CONCEPT: EQUATIONS OF MOTION (KINEMATICS EQUATIONS)

- Remember: for constant velocity **(a=0)**, the only equation you can use is: $v = \frac{\Delta x}{\Delta t} \rightarrow x = x_0 + vt$

- If **a** is **NOT** 0, you will need the 4 Equations of Motion, also called **U**niformly **A**ccelerated **M**otion (**UAM)** equations.
  - To use these equations, acceleration ***must*** be ______________.

UAM Equations	Δx	v_0	v	a	t
(1) $v = v_0 + at$					
(2) $v^2 = v_0^2 + 2a\Delta x$					
(3) $x = x_0 + v_0 t + \frac{1}{2}at^2$ OR $\Delta x = v_0 t + \frac{1}{2}at^2$					
(4)* $\Delta x = \left(\frac{v_0 + v}{2}\right) t$					

*Check to see if your professor allows this!

- To solve *any* motion problem with these equations, you'll *always* **NEED** ____ out of 5 variables.

EXAMPLE: A racing car starting from rest accelerates constantly down a 160-m track before crossing the finish line. If the car crosses the finish line after 8s, **(a)** What is the acceleration of the car? **(b)** What is the car's velocity at the finish line?

MOTION w/ ACCELERATION
1) Draw Diagram & list 5 variables
2) Identify known & target variables
3) Pick UAM Eq. ***without*** "Ignored" Variable
4) Solve

UAM Equations
(1) $v = v_0 + at$
(2) $v^2 = v_0^2 + 2a\Delta x$
(3) $\Delta x = v_0 t + \frac{1}{2}at^2$
(4) $\Delta x = \left(\frac{v + v_0}{2}\right) t$

- Pick equation containing target variable and excluding ____________ variable
  - Ignored Variable ⇒ variable **not asked for** *nor* **given**

PRACTICE: A car accelerates from 5 m/s to 21 m/s at a constant 3.0 m/s^2. How far does it travel while accelerating?

MOTION w/ ACCELERATION
1) Draw Diagram & list 5 variables
2) Identify known & target variables
3) Pick UAM Eq. ***without*** "Ignored" Variable
4) Solve

UAM Equations
(1) $\boldsymbol{v = v_0 + at}$
(2) $\boldsymbol{v^2 = {v_0}^2 + 2a\Delta x}$
(3) $\boldsymbol{\Delta x = v_0 t + \frac{1}{2}at^2}$
(4) $\boldsymbol{\Delta x = \left(\frac{v+v_0}{2}\right)t}$

PRACTICE: A moving hockey puck encounters a patch of rough road and slides 90cm before coming to a full stop. Assuming a constant deceleration of 8 m/s^2, what was the puck's initial speed?

MOTION w/ ACCELERATION
1) Draw Diagram & list 5 variables
2) Identify known & target variables
3) Pick UAM Eq. ***without*** "Ignored" Variable
4) Solve

UAM Equations
(1) $\boldsymbol{v = v_0 + at}$
(2) $\boldsymbol{v^2 = {v_0}^2 + 2a\Delta x}$
(3) $\boldsymbol{\Delta x = v_0 t + \frac{1}{2}at^2}$
(4) $\boldsymbol{\Delta x = \left(\frac{v+v_0}{2}\right) t}$

PRACTICE: Certain rifles can fire a bullet with a speed of 970 m/s just as it leaves the barrel. The barrel is 70.0 cm long and the bullet is accelerated uniformly from rest within it. For how long is the bullet accelerated through the barrel?

MOTION w/ ACCELERATION
1) Draw Diagram & list 5 variables
2) Identify known & target variables
3) Pick UAM Eq. ***without*** "Ignored" Variable
4) Solve

UAM Equations
(1) $\boldsymbol{v = v_0 + at}$
(2) $\boldsymbol{v^2 = {v_0}^2 + 2a\Delta x}$
(3) $\boldsymbol{\Delta x = v_0 t + \frac{1}{2}at^2}$
(4) $\boldsymbol{\Delta x = \left(\frac{v+v_0}{2}\right)t}$

CONCEPT: HOW ACCELERATION SIGN AFFECTS VELOCITY & SPEED

● Be careful! "Speeding up" or "going faster" does NOT always mean positive acceleration!

- *Positive* acceleration means your velocity is becoming ________________
- *Negative* acceleration means your velocity is becoming ________________

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

EXAMPLE: In the following problems, indicate whether the acceleration is positive or negative, and if the speed is increasing or decreasing. Assume Δt=4s for all parts.

a) v_0 = 10 m/s, v_f = 30 m/s

Acceleration [POS | NEG] **Speed** [INC | DEC]

b) v_0 = -10 m/s, v_f = -30 m/s

Acceleration [POS | NEG] **Speed** [INC | DEC]

- Speeding up = ____________, magnitude of $\vec{v}$ **[INCREASES | DECREASES]**, $\vec{a}$ & $\vec{v_0}$ **[SAME | OPPOSITE] sign**

c) v_0 = 30 m/s, v_f = 10 m/s

Acceleration [POS | NEG] **Speed** [INC | DEC]

d) v_0 = -30 m/s, v_f = -10 m/s

Acceleration [POS | NEG] **Speed** [INC | DEC]

- Slowing down = ____________, magnitude of $\vec{v}$ **[INCREASES | DECREASES]**, $\vec{a}$ & $\vec{v}_0$ **[SAME | OPPOSITE] sign**

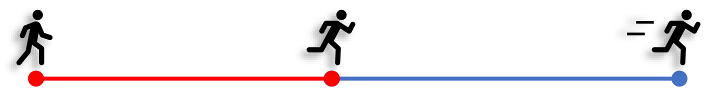
EXAMPLE: The driver of truck moving to the left at 30 m/s slows down by taking their foot off the pedal. The truck comes to a stop after travelling 150m. Calculate the magnitude (assumed constant) and direction of the acceleration.

MOTION w/ ACCELERATION
1) Draw Diagram & list 5 variables
2) Identify known & target variables
3) Pick UAM Eq. ***without*** "Ignored" Variable
4) Solve

UAM Equations
(1) $v = v_0 + at$
(2) $v^2 = {v_0}^2 + 2a\Delta x$
(3) $\Delta x = v_0 t + \frac{1}{2}at^2$
(4) $\Delta x = \left(\frac{v+v_0}{2}\right)t$

CONCEPT: CONSTANT ACCELERATION PROBLEMS WITH MULTIPLE PARTS

● You'll need to solve problems where objects move under constant *acceleration* in one or multiple parts.



EXAMPLE: You're driving at constant 30m/s when you suddenly see a road hazard, but it takes 0.7s for you to "react" and slam the brakes, causing the car to decelerate at constant 6m/s^2 until the car comes to a stop. Calculate:

a) How far you travel before applying the brakes
b) The time it takes to stop after applying the brakes
c) The total distance traveled

STEPS
Setup
1) Draw Diagram & list 5 variables
For Each Part
2) Identify known & target variables
3) Pick UAM Eq. ***without*** "Ignored" Variable
4) Solve

Motion Equations	
When a = 0	When a **NOT** = 0
$v = \frac{\Delta x}{\Delta t}$	(1) $v = v_0 + at$
	(2) $v^2 = {v_0}^2 + 2a\Delta x$
	(3) $\Delta x = v_0 t + \frac{1}{2}at^2$
	(4) $\Delta x = \left(\frac{v_0+v}{2}\right)t$

EXAMPLE: A subway train starts from rest at a station and accelerates at $1.50 m/s^2$ for 14.0 s. It runs at constant speed for 60.0s, then finally slows down at $3.50 m/s^2$ until it stops at the next station. What is the total distance the train covers?

STEPS
Setup
1) Draw Diagram & list 5 variables
For Each Part
2) Identify known & target variables
3) Pick UAM Eq. ***without*** "Ignored" Variable
4) Solve

Motion Equations	
When a = 0	When a **NOT** = 0
$v = \frac{\Delta x}{\Delta t}$	(1) $v = v_0 + at$
	(2) $v^2 = {v_0}^2 + 2a\Delta x$
	(3) $\Delta x = v_0 t + \frac{1}{2}at^2$
	(4) $\Delta x = \left(\frac{v_0+v}{2}\right)t$