UNIT 2: ACCELERATED MOTION

Topic 2A: Acceleration

Skill 12: Recognizing Acceleration, Defining Variables

Acceleration is the rate of change in velocity of an object.

An accelerating object, speeds-up, slows-down or changes direction due to an unbalanced force.

In order to analyze the motion of an object that is accelerating we must understand the following variables. **ACCELERATION IS A VECTOR** (If an object with v_i east experiences an acceleration west it will slow down)

	Variable	Units	Definitions	Equations
Initial Velocity	v_i	m/s	Speed/Velocity at the **start** of the scenario	$v_f = v_i + at$ $v_f = v_i + \Delta v$
Final Velocity	v_f	m/s	Speed/Velocity at the **end** of the scenario	
Average Velocity	$\bar{v}$	m/s	The total distance over time for non-uniform motion… Or the mid-point in velocity for uniform acceleration and uniform net force.	$\bar{v} = \frac{d}{t}$ $\bar{v} = \frac{v_i + v_f}{2}$
Change in Velocity	Δv	m/s	The change in speed or velocity. Change is final speed minus initial speed.	$\Delta v = at$ $\Delta v = v_f - v_i$
Acceleration	a	m/s^2	Speeding up, slowing down or changing direction as a result of a net force. Uniform (constant) acceleration means the same force is applied for the entire scenario. All equations including "a" are for uniform acceleration.	$a = \frac{\Delta v}{t}$ $a = \frac{v_f - v_i}{t}$
Displacement	d	m	The change in position of an object during the scenario. (Only use d=$\bar{v}t$ in acceleration problems after you have averaged initial velocity and final velocity)	$d = \bar{v}t = \left(\frac{v_i + v_f}{2}\right)t$ $d = v_i t + \frac{1}{2}at^2$ $v_f{}^2 = v_i{}^2 + 2ad$
Time	t	s	The time interval for any scenario	$t = \frac{d}{\bar{v}} = \frac{2d}{v_i + v_f}$ $t = \frac{\Delta v}{a}$ $t = \frac{v_f - v_i}{a}$

Non-uniform acceleration

For objects that change speed, but don't undergo uniform changes in speed;

- The average speed can be found by determining the total distance over time.
- The average velocity can be found by determining the total displacement over time. (velocity must keep in mind the displacement which includes direction)

So average velocity can be found using $\bar{v} = \frac{d}{t}$

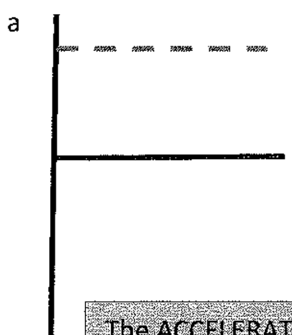
Or displacement can be found using **$d = \bar{v}t$**

> Be sure to use total distance over time rather than average the speeds (unless all times frames are equal)

UNIFORM ACCELERATION

Most objects undergo a UNIFORM (constant) change in speed or velocity. A UNIFORM acceleration means that the value of the acceleration is the same for the entire problem. For example, an object speeds up by "5m/s each second" for 10s. In this scenario, position changes, velocity changes with time but the "rate of change in velocity" (acceleration) is constant or UNIFORM.

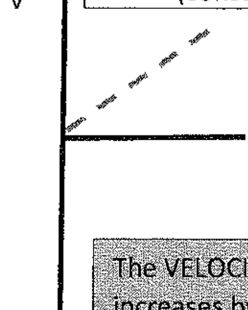
The graphs below all represent the same accelerated motion ($5m/s^2$) vs. a time interval of 0-10 seconds.



The ACCELERATION is a **uniform**

Ex: $5m/s^2$ for the entire 10 seconds

Acceleration is the slope (constant)



The VELOCITY increases by 5m/s each second for 10s

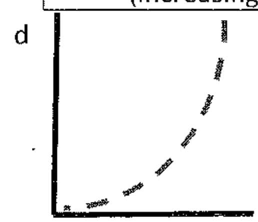
$v_i = 0$

$v_f = 50m/s$

$\Delta v = 50 m/s$

$V_{avg} = \bar{v} = 25m/s$

Velocity is the slope (increasing)



The change in POSITION increases each second

Time	Position
0	0
1	2.5 m
2	10 m
3	22.5m
4	40m
5	62.5 m
6	90 m
7	122.5m
8	160m
9	202.5 m
10	250 m

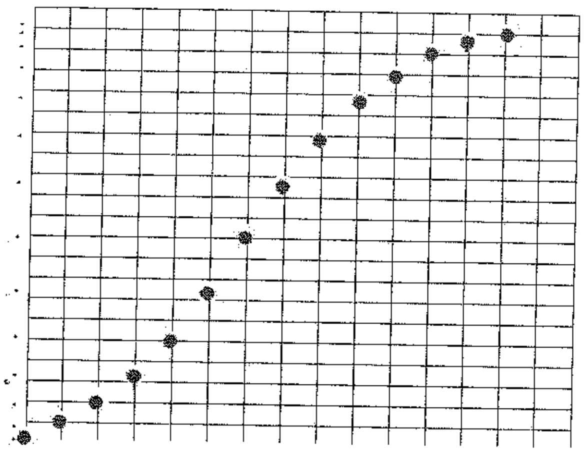
- **V_i** is the starting speed
- **V_f** is the final speed
- $\bar{v}$ is the average speed (mid-point of Δv)
- Δv is the change in value on the "y" axis (velocity)
- d is the change in position
- a is the acceleration (rate of change in velocity)
- t is the time interval of the problem

Translating between 1-dimensional "dot-diagrams" to position vs. time graphs, velocity vs. time graphs and acceleration vs. time graphs.

Each dot represents the position of an object after 0.1 second time intervals.

The dot diagram above represents 1.3 seconds of motion. Each point can be measured from the reference point "t=0". To represent this motion on a distance versus time the positions are plotted on the vertical "y" axis and then expanded across the time axis.

<u>**Distance vs. Time**</u>



> This object speeds up for 0.5 seconds, moves at constant speed for 0.2 seconds, and slows down for 0.6 seconds.

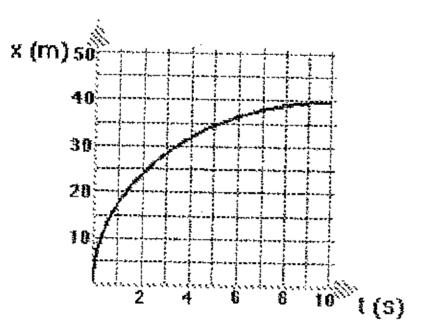
> **Acceleration** (speeding up, slowing down) is represented on a **position vs. time** graph by a **curve**.
> - A **straight sloped line** represents a **constant speed**.
> - A **straight line with zero slope** represents an object at **rest**.

Linking position vs. time; velocity vs. time; acceleration vs. time

The slope of a distance vs. time graph is speed or velocity

Whatever the slope of d vs t is doing the speed is doing

Away – positive slope	**Speeding up – increasing slope**
Toward – negative slope	**Slowing Down – decreasing slope**



High positive slope decreases to zero…
This object is moving AWAY from the observer and SLOWING to Rest (zero)