Acceleration

Acceleration

When you’re in a car, do you ever feel like you’re moving?

Acceleration

We only feel motion when we speed up or slow down, i.e. when we experience acceleration

Acceleration: a change in velocity over time.

$\vec{a}$, vector quantity.

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

$a \rightarrow$ magnitude.

Accelerated vs Uniform Motion

Uniform Motion: motion in one direction at constant speed.

Uniform motion is simpler to calculate, but accelerated motion is much more common in real life.

Accelerated Motion: motion at varying speeds.

Accelerated vs Uniform Motion

Examples of accelerated motion:

- A car speeding up or slowing down
- A ball falling downward
- A space shuttle launching
- any thing that changes speed

Calculating Acceleration

Acceleration is a change in velocity over a time period. This definition tells us the formula we will use:

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

Calculating Acceleration

A race car driver accelerates from rest to a velocity of 25.0 m/s [W], in 4.00s. What is the acceleration of the car?

rest $= 0\,m/s$

$t = 4.00s$

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

$\Delta\vec{V}$ = change in velocity.

$\vec{V}_f = 25.0\,m/s\ [W]$

$\vec{V}_i = 0\,m/s$

$a = \frac{\Delta\vec{V}}{t} = \frac{\vec{V}_f - \vec{V}_i}{t}$

$\frac{\left(\frac{m}{s}\right)}{s}$

$= \frac{25.0\,m/s - 0\,m/s}{4.00s}$

$= 6.25\,m/s^2\ [W]$

Calculating Acceleration

A bus is travelling at 15 m/s [N], and applies its brakes, coming to a stop in 3.0s. What is the acceleration of the bus?

$$\vec{a} = \frac{\Delta \vec{v}}{t} = \frac{\vec{v}_f - \vec{v}_i}{t} = \frac{0 - 15}{3.0}$$

$\vec{v}_i = 15\,m/s$ N

$\vec{v}_f = 0\,m/s$

$t = 3.0\,s$

$$= -5.0\,m/s^2\ [N]$$

$$= 5.0\,m/s^2\ [S]$$

Calculating Acceleration

A golf ball rolling on a green slows down from 2.00 m/s to 1.50 m/s in 2.00s. What is the magnitude of the acceleration of the ball?

how much
number.

$V_f = 1.50$ m/s

$V_i = 2.00$ m/s

$t = 2.00$s

$$a = \frac{V_f - V_i}{t} = \frac{1.50 - 2.00}{2.00}$$

$$a = -0.25 \text{ m/s}^2$$

Calculating Acceleration

An ball, initially at rest, is dropped off a building and accelerates to Earth at -9.81 m/s^2. (9.81 m/s^2 [downward]). How long will it take the ball to reach a final velocity of -49.1 m/s?

$$t \times \vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t} \times t$$

$$\frac{t \times \vec{a}}{\vec{a}} = \frac{\vec{v}_f - \vec{v}_i}{\vec{a}}$$

$$t = \frac{\vec{v}_f - \vec{v}_i}{\vec{a}}$$

$$= \frac{(-49.1\ m/s) - 0}{-9.81\ m/s^2}$$

$$= 5.01\ s$$

Calculating Acceleration

A cyclist starts at rest and accelerates at 2.50 m/s^2 [N] for 6.00 s. What is the final velocity of the object?

$\vec{v}_f = ?$

$t \times \vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t} \times t$

$t \times \vec{a} = \vec{v}_f - \vec{v}_i$

$+\vec{v}_i \qquad +\vec{v}_i$

$t \times a + \vec{v}_i = \vec{v}_f$

$\vec{v}_f = 6.00\,s \times 2.50\,m/s^2 + 0$

$= 15.0\,m/s\,[N]$

Positive and Negative Acceleration

Our previous examples had some positive and negative answers. How do we know when acceleration is positive or negative?

Positive and Negative Acceleration

(a) Positive acceleration: both the change in the magnitude and the direction of the velocity are positive.

(b) Positive acceleration: both the change in the magnitude and the direction of the velocity are negative.

(c) Negative acceleration: the change in the magnitude of the velocity is negative while the direction is positive.

(d) Negative acceleration: the change in the magnitude of the velocity is positive but the direction is negative.

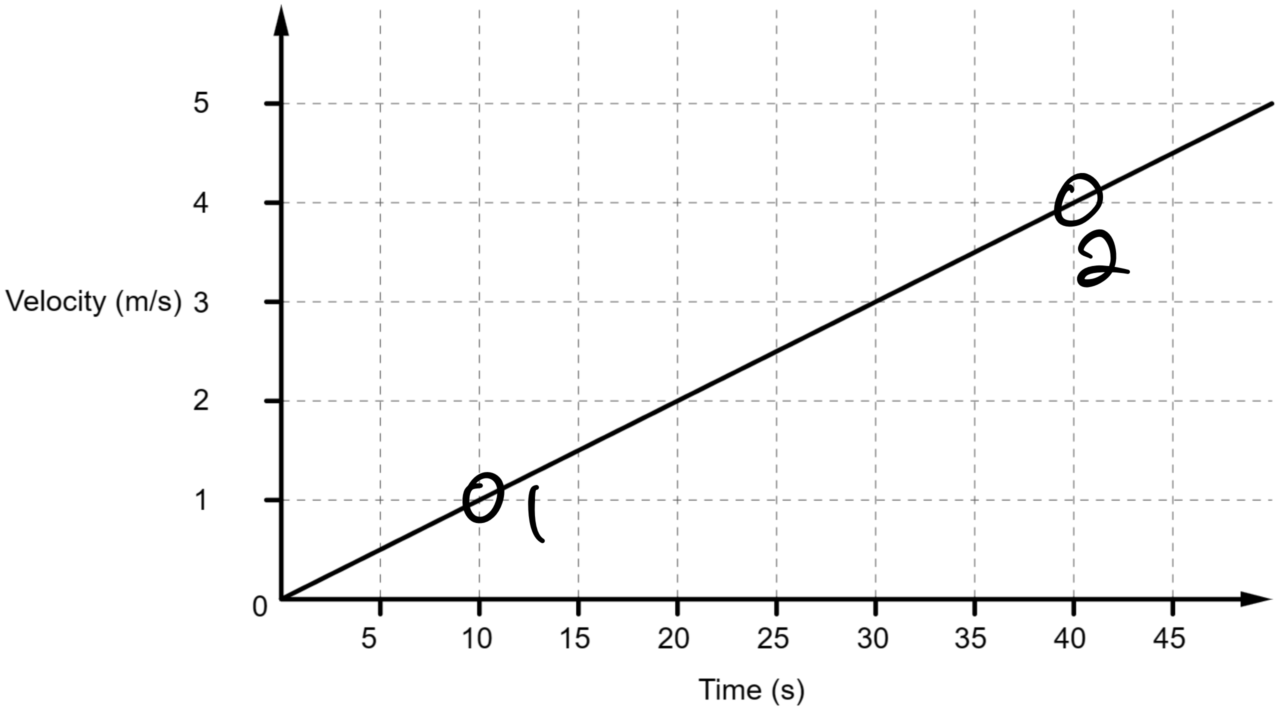
Positive and Negative Acceleration

Acceleration From a Graph

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$$

Calculating Acceleration

Acceleration is the change in velocity over time.



$\vec{a}$ = slope.

$\vec{d}$ = area.

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

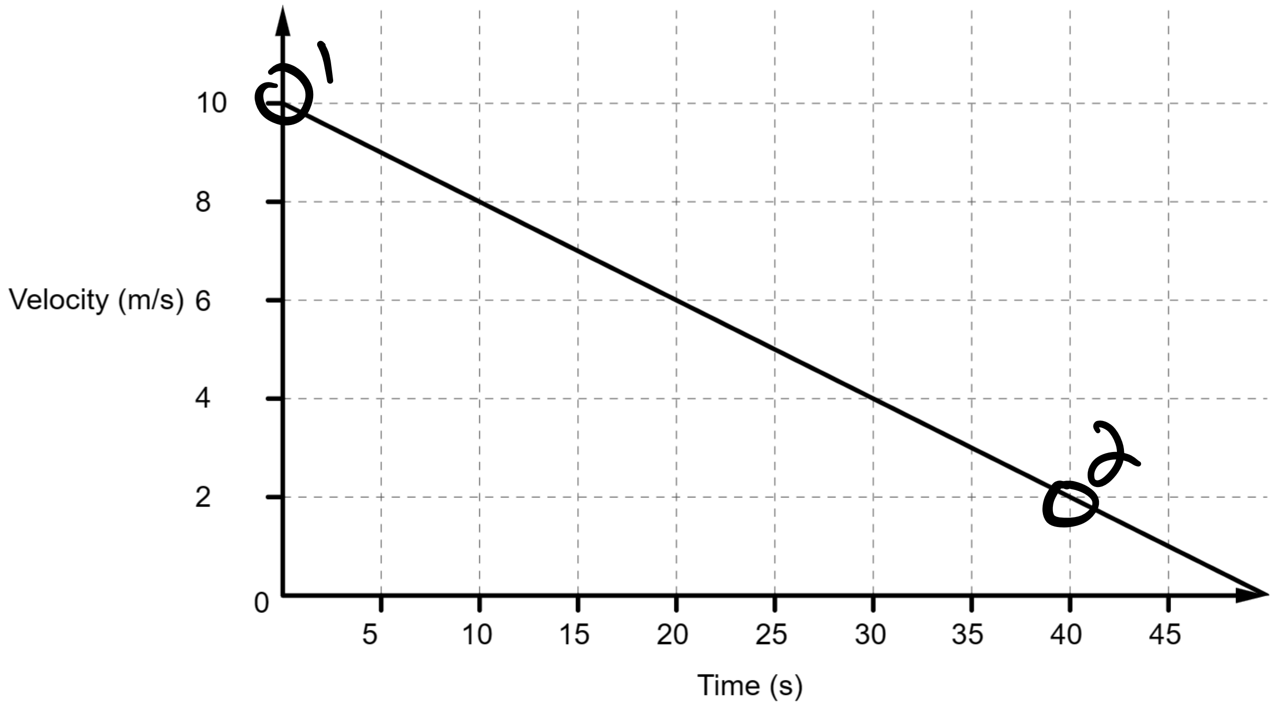
$$= \frac{v_2 - v_i}{t_2 - t_1}$$

$$= \frac{4 - 1}{40 - 10}$$

$$= \underline{3}$$

$$\frac{}{30}$$

$$= 0.1\ m/s^2$$



$$\vec{a} = \text{slope}$$

$$= \frac{v_2 - v_1}{t_2 - t_1}$$

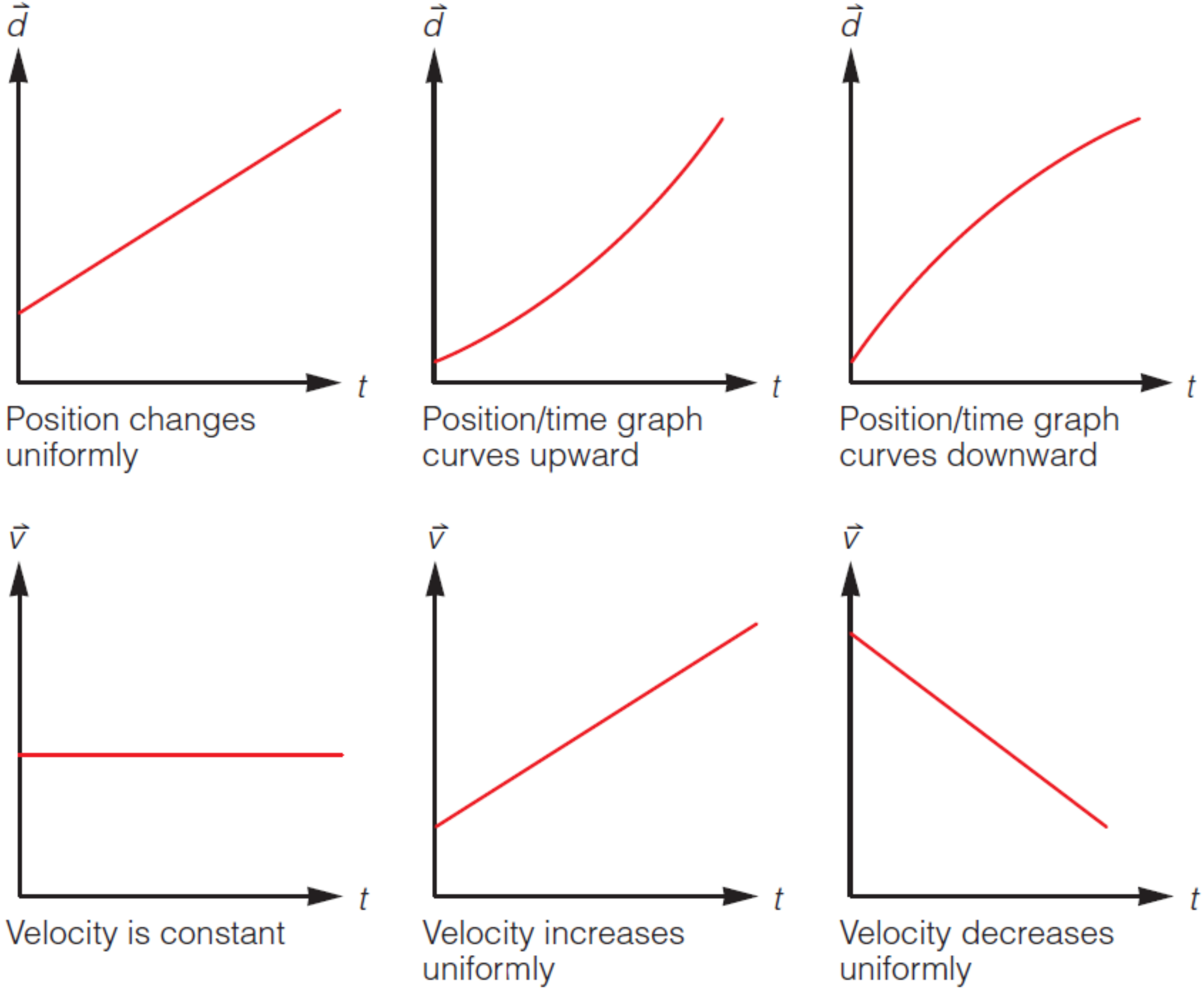
$$= \frac{2 - 10}{40 - 0}$$

$$= \frac{-8}{40}$$

$$= -0.2\ m/s^2$$

Acceleration Graphs

What does acceleration look like on different types of graphs?



$\vec{d}$
t
Position changes uniformly
$\vec{d}$
t
Position/time graph curves upward
$\vec{d}$
t
Position/time graph curves downward
$\vec{v}$
t
Velocity is constant
$\vec{v}$
t
Velocity increases uniformly
$\vec{v}$
t
Velocity decreases uniformly

A bull starts from rest, and charges. It reaches a velocity of 4.5 m/s [E] after 3.0s. What was its average acceleration?

$\vec{V}_i = 0$

$\vec{V}_f = 4.5\,m/s$ [E]

$t = 3.0s$

$$\vec{a} = \frac{\vec{V}_f - \vec{V}_i}{t}$$

$$= \frac{4.5 - 0}{3}$$

$$= 1.5\,m/s^2 \text{ [E]}$$