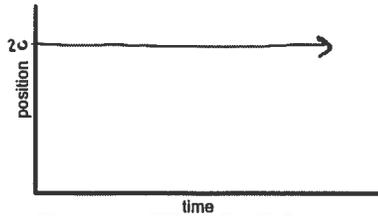# L03 – Position-Time Graphs, Velocity-Time Graphs

**Agenda:**
- Part 1: Position-Time Graphs Lesson
- Part 2: Position-Time Graphs Practice
- Part 3: Acceleration as a Change in Velocity
- Part 4: Velocity-Time Graphs Lesson
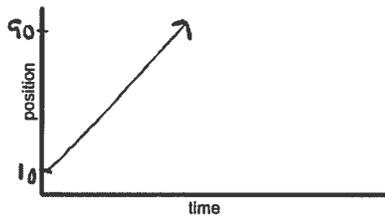- Part 5: Velocity-Time Graphs Practice
- Part 6: Summary

*Part 1: Position-Time Graphs Lesson*

**Q1:** Draw a position - time graph for a stationary object
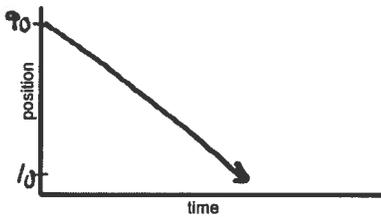


**Q2:** Draw a position - time graph for an object moving with uniform motion in the positive direction.
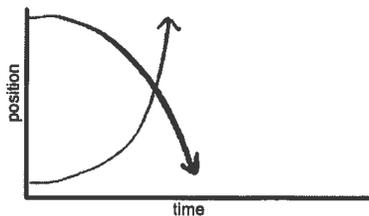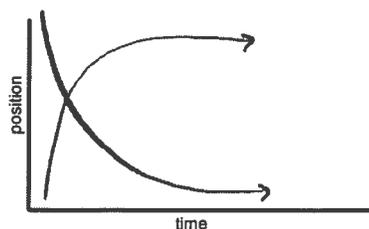
Constant Speed



**Q3:** Draw a position - time graph for a for an object moving with uniform motion in the negative direction.



**Q4:** Draw a position - time graph for a for an object speeding up.
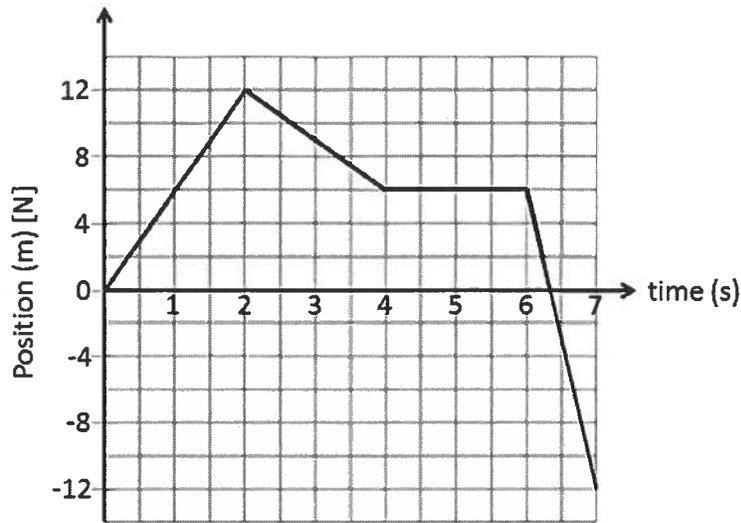


**Q5:** Draw a position - time graph for a for an object moving slowing down.

*Part 2: Position-Time Graphs Practice*



**Q6:** What is happening between 0 and 2 seconds?

Move 12m[N] in 2s.

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t} = \frac{12m[N]}{2s} = 6m/s[N]$$

**Q7:** What is happening between 2 and 4 seconds?

Move 6m[S] in 2s

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t} = \frac{6m[S]}{2s} = 3m/s[S]$$

$$-3m/s[N]$$

**Q8:** What is happening between 4 and 6 seconds?

Position (y-axis) isn't changing.

**Q9:** What is happening between 6 and 7 seconds?

Move 18m[S] in 1s

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t} = \frac{18m[S]}{1s} = 18m/s[S]$$

$\vec{d}_i = 6m[N]$

$\vec{d}_f = -12m[N]$

$$\Delta \vec{d} = \vec{d}_f - \vec{d}_i$$
$$= -12m[N] - (6m[N])$$
$$= -18m[N]$$
$$= 18m[S]$$
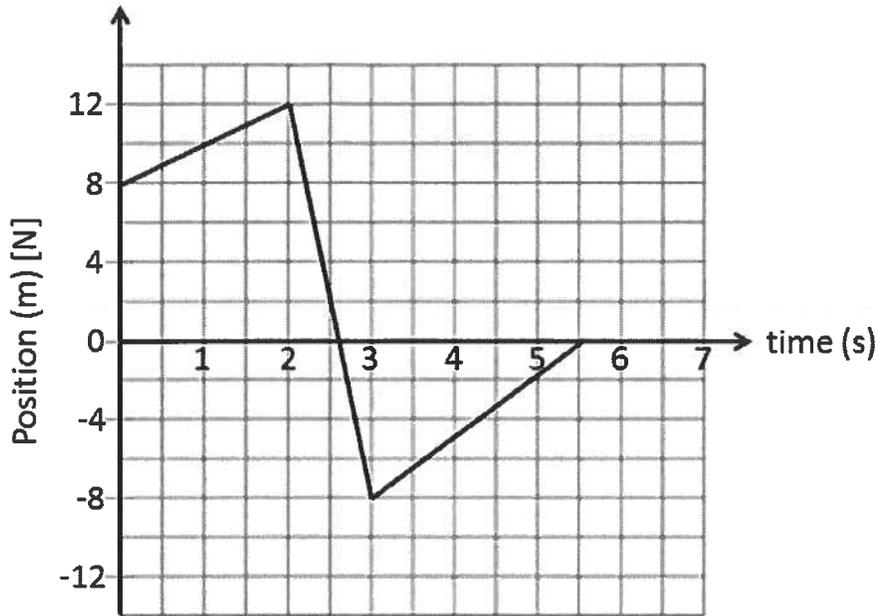
**Q10:** What is happening between 0 and 2 seconds?

Moving 4m[N] in 2s.                    North of origin (above 0 on y-axis)

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t} = \frac{4m[N]}{2s} = 2 m/s [N]$$

**Q11:** What is happening between 2 and 2.6 seconds?

Move 12m[S] in 0.6s                    North of origin.
                                       Moving south.

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t} = \frac{12m[S]}{0.6s} = 20 m/s [S]$$

**Q12:** What is happening between 2.6 and 3 seconds?

Same line = Same slope.                South of origin (below 0 on y-axis)

$$\vec{v} = 20 m/s [S]$$              Moving south

**Q13:** What is happening between 3 and 5.5 seconds?
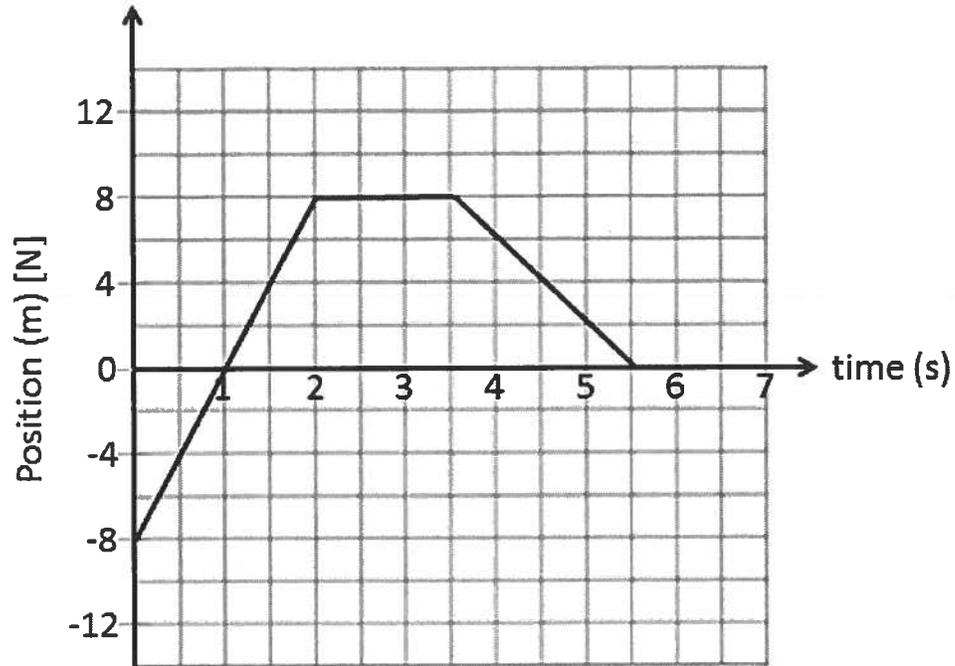
Move 8m[N] in 2.5s                     South of origin (below 0 on y-axis)
                                       Moving north (positive north velocity)

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t} = \frac{8m[N]}{2.5s} = 3.2 m/s [N]$$

**Q14:** What is happening between 0 and 1 seconds?

**Q15:** What is happening between 1 and 2 seconds?

**Q16:** What is happening between 2 and 3.5 seconds?

**Q17:** What is happening between 3.5 and 5.5 seconds?

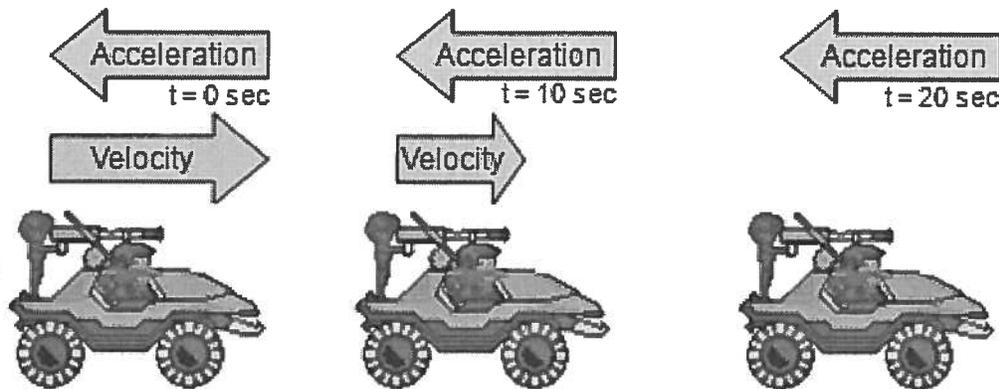*Part 3: Acceleration as a Change in Velocity*

# Velocity and Acceleration

Depicted below is a car travelling with ___positive___ velocity, and either positive or negative acceleration. The length of the arrows describe the magnitude of the acceleration (rate of change of velocity).

**Example #1:** Positive Velocity and Positive Acceleration
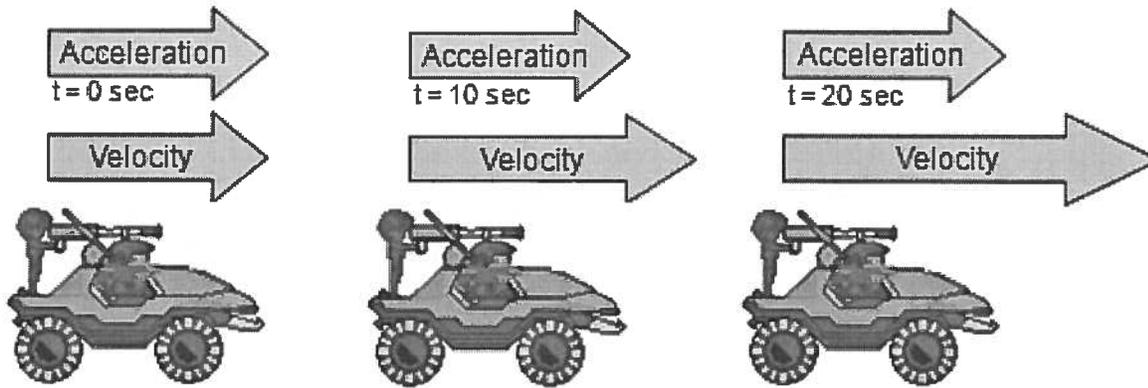


The positive acceleration will make the car's velocity more ___positive___ over time. The longer the time, the faster the car will be travelling to the right.

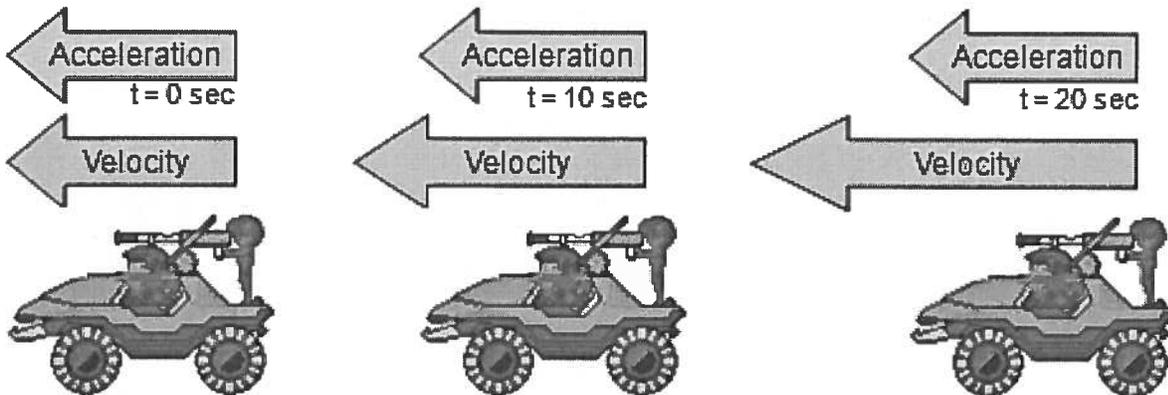**Example #2:** Positive Velocity and Negative Acceleration



The negative acceleration will make the car's velocity more ___negative___ over time. The longer the time, the more negative the velocity, until it is eventually zero, and the car has stopped.
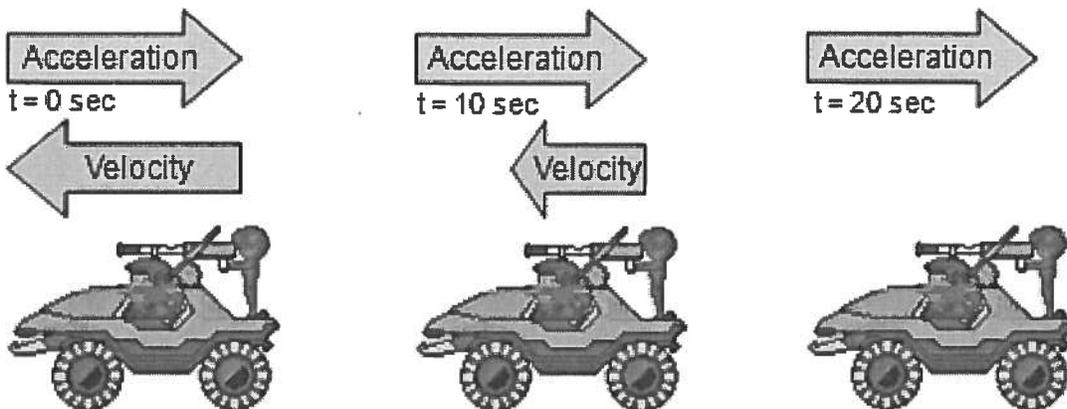
# Velocity and Acceleration

Depicted below is a car travelling with ___negative___ velocity, and either positive or negative acceleration. The length of the arrows describe the magnitude of the acceleration (rate of change of velocity).

**Example #3:** Negative Velocity and Negative Acceleration



The negative acceleration will make the car's velocity more ___Negative___ over time. The longer the time, the faster the car will be travelling to the left.

**Example #4:** Negative Velocity and Positive Acceleration



The positive acceleration will make the car's velocity more ___positive___ over time. The longer the time, the more positive the velocity, until it is eventually zero, and the car has stopped.

*Part 4: Velocity-Time Graphs Lesson*
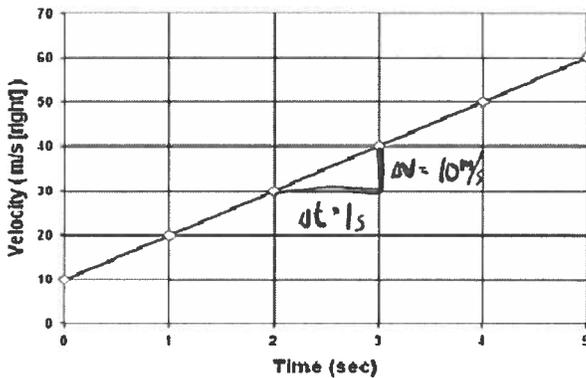
# Reading Velocity vs. Time Graphs

**Displacement** ($\overrightarrow{\Delta d}$) - The change in position.

**Velocity** ($\overrightarrow{v}$) - The rate of change of position.

**Acceleration** ($\overrightarrow{a}$) - The rate of change of velocity.

$$\frac{m}{s} \left( \div \frac{s}{1} \right) \Rightarrow \frac{m}{s} \times \frac{1}{s} = \frac{m}{s^2}$$
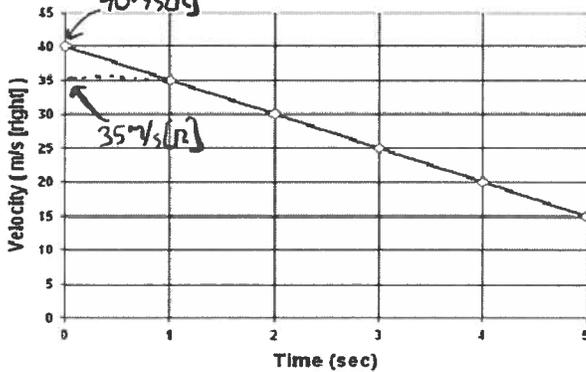
### Velocity vs. Time



**Q18:** What is the Acceleration?

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{10 \text{ m/s [R]}}{1s} = 10 \text{ m/s}^2 \text{ [R]}$$
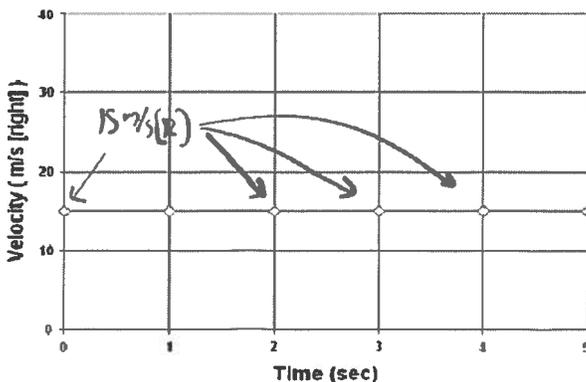
Accelerating (speeding up)

### Velocity vs. Time



**Q19:** What is the Acceleration?

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{-5 \text{ m/s [R]}}{1s} = \boxed{-5 \text{ m/s}^2 \text{ [R]}}$$

$$\Downarrow$$

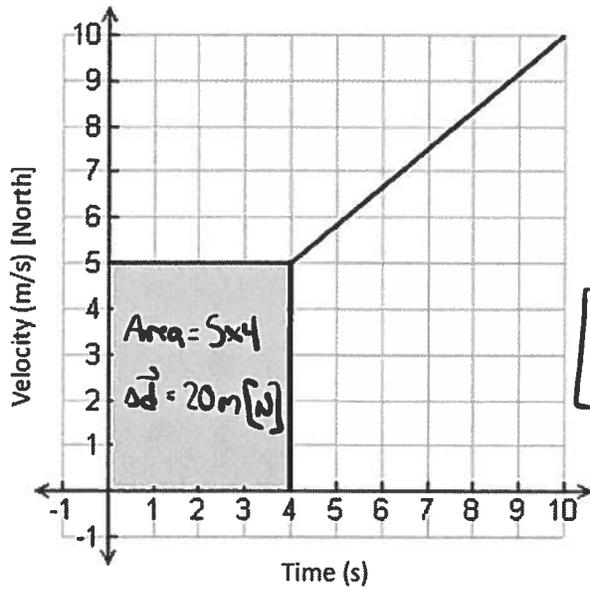$$\boxed{5 \text{ m/s}^2 \text{ [L]}}$$

### Velocity vs. Time



**Q20:** What is the Acceleration?

Moving with → Constant Speed
→ Uniform Motion

$$\vec{a} = \text{Slope} = \frac{\Delta \vec{v}}{\Delta t} = \boxed{0 \text{ m/s}^2 \text{ [R]}}$$
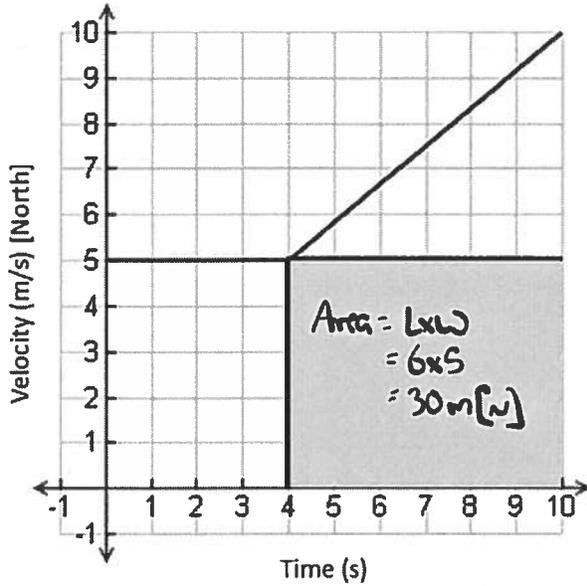
8

## Velocity vs. Time Graphs – Displacement

**Q21:** What is the displacement between 0-4 sec?

$$v = \frac{d}{t} \implies d = vt$$

$$A = L \times W$$

Area under a velocity-time graph is displacement

*(graph: Velocity (m/s) [North] vs Time (s), line rising from (4,5) to (10,10); shaded rectangle from 0-4 sec at height 5)*

Area = 5×4

$\vec{\Delta d} = 20 \, m \, [N]$

# $\mathcal{V}$elocity vs. $\mathcal{T}$ime $\mathcal{G}$raphs – $\mathcal{D}$isplacement

**Q22:** What is the displacement between 4-10 sec?

Area = 30 + 15
    = 45

$\Delta \vec{d} = 45m [N]$

Area = L x W
    = 6 x 5
    = 30 m [N]
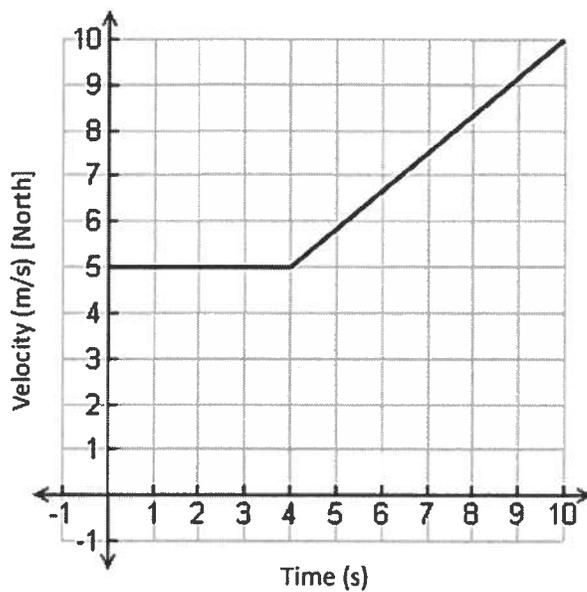
Area = ½ bh
    = ½ (6)(5) = 15 m [N]
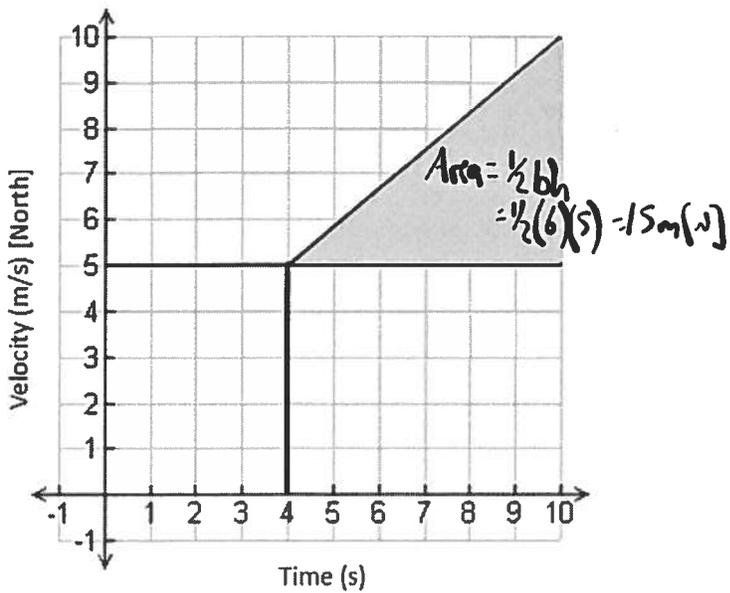
# Velocity vs. Time Graphs – Acceleration

**Displacement ( $\vec{\Delta d}$ )** - The change in position.
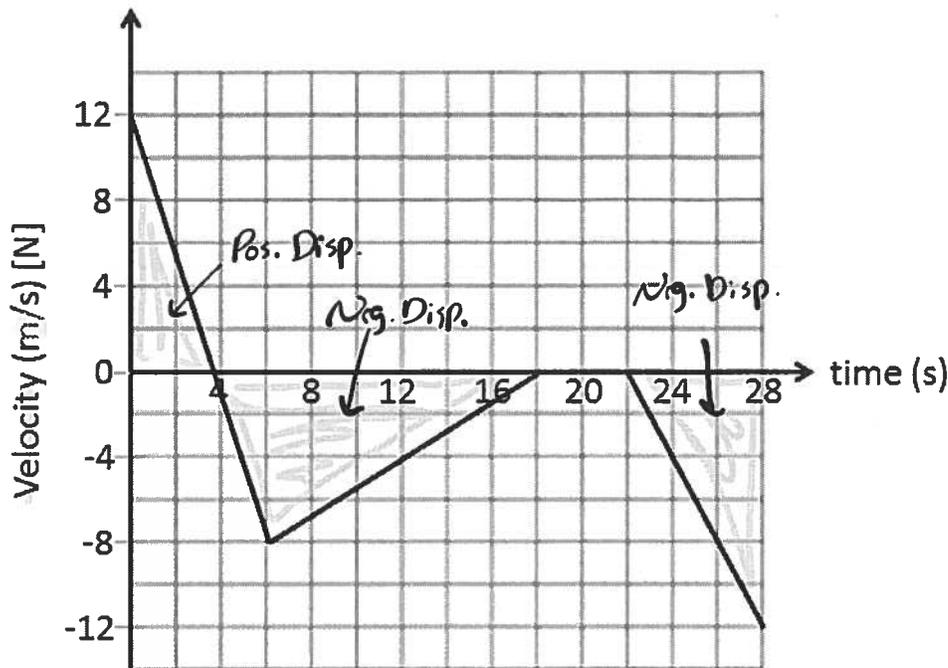
**Velocity ( $\vec{v}$ )** - The rate of change of position.

**Acceleration ( $\vec{a}$ )** - The rate of change of velocity.



**Q23:** What is happening in this graph?

*Part 5: Velocity-Time Graphs Practice*



**Q24:** What is happening between 0 and 3.6 seconds?

Ⓐ Start at $12 m/s [N]$ and decelerate to $0 m/s [N]$.

Ⓑ No idea where we started (initial position = ???)

Ⓒ Displacement = Area under graph = $\frac{1}{2}(12)(3.6) = 21.6 m [N]$
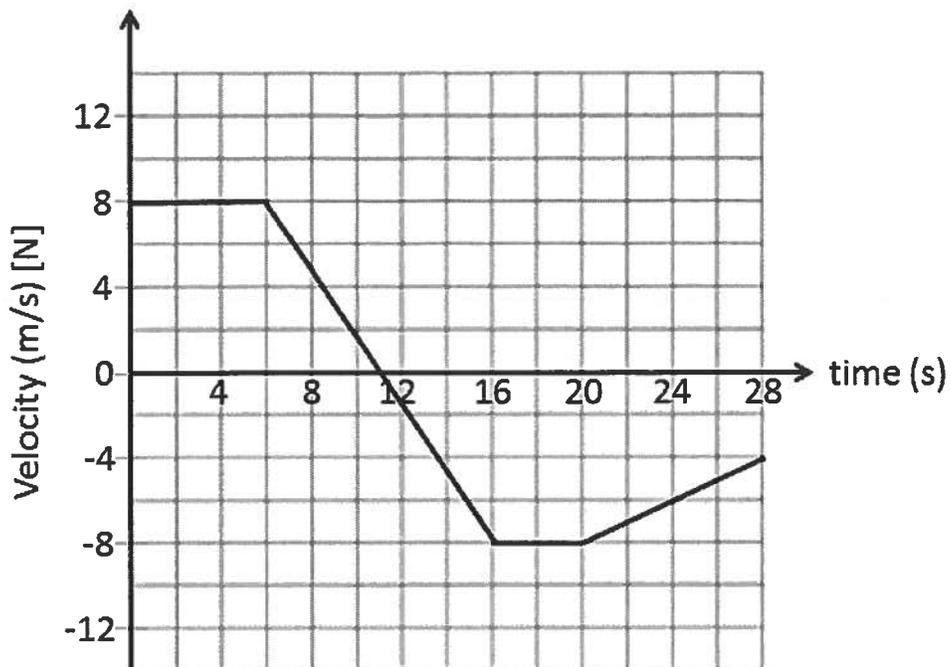
Velocity is never in South direction

**Q25:** What is happening between 3.6 and 6 seconds?

Ⓐ Start at $0 m/s [S]$... speed up to $8 m/s [S]$  $a = \frac{\Delta v}{\Delta t} = \frac{8 m/s [S]}{2.4 s} = 3.3 m/s^2 [S]$

Ⓑ Displacement is negative.

Ⓒ What direction are we moving? South

**Q26:** What is happening between 6 and 18 seconds?

Ⓐ Velocity from $8 m/s [S]$ to $0 m/s [S]$ ⟹ Decelerating

**Q27:** What is happening between 18 and 22 seconds?
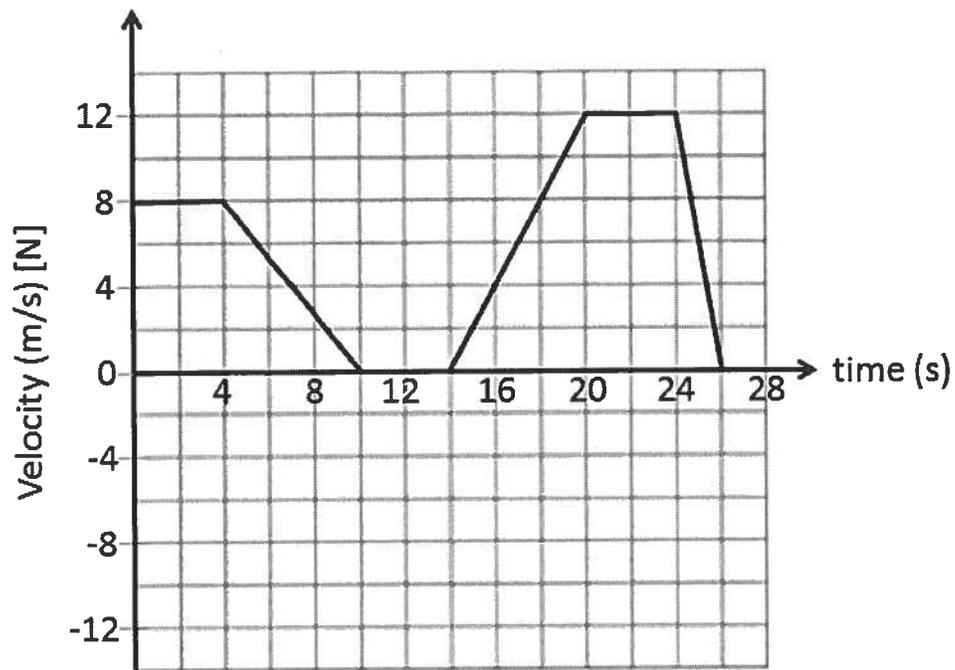
**Q28:** What is happening between 0 and 6 seconds?

**Q29:** What is happening between 6 and 11 seconds?

**Q30:** What is happening between 11 and 16 seconds?

**Q31:** What is happening between 16 and 20 seconds?

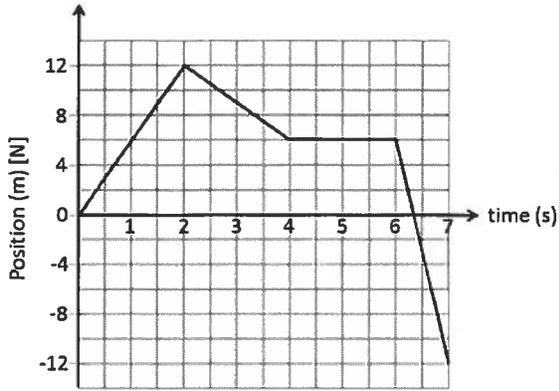**Q32:** What is happening between 0 and 4 seconds?

**Q33:** What is happening between 4 and 10 seconds?

**Q34:** What is happening between 10 and 14 seconds?

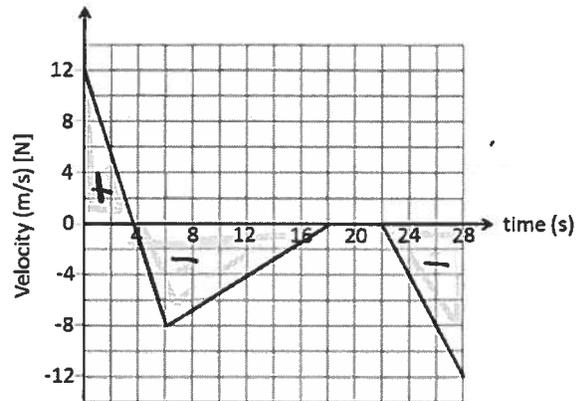**Q35:** What is happening between 14 and 20 seconds?

## Part 6: Summary

| Position-Time Graphs | Velocity-Time Graphs |
|---|---|

① Displacement (change in position) is simply change in y value.

② Velocity = $\frac{\Delta d}{\Delta t}$ or slope

③ Cannot determine acceleration.

① Displacement = area under graph

② Velocity → Read y-axis

③ $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$ or slope    $\frac{\Delta \vec{v}}{\Delta t} = \frac{rise}{run}$