KINEMATICS

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What is Kinematics?

The description of **how** things move

IMPORTANT THINGS TO KNOW

- Scalar vs. Vector Quantities
- Distance vs. Displacement
- Speed vs. Velocity
- Acceleration
- Kinematic Equations
- Freefall
- Adding/subtracting vectors
- Projectile motion

Linear Motion

Things to know about linear motion

- Scalar vs. Vector Quantities
- Distance vs. Displacement
- Speed vs. Velocity
- Acceleration
- Kinematic Equations
- Freefall

Scalar Quantities

Magnitude **only**

- Distance

Vector Quantities

Magnitude **and** direction

- Displacement

Distance vs. Displacement

- Total <u>distance</u> refers to the length of the entire path taken
  - EX) 40 m north, 30 m south ↠ 40m + 30m = 70m
  - Direction is irrelevant because distance is a scalar
- <u>Displacement</u> refers the the distance from the starting point directly to the ending point
  - EX) 40 m north, 30 m south ↠ 40m + (-30m) = 10m
  - Direction matters because displacement is a vector

Ex) A Walking Sally

Sally moves 10 m north, 5 m east, 10 m south, and 5 m west.

What is her distance travelled?

20 Meters

What is her displacement?

0 Meters

Ex) A Walking Johnny Walker

Johnny Walker Walks 15 m north, 10 m east, 15 m south, and 10 m west.

What is her distance travelled?

50 Meters

What is her displacement?

0 Meters

Scalar Quantities

Magnitude **only**

- Distance
- Speed

Vector Quantities

Magnitude **and** direction

- Displacement
- Velocity

Average speed vs. Average speed

- Average velocity= displacement/ time
  - $v = \Delta x / \Delta t$
- Average speed = distance traveled/time elapsed
  - $s = \Delta d / \Delta t$
- Measured in m/s

Example - average velocity

- Average velocity= displacement/ time
  - $v = \Delta x / \Delta t$
  - Katniss travels 15 miles to buy her favorite food: Peeta Bread. What is her velocity if it took her 5 hours to reach the bread?
    - *3 mph*
  - Katniss then travels back to her house, which takes her 10 more hours. What is her average velocity (roundtrip)?
    - *0 mph*

Acceleration

- $A = \Delta V / \Delta T$
  - Something accelerates if it changes velocity and/or changes direction
- If our velocity is constant, that means it is unchanging. If our velocity is unchanging, that means our acceleration is zero.
- If our velocity is changing at a constant rate, then slope is constant and therefore acceleration is a straight line.
- Measured in m/s^2

Sanity Check

- T/F: If acceleration is zero, then velocity is zero
  - FALSE
    - Velocity could be unchanging (zero slope) and therefore have zero acceleration, but still be moving at a constant velocity.
- T/F: If velocity is zero, then acceleration is zero
  - FALSE
    - Acceleration could be decelerating at a designated rate, and at that point, velocity might be zero, but the slope (acceleration) would still be a number. Another example is a direction change.

Scalar Quantities

Magnitude **only**

- Distance
- Speed

Vector Quantities

Magnitude **and** direction

- Displacement
- Velocity
- Acceleration

Equations (so far)

- Average velocity= displacement/ time
  - $v = \Delta x / \Delta t$
- Average speed
  - $s = \Delta d / \Delta t$
- Acceleration = change in velocity/ change in time
  - $a = \Delta v / \Delta t$

Equations

- Average velocity= displacement/ time
  - $v = \Delta x / \Delta t$
- Average speed = distance traveled/time elapsed
- Acceleration = change in velocity/ change in time
  - $a = \Delta v / \Delta t$
- **Kinematic Equations**
  - $v_f = v_i + a\Delta t$
  - $x_f = x_i + v_i\Delta t + \frac{1}{2} a\Delta t^2$
  - $v_f^2 = v_i^2 + 2a\Delta x$

Example- Kinematic Equations

- Kinematic Equations
  - $vf = vi + a\Delta t$
  - $xf = xi + vi\Delta t + \frac{1}{2} a\Delta t^2$
  - $vf^2 = vi^2 + 2a\Delta x$
  - Harry Potter is casually flying his broomstick at a speed of 70 m/s when he spots the snitch 7000 meters away. How fast does he need to accelerate to reach the snitch (assuming that it's stationary) if he wants to reach it in less than 10 seconds?
    - A =126 m/s^2

Solution

Step 1) List what you know, and what you're trying to find
Velocity: 70 M/S
Displacement: 7000 Meters
Time elapsed: 10 Seconds
Acceleration: ?

Step 2) Identify which equation to use, and substitute in values

- $xf = xi + vi\Delta t + \frac{1}{2} a\Delta t^2$

$7000 = 0 + (70)(10) + \frac{1}{2} A(10)^2$

Step 3) Solve
$A = 126\ m/s^2$

Freefall

- Objects in freefall are subject to the force of gravity, which accelerates them towards the Earth
- Acceleration due to gravity = 9.81 m/s^2
- NOTE: without air resistance, all objects regardless of mass will accelerate at 9.81 m/s^2
- To solve ↣ use kinematic equations

TIP for freefall

When determining which kinematic equation to use, first determine what is given to you in the problem.

If you are not given time, do not use the two equations that have the time variable.

If you do not have position, do not use the equations that deal with position

Examples- Freefall

- Kinematic Equations
  - $vf= vi + a\Delta t$
  - $xf= xi + vi\Delta t+ \frac{1}{2} a\Delta t^2$
  - $vf^2=vi^2 + 2a\Delta x$
  - Zach and Cody are having a suite time playing basketball on the roof of the Tipton when they decide it would be a good idea to drop it onto the ground. If the Tipton is 5000. feet tall, what is the ball's speed right before it hits the floor?
    - 313.2 m/s

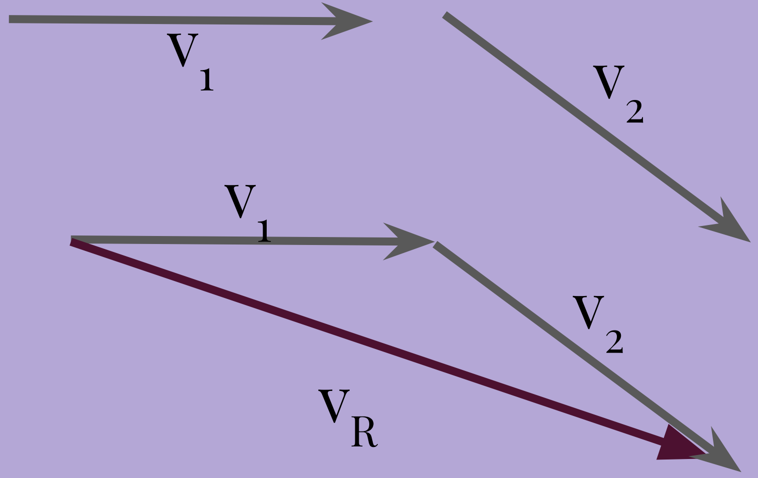
Projectile Motion

Things to know about projectile motion

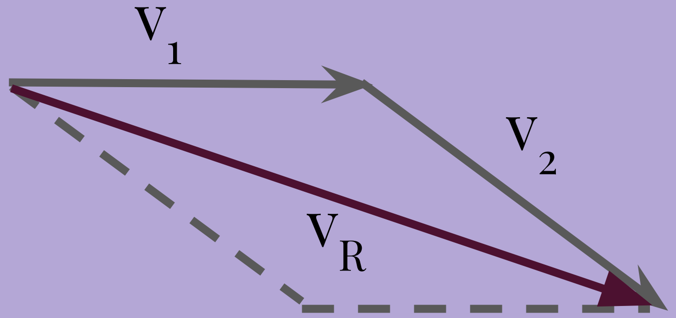
- ➢ Adding/Subtracting vectors
- ➢ Horizontal vs. vertical components
- ➢ Projectile motion/trajectory

How to add vectors

- Tail to tip

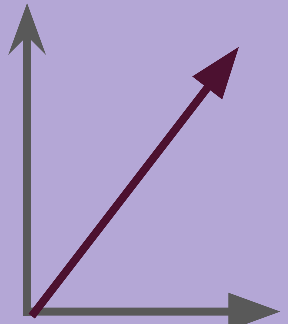


- Parallelogram



How to add vectors

- When dealing with vectors that are perpendicular to each other ↠ pythagorean theorem
- Simplify horizontal and vertical components before using pythagorean



How to add vectors

- Finding the magnitude of the resultant vector
  - $\sqrt{(\Sigma X^2 + \Sigma Y^2)}$
- Finding the direction of the resultant vector
  - $\text{Tan } \theta = (\Sigma Y / \Sigma X)$

Remember: if a vector is not always parallel to the x or y axis, break the vector down into its horizontal and parallel components

Projectile Motion

- Vertical velocity is exactly the same as freefall; therefore, kinematic equations can be reused! (reuse, reduce, recycle, and save the earth)
- The horizontal component is independent of the vertical, and remains constant; therefore, the horizontal component does not accelerate.

Things to remember conceptually

- At a projectile’s maximum height, velocity is zero
- The time is takes for a projectile to reach its maximum is the same has the time it takes for it to hit the ground from its maximum
- Likewise, a projectile's velocity traveling upwards a particular height is the same as its velocity traveling downwards at that same height.

Example of Projectile Motion

- Angry at her sister for getting her birthday wrong, Erica kicks the .5 kg Tiffany bracelet her sister got her. If she kicked it at an angle of 30°, at a velocity of 6 m/s, how far from Erica did the bracelet land?

- 3.11 Meters

END