ACCELERATION

Think of playing tennis with Venus Williams – If she were to hit you a serve – it might travel to you at over 200km/h. When the ball hits your tennis racket it will slow to 0 for a fraction of a second and then travel backwards from the direction it came at a different velocity. That situation deals with acceleration!

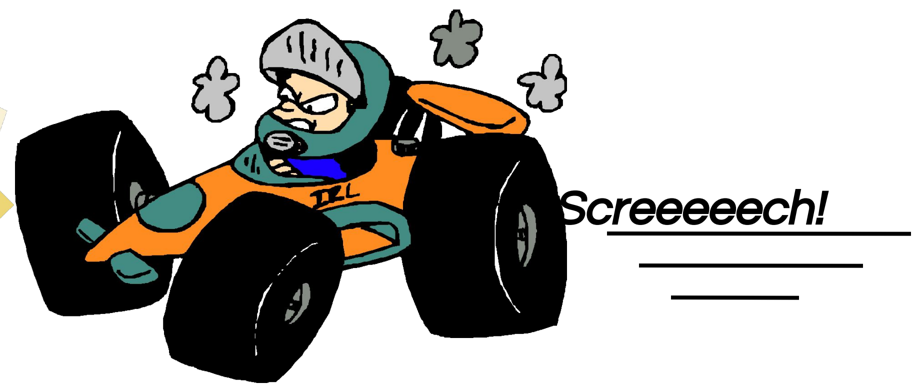
Acceleration is the rate of change in Velocity!

Positive Acceleration:

- When speed is increasing (speed is in the same direction of the acceleration) – the acceleration is positive.
- When a drag racer gets the green light and hits the gas to move forward by speeding up– that is positive acceleration

Negative Acceleration:

- When velocity is decreasing (in the opposite direction of the acceleration)– the acceleration is negative.
- When a drag racer finishes the race – he hit’s the brakes (and uses a parachute out the back) to decrease his velocity rapidly, causing the acceleration to decrease - that is negative acceleration



Another Example: Launching a Space shuttle!

- Within the first minute after lift-off – the velocity is about 350 m/s and covers about 16 km of distance. During the next minute, the space shuttle’s velocity is about 1200 m/s and covers about 30 km of distance
- So in the first minute it moves 16km
- In the second minute it moves 30km (must be moving a lot faster!)
- That is acceleration!! The velocity is changing

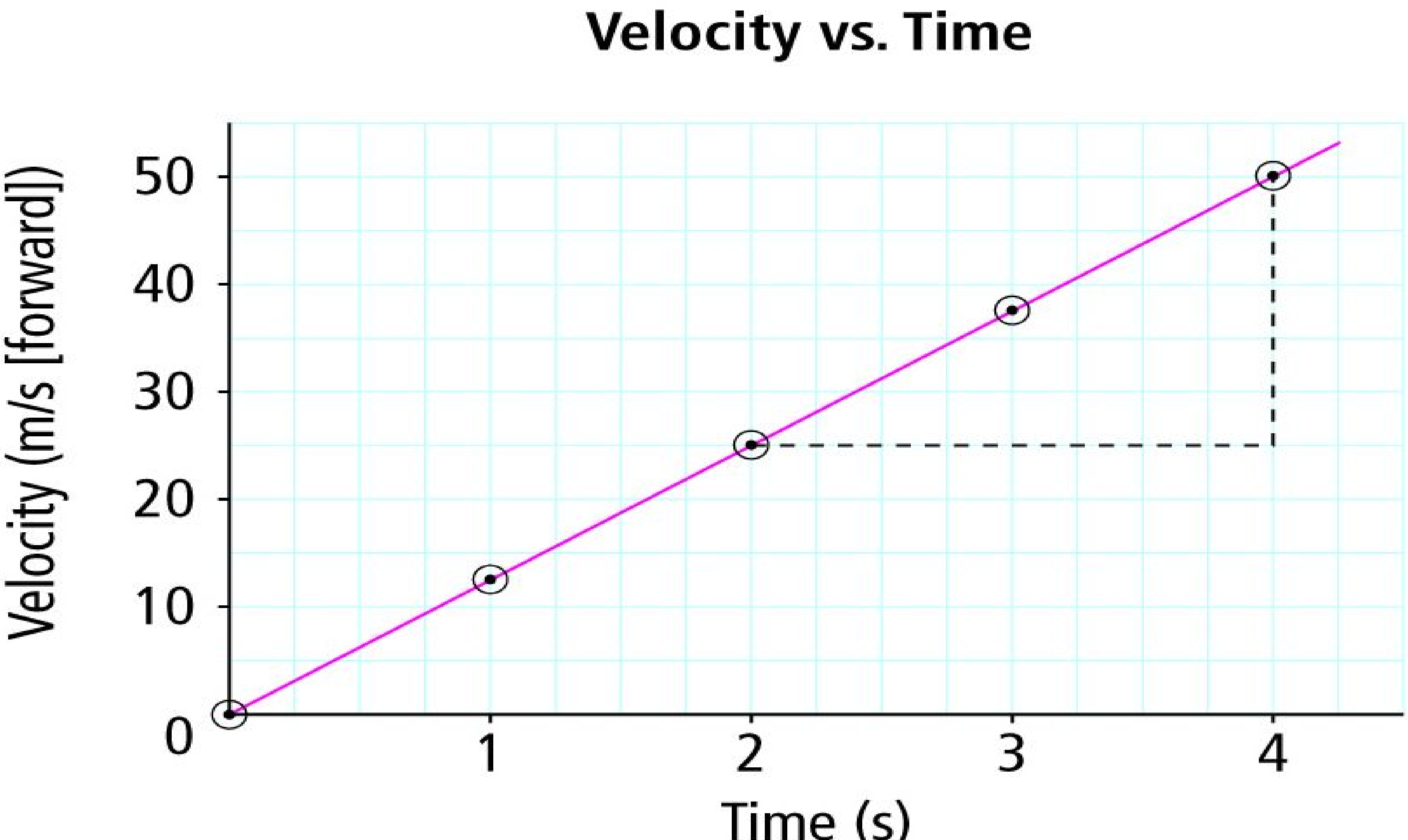
Another Example: Airbags

- Airbags are designed so that when a person is halted suddenly by crashing into something – the airbag deploys and slows down the velocity of the person in the car as gradually as possible by creating a cushion for them to hit and slow them down. Causes slower negative acceleration!
- So that you don't go from 60km/hr to 0 in 1 second – you would probably snap your neck because of the jolt.

Calculating Acceleration!!!

- **Acceleration** $\vec{a}$: The change in velocity divided by the change in time.
- Equation: $\vec{a} = \dfrac{\Delta V}{\Delta t}$ <u>So</u>… $\vec{a} = \dfrac{V_f - V_i}{\Delta t}$
- Units: **m/s²**
- How can you show acceleration?:
  A Velocity-Time graph
- The slope of the Velocity-Time graph is the acceleration!

Suppose you plot the data for a roller coaster as it starts out forward at the beginning of a ride and you plot this best fit line – what does it tell you?



The Slope of that line is the acceleration, so… Let's find the Slope!

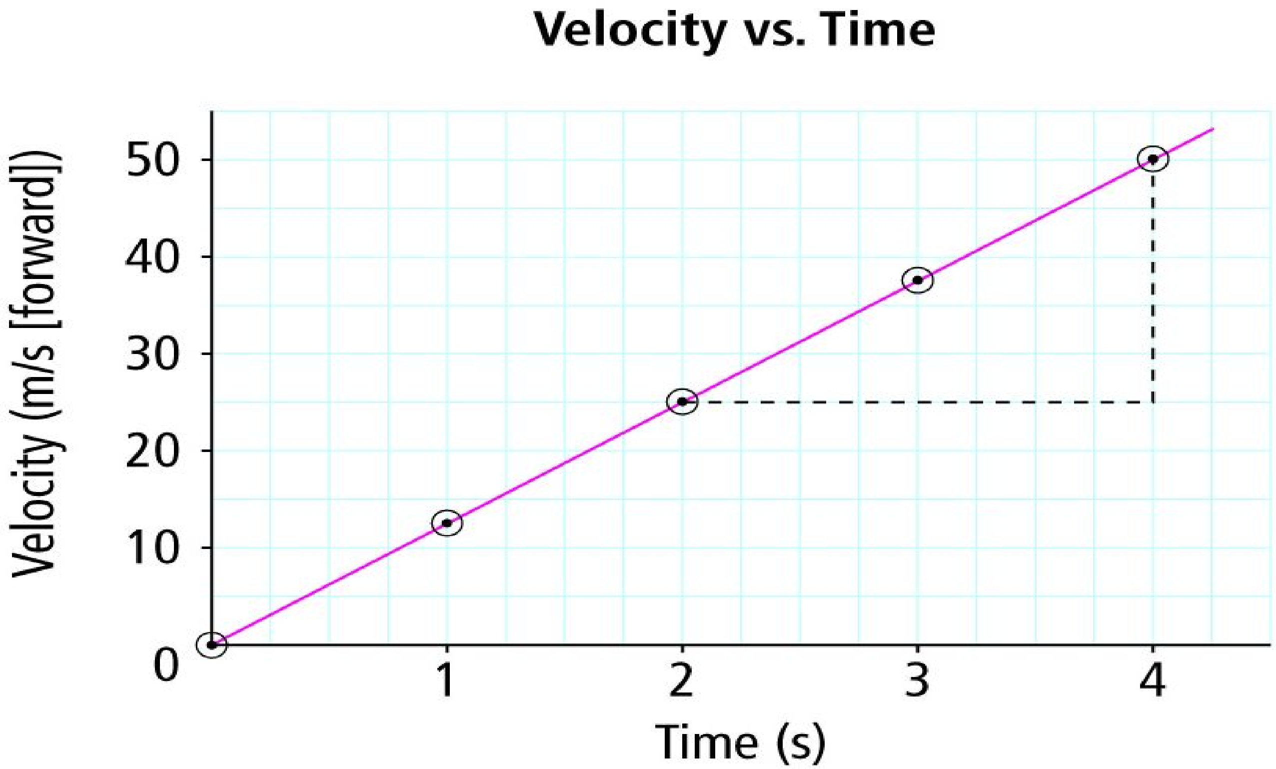
$$\text{slope} = \frac{\text{rise}}{\text{run}}$$

$$= \frac{50\ \text{m/s} - 25\ \text{m/s}}{4.0\ \text{s} - 2.0\ \text{s}}$$

$$= \frac{25\ \text{m/s}}{2.0\ \text{s}}$$

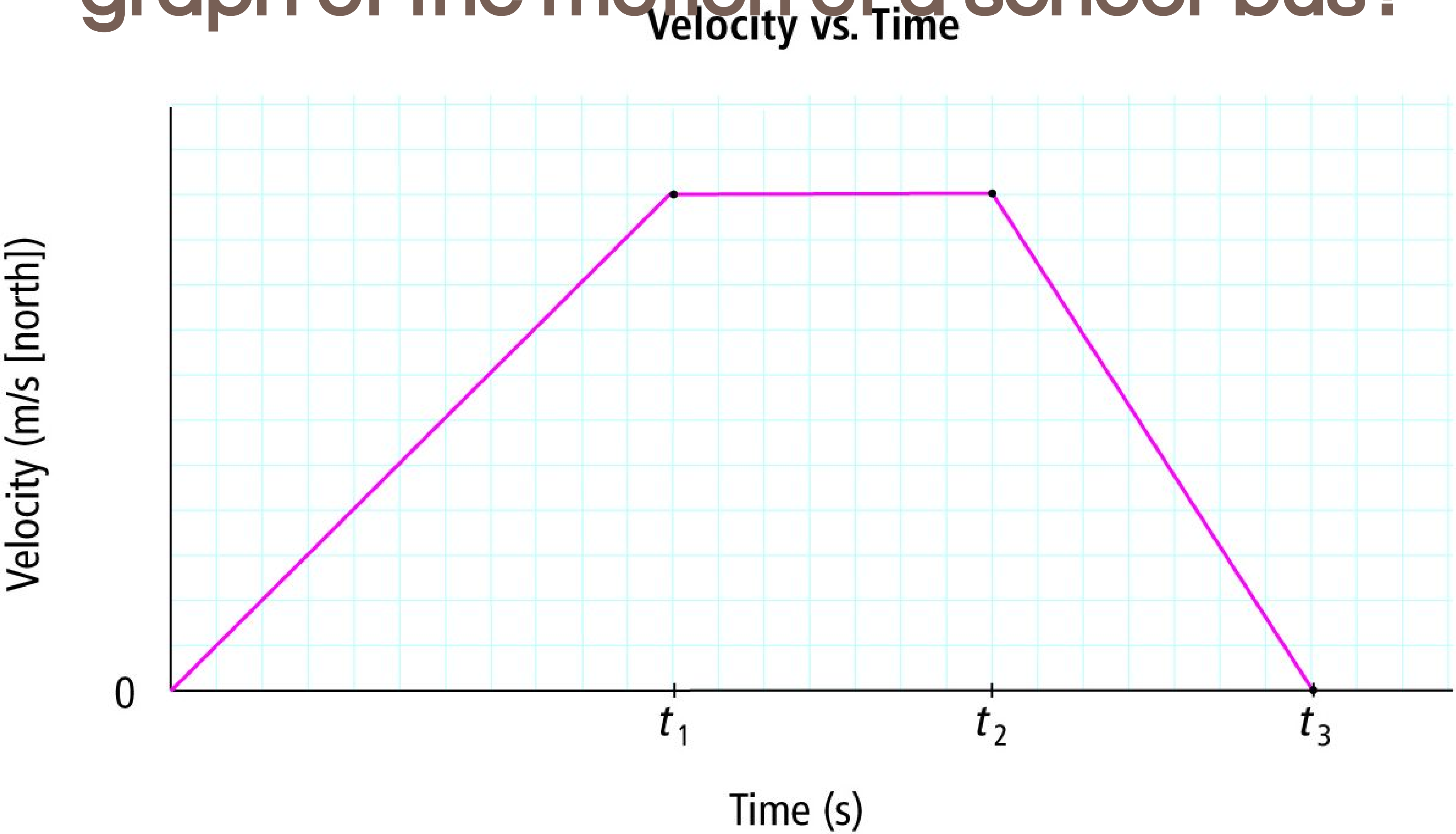
$$= 13\ \text{m/s}^2$$

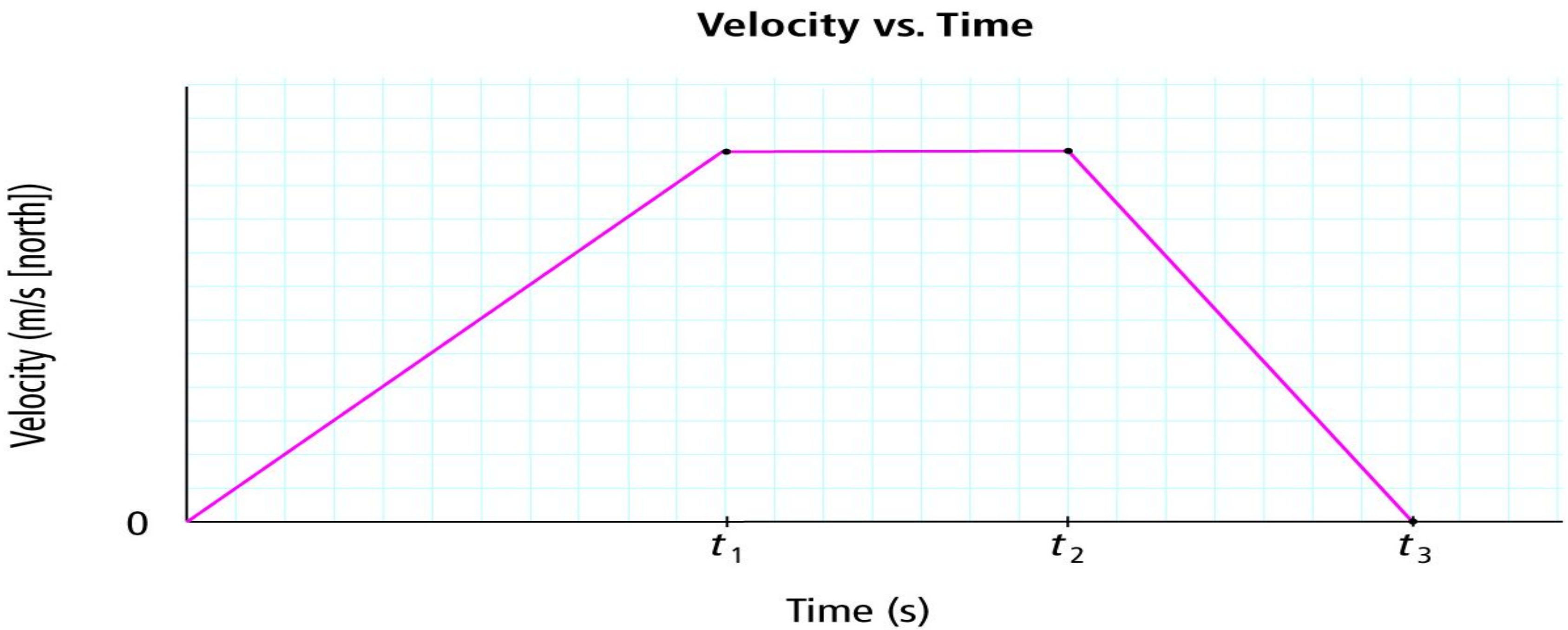
- Notice that m/s/s just simplifies to m/s^2
- Therefore the acceleration is 13 m/s^2 meaning that the rollercoaster's velocity increased by 13m/s every 1.0 seconds.



- If the best-fit line passes directly through **<u>all</u>** the points on the graph = **constant acceleration** (it's always exactly the same, so it's constant
- If the best-fit line **<u>does not</u>** pass directly through all the points on the graph (ie. Some above and some below) = **average acceleration** (it's not always exactly the same)

What can you figure out from this graph of the motion of a school-bus?





Time Interval	$0 – t_1$	$t_1 – t_2$	$t_2 – t_3$
Acceleration	+	0	-
Velocity	**Starts from rest and increases it's speed at a constant rate**	**Travels N at a constant speed**	**Slows down at a constant rate to a stop (still going North**

Check if we get it... Answer these!

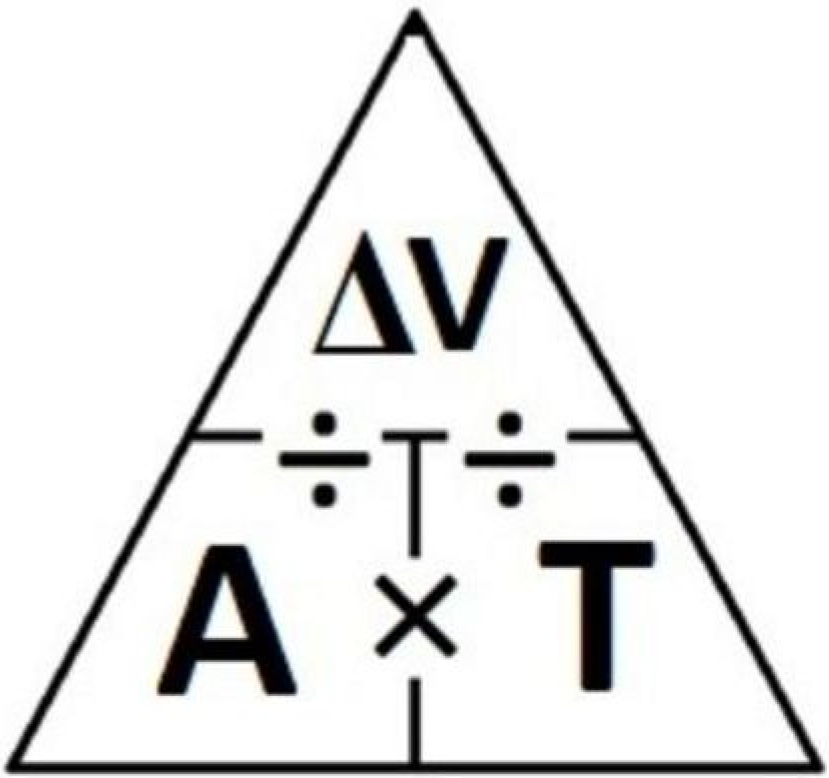
- 1) What does the slope of a velocity time graph represent?
- **Answer**: Acceleration
- 2) What does a straight line on a Velocity-Time graph tell you about:
- A) the object's change in velocity?
- B) the objects acceleration?
- **Answer to A):** If line has + slope – the velocity is increasing, if 0 slope – the velocity is constant, if – slope, the speed is decreasing
- **Answer to B):** If line has + slope – the acceleration is constant and in a forward direction, if 0 slope – there is no acceleration, if – slope, the acceleration is decreasing (slowing down)

Here are the equations you need to know!!!

$$d = \vec{v}t$$

$$\vec{v} = \vec{a}t$$

Acceleration Triangle

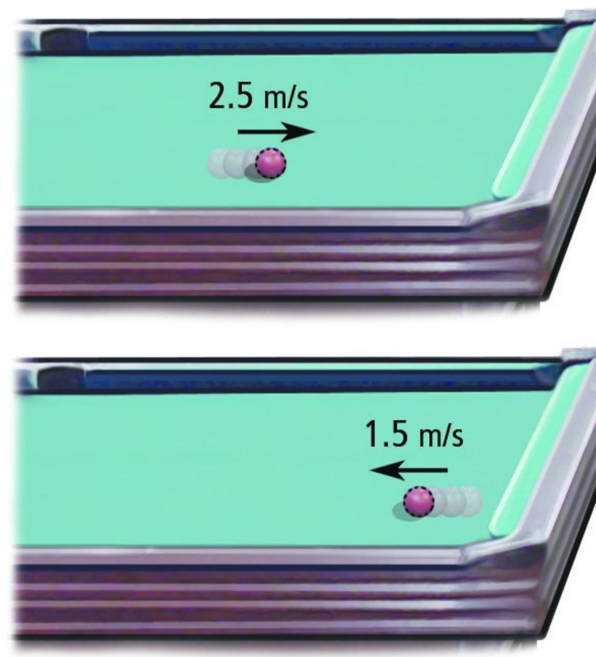


How to find Acceleration without a Graph…

- Remember: Acceleration is

$$\vec{a} = \frac{\Delta V}{\Delta t}$$

- Q: Suppose you shoot a pool ball at 2.5m/s and bounce it off the side of the pool table and it travels at 1.5m/s to the far corner pocket. Assuming it was in contact with the side of the table for 0.20s, **What is the acceleration of the pool ball as it travels to the corner pocket after hitting the side?**



A) B)

How to start:

- 1: Make assumptions about + and – first. If the ball is moving right to the side of the pool table – that velocity is "+". When the ball hits and moves backwards, it is going left and so the velocity is "–"
- 2: Get the change in velocity:
- 3: Divide the change in velocity by the time.

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- **1. Equation: (E:)** $\vec{a} = \frac{\Delta V}{\Delta t}$ or $\vec{a} = \frac{V_f - V_i}{\Delta t}$
- **Substitute: (S:)** V_f = -1.5 V_i = 2.5m/s² Δt = 0.20s
- **Evaluate: (E:)** $\vec{a} = \frac{-1.5m/s - 2.5m/s}{0.20s}$
- **Answer: -20m/s².** So that means the ball is travelling to the pocket away from the place it hit the side at 20 m/s².

Now let's try some Questions…

1. The Japanese bullet train accelerates from rest at 2.0m/s^2 forward for 37s. **What is the velocity** at the end of the 37 s?

Answer: Use your acceleration triangle to write down the equation. Then substitute… then evaluate.

$$\Delta \vec{V} = \vec{a}\Delta t$$

ΔV = (2.0m/s^2) (37s)

= <u>74 m/s forward</u>

2. A Chevette (car) is travelling North at 22m/s. **How long would it take** to slow this car to 12 m/s if it accelerates 2.5 m/s^2?

Answer: **E**quation, **S**ubstitute, **E**valuate

$$\Delta t = \frac{\Delta V}{a} = \frac{Vf - Vi}{a}$$

$$\Delta t = \frac{12\text{m/s} - 22\text{m/s}}{-2.5\text{m/s}^2}$$

$$\Delta t = \frac{-10\text{ m/s}}{-2.5\text{m/s}^2} = 4.0\text{s}$$ to slow the car

3. A "mo"ped starting from rest accelerates uniformly to 15m/s [E] in 5 seconds. What is the bike's acceleration?

First: Get your equation, then Substitute what you know, then evaluate

$$\vec{a} = \frac{\Delta \vec{V}}{\Delta t}$$

$$\vec{a} = \frac{15\text{m/s}}{5\text{s}}$$

$\vec{a}$ = **3m/s^2 is the acceleration**