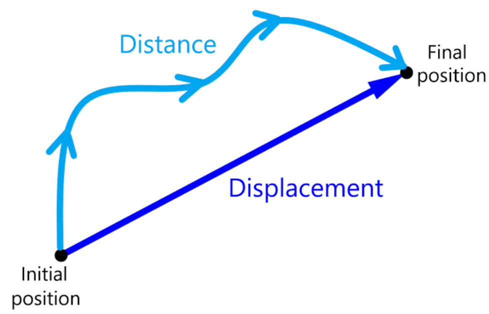
GENERAL PHYSICS

KINEMATIC EQUATIONS OF MOTIONS

Introduction to Kinematics

Kinematics: description of motion
Dynamics: forces causing motion
Focus: One-dimensional motion (translation)

Displacement vs. Distance



Position: Location relative to a reference point
Distance: Scalar; total path traveled
Displacement (Δx): Vector; straight-line change in position

FORMULA FOR DISPLACEMENT(Δx):

$\Delta x = X_f - X_i$

Δx: displacement

X_f : final position

X_i : initial position

Sample Problem
A person walks 4 meters west, turns around, and walks 4 meters east. Find:

a. The total distance traveled.
b. The total displacement.

Given: X_f : 4 meters west; X : 4 meters east

REMEMBER!

For DISPLACEMENT: The sign (+ or -) depends entirely on where the final position is relative to the start.

NORTH (+) SOUTH (-) EAST (+) WEST (-)

A. Total distance traveled:

d = 4 meters + 4 meters

d= 8 m

B. Total displacement:

$\Delta x = X_f - X_i$

= 4 m – 4 m

Δx = 0 m

Speed vs Velocity

Speed: Scalar: rate of covering distance

FORMULA FOR SPEED $$v = \frac{d}{t}$$

Velocity: Vector: includes direction

FORMULA FOR VECTOR $$\vec{v} = \frac{x_f - x_i}{t_f - t_i}$$

EXAMPLE

A delivery truck drives **120 kilometers East** for **2 hours** to make its first delivery of the day. Find its average speed and average velocity.

GIVEN:
Total Time: 2 hours
Total Distance: 120 km

Average Speed:

V = $\frac{d}{t}$ **V = 60 km/hr**

V = $\frac{120\ km}{2\ hr}$

Average velocity

$$\vec{v} = \frac{x_f - x_i}{t_f - t_i}$$

$\vec{v} = \frac{120\ km - 0\ km}{2\ hr - 0\ hr}$

$\vec{V}$ = 60 km/hr East

Acceleration

Rate of change of velocity (vector)
Types of change: **magnitude, direction, or both**
positive acceleration = speeding up
negative acceleration = slowing down

FORMULA FOR ACCELERATION

$$a = \frac{vf - vi}{t}$$

EXAMPLE

A motorcycle traveling North along a straight road change its velocity from **12.0 m/s** to **30.0 m/s** in a time interval of **4.5 seconds**. Calculate the average acceleration of the motorcycle.

GIVEN

V_f = 30.0

V_i = 12.0

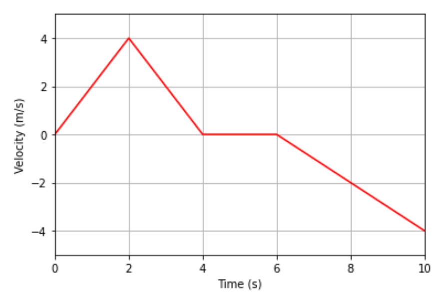
t = 4.5s

$$a = \frac{vf - vi}{t}$$

$$a = \frac{30.0 - 12.0}{4.5}$$

a = +4.0 m/s North

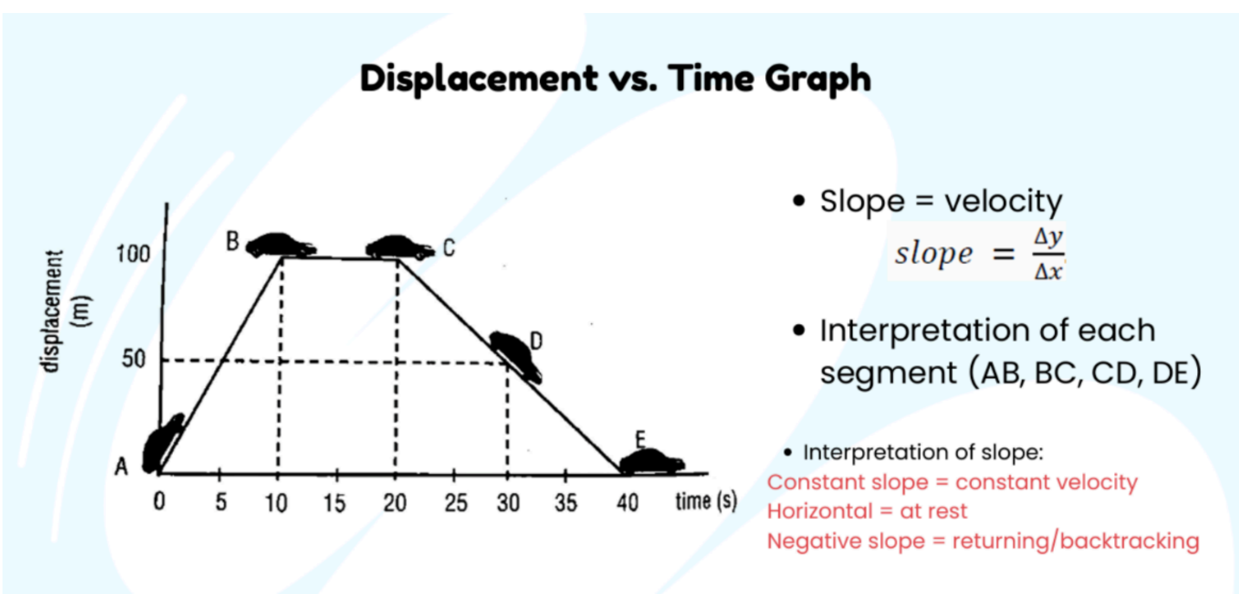
GRAPHICAL REPRESENTATION OF MOTION



Graph: A diagram which describes relationships between two variables.

Line Graph: Consists to two number lines to display progression.

Displacement vs. Time Graph



FOR EXAMPLE:

FOR AB

AB = Slope = $\frac{\Delta y}{\Delta x} = \frac{100-0}{10-0} = 10\ m/s$

Final Initial

Kinematics

Equations of Motion with Uniform Acceleration

Uniform acceleration means that an object's velocity changes by the same amount every equal interval of time.

CALCULATING FOR FINAL VELOCITY (EQ 1)

FORMULA FOR FINAL VELOCITY

$V_f = V_i + at$

Calculating Final Velocity

Using the equation of acceleration, we can produce an equation that can find the value of the final velocity:

An airplane lands with an initial velocity of 70.0 m/s and then accelerates opposite to the motion at 1.50 m/s2 for 40.0 s. What is its final velocity?

$\boxed{v_f = v_0 + at}$ **Eq. 1**

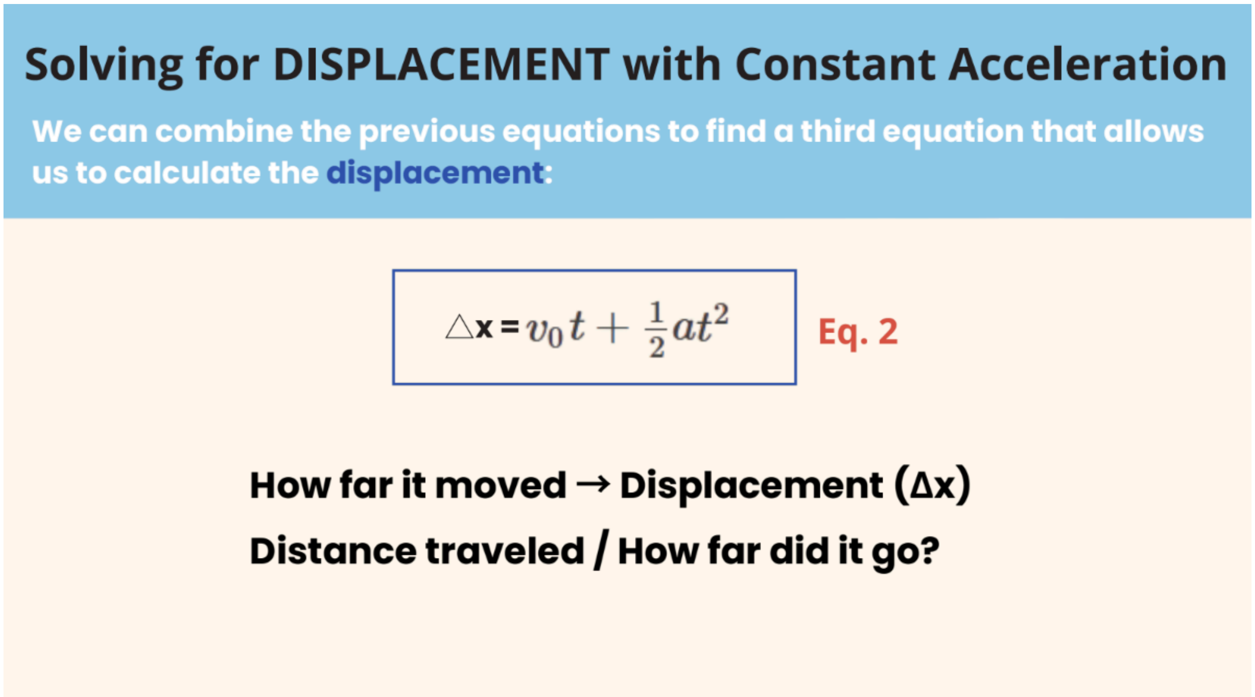
$$= 70.0\ \mathrm{m/s} + \left(-1.50\ \mathrm{m/s^2}\right)(40.0\ \mathrm{s}) = 10.0\ \mathrm{m/s}.$$

$$= 10.0\ \mathrm{m/s}.$$

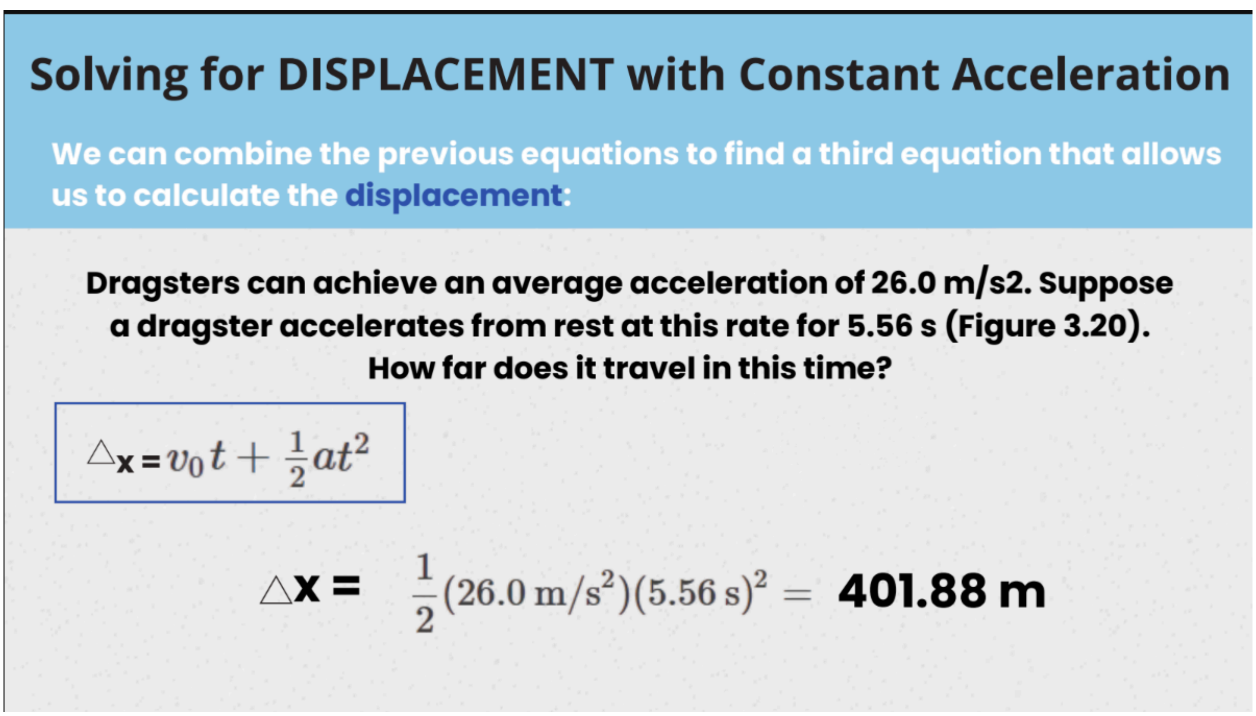
SOLVING FOR DISPLACEMENT WITH CONSTANT ACCELERATION (EQ 2)

FORMULA FOR DISPLACEMENT:

Δx = $Vo\,t + \frac{1}{2}at^2$



EXAMPLE



ALTERNATE EQUATION FOR DISPLACEMENT (EQ 3)

FORMULA FOR DISPLACEMENT:

$$\triangle x = \left(\frac{v_0+v_f}{2}\right)\Delta t$$

Alternate Equation for Displacement

(Distance when initial and final velocity are given)

A ship cruising through a channel increases its speed from 6 m/s to 12 m/s over a period of 30 seconds. Assuming the acceleration is uniform, how far does the ship travel during this time?

$$\boxed{\triangle x = \left(\frac{v_0+v_f}{2}\right)\Delta t} \quad \text{Eq. 3}$$

ANSWER: 270 m

the ship's acceleration is uniform, meaning its velocity changes at a constant rate

$$\Delta x = \left(\frac{6+12}{2}\right)(30) = 270\ m$$

CALCULATING FINAL VELOCITY (EQ 4)

FORMULA FOR FINAL VELOCITY:

$$v^2 = v_0^2 + 2a(x - x_0)$$ **OR** $V_f^2 = V_0^2 + 2a(X_f - X_0)$

Calculating Final Velocity

(Final velocity without time)

$$\boxed{v^2 = v_0^2 + 2a(x - x_0)} \quad \text{Eq. 4}$$

Dragsters can achieve an average acceleration of 26.0 m/s2. Suppose a dragster accelerates from rest with a displacement 401.88 m. How far does it travel in this time?

$V_f^2 = (0)^2 + 2(26.0)(401.88)$

$V_f^2 = 20897.76$

$= \sqrt{20897.76}$

V_f^2 = **144.56 m/s**

ACCELERATION AND FREE FALL

Acceleration is the change in velocity over time.

GALILEO'S DISCOVERY ABOUT FALLING OBJECTS

ARISTOTLE'S IDEA

-He believed that heavier objects fall faster than lighter objects.
-This idea was accepted for nearly 2000 years.

GALILEO CHALLENGED ARISTOTLE BELIEF

He concluded that objects with different masses fall at the same rate when air resistance is ignored.

Air resistance is a force that opposes the motion of an object as it moves through the air. It acts in the opposite direction of the object's movement, causing the object to slow down.

Factors that affect air resistance:

Factors that affect air resistance:

1. Surface area
Larger surface area → greater air resistance
Smaller surface area → less air resistance

2. Shape of the object
Streamlined shapes experience less air resistance.

3. Speed of the object
Faster objects experience more air resistance.

GALILEO'S INCLINED PLANE EXPERIMENT

PURPOSE: TO SLOW DOWN MOTION AND MEASURE FALLING OBJECTS ACCURATELY.
GALILEO USED: INCLINED PLANES BALLS WITH DIFFERENT MASSES, AND WATER CLOCK TO MEASURE TIME

OBSERVATION: OBJECTS REACHED THE GROUND AT THE SAME TIME
CONCLUSION: OBJECTS IN MOTION EXPERIENCE CONSTANT ACCELERATION

FREE FALL IS THE MOTION OF AN OBJECT AFFECTED ONLY BY GRAVITY.

Acceleration due to gravity: **$g = 9.8\ m/s^2$ (ayawg kalimti ni gaiz)**

FREE FALL EQUATIONS:

For objects falling vertically:

NOTE FOR GRAVITY:

- Upward direction = positive (+)
- Downward direction = negative (-)

FINAL VELOCITY:

$$V_f = V_i + gt$$

DISPLACEMENT:

$$\triangle x = V_i t + \tfrac{1}{2} gt^2$$

UNIFORM CIRCULAR MOTION

Motion of an object along a circular path at a constant speed.

CENTRIPETAL ACCELERATION is the acceleration that keeps an object moving in a circle is always directed toward the center of the circular path.

FORMULA:

$$a_c = \frac{v^2}{r}$$

Ac = Centripetal Acceleration (m/s2)
V = Velocity

NOTE: TO FIND VELOCITY, USE THIS EQUATION.

FORMULA:

$$v = \frac{2\pi R}{T}$$

where:
R = radius of the circle
T = period (time for one complete revolution)

NOTE: IF NO VELOCITY IS GIVEN, USE THIS EQUATION.

FORMULA:

$$a_c = \frac{4\pi^2 R}{T^2}$$

where:
ac = centripetal acceleration (m/s²)
R = radius of the circular path (m)
T = period (time needed for one complete revolution) (s)

==Projectile Motion== is the movement of an object thrown at an angle and affected by gravity.

A projectile follows a curved path called a **==Trajectory.==**

COMPONENTS FOR INITIAL VELOCITY

HORIZONTAL COMPONENT: **Constant velocity & No acceleration**

$V0x = Vo \cos \theta$

VERTICAL COMPONENT: **Changing velocity & Acceleration due to gravity**

$V0y = Vo \sin \theta$

PROJECTILE MOTION EQUATIONS

HORIZONTAL DISTANCE:

$$dx = Vo \cos \theta \, (t)$$

EQUATION FOR TIME:

$$\triangle t = \frac{2 Vo \sin \theta}{g}$$

Motion covered: UP AND DOWN

NOTE: Use this equation for finding for TOTAL TIME.

VERTICAL DISTANCE:

$$dy = Vo \sin \theta \, (t) - 1/2 \, gt^2$$

$$\triangle t = \frac{Vo \sin \theta}{g}$$

Motion covered: UP ONLY

NOTE: Use this equation for finding for TIME FOR MAXIMUM HEIGHT.

NOTE: SOLVE BOTH HORIZONTAL AND VERTICAL DISTANCE (STEP 1) AND USE THE EQUATION FOR TIME WHEN THERES NO GIVEN TIME.

EXAMPLE

A BALL THROWN WITH AN INITIAL VELOCITY OF 10 M/S AND AN ANGLE OF 30°. FIND ITS RANGE (dx) & MAXIMUM HEIGHT (dy)

1. SOLVE FOR INITIAL VELOCITY COMPONENTS

$$V0x = Vo \cos \theta$$
$$= (10.0 \text{ m/s}) \cos 30.0^\circ$$
$$\boxed{= 8.66 \text{ m/s}}$$

$$V0y = Vo \sin \theta$$
$$= (10.0 \text{ m/s}) \sin 30.0^\circ$$
$$\boxed{= 5.00 \text{ m/s}}$$

2. SOLVE FOR RANGE

FORMULA: $dx = V_o \cos\theta\,(t)$

GIVEN: $V_o = 10$ m/s Launch angle: $\theta = 30°$

$g = 9.8$ m/s2 $dx = ?$

$t = ?$

WE DON'T HAVE VALUE FOR TIME, SOLVE FOR TIME FIRST!

$$\Delta t = \frac{2 V_o \sin\theta}{g} = \frac{2\,(5.00\text{ m/s})}{9.8\text{ m/s2}} = \boxed{1.02\text{ s}}$$

2. SOLVE FOR RANGE

FORMULA: $dx = V_o \cos\theta\,(t)$

GIVEN: $V_o = 10$ m/s Launch angle: $\theta = 30°$

$g = 9.8$ m/s2 $dx = ?$

$t = 1.02$ s

$$dx = V_o \cos\theta\,(t)$$
$$= 8.66\text{ m/s }(1.02\text{ s})$$
$$\boxed{= 8.83\text{ m}}$$

3. SOLVE FOR MAXIMUM HEIGHT

FORMULA: $dy = V_o \sin\theta\,(t) - \frac{1}{2} g t^2$

GIVEN: $V_o = 10$ m/s Launch angle: $\theta = 30°$

$g = 9.8$ m/s2 $dy = ?$

$t = ?$

WE DON'T HAVE VALUE FOR TIME, SOLVE FOR TIME FIRST!

$$\Delta t = \frac{V_o \sin\theta}{g} = \frac{5.00\text{ m/s}}{9.8\text{ m/s2}} = \boxed{0.51\text{ s}}$$

3. SOLVE FOR MAXIMUM HEIGHT

FORMULA: $dy = Vo \sin\theta\,(t) - \frac{1}{2} gt^2$

GIVEN: $Vo = 10$ m/s Launch angle: $\theta = 30°$

$g = 9.8$ m/s2 $dy = ?$

$t = 0.51$ s

$$dy = Vo \sin\theta\,(t) - \tfrac{1}{2} gt^2$$

$$= 5.00 \text{ m/s } (0.51\text{s}) - \tfrac{1}{2}(9.8\text{m/s2})(0.51)^2$$

$$\boxed{= 1.28 \text{ m}}$$

TO SUMMARIZE, THE RANGE AND MAXIMUM HEIGHT OF THE BALL THROWN IS:

1. RANGE (dx) = 8.83 m
2. MAXIMUM HEIGHT (dy) = 1.27 m