Non-Uniform Motion

Outcomes:

S2-3-03 Analyze the relationships among velocity, time and acceleration for an object accelerating at a constant rate.

Non-Uniform Motion…

Average velocity:

- Velocity of an object over an **INTERVAL** of time
- **SLOPE** of a d-t graph

Ex) You drive to Brandon (200km) in 2 hours. What is your average velocity?

$$V_{avg} = \frac{\Delta d}{\Delta t} = \frac{200km}{2 hr} = 100 \ km/hr$$

Instantaneous velocity:

- Velocity of an object at an **INSTANT** in time

Ex) ***An hour after you left Winipeg, you were driving 60km/hr because of a construction zone***

Non-Uniform Motion…

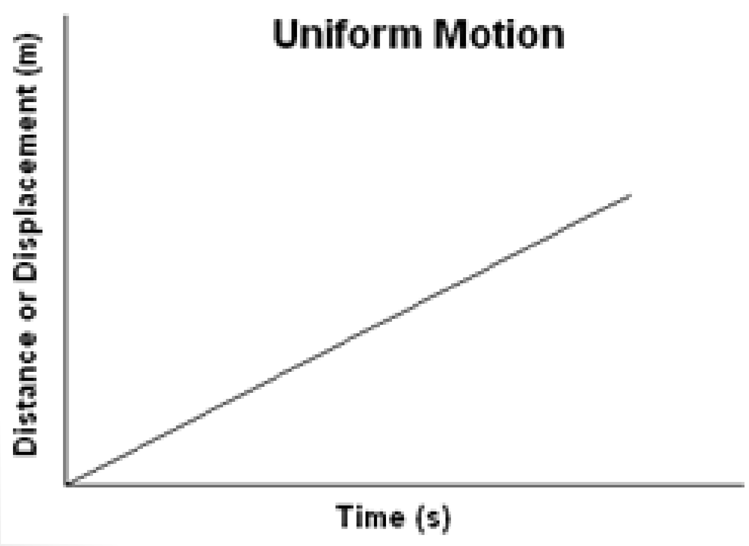
So far we have only looked at uniform motion, and for uniform motion:

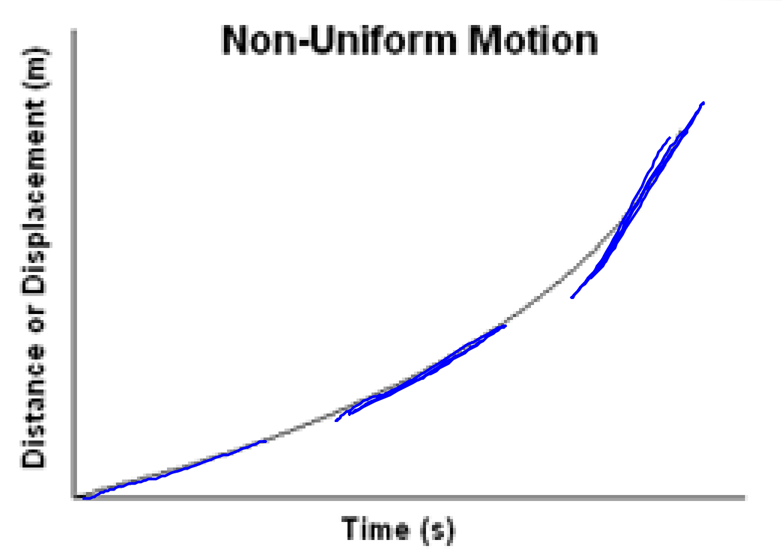
Average Velocity = Instantaneous Velocity

With **<u>NON</u>**-**<u>UNIFORM</u>** motion, an object will be **<u>ACCELERATING</u>** or **<u>DECELERATING</u>**, causing changes in its **<u>VELOCITY</u>** Therefore:

Average Velocity ≠ Instantaneous Velocity

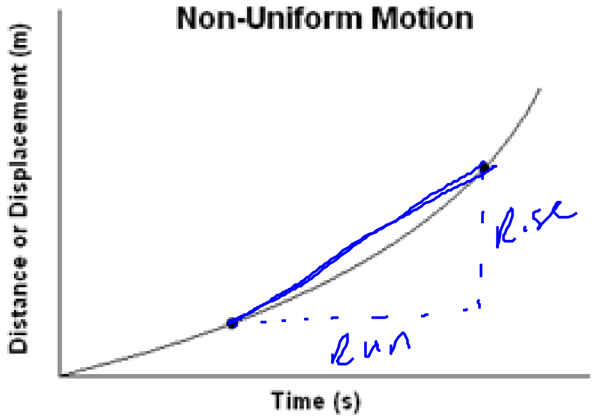
If speed or velocity is non-uniform, then a distance-time or position-time graph will be **<u>CURVED</u>**:





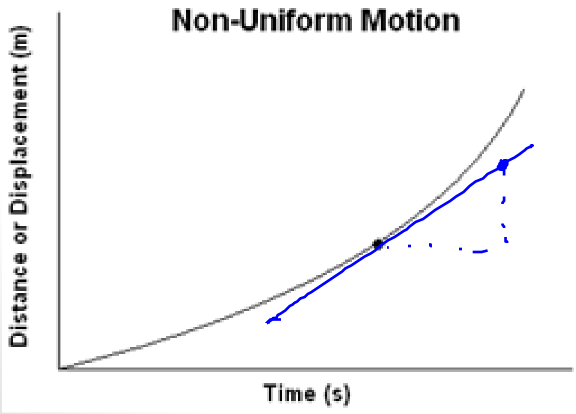
Non-Uniform Motion…

To find the **AVERAGE** velocity for the curve (or part of it), you would still find the **SLOPE** of a line between **TWO POINTS**;



$$v_{av} = \frac{Rise}{Run} = \frac{\Delta d}{\Delta t}$$

If you want to find the **INSTANTANEOUS** velocity at an exact moment in time, you would draw a **TANGENT** line at that point and find its **SLOPE**:



$$v_{inst} = \frac{Rise}{Run} = \frac{\Delta d}{\Delta t}$$

Acceleration…

- Acceleration is the **RATE** of **CHANGE** of **VELOCITY** or **SPEED**.
- It is calculated by the **CHANGE** in **SPEED** versus the **CHANGE** in **TIME**.

$$a_{av} = \frac{\Delta v}{\Delta t} \quad \textbf{OR} \quad a_{av} = \frac{v_2 - v_1}{\Delta t}$$

- **UNITS** for acceleration are **m/s^2** (or **km/hr^2**).
- Acceleration needs a **DIRECTION** if **VELOCITY** is used.

  Ex) Gravity causes objects to accelerate toward the earth at a rate of 9.8 m/s^2

  → ***a skydivers velocity will increase by 9.8m/s every second.***

Like velocity, acceleration can be **UNIFORM** or **NON-UNIFORM**. In this course we will concentrate on **UNIFORM** (constant) acceleration.

Acceleration Examples…

1. If you speed up on a motorcycle from rest (0m/s) to 9.0m/s in a time of 2 seconds, what is your acceleration?

V_1 V_2 Δt

$$\vec{a} = \frac{\vec{V}_2 - \vec{V}_1}{\Delta t}$$

$$= \frac{(9.0\,\frac{m}{s} - 0\,\frac{m}{s})}{2\,s} = \frac{9\,\frac{m}{s}}{2\,s} = +4.5\,m/s^2$$

2. If a car accelerates from 0 to 100km/hr in 6 seconds. What is the average acceleration of the car?

V_1 V_2 Δt

$\hookrightarrow \div 3.6 = 27.8\,m/s$

$$\vec{a} = \frac{\vec{V}_2 - \vec{V}_1}{\Delta t} = \frac{27.8\,m/s - 0\,m/s}{6\,s} = \frac{27.8\,m/s}{6\,s} = +4.63\,m/s^2$$

Try these ones…

1. A snowboarder is moving 1.8m/s near the top of a hill. 4.2s later he is travelling at a velocity of 8.3m/s down the hill. What is his average acceleration?

V_1 Δt V_2

$$\vec{a} = \frac{\vec{V}_2 - \vec{V}_1}{\Delta t} = \frac{(8.3\frac{m}{s} - 1.8\frac{m}{s})}{4.2s} = \frac{6.5\frac{m}{s}}{4.2s} = +1.5\ m/s^2$$

2. If a race car is travelling at 100km/h comes to a stop in 5.0s what is the average acceleration?

V_1 $V_2 = 0$

↳ m/s 100 km/hr ÷ 3.6 = 27.8 m/s

$$\vec{a} = \frac{\vec{V}_2 - \vec{V}_1}{\Delta t} = \frac{0\,m/s - 27.8\,m/s}{5.0s} = \frac{-27.8\,m/s}{5.0s} = -5.56\ m/s^2$$

Try this one…

A bus with an initial speed of 12m/s accelerates at 0.62m/s² for 15s, what is the final speed of the bus?

$\vec{v}_1$ $\qquad$ $\vec{a}$ $\qquad$ Δt

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$

$$\times 15s \quad 0.62\,m/s^2 = \frac{\vec{v}_2 - 12\,m/s}{(15s)} \quad \times 15s$$

$$(15s)(0.62\,m/s^2) = v_2 - 12\,m/s$$

$$(15s)(0.62\,m/s^2) + 12\,m/s = v_2$$

$$v_2 = 21.3\,m/s$$