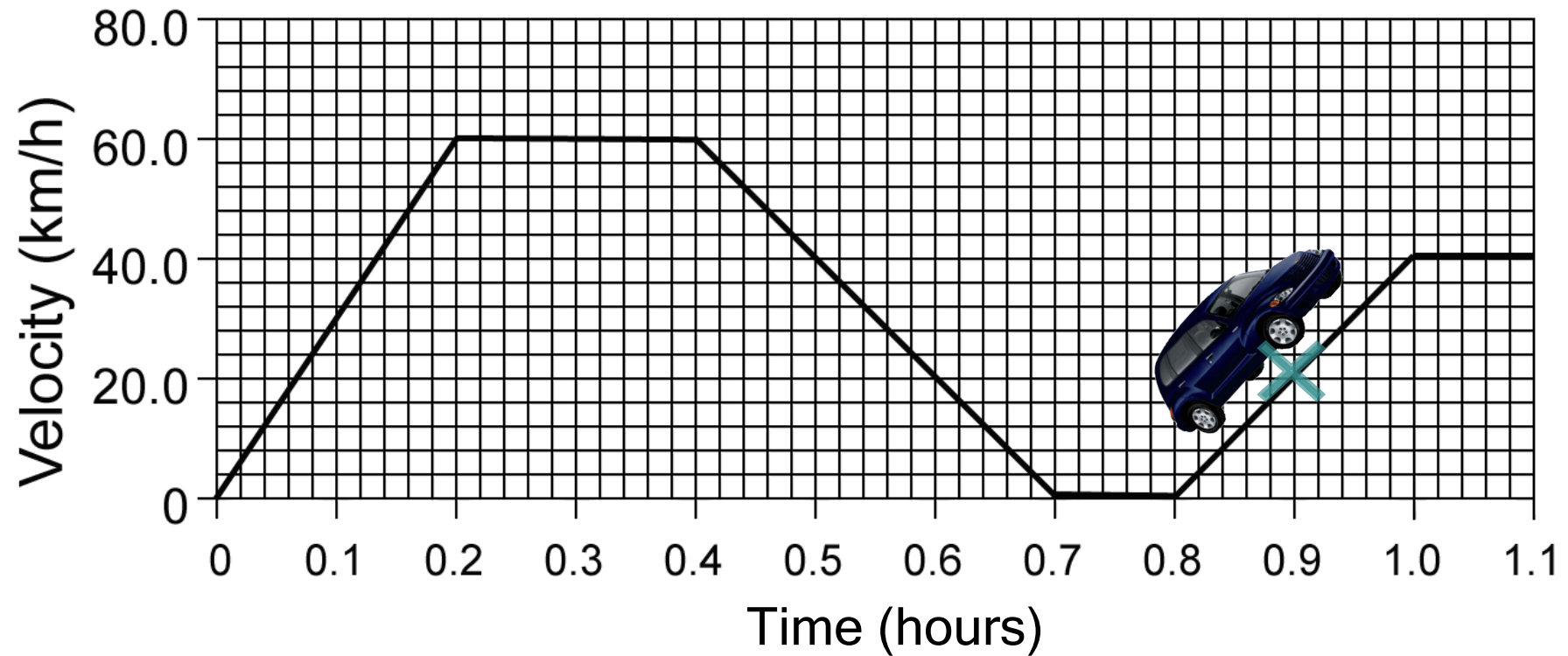
**e. How fast was the car going at 1.0h? ★**

**We look at the horizontal axis to find to find time = 1.0 hour.  
We then move up the graph find the velocity at 1.0 hour. Using  
the vertical axis, we see that at time 1 hour, the velocity is 40.0  
km/h.**



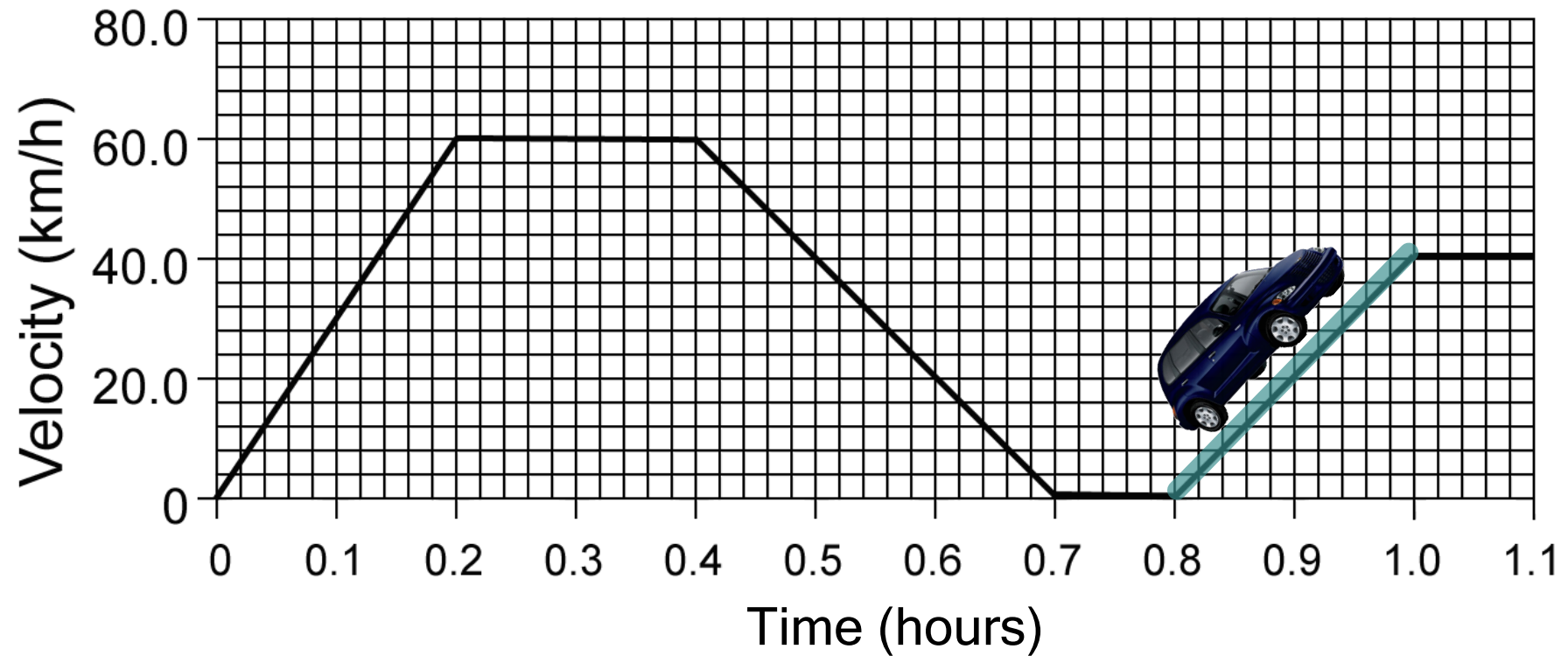
f. What is the acceleration at 0.9 h?

\_\_\_\_\_



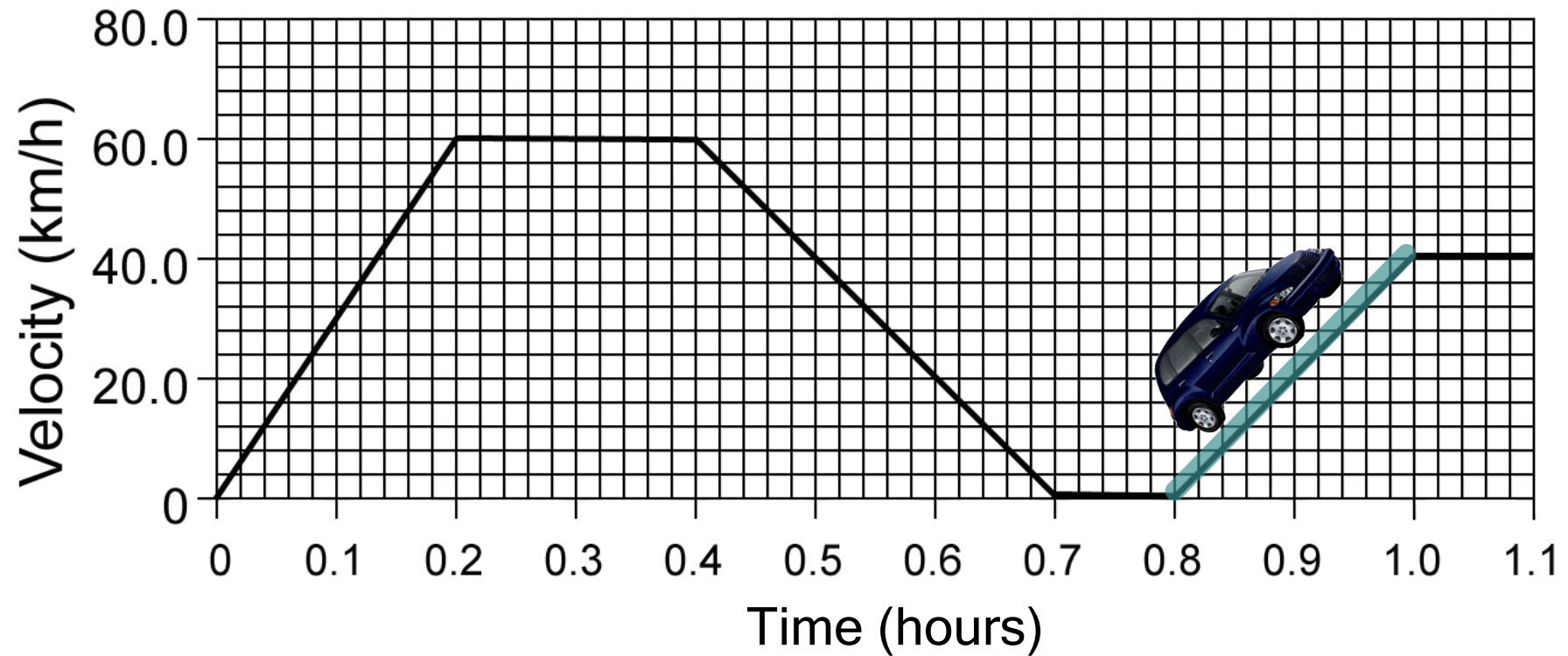
\_\_\_\_\_ f. What is the acceleration at 0.9 h? ★

- To find the acceleration, we need to calculate the slope of the line at time = 0.9h. The slope tell us how the velocity is changing. Change in velocity = ACCELERATION!



\_\_\_\_\_ f. What is the acceleration at 0.9 h? ★

- Since the slope is constant from 0.8-1.0h (as shown by the green line), we use this as our range for time. During this interval, velocity changes from 0-40.0 km/h.
- Then we just use the equation for slope, which in this case is the equation for finding acceleration:  $\text{Slope} = (y_2 - y_1) / (x_2 - x_1)$ .
- And so acceleration =  $(v_2 - v_1) / (t_2 - t_1)$



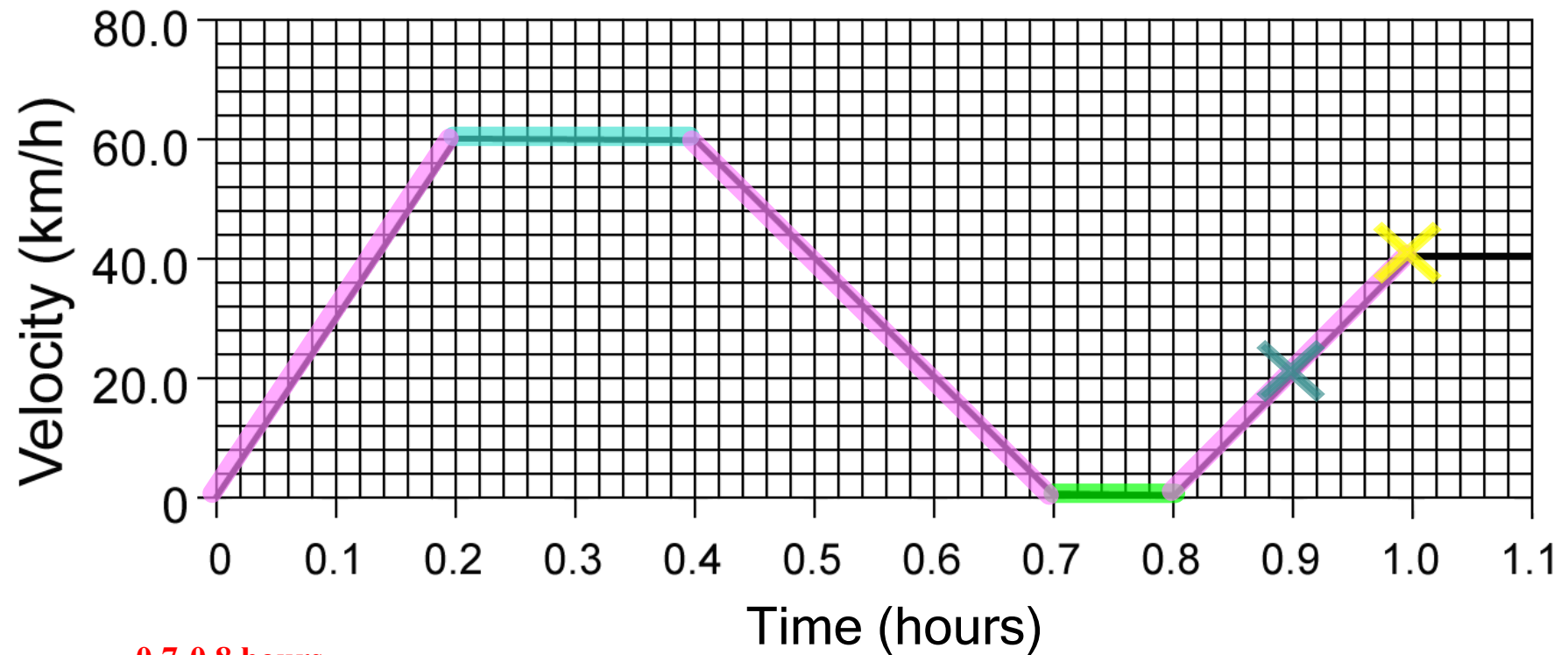
**200 km/h<sup>2</sup>**

**f. What is the acceleration at 0.9 h? ★**

- Now we just plug our numbers into our equation:  $A = (v_2 - v_1)/(t_2 - t_1)$

$$A = (v_2 - v_1)/(t_2 - t_1) = (40.0 \text{ km/h} - 0 \text{ km/h})/(1.0 \text{ h} - 0.8 \text{ h})$$

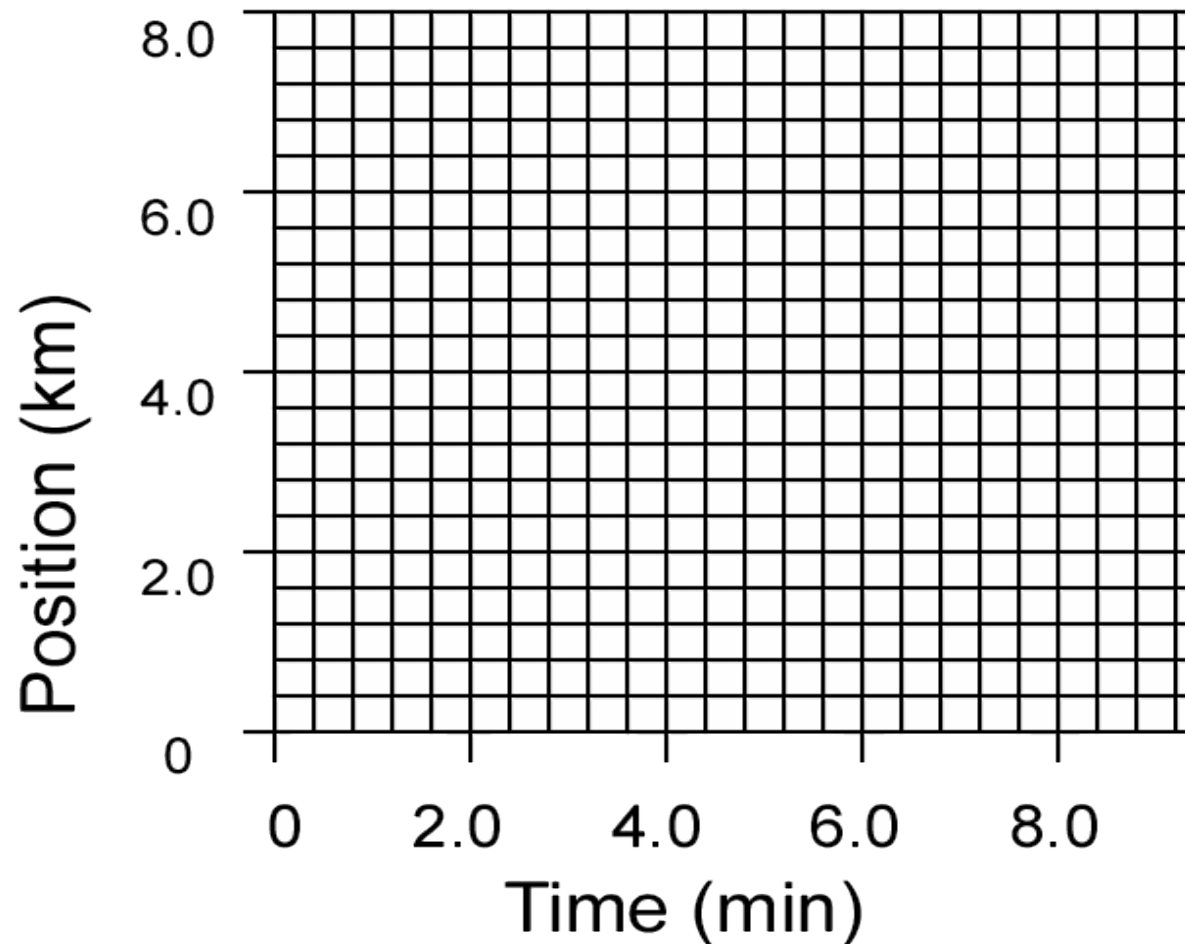
$$= (40.0 \text{ km/h})/(0.2 \text{ h}) = 200 \text{ km/h}^2$$



- 0.7-0.8 hours a. At what time was the car stopped? ★
- 0.2-0.4 hours b. At what time did the car have the greatest velocity? ★
- 60 km/h c. What was the greatest velocity? ★
- 0-0.2h, 0.4-0.7h, 0.8-1.0h d. At what time(s) was the car accelerating? ★
- 40 km/h e. How fast was the car going at 1.0h? ★
- 200 km/h<sup>2</sup> f. What is the acceleration at 0.9 hr? ★

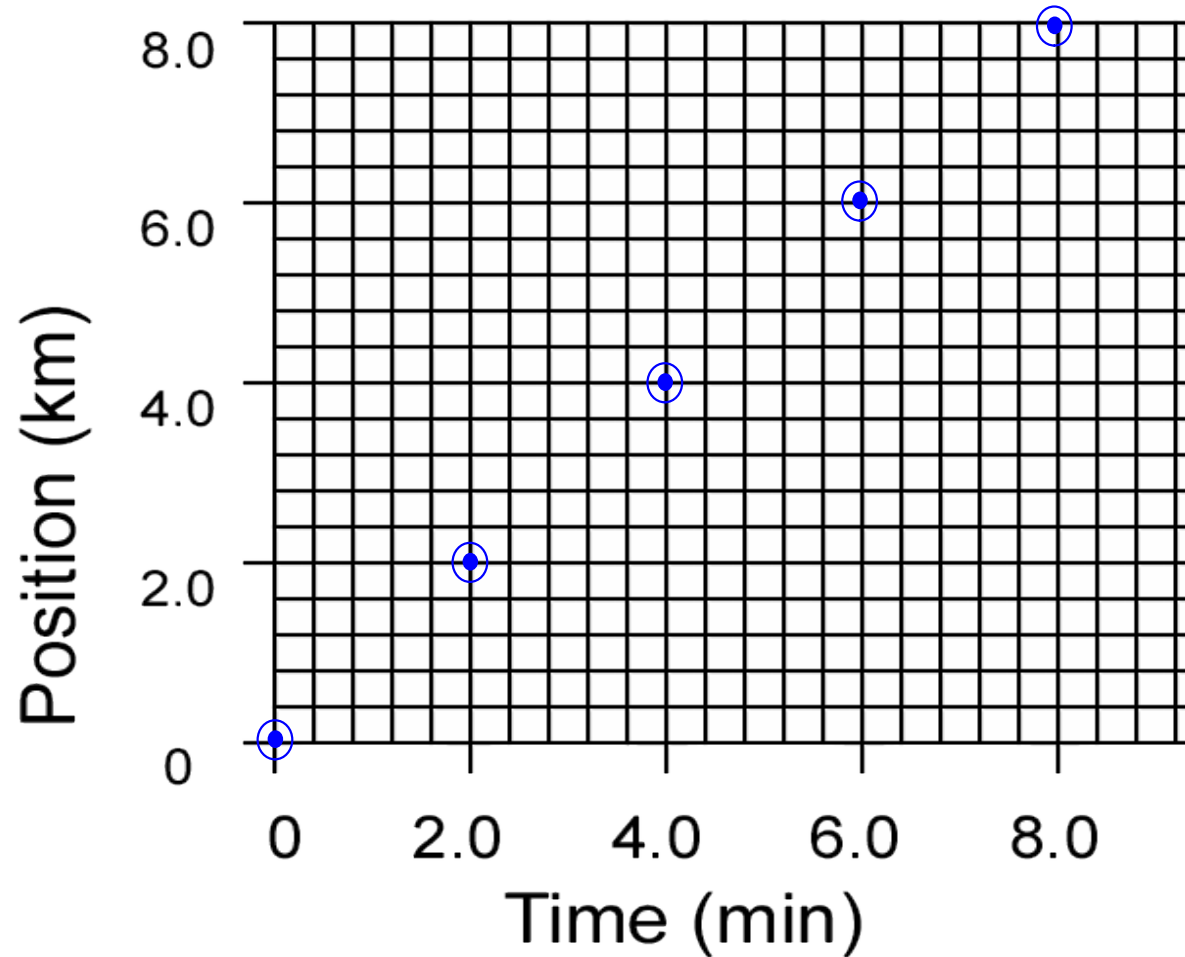


2. The following table shows the positions of two cars at the times indicated. Graph the data for each car on one set of axis and compute the velocity of each car.



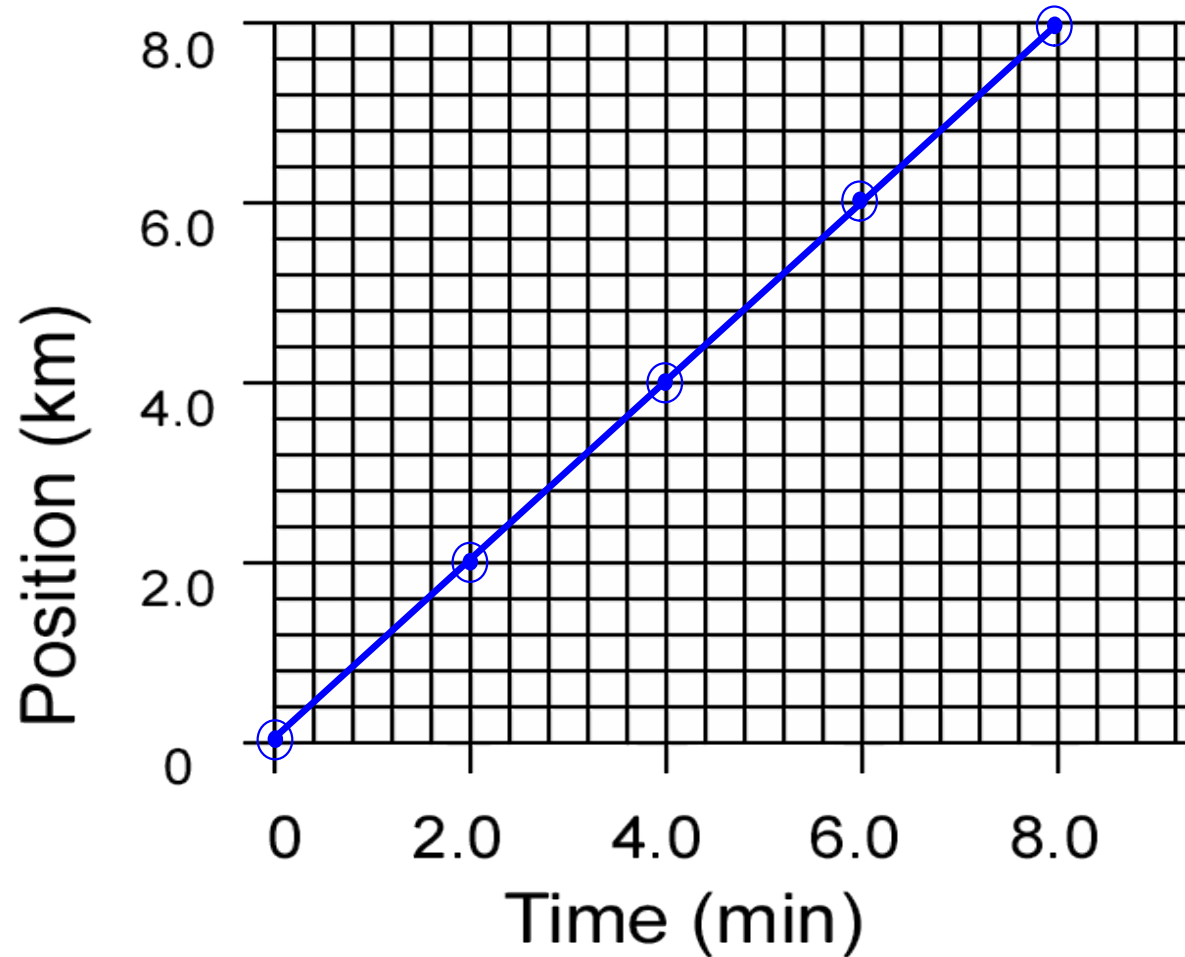
TIME (min)	Position	
	<u>CAR A (km)</u>	<u>CAR B (km)</u>
0	0	2
2	2	3.5
4	4	5
6	6	6.5
8	8	8

2. The following table shows the positions of two cars at the times indicated. Graph the data for each car on one set of axis and compute the velocity of each car.



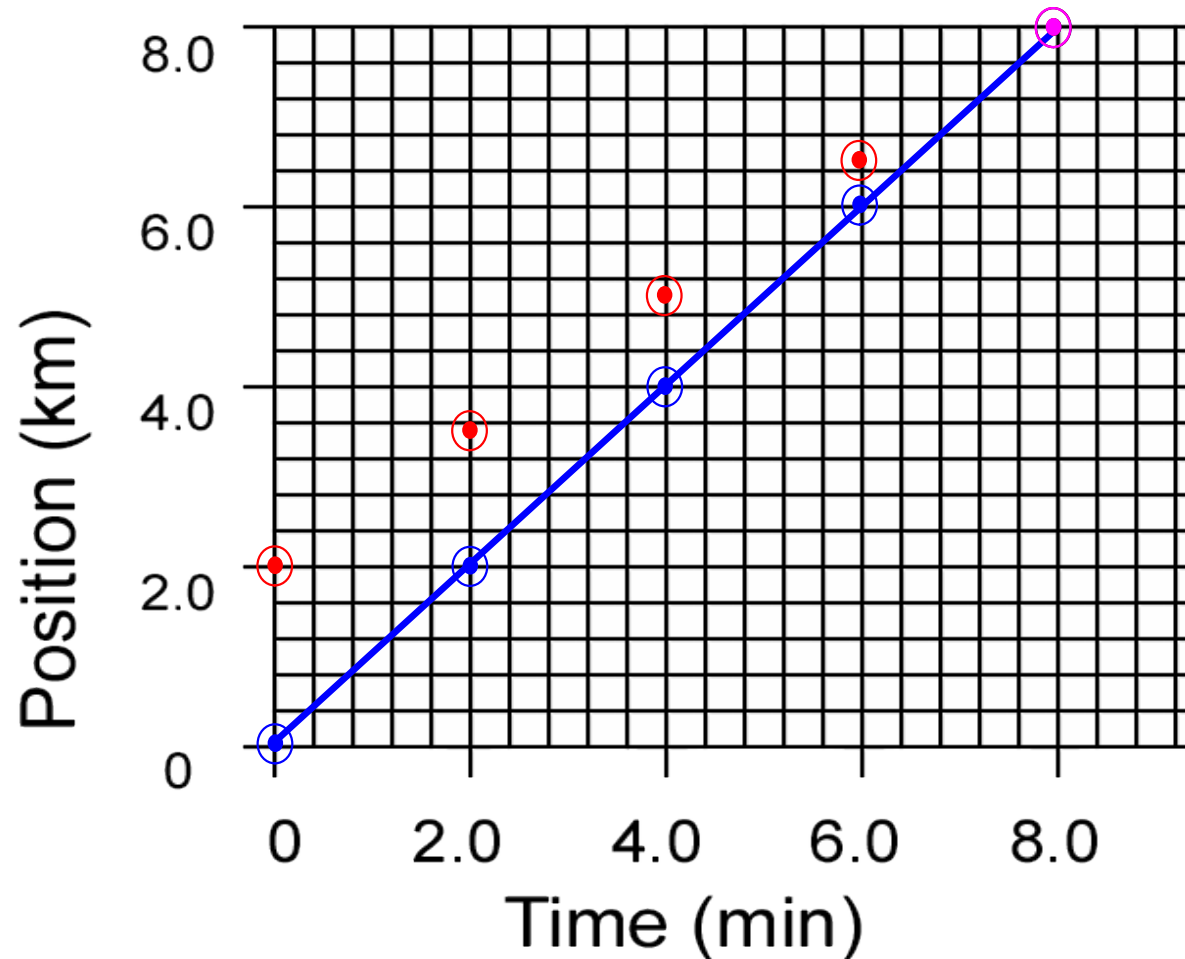
TIME (min)	Position	
	CAR A (km)	CAR B (km)
0	0	2
2	2	3.5
4	4	5
6	6	6.5
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2. The following table shows the positions of two cars at the times indicated. Graph the data for each car on one set of axis and compute the velocity of each car.



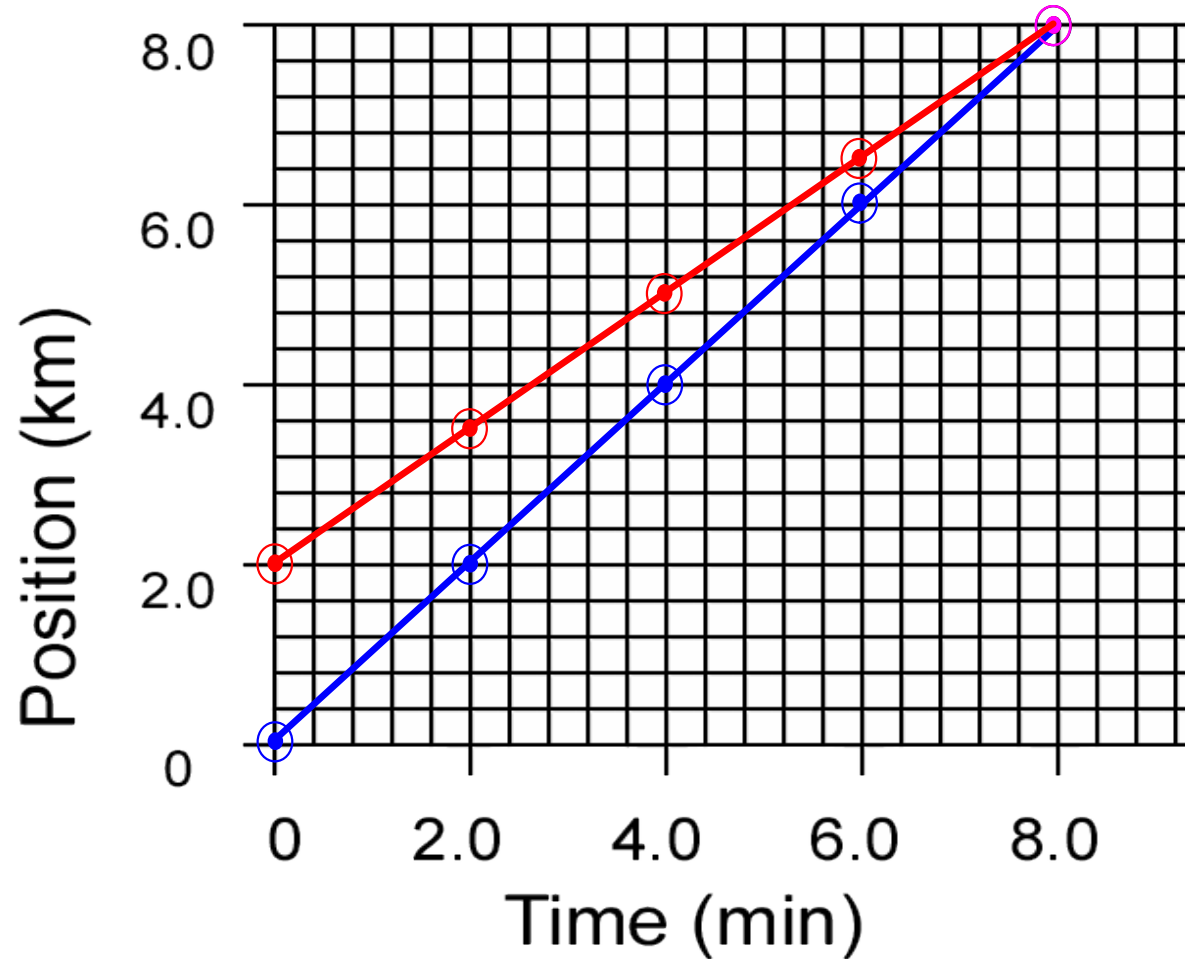
TIME (min)	Position	
	CAR A (km)	CAR B (km)
0	0	2
2	2	3.5
4	4	5
6	6	6.5
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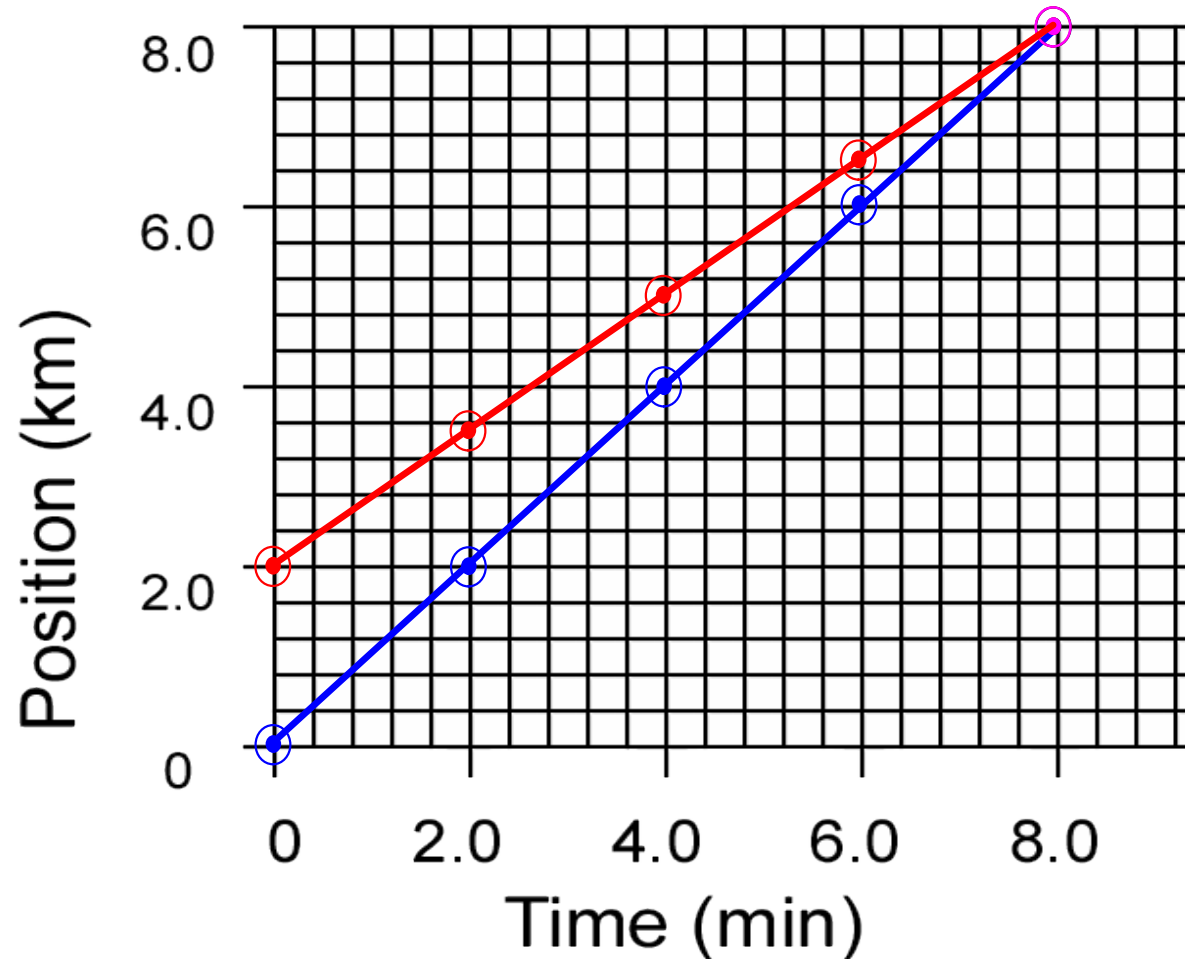
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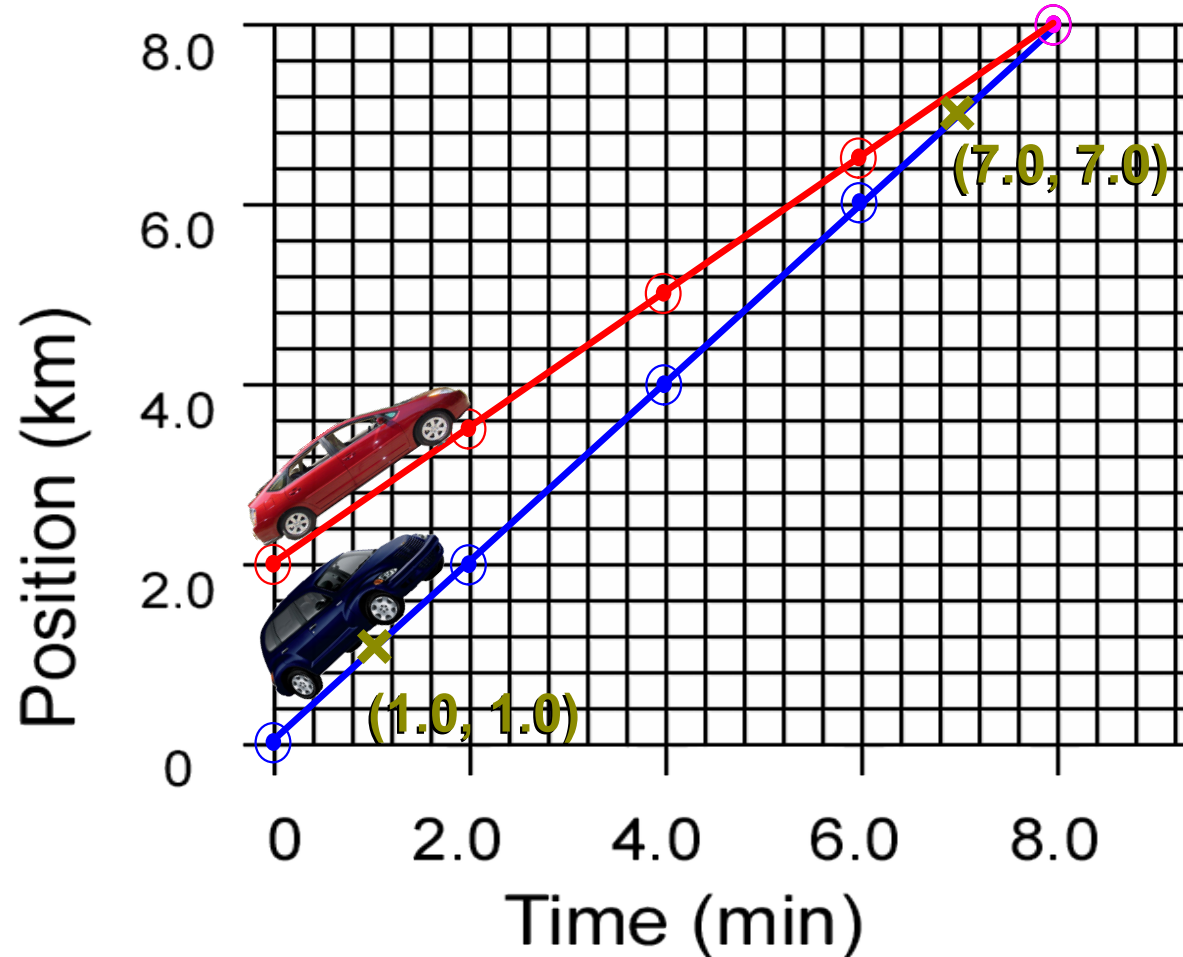
TIME (min)	Position	
	CAR A (km)	CAR B (km)
0	0	2
2	2	3.5
4	4	5
6	6	6.5
8	8	8

2. The following table shows the positions of two cars at the times indicated. Graph the data for each car on one set of axis and compute the velocity of each car.



Velocity for each car will just be equal to the slope of the line for position vs. time for each car.

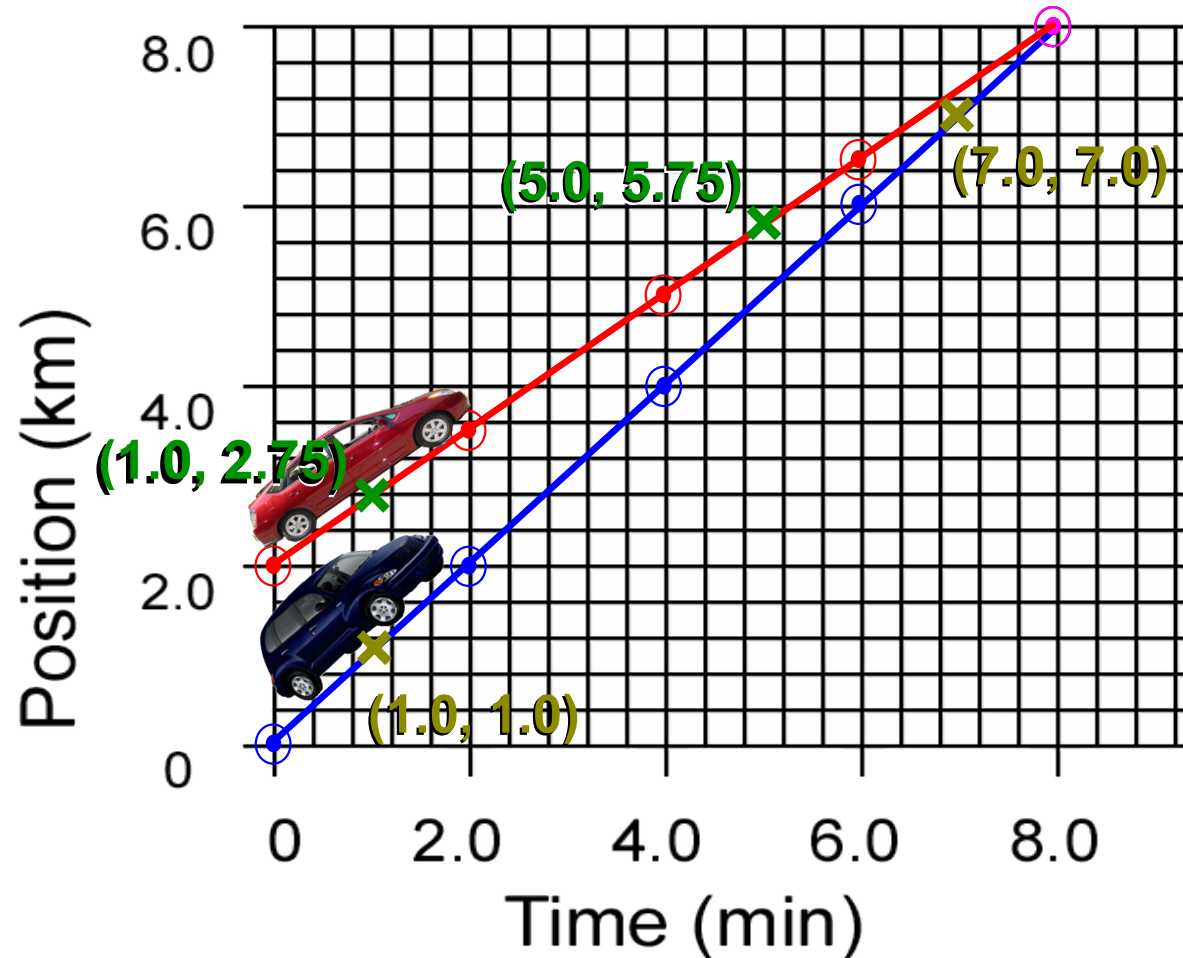
2. The following table shows the positions of two cars at the times indicated. Graph the data for each car on one set of axis and compute the velocity of each car.



**CAR A:**

$$V = \frac{(7.0 \text{ km} - 1 \text{ km})}{(7.0 \text{ min} - 1 \text{ min})}$$
$$V = \frac{6.0 \text{ km}}{6.0 \text{ min}}$$
$$V = 1.0 \text{ km/min}$$

2. The following table shows the positions of two cars at the times indicated. Graph the data for each car on one set of axis and compute the velocity of each car.



**CAR A:**

$$V = \frac{(7.0 \text{ km} - 1 \text{ km})}{(7.0 \text{ min} - 1 \text{ min})}$$

$$V = \frac{6.0 \text{ km}}{6.0 \text{ min}}$$

$$V = 1.0 \text{ km/min}$$

**CAR B:**

$$V = \frac{(5.75 \text{ km} - 2.75 \text{ km})}{(5.0 \text{ min} - 1 \text{ min})}$$

$$V = \frac{3.0 \text{ km}}{4.0 \text{ min}}$$

$$V = 0.75 \text{ km/min}$$



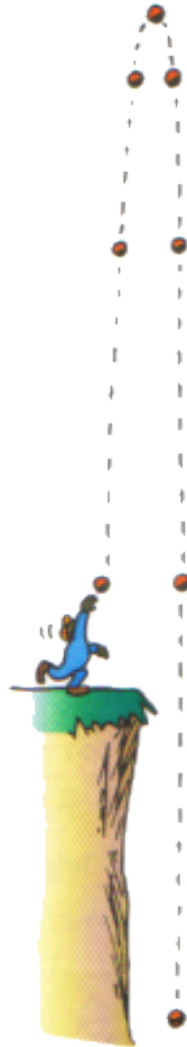
Part II: accelerated motion

3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)



Part II: accelerated motion

3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)



**Before we create our graph, let's look at how gravity affects the motion of the ball.**

**Gravity =  $9.8 \text{ m/s}^2$  down,**

**but we'll approximate gravity as:**

**$g = 10 \text{ m/s}^2$  down.**

**Let's also say that the ball has an initial velocity of  $30 \text{ m/s}$  up.**

Part II: accelerated motion

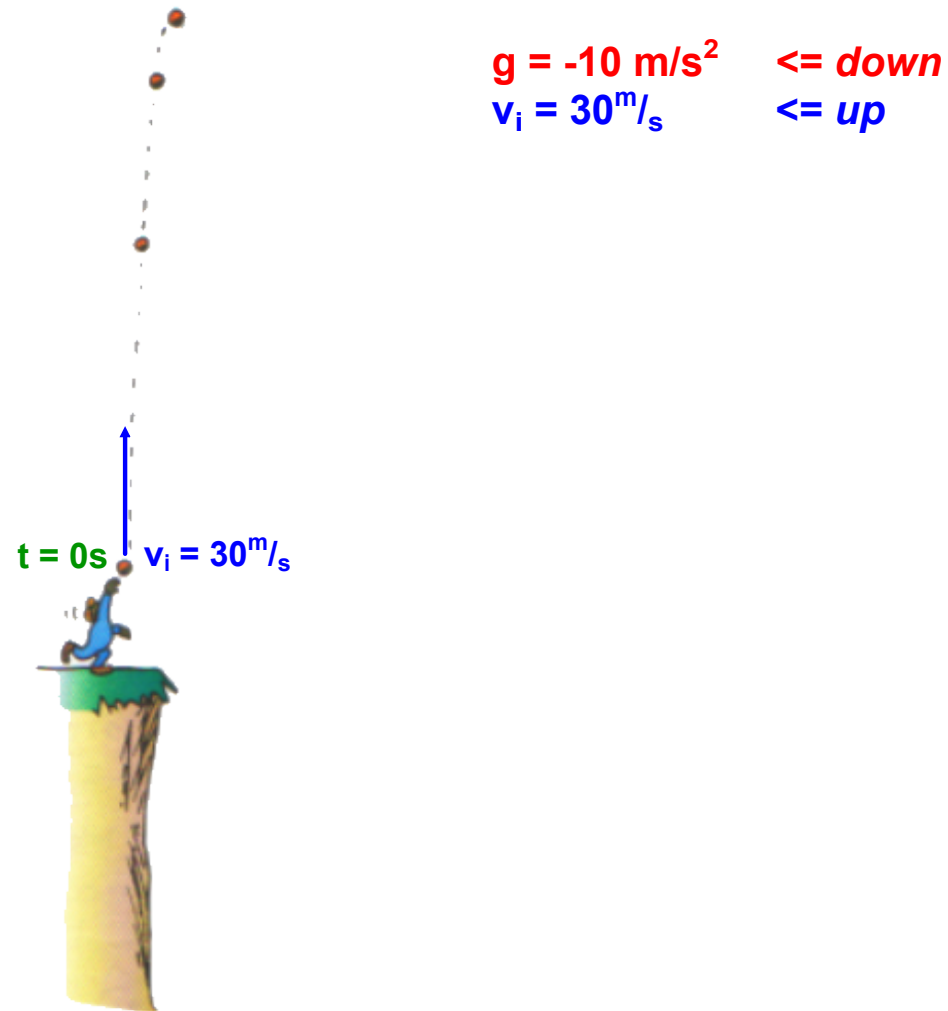
3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)



$$g = -10 \text{ m/s}^2 \quad \leq \text{down}$$
$$v_i = 30 \text{ m/s} \quad \leq \text{up}$$

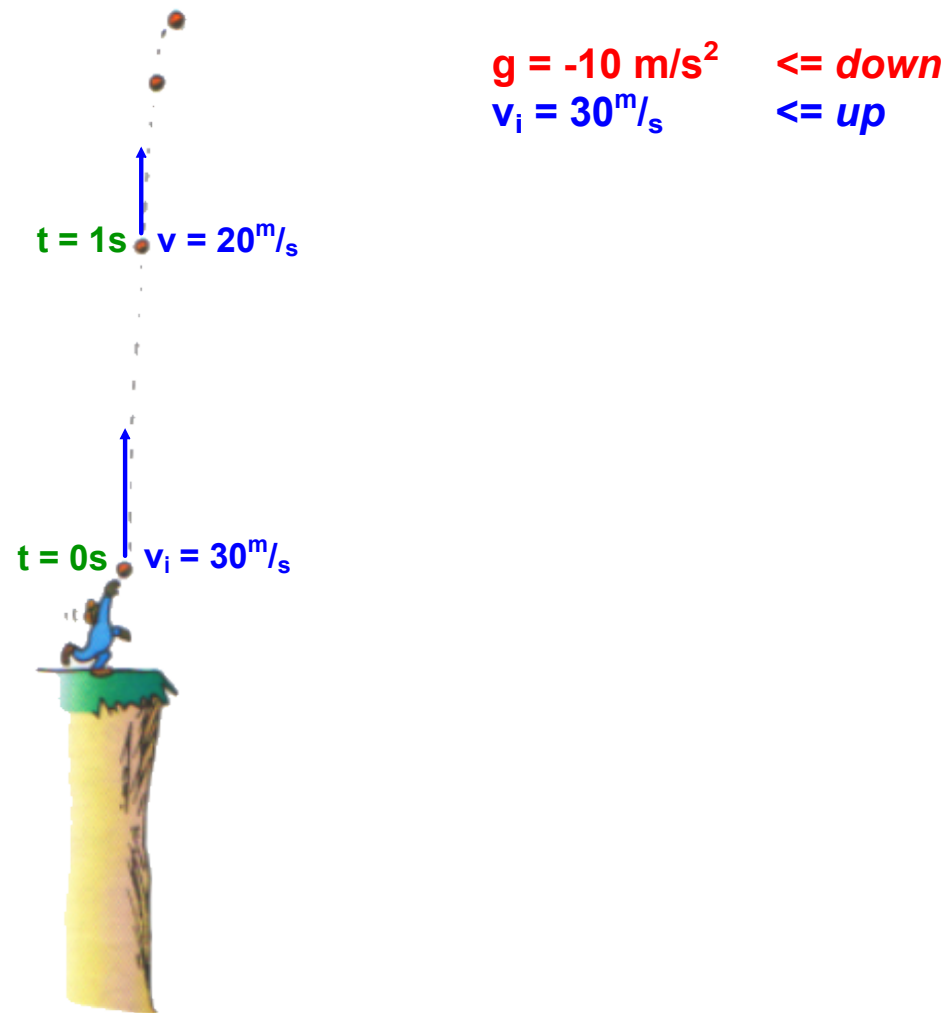
Part II: accelerated motion

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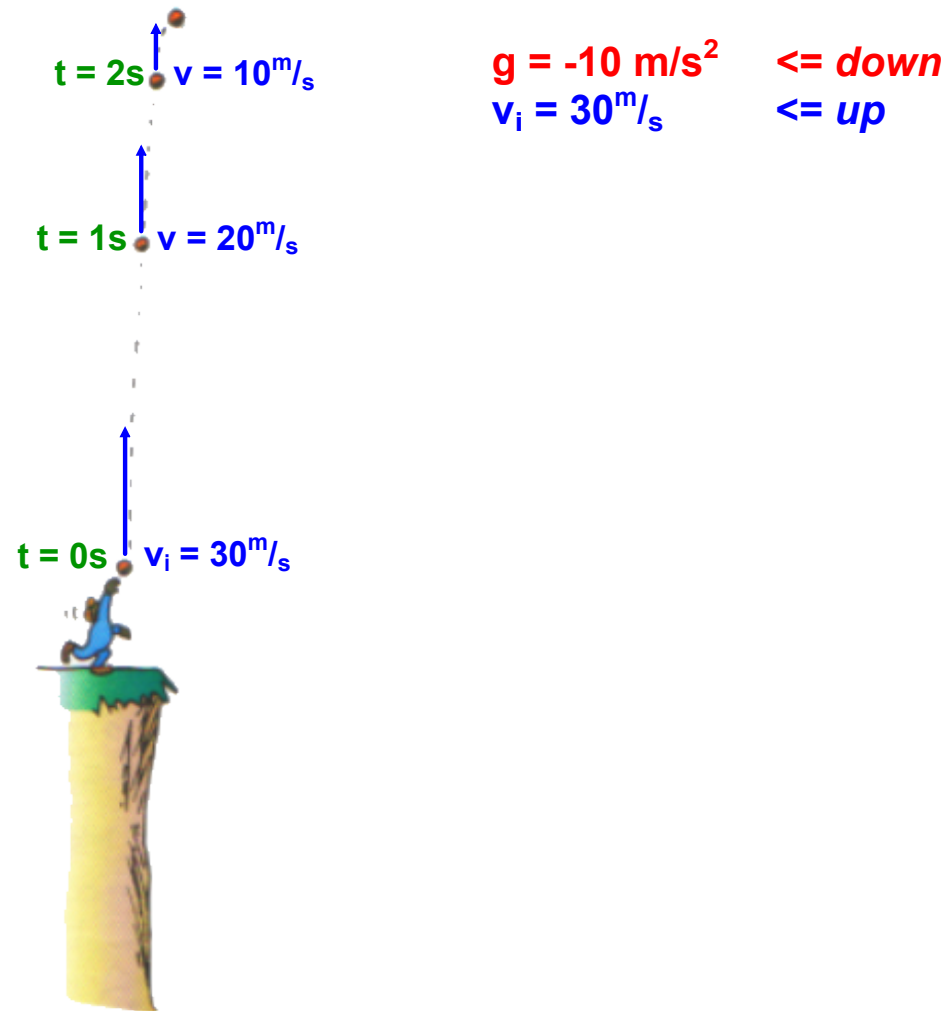
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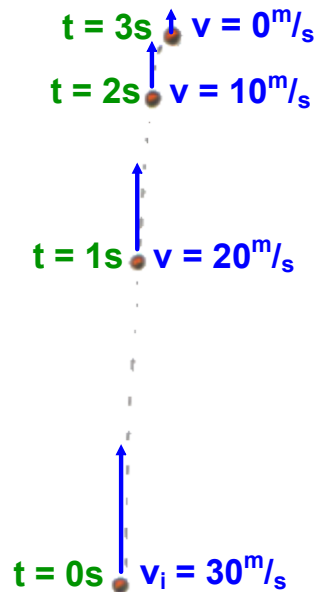
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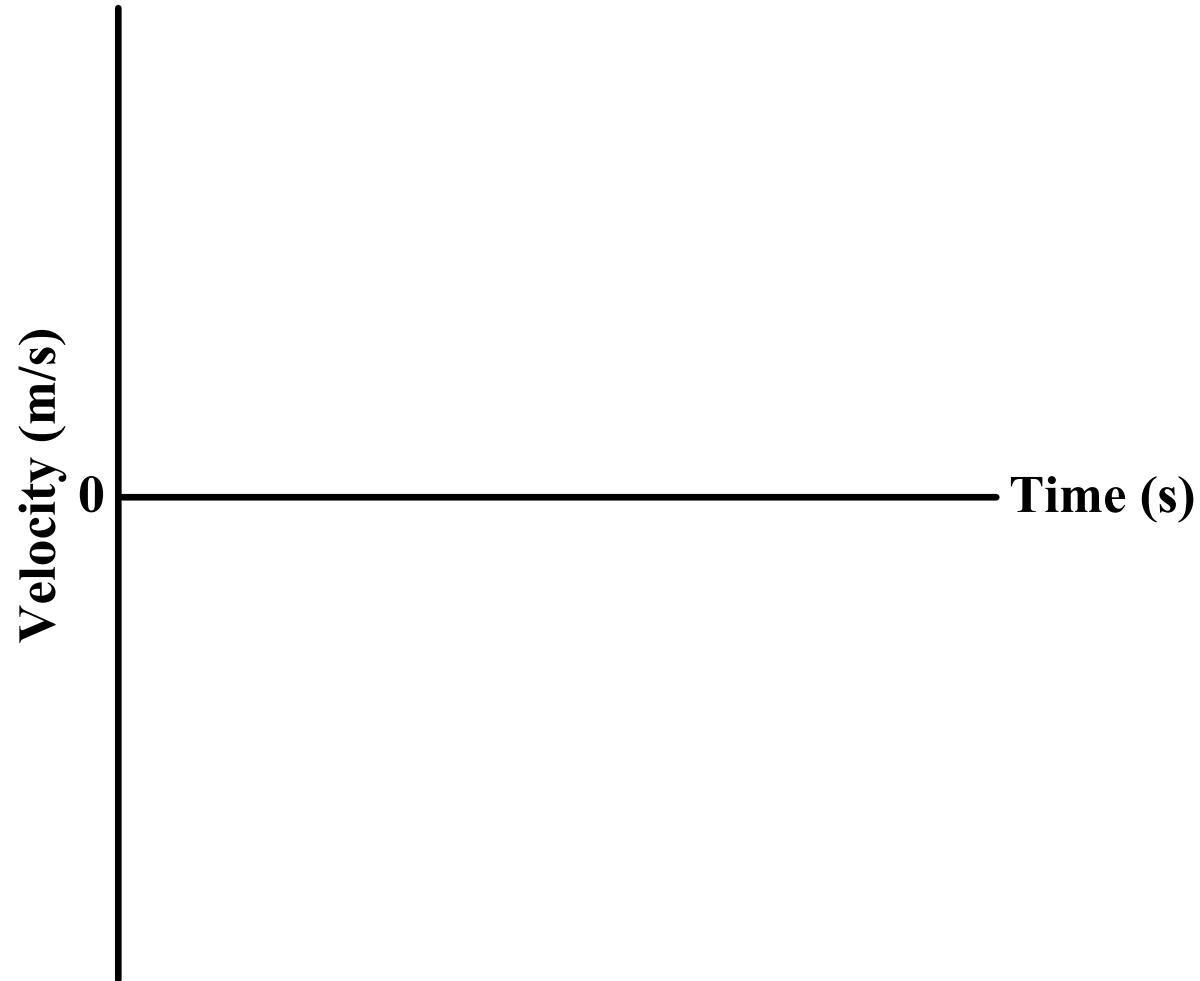


$$g = -10 \text{ m/s}^2 \quad \leq \text{down}$$
$$v_i = 30\text{ m/s} \quad \leq \text{up}$$

Let's start our graph, then we will look at the ball's trip *down*.

Part II: accelerated motion

3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)

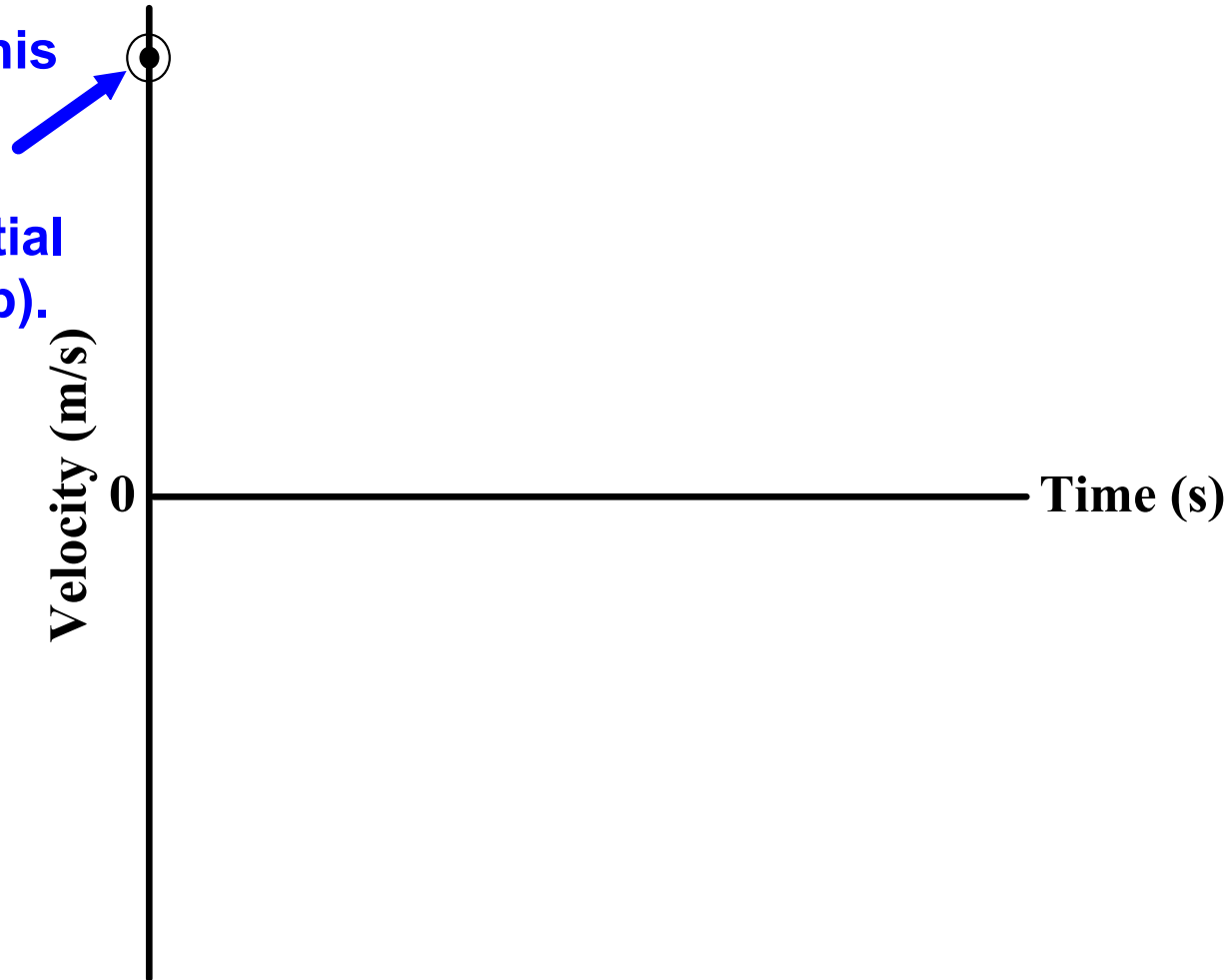




Part II: accelerated motion

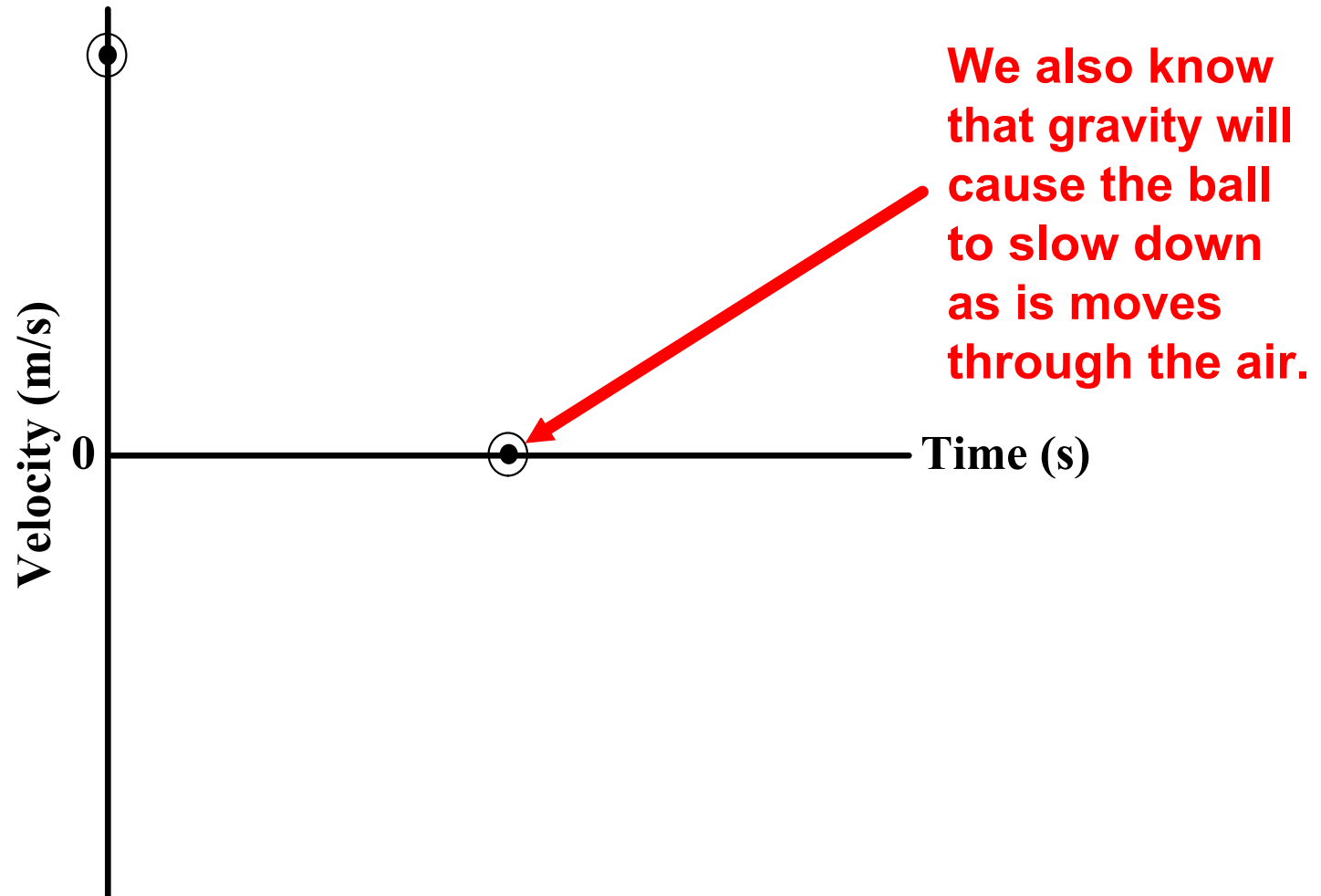
3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)

**We know this ball starts with some positive initial velocity (up).**



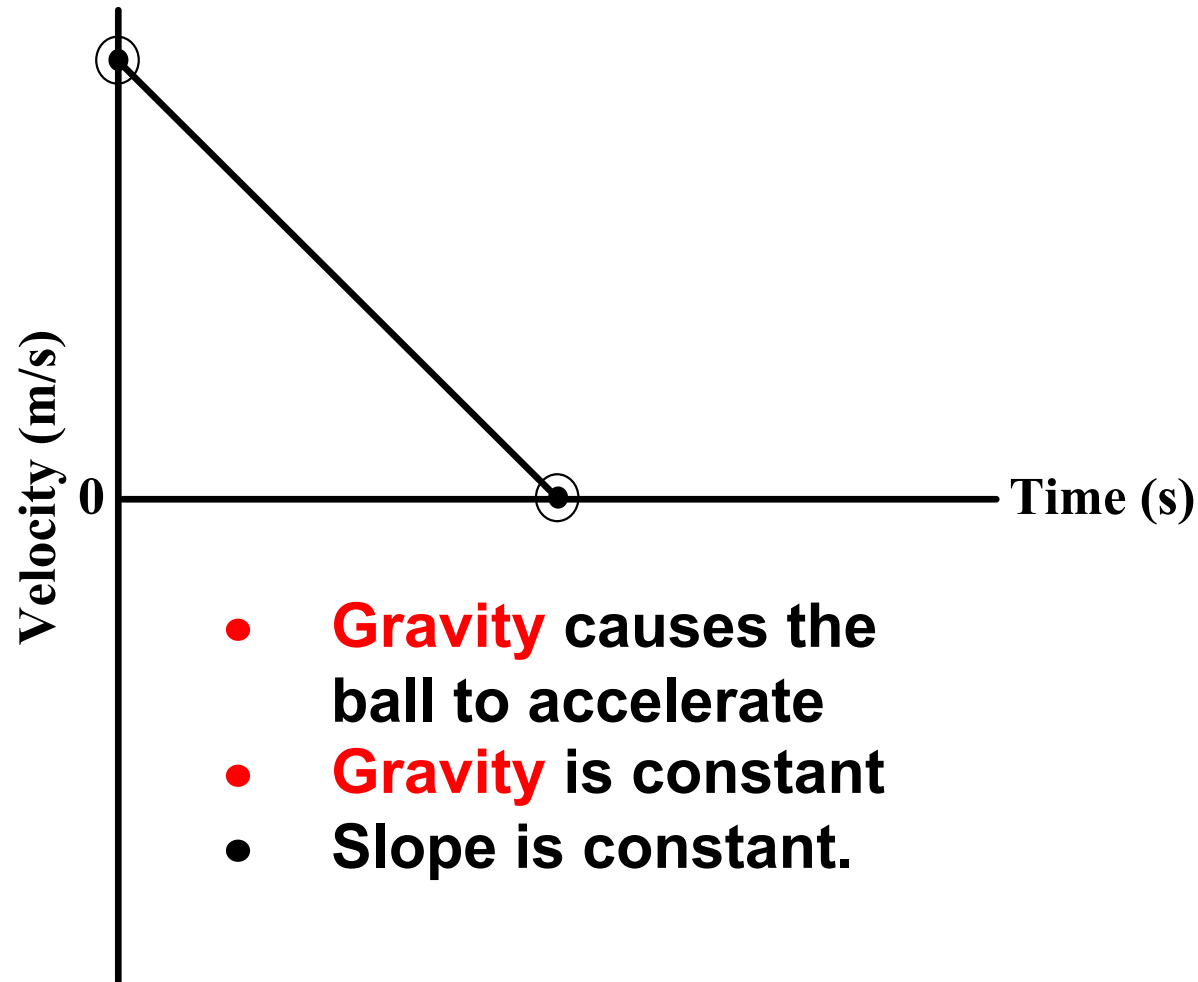
## Part II: accelerated motion

3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)



## Part II: accelerated motion

3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)



Part II: accelerated motion

3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)

$t = 3\text{s}$   $\uparrow$   $v_i = 0\text{ m/s}$

$g = -10\text{ m/s}^2$   $\leq$  *down*  
 $v_i = 0\text{ m/s}$



**Now let's look at the  
ball's trip down.**

Part II: accelerated motion

3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)

$t = 3\text{s}$   $\uparrow$   $v_i = 0\text{ m/s}$

$t = 4\text{s}$   $\downarrow$   $v = -10\text{ m/s}$

$g = -10\text{ m/s}^2$   $\Leftarrow$  *down*  
 $v_i = 0\text{ m/s}$



Part II: accelerated motion

3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)

$t = 3s$   $\uparrow$   $v_i = 0\text{ m/s}$

$t = 4s$   $\downarrow$   $v = -10\text{ m/s}$

$t = 5s$   $\downarrow$   $v = -20\text{ m/s}$

$g = -10\text{ m/s}^2$   $\Leftarrow$  *down*  
 $v_i = 0\text{ m/s}$



Part II: accelerated motion

3. Draw a velocity-time graph for a ball that has been thrown straight up into the air and returns to its original position. (neglect air friction)

$t = 3s$   $v_i = 0^m/s$

$t = 4s$   $v = -10^m/s$

$t = 5s$   $v = -20^m/s$

$t = 6s$   $v = -30^m/s$

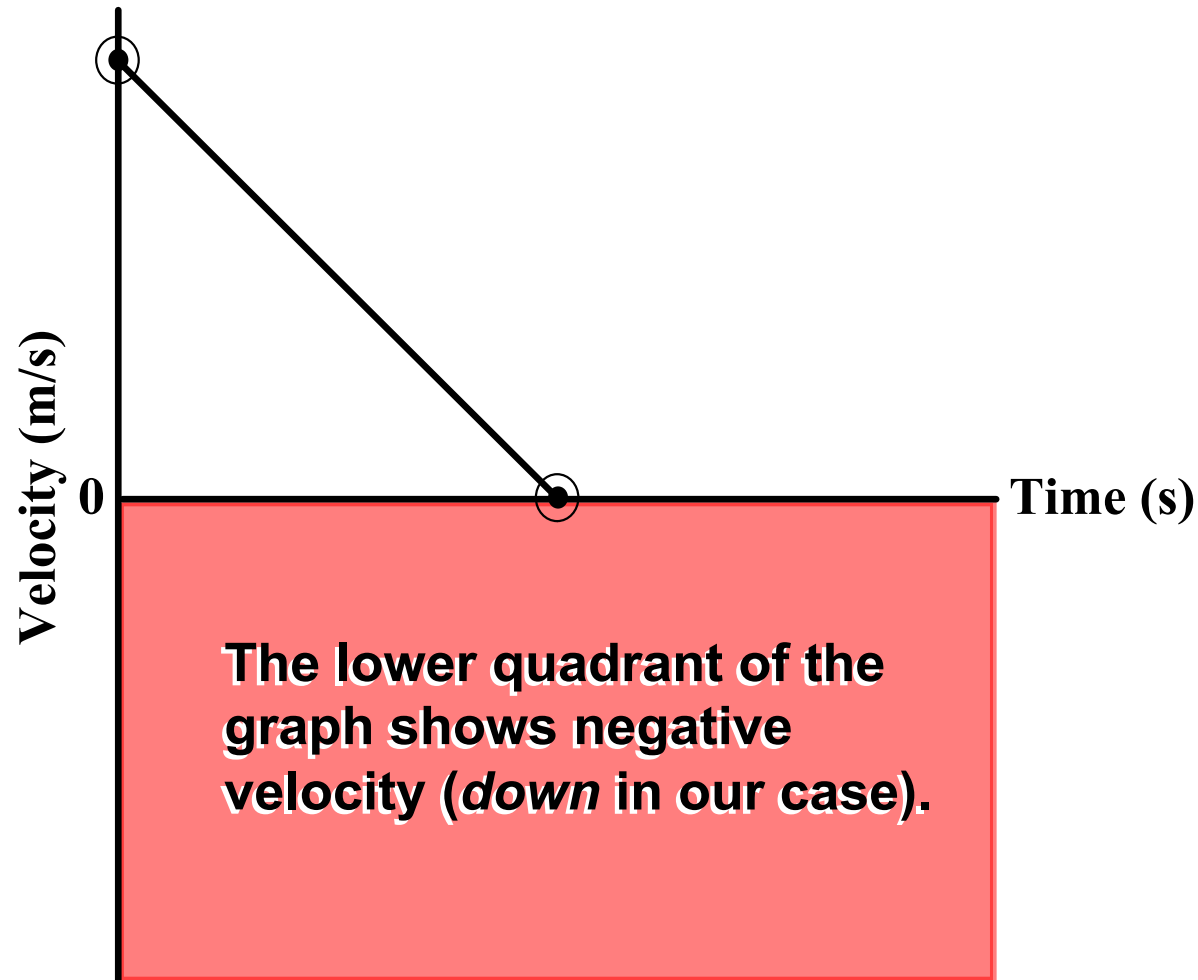
$g = -10 \text{ m/s}^2$   $\leq \text{down}$   
 $v_i = 0^m/s$

Now we are ready to  
finish our graph.



## Part II: accelerated motion

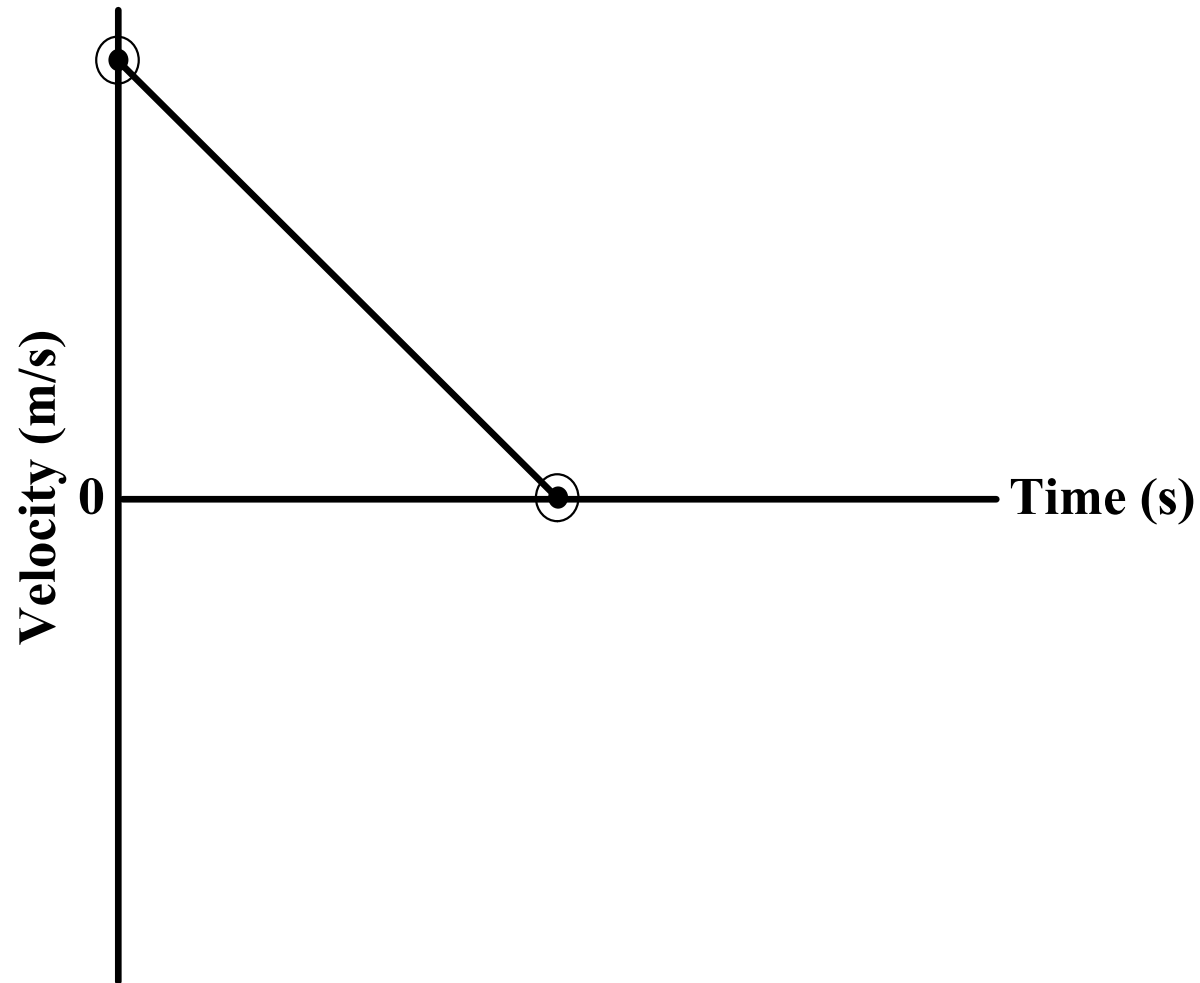
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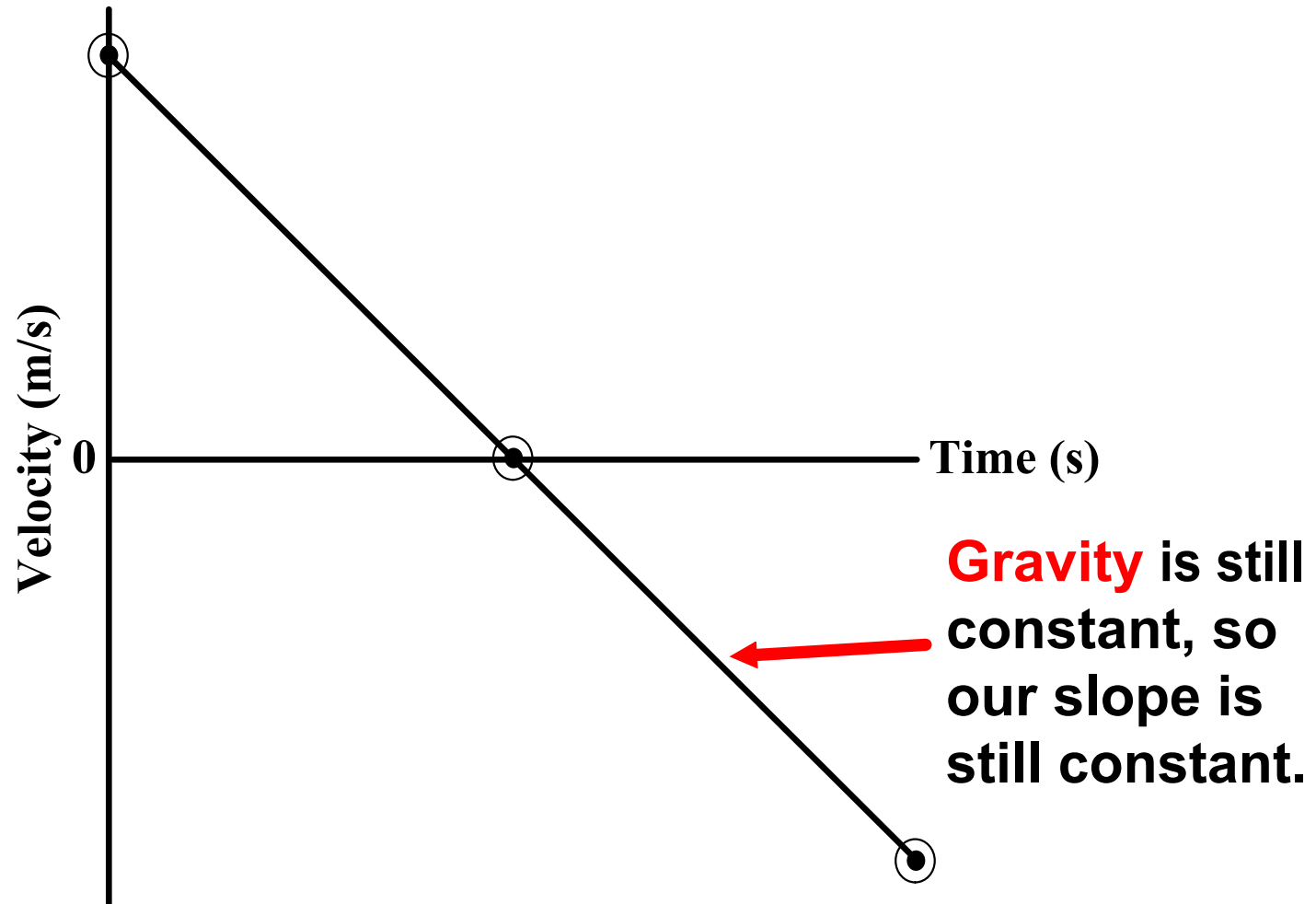
Part II: accelerated motion

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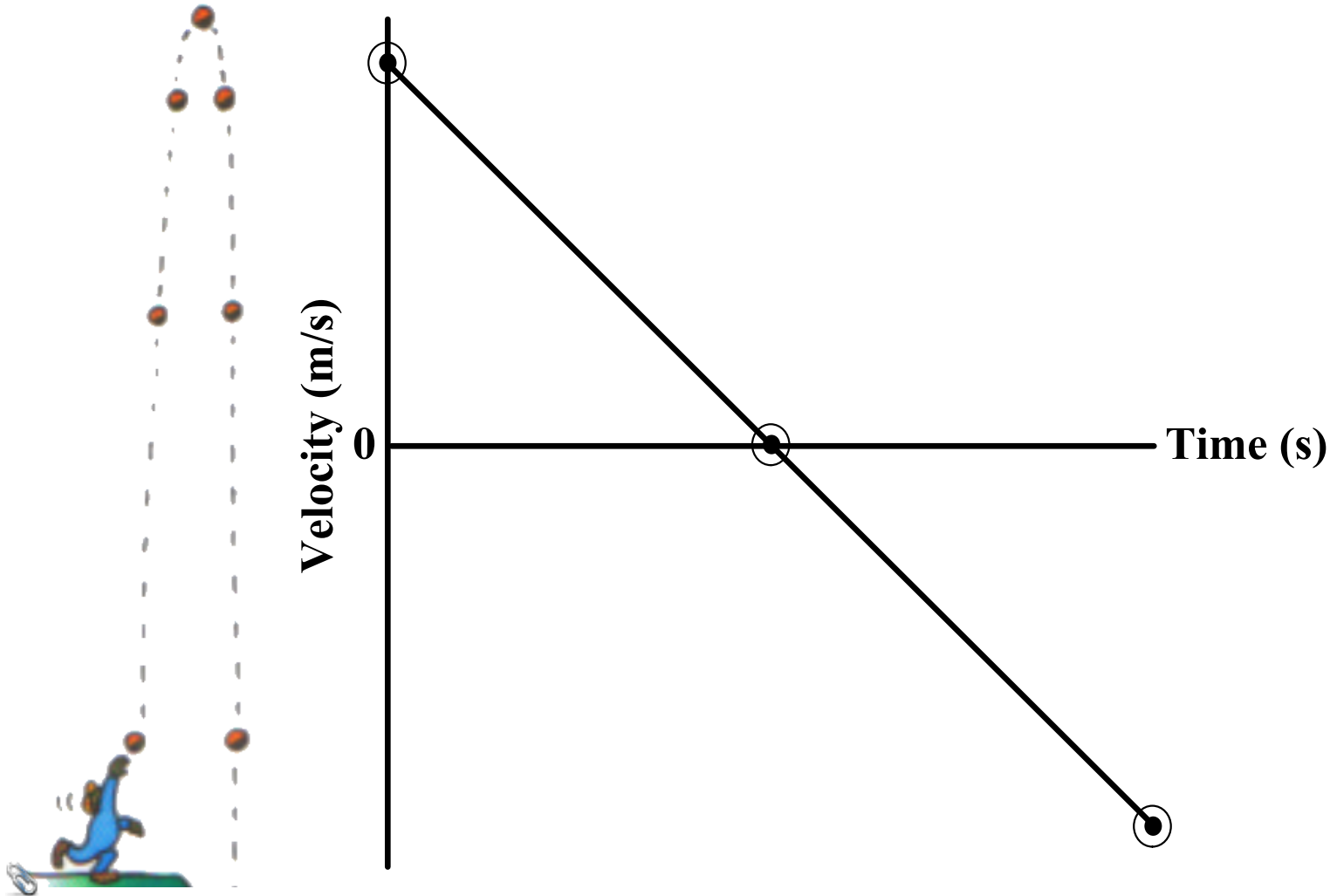
## Part II: accelerated motion

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## Part II: accelerated motion

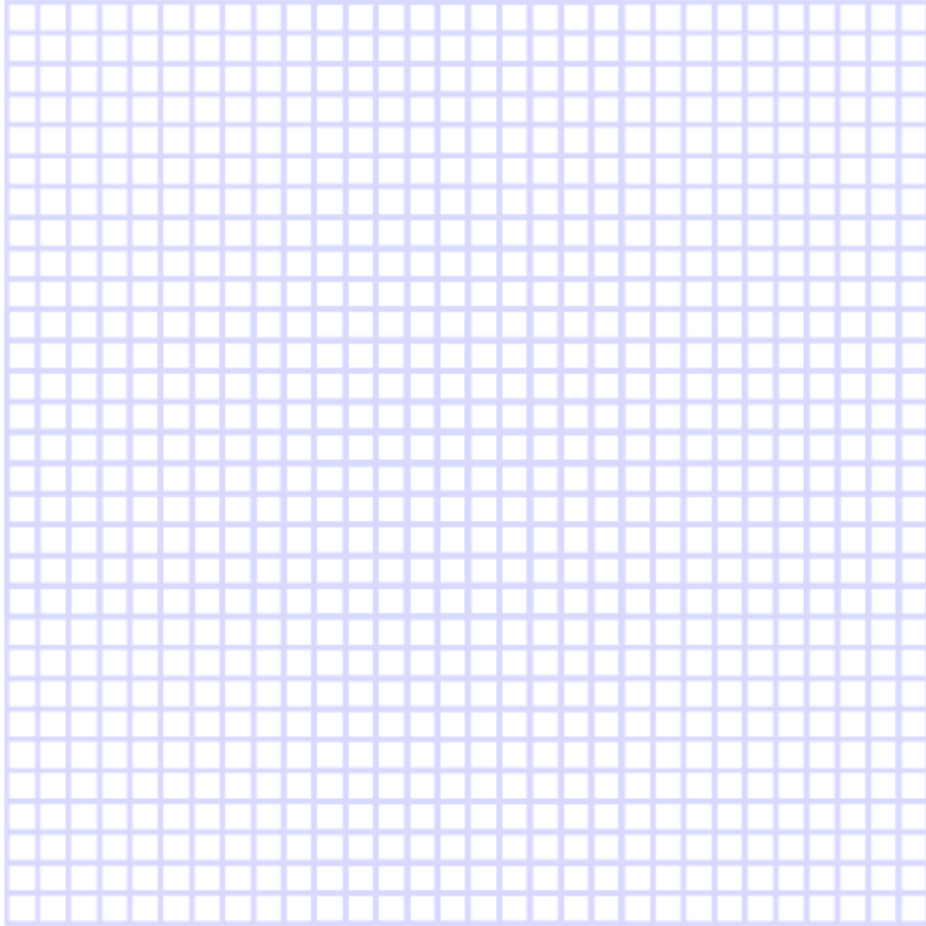
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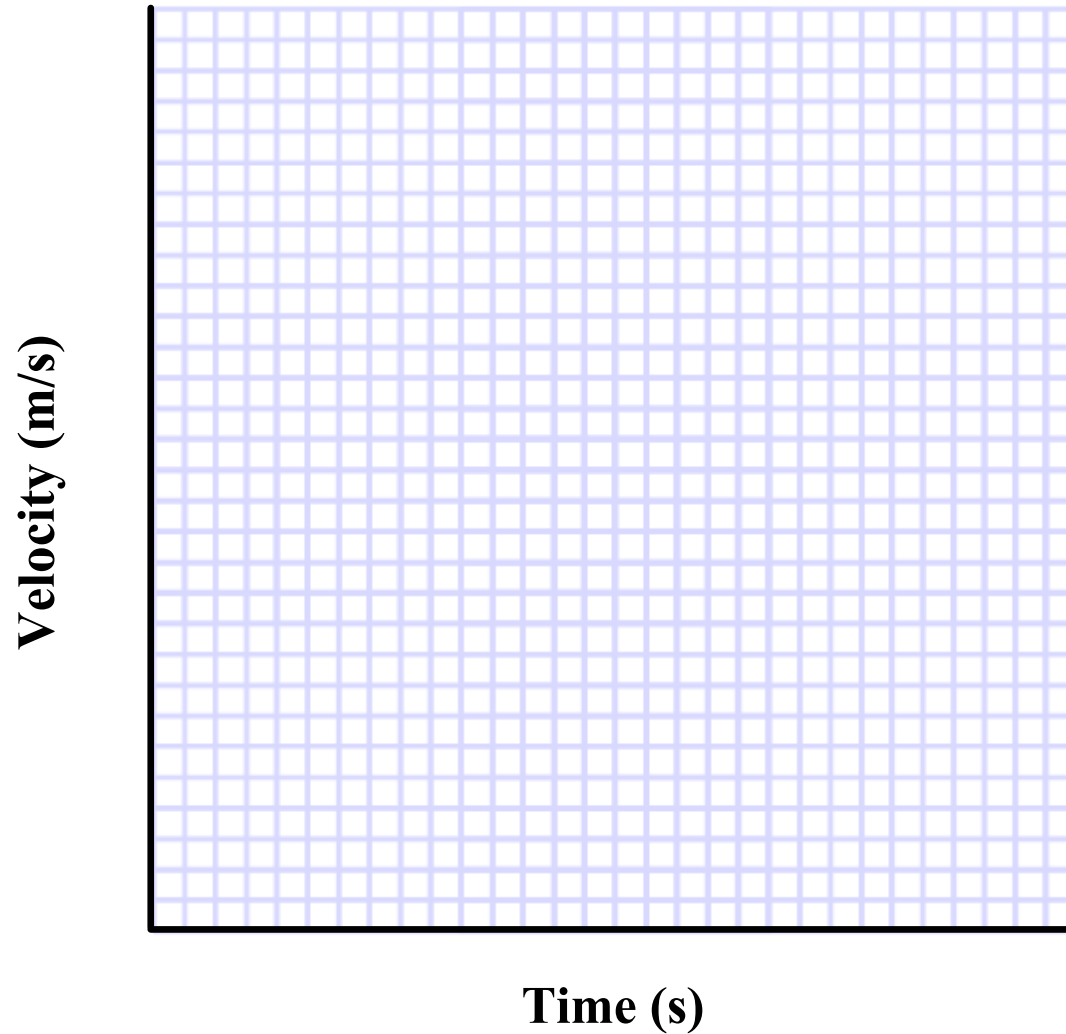
4. A **police car is stopped** at a red light. As the light turns green, a **diesel truck** hurtles past in the next lane traveling at a **constant speed of 28.0 m/s**. If the **police car**, sirens blaring and lights flashing, **accelerates at  $4.0 \text{ m/s}^2$** , how many seconds will it take it to catch the truck?

**Hint: On the same set of axis, draw velocity-time graphs for the car and the truck.**

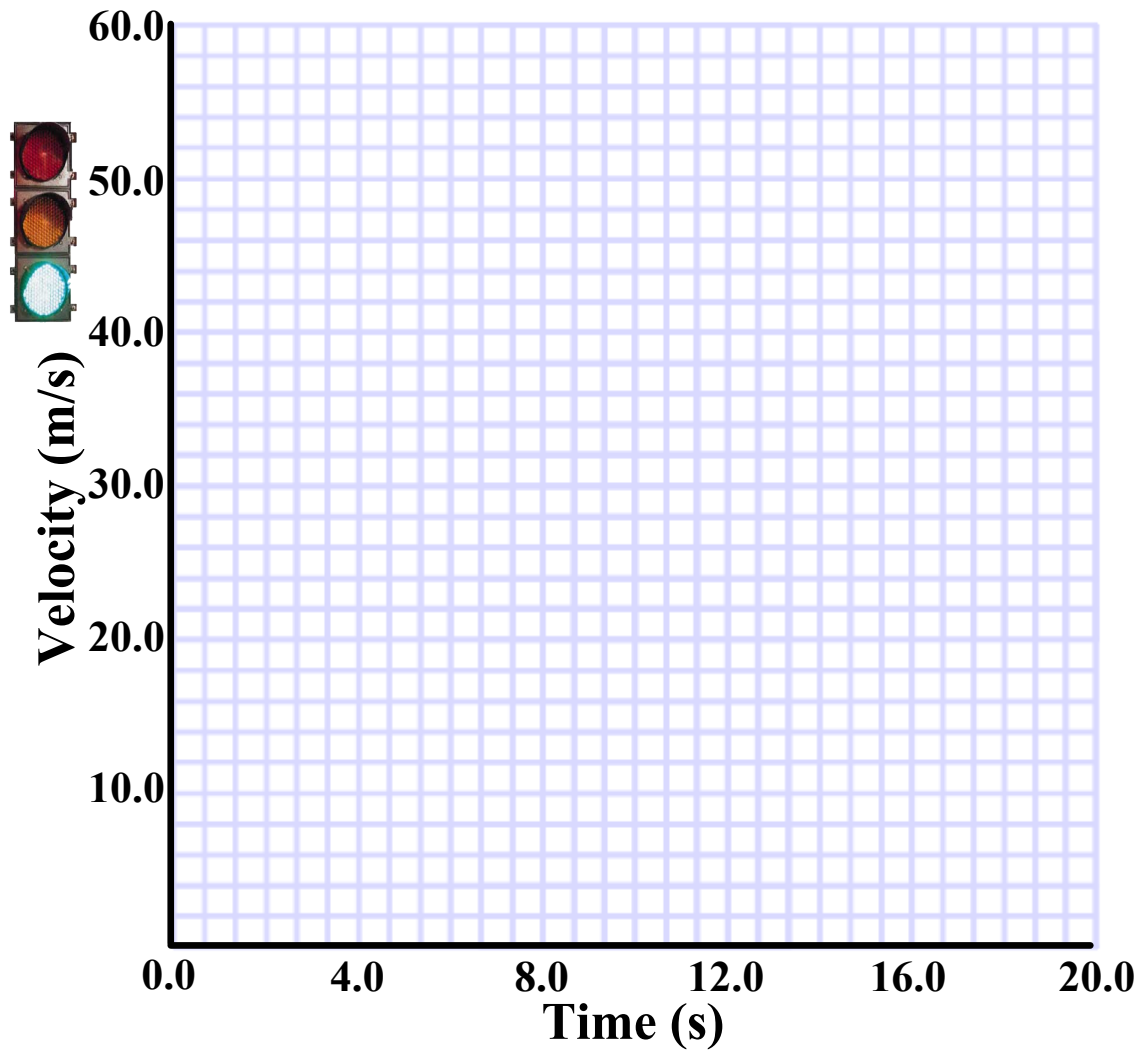
4) A **diesel truck** hurtles past in the next lane traveling at a **constant speed of 28.0 m/s**.



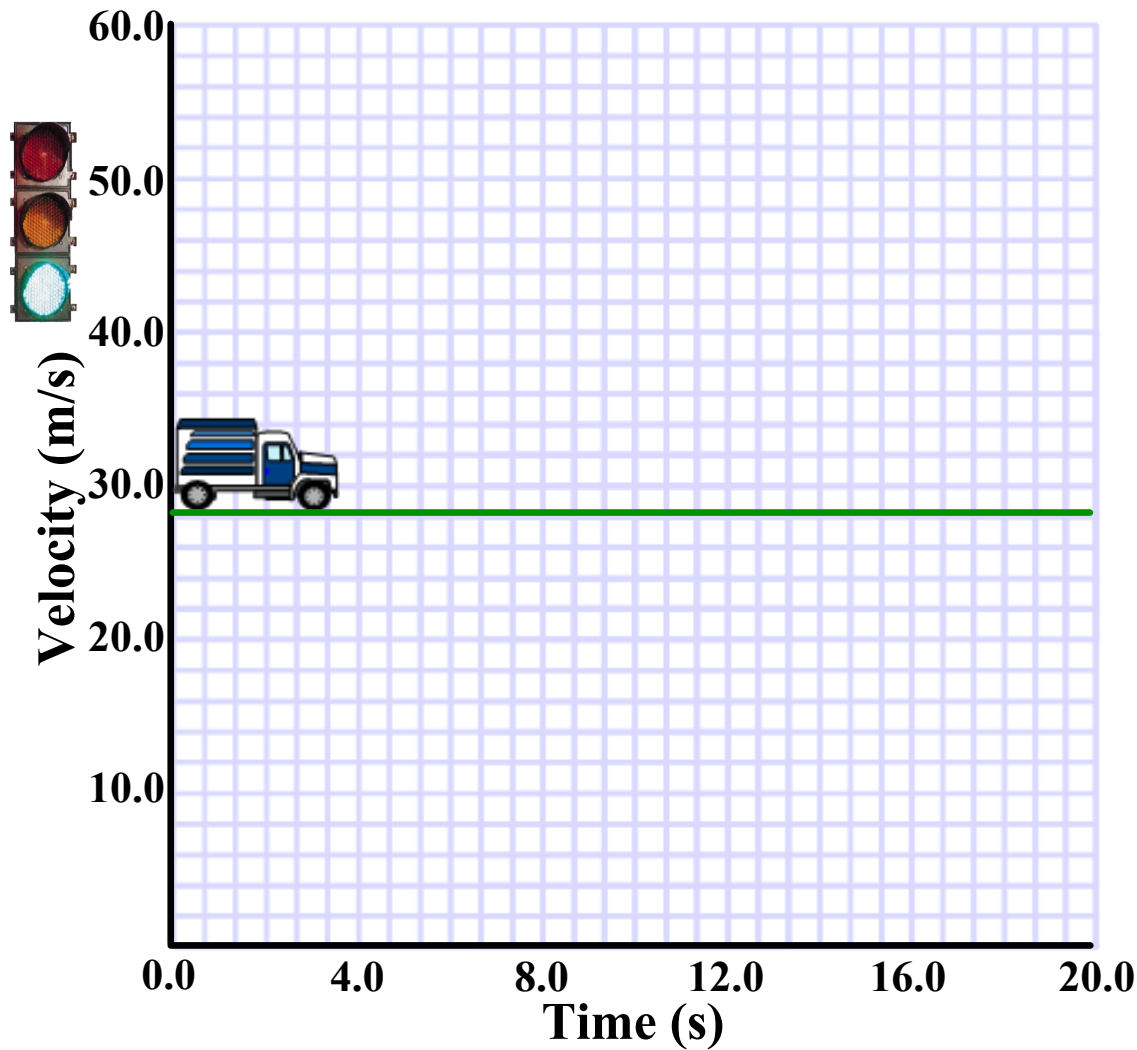
4) A **diesel truck** hurtles past in the next lane traveling at a **constant speed of 28.0 m/s**.



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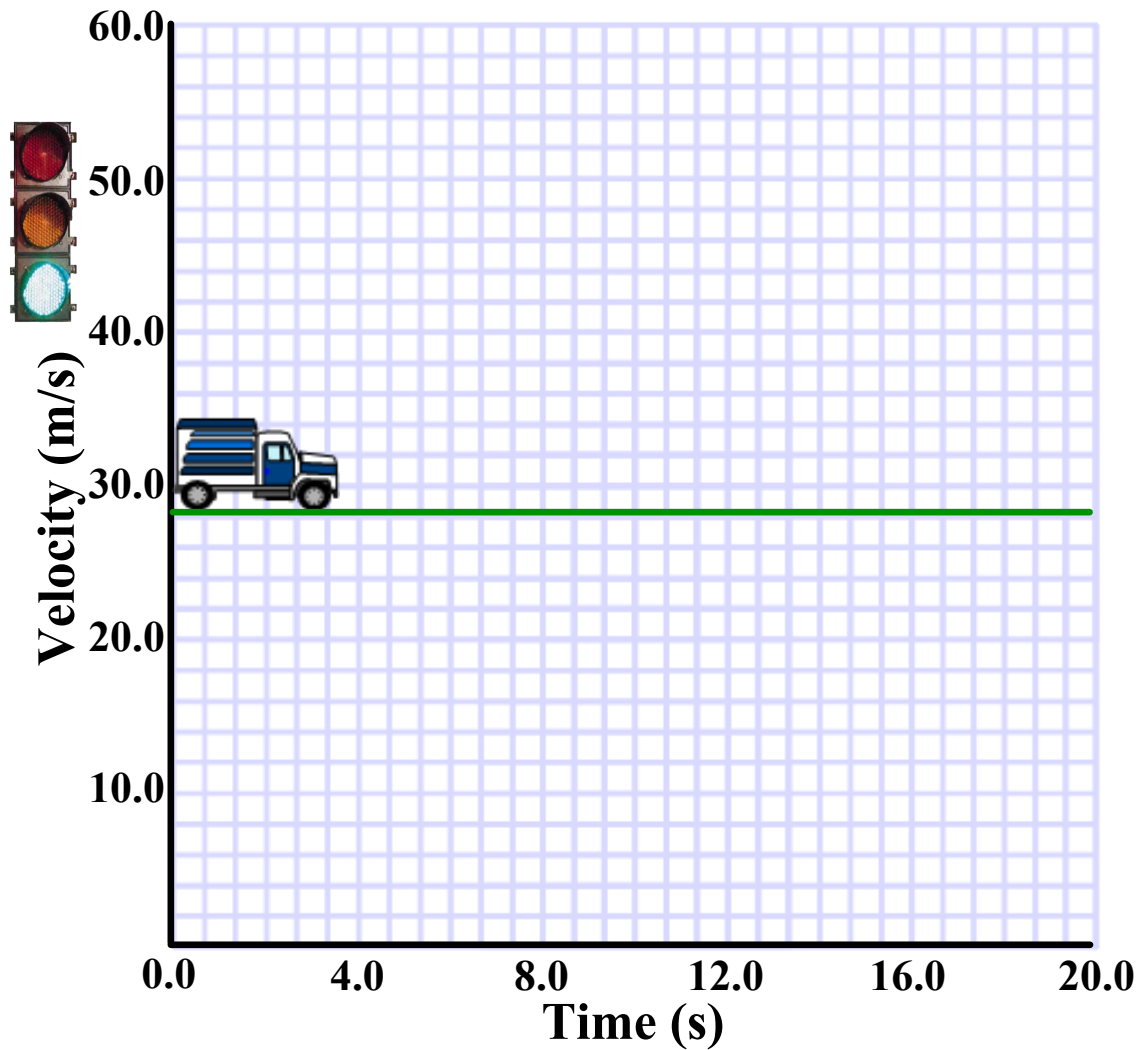


4) A **diesel truck** hurtles past in the next lane traveling at a **constant speed of 28.0 m/s**.

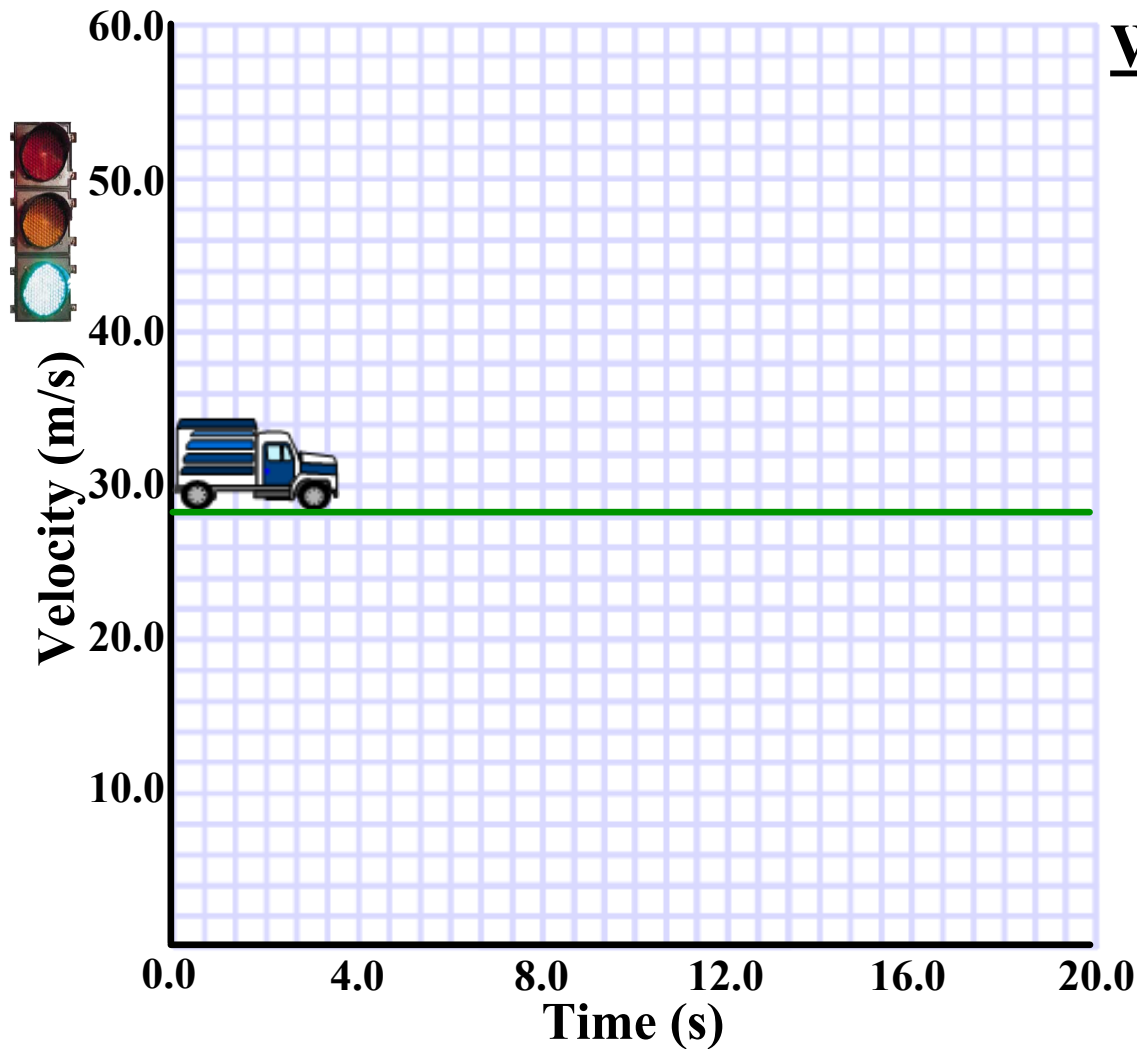




- 4) A **police car is stopped** at a red light. If the **police car...accelerates at  $4.0 \text{ m/s}^2$** , how many seconds will it take it to catch the truck?



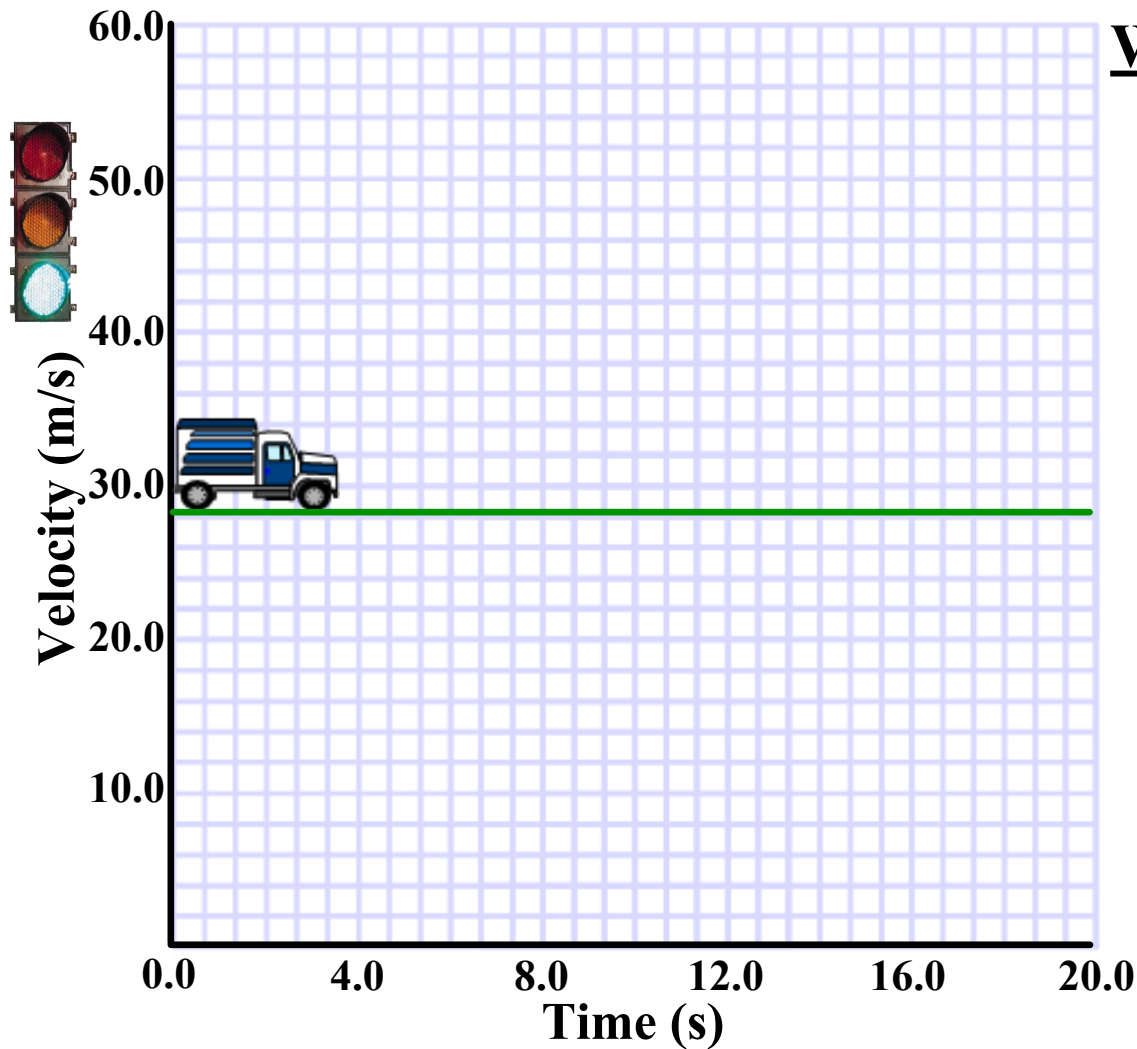
- 4) A **police car is stopped** at a red light. If the **police car...accelerates at  $4.0 \text{ m/s}^2$** , how many seconds will it take it to catch the truck?



We want the time when:

$$d_{\text{truck}} = d_{\text{cop}}$$

- 4) A **police car is stopped** at a red light. If the **police car...accelerates at  $4.0 \text{ m/s}^2$** , how many seconds will it take it to catch the truck?



We want the time when:

$$d_{\text{truck}} = d_{\text{cop}}$$

$$v_{\text{truck}} * t = \frac{1}{2} a_{\text{cop}} t^2$$

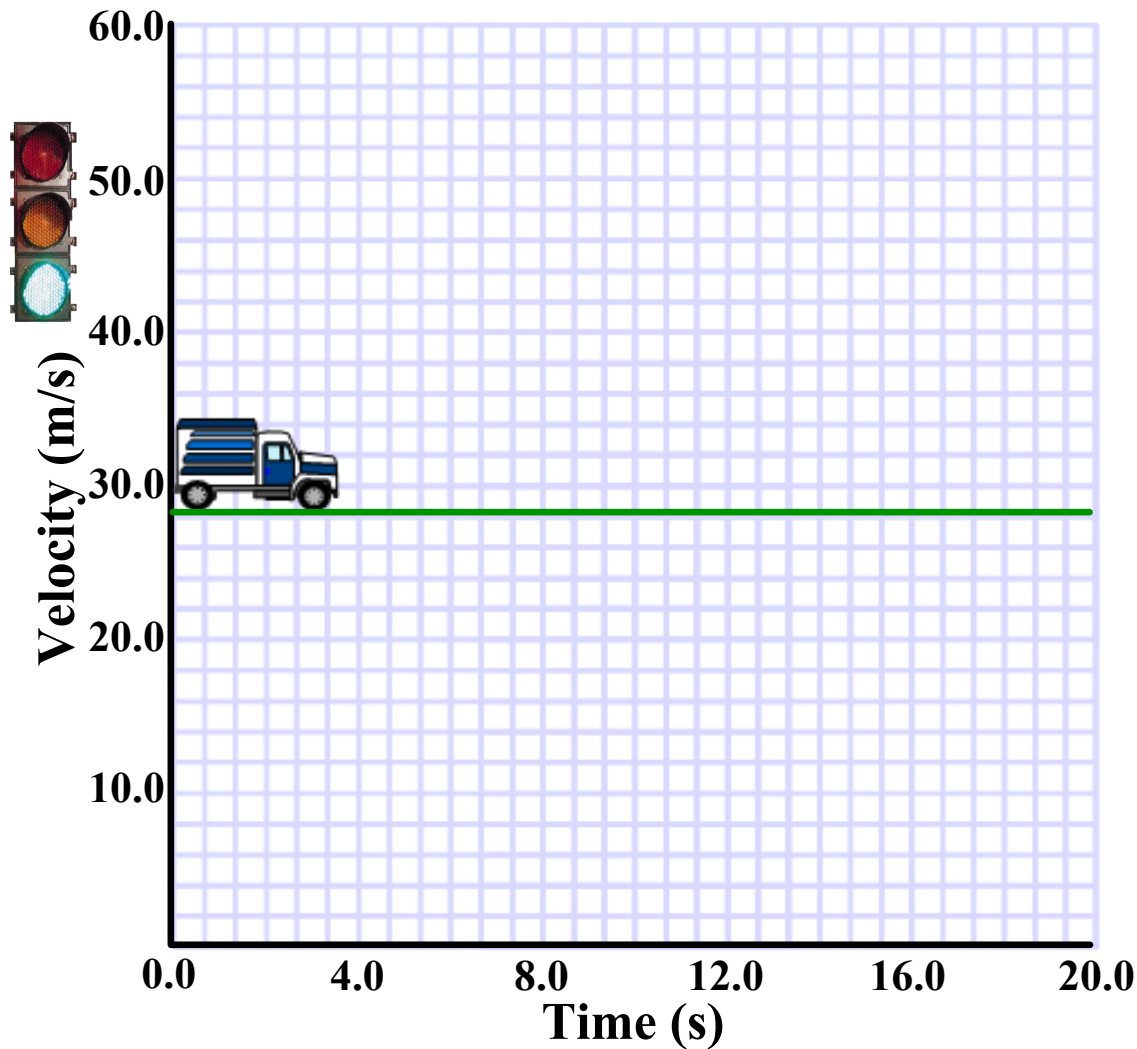
$$v_{\text{truck}} = \frac{1}{2} a_{\text{cop}} t$$

$$2v_{\text{truck}} / a_{\text{cop}} = t$$

$$t = 2(28^{\text{m}}/\text{s}) / (4.0^{\text{m}}/\text{s}^2)$$

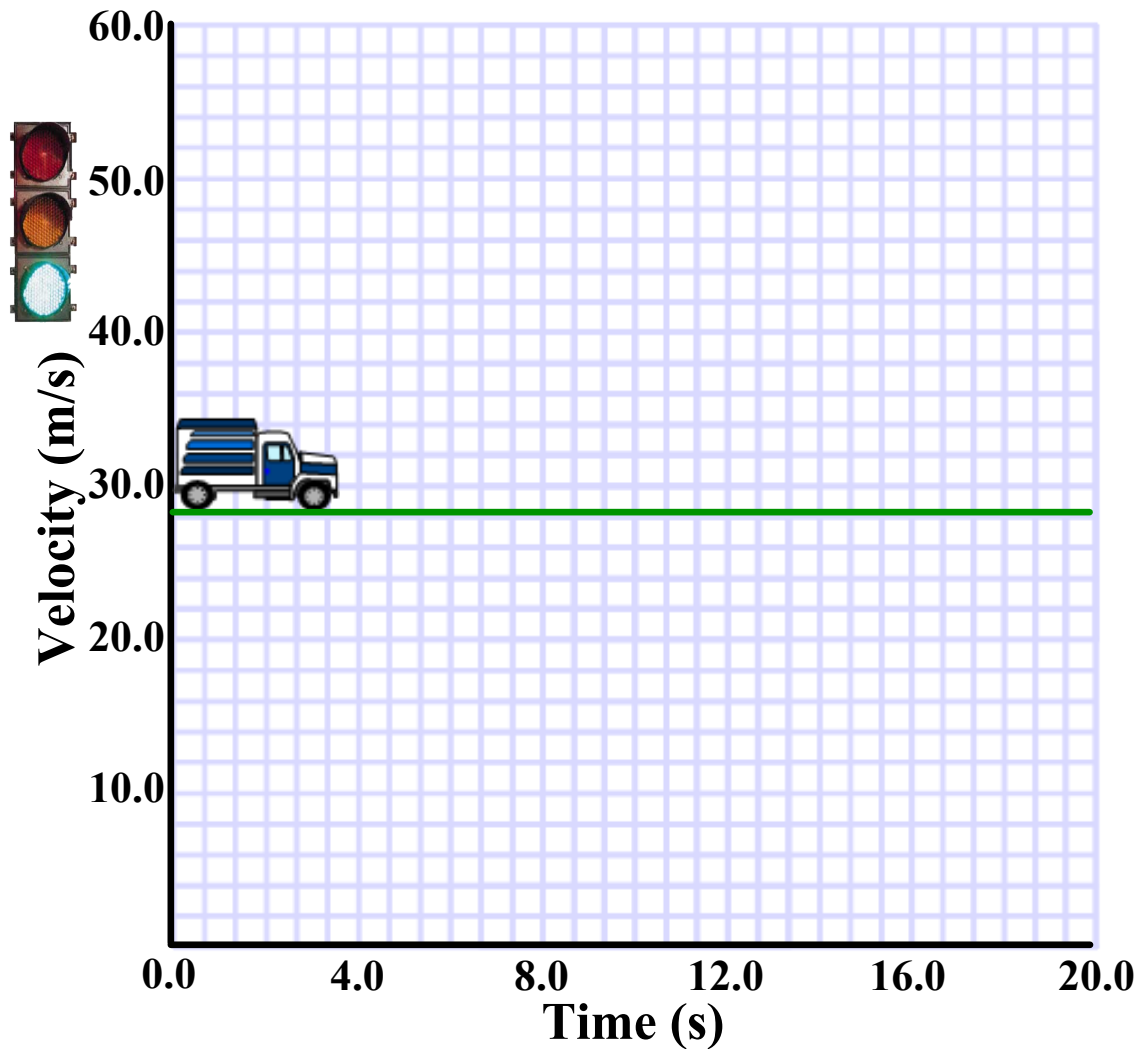
$$t = 14\text{s}$$

- 4) A **police car is stopped** at a red light. If the **police car...accelerates at  $4.0 \text{ m/s}^2$** , how many seconds will it take it to catch the truck?



Speed of the Car:

- 4) A **police car is stopped** at a red light. If the **police car...accelerates at  $4.0 \text{ m/s}^2$** , how many seconds will it take it to catch the truck?



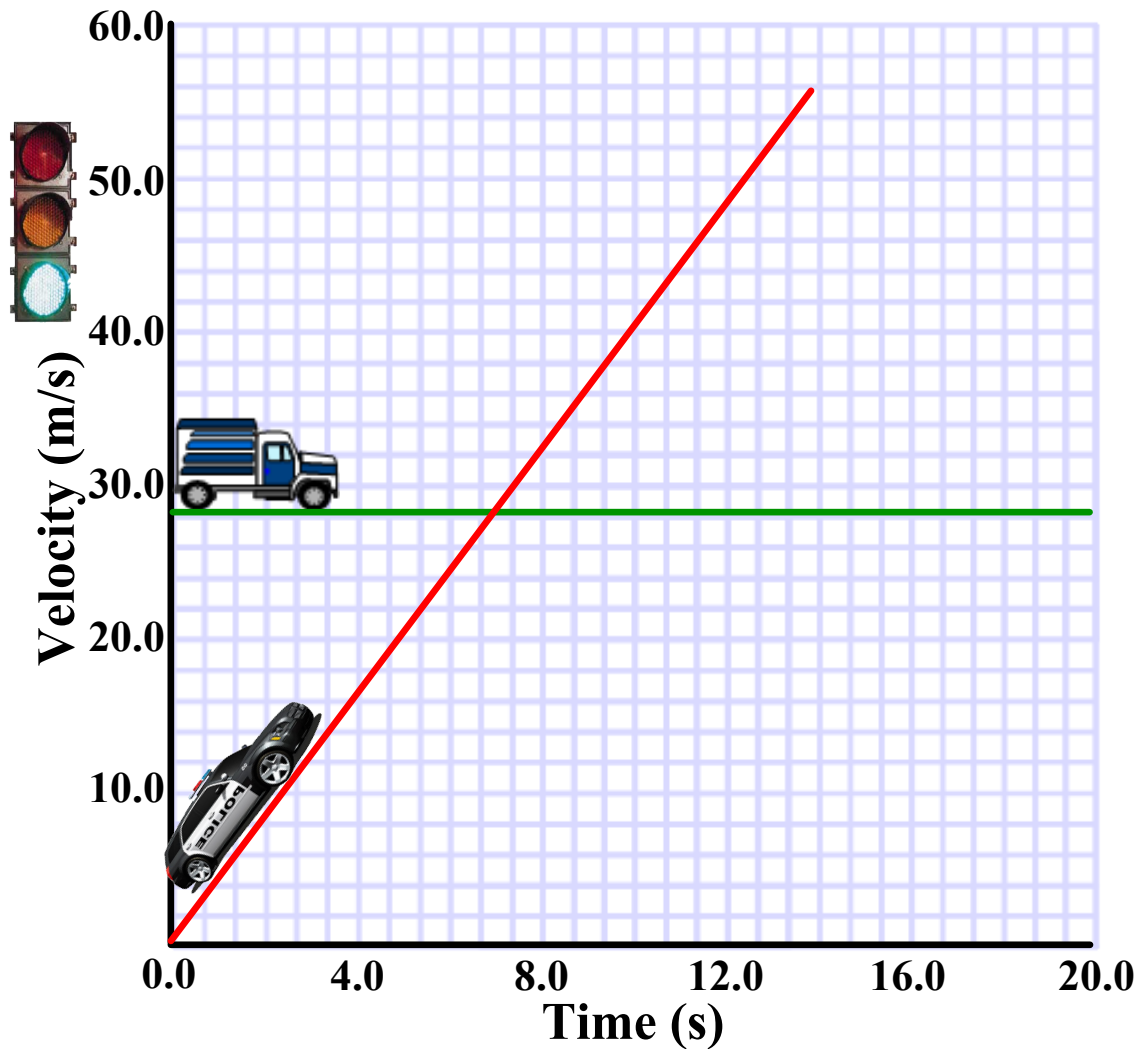
Speed of the Car:

$$v_f = v_i + at$$

$$v_f = (4.0 \text{ m/s}^2)(14\text{s})$$

$$v_f = 56 \text{ m/s}$$

- 4) A **police car is stopped** at a red light. If the **police car...accelerates at  $4.0 \text{ m/s}^2$** , how many seconds will it take it to catch the truck?



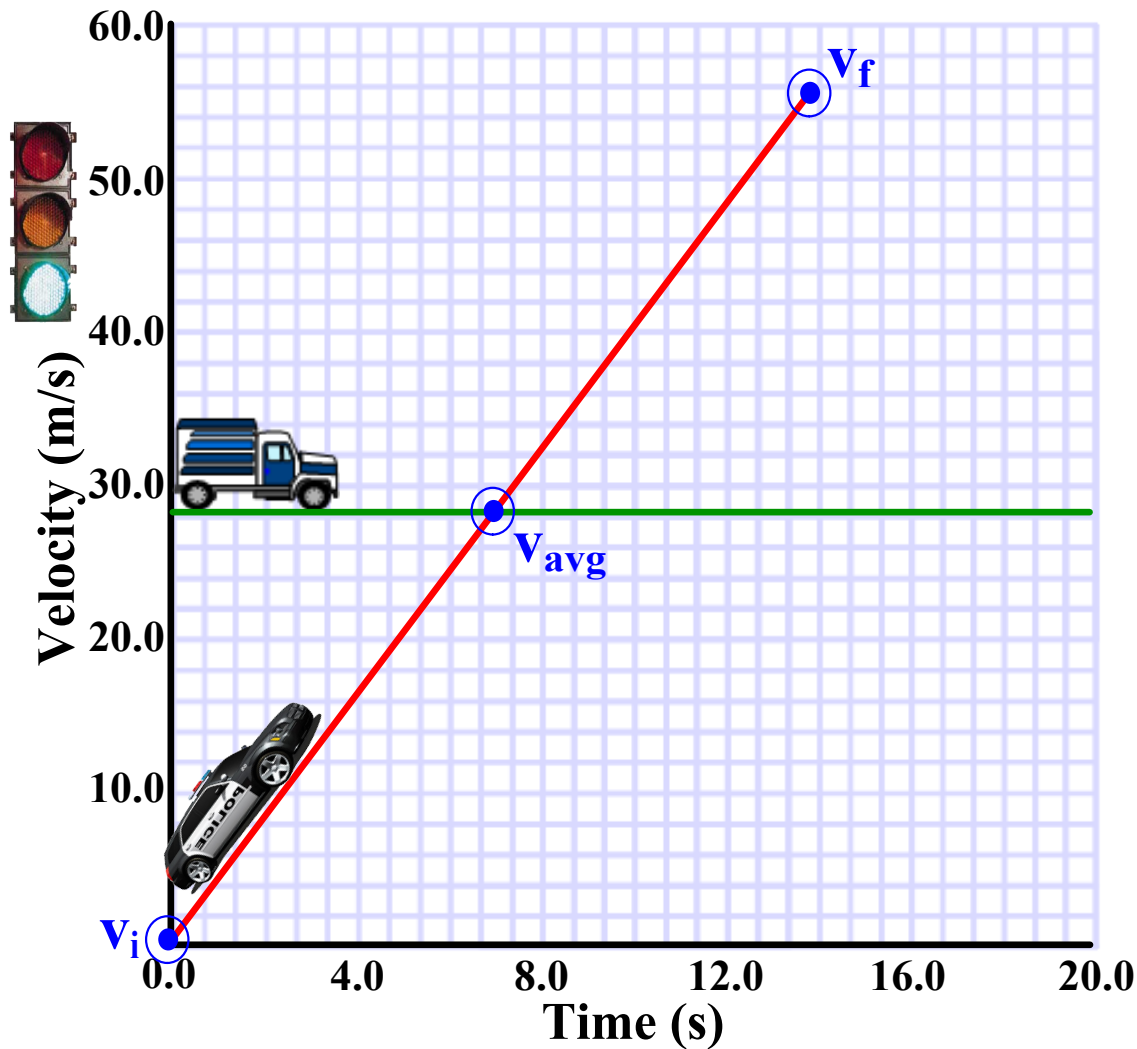
Speed of the Car:

$$v_f = v_i + at$$

$$v_f = (4.0 \text{ m/s}^2)(14\text{s})$$

$$v_f = 56 \text{ m/s}$$

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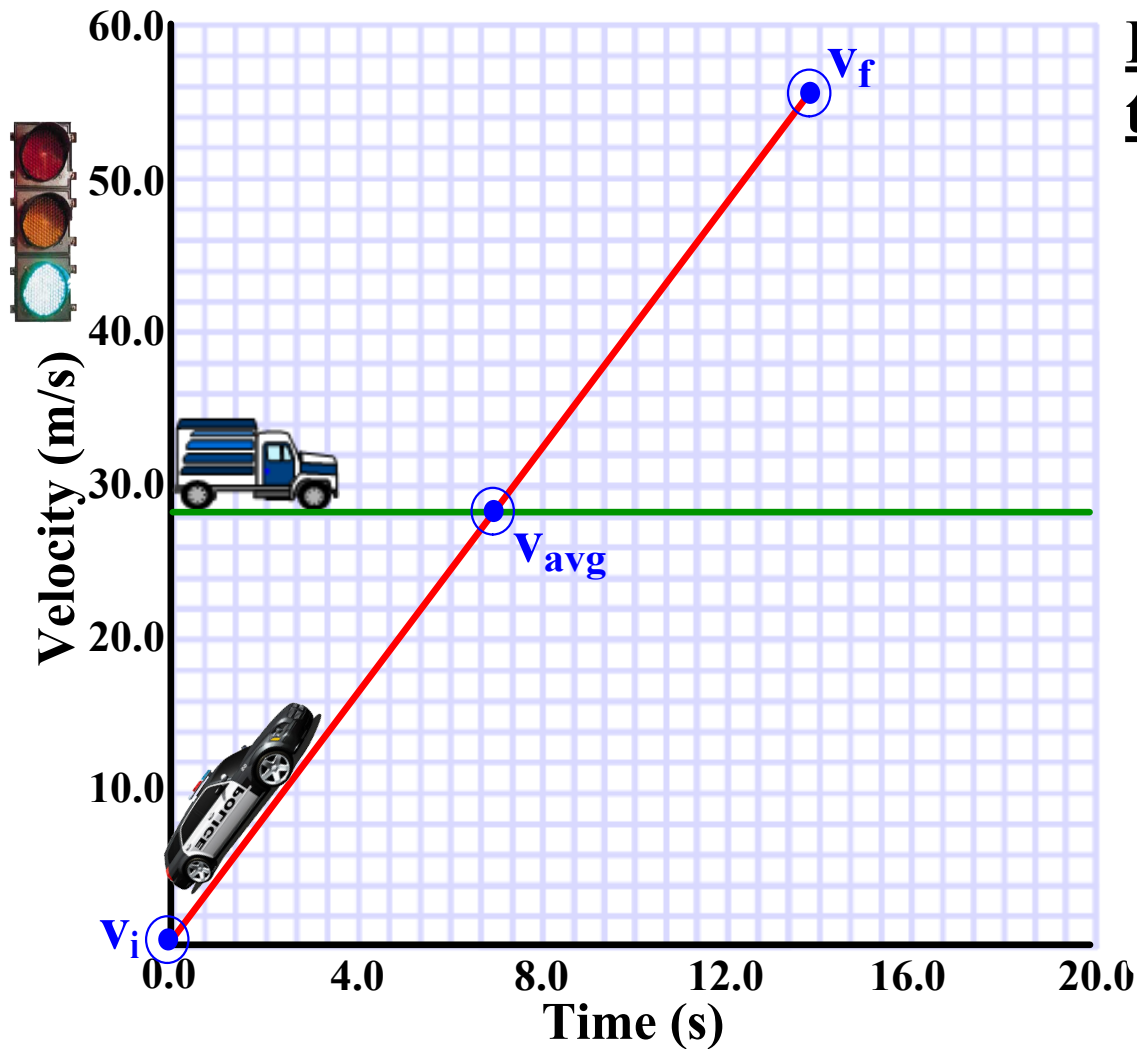
Also Notice:

$$V_{avg} = \frac{V_f + V_i}{2} = \frac{V_f}{2}$$

$$V_{avg} = \frac{56 \text{ m/s}}{2}$$

$$V_{avg} = 28 \text{ m/s}$$

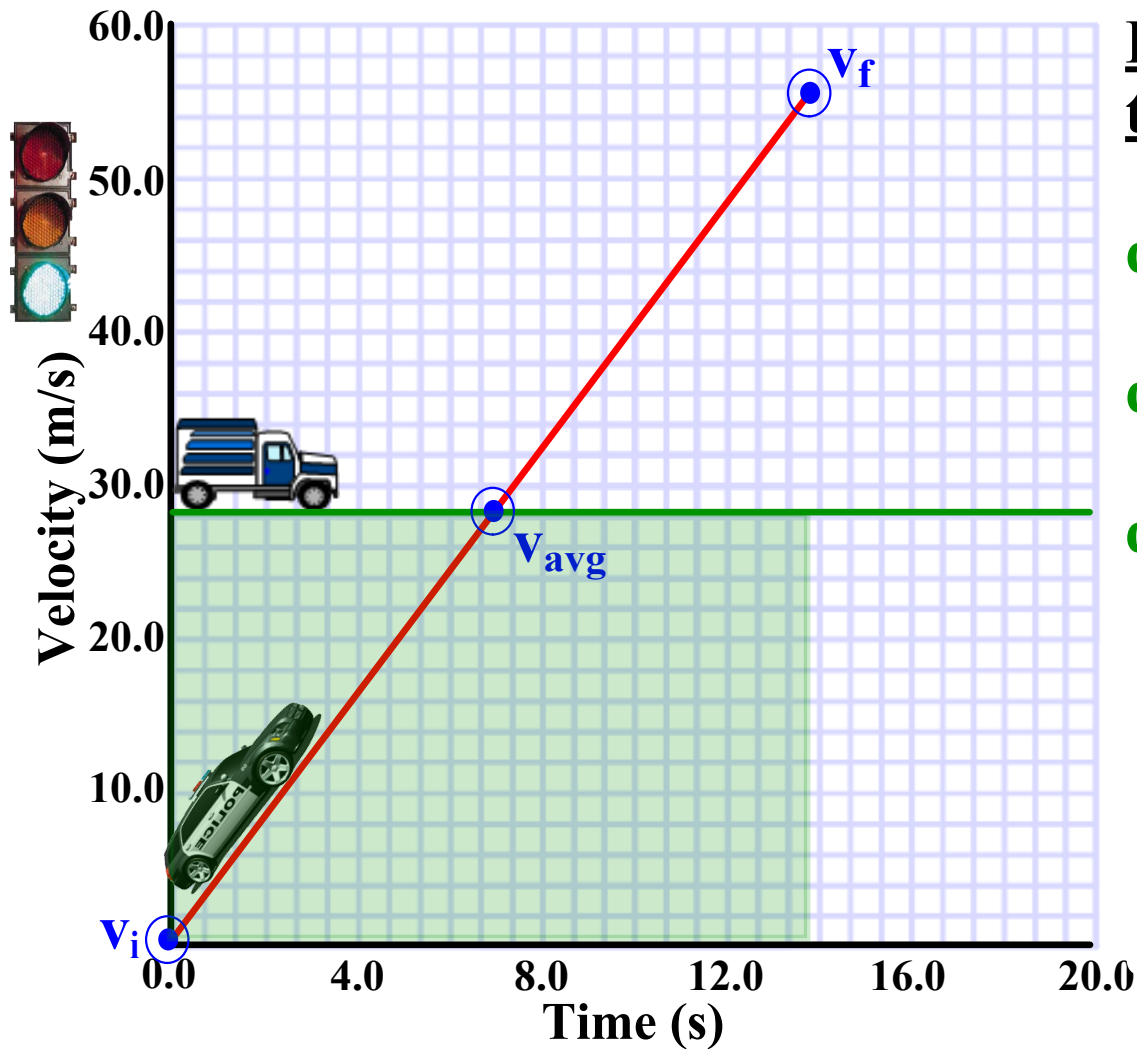
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Let's look at this in terms of distance:



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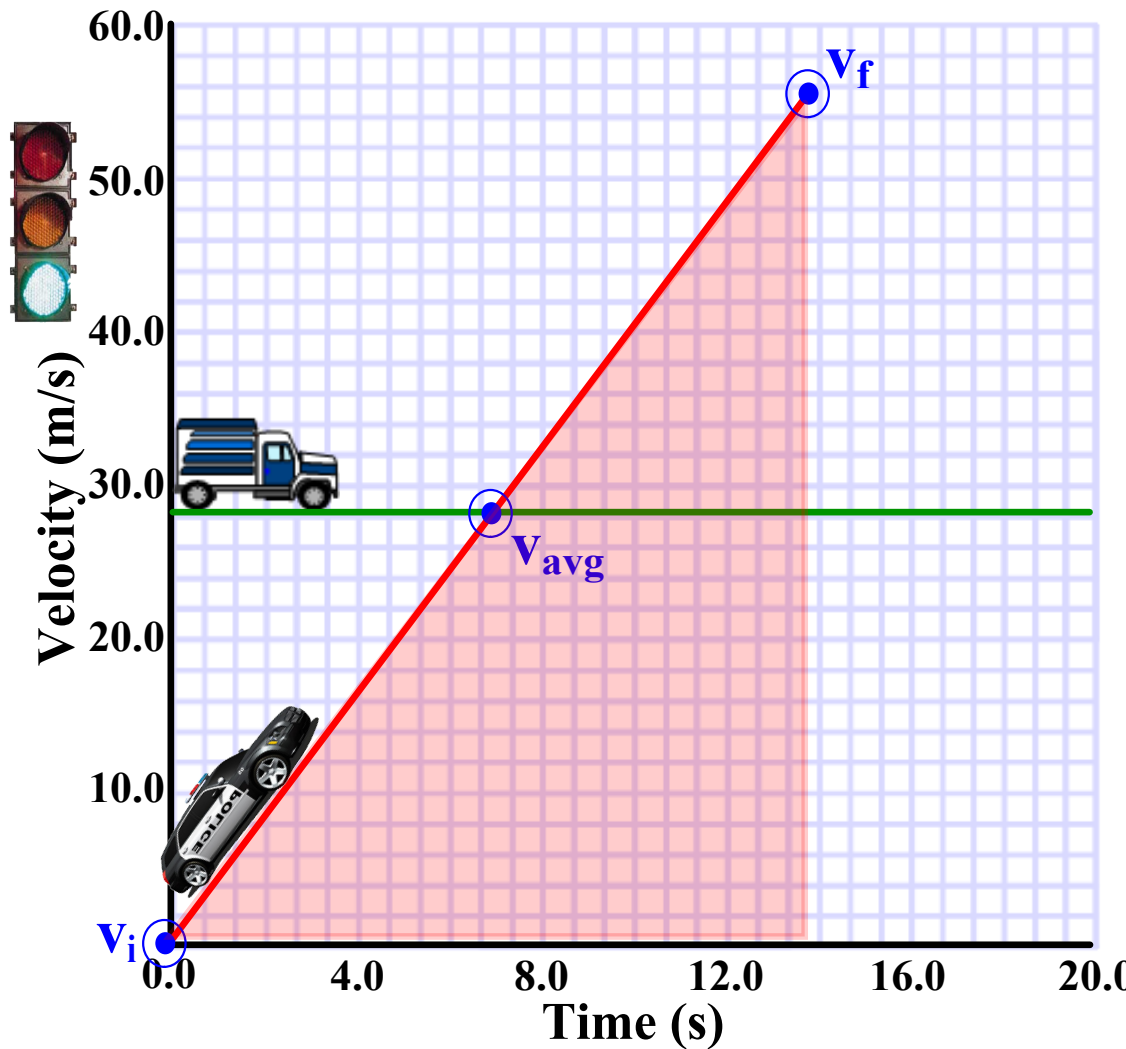
Let's look at this in terms of distance:

$$d_{\text{truck}} = v \cdot t$$

$$d_{\text{truck}} = (28^{\text{m/s}})(14\text{s})$$

$$d_{\text{truck}} = 392 \text{ m}$$

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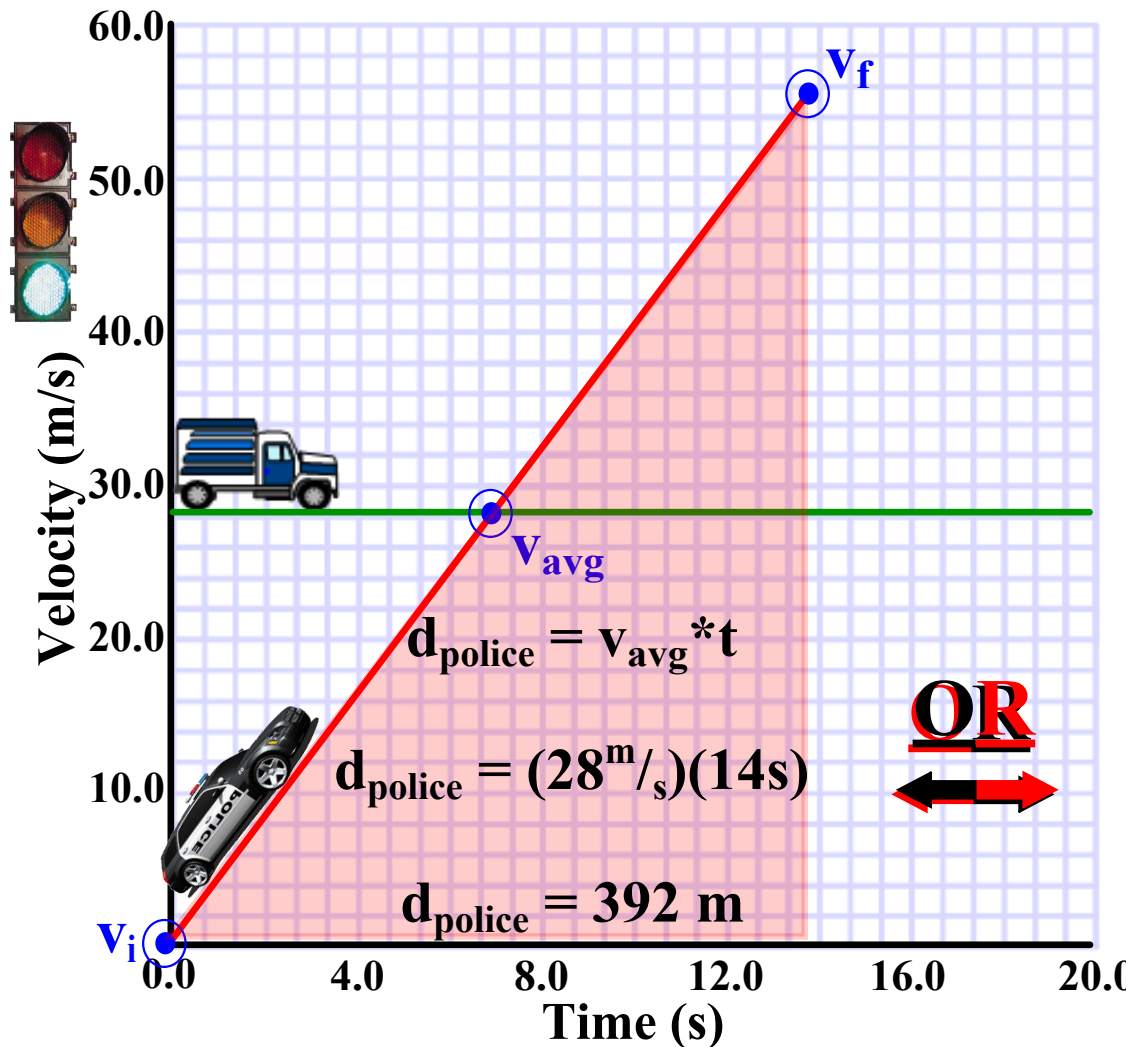
$$d_{\text{truck}} = 392 \text{ m} \checkmark$$

$$d_{\text{police}} = \frac{1}{2}at^2$$

$$d_{\text{police}} = \frac{1}{2}(4.0 \text{ m/s}^2)(14\text{s})^2$$

$$d_{\text{police}} = 392 \text{ m} \checkmark$$

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Let's look at this in terms of distance:

$$d_{truck} = v * t$$

$$d_{truck} = (28 \text{ m/s})(14 \text{ s})$$

$$d_{truck} = 392 \text{ m}$$

$$d_{police} = \frac{1}{2}at^2$$

$$d_{police} = \frac{1}{2}(4.0 \text{ m/s}^2)(14 \text{ s})^2$$

$$d_{police} = 392 \text{ m}$$



**This is an example of a 'Step' Graph. What do the vertical lines represent, and why do we use step graphs?**

