

Formula

speed $s = d/t \rightarrow 50 + 30 = 80 \text{ miles}, 1+1 = 2h \rightarrow 80 \text{ miles}/2h = 40 \text{ mph}$

velocity $v = \Delta x/t$

average velocity $v_{avg} = \Delta x/\Delta t = x_f - x_i/t_f - t_i \rightarrow$
 $100 \text{ m in } 10.61 \text{ s} \rightarrow x_f = 100 \text{ m}, x_i = 0 \text{ m}, t_f = 10.61 \text{ s}, t_i = 0 \text{ s} \rightarrow v_{avg} = 100 \text{ m} - 0 \text{ m} / 10.61 \text{ s} - 0 \text{ s} = 100/10.61 = 9.43 \text{ m/s}$

Speed and Velocity

speed the distance traveled per unit of time. Speed is a scalar, a quantity that is described by magnitude alone. Constant speed refers to a fixed distance per unit of time. Average speed includes the total distance and total time.

Speed and Velocity (cont)

velocity the displacement of an object per unit of time. Since displacement includes a direction, so does velocity. Speed with direction. Velocity is a vector a quantity that has both magnitude and direction.

vector a quantity that has both magnitude and direction

reference frame the position from which an event is observed

motion map an image that represents the position, velocity, and acceleration of an object at one-second intervals

scalar a quantity that is described by magnitude alone

Motion and reference frame All motion is relative. It depends on a reference frame. An object may appear to move faster or slower depending on the reference frame.

Speed and Velocity (cont)

average velocity The slope of a line changes when the velocity of an object changes $\rightarrow$ The steeper the slope, the greater the velocity. The average velocity will be different than any of the other. Any point on the line will give only an instantaneous velocity.

change in direction A change in direction is represented when the line on a position-time graph changes from a positive slope to a negative slope or from a negative slope to a positive slope. A negative slope indicates an object moving towards the origin. A positive slope indicates an object moving away from the origin.

No motion horizontal line - means object is not moving $\rightarrow$ The object's position does not change

Motion Displayed in a vector !



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Key concepts

Review: Key concepts

	Horizontally Launched Projectile	Projectile Launched at an Angle
Horizontal Motion	$v_x = \text{constant}$ $\Delta x = v_x \Delta t$	$v_x = v_{0x} = v_0 \cos \theta = \text{constant}$ $\Delta x = (v_0 \cos \theta) \Delta t$
Vertical Motion	$v_y = a_y \Delta t$ $v_y^2 = 2a_y \Delta y$ $\Delta y = \frac{1}{2} a_y (\Delta t)^2$	$v_{0y} = v_0 \sin \theta + a_y \Delta t$ $v_{0y}^2 = v_i^2 (\sin \theta)^2 + 2a_y \Delta y$ $\Delta y = (v_0 \sin \theta) \Delta t + \frac{1}{2} a_y (\Delta t)^2$

Horizontal motion example

EXAMPLE

Riley and Miguel are playing catch. Riley throws the ball at an angle of 25° relative to the ground at a speed of 23.0 m/s. The ball travels 42.0 m to Miguel, who catches the ball. How long was the ball in the air?

Given:

$$\theta = 25^\circ$$

$$v_i = 23.0 \text{ m/s}$$

$$\Delta x = 42.0 \text{ m}$$

Unknown:

$$\Delta t = ?$$

The equation that we need to use is:

$$\begin{aligned} \Delta x &= (v_i \cos \theta) \Delta t \\ \Delta t &= \frac{\Delta x}{(v_i \cos \theta)} \\ &= \frac{42.0 \text{ m}}{(23.0 \text{ m/s})(\cos 25^\circ)} \\ &= 2.0 \text{ s} \end{aligned}$$

Formula

Two vectors added at a right angle (90°)	$R^2 = A^2 + B^2$
Magnitude and sign of component vectors	$A_x = A \cos \theta$ $A_y = A \sin \theta$
Magnitude of the resultant vector	$R^2 = R_x^2 + R_y^2$
Angle or direction of the resultant vector	$\tan \theta = \frac{R_y}{R_x}$

Displacement during constant acceleration

Displacement during constant velocity	$\Delta x = vt$
Displacement during acceleration	$\Delta x = \frac{1}{2}(v_f + v_i)t$
Total displacement is the sum of the two	$\Delta x = v_i t + \frac{1}{2}(v_f - v_i)t$
Terms are combined	$\Delta x = \frac{1}{2}(v_f + v_i)t$
When the initial position is not zero	$x_f = x_i + \frac{1}{2}(v_f + v_i)t$

Acceleration example

Example: A race car moving west speeds up from 17 m/s to 47 m/s in 2 seconds. What is the car's acceleration?

$$a = \frac{47 \text{ m/s} - 17 \text{ m/s}}{2 \text{ s}} = 30 \text{ m/s}^2$$

$$v_i = 17 \text{ m/s}$$

$$v_f = 47 \text{ m/s}$$

$$t = 2 \text{ s}$$

acceleration

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

Acceleration

positive an increase in velocity over time
acceleration

negative a decrease in velocity over time
acceleration

acceleration the rate at which velocity changes over time

constant staying the same; unchanging

Positive speeds up in the positive direction. slows down in the negative direction

Negative slow down down in the positive direction. speeds up in the negative direction.

Slope of the line on a velocity vs. time graph represents acceleration. Positive slope = acceleration, negative slope = negative acceleration

vectors

quadrant a quarter of the coordinate plane

components the two parts of a vector that are perpendicular to each other

resultant the sum of two or more vectors

vector the process by which the components of a vector are determined

Properties of a vector A vector is a quantity that has both magnitude and direction. Examples of vectors: Displacement, velocity, acceleration. Vectors are drawn using an arrow

More

Magnitude of the Resultant Vector

$$R^2 = A^2 + B^2$$

$$A = 300 \text{ m} \quad B = 300 \text{ m}$$

$$R^2 = 300^2 + 300^2$$

$$R^2 = 180,000$$

$$R = 424.26 \text{ m}$$



Components of Vectors

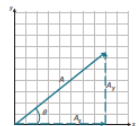
A vector that is diagonal is made up of a horizontal part and a vertical part.

The components of a vector are the two parts of a vector that are perpendicular to each other.

$$A_x = A \cos \theta \quad \cos \theta = \frac{A_x}{A}$$

$$A_y = A \sin \theta \quad \sin \theta = \frac{A_y}{A}$$

Vector resolution is the process by which the components of a vector are determined.



Sign of a component

Second quadrant	First quadrant
$A_x < 0$ (-)	$A_x > 0$ (+)
$A_y > 0$ (+)	$A_y > 0$ (+)
Third quadrant	Fourth quadrant
$A_x < 0$ (-)	$A_x > 0$ (+)
$A_y < 0$ (-)	$A_y < 0$ (-)

The sign of a component depends on the quadrant of the coordinate system it is in.

Projectile Motion

projectile an object that is set in motion following a path in which the only force acting on it is gravity.

inertia the natural tendency of objects to resist a change in motion

projectile motion the curved motion that results from the combination of an object's horizontal inertia and the force due to gravity pulling the object downward. I.e. A ball rolling off the table, A player shooting a jump shot -> Projectiles follow a parabolic path

parabolic having the shape of a parabola

Projectile Motion (cont)

vectors Vectors are used to describe motion in two dimensions. Vectors can be broken down into x and y components. The components of a vector are the two parts of a vector that are perpendicular to each other

Add

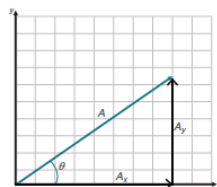
$$\cos \theta = \frac{A_x}{A}$$

$$\sin \theta = \frac{A_y}{A}$$

If we rearrange these we now get:

$$A_x = A \cos \theta$$

$$A_y = A \sin \theta$$



Horizontal

Horizontally Launched Projectiles

• Horizontal motion:

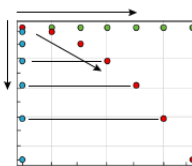
• Velocity is **constant**.

• **Acceleration** is zero.

• Vertical motion:

• Velocity is changing.

• Acceleration is **-9.8** m/s².



Horizontally Launched Projectiles

• Horizontal motion:

• $v_x = \text{constant}$

$$\Delta x = v_x \Delta t$$

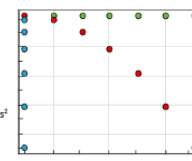
$$v_x = \frac{\Delta x}{\Delta t}$$

• Vertical motion:

$$v_y = a_y \Delta t$$

$$v_y = -9.8 \Delta t$$

$$\Delta y = \frac{1}{2} a_y (\Delta t)^2$$



Horizontal example

Horizontally Launched Projectiles

EXAMPLE

A pencil rolls off a desk that is 0.76 m tall. If the pencil hits the floor 0.32 m from the base of the desk, how fast was the pencil rolling?

Given:

$$\Delta y = -0.76 \text{ m}$$

$$\Delta x = 0.32 \text{ m}$$

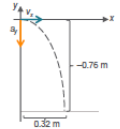
$$a_y = -g = -9.8 \text{ m/s}^2$$

Unknown:

$$v_x = ?$$

We can use the equation:

$$\Delta x = v_x \Delta t$$



SOLVE FOR T

To solve for v_x , we first need to solve for time, t , by rearranging the formula:

$$\Delta y = \frac{1}{2} a_y (\Delta t)^2$$

Plugging in values we have:

$$\Delta t = \sqrt{\frac{2\Delta y}{a_y}}$$

$$\Delta t = \sqrt{\frac{2(-0.76 \text{ m})}{(-9.8 \text{ m/s}^2)}}$$

$$\Delta t = 0.39 \text{ s}$$

continued

So if we rearrange our first formula to solve for v_x , we get:

$$v_x = \frac{\Delta x}{\Delta t}$$

$$v_x = \frac{0.32 \text{ m}}{0.39 \text{ s}}$$

$$= 0.82 \text{ m/s}$$