Uniform Acceleration

- **Acceleration is a vector quantity which is defined as "the rate at which an object changes its velocity." An object is accelerating if it is changing its velocity.**
- ***Uniform* or *constant* acceleration is a type of motion in which the velocity of an object changes by an equal amount in every equal time period.**
- **A common example of uniform acceleration is an object in '*free-fall*'.**

Acceleration

Observe the animation of the three cars below. Which car or cars (red, green, and/or blue) are undergoing an acceleration?

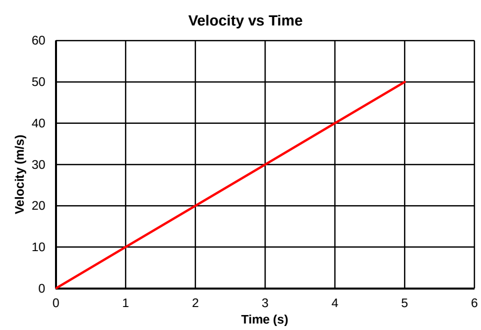
The green and blue cars are undergoing acceleration.

Acceleration

- **Acceleration has to do with changing how an object is moving.**
- **If an object is not changing its velocity, then the object is not accelerating.**

Time (s)	Velocity (m/s)
0	0
1	10
2	20
3	30
4	40
5	50

The velocity in the table is changing with respect to time. In fact, the velocity is changing by a constant amount (10 m/s) in each second of time.



The slope of a velocity—time graph equals the average acceleration

The acceleration of any object is calculated using the equation

$$\text{Avg. acceleration} = \frac{\Delta\text{velocity}}{\Delta\text{time}} = \frac{V_f - V_i}{\Delta t}$$

Acceleration values are expressed in units of velocity/time. Typical acceleration units include the following:

m/s/s, mi/hr/s, km/hr/s

- Since acceleration is $\Delta v/t$, its units would be velocity units per time units.
- This is written as m/s^2

- **Since acceleration is a vector quantity, it will always have a direction associated with it. The direction of the acceleration vector depends on two things:**
  - **whether the object is speeding up or slowing down**
  - **whether the object is moving in the + or - direction**
- **The general RULE OF THUMB is:**
  - **If an object is slowing down, then its acceleration is in the opposite direction of its motion.**

Sample Problem

- While escaping a cheetah a gazelle initially moving at 5 m/s accelerates at a rate of 2 m/s² for 6 seconds. What was the final velocity of the gazelle?

$v_i = 5\ m/s$

$a = 2\ m/s^2$

$\Delta t = 6\ s$

$v_f = ?$

$$a_{avg} = \frac{v_f - v_i}{\Delta t}$$

$$2m/s^2 = \frac{v_f - 5m/s}{6s}$$

$$12m/s = v_f - 5m/s$$

$$v_f = 17m/s$$

Practice Problem

- A car traveling 40 mi/hr comes to a complete stop in 3 seconds. What was its acceleration in m/s²?

$v_i = \sout{40\ mi/hr} = 17.78\ m/s$

$v_f = \sout{0\ mi/hr} = 0\ m/s$

$\Delta t = 3\ sec$

$a = ?$

$$a = \frac{v_f - v_i}{\Delta t}$$

$$\frac{40\ \text{mi}}{1\ \text{hr}} \cdot \frac{1600\ \text{m}}{1\ \text{mi}} \cdot \frac{1\ \text{hr}}{3600\ \text{s}} = 17.78m/s$$

$$a_{avg} = \frac{0m/s - 17.78m/s}{3s} = \boxed{-5.93\ m/s^2}$$

Read note on previous page and knock that out so there is a better example here…

Practice Problem

- In 1954 Col. Stapp did a variety of tests for the military to determine the limits of the human body under extreme acceleration. In one rocket sled test he went from 1020 km/hr to rest in the small time of 1.4 seconds. What acceleration did he experience as he came to a stop?

Practice Problem

$v_i = 1020km/hr$ $\quad$ $v_i = 283.33m/s$

$v_f = 0m/s$

$\Delta t = 1.4\sec$

$a = ?$

$$\frac{1020\,km}{1\,hr} \cdot \frac{1000\,m}{1\,km} \cdot \frac{1\,hr}{3600\,s}$$

$$a_{avg} = \frac{v_f - v_i}{\Delta t} \qquad a = \frac{0m/s - 283.33m/s}{1.4s}$$

$$a = -202.38m/s^2 \qquad a = -20.65g$$