Warm-Up | Vectors

Lesson Question

How can vectors be used to describe and analyze motion in two dimensions?

Lesson Goals

Describe motion using vectors.

Interpret vector diagrams to determine the resultant vector.

Resolve a vector into horizontal and vertical components.

Words to Know

Fill in this table as you work through the lesson. You may also use the glossary to help you.

quadrant	a quarter of the coordinate plane
components	the two parts of a vector that are perpendicular to each other
resultant vector	the sum of two or more vectors
vector resolution	the process by which the components of a vector are determined

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Properties of Vectors

- A vector is a quantity that has both magnitude and direction.
- Examples of vectors:
  - Displacement
  - Velocity
  - Acceleration
- Vectors are drawn using an arrow.

Instruction | Vectors

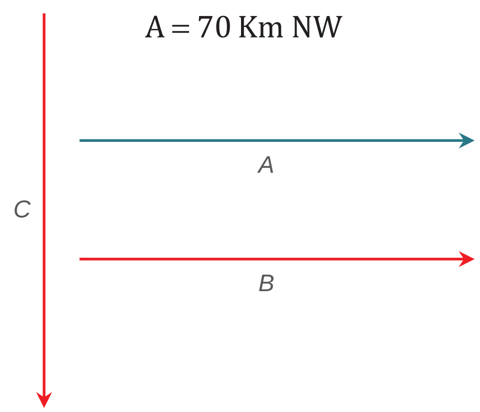
Slide 2

Vector Quantities

- A vector may be represented graphically or algebraically.
- Two different displacements are equal when their distances and [directions] are the same.

Draw vector B to be equal in both magnitude and direction to vector A.

Draw vector C to be unequal, with the same magnitude as but different direction from A.



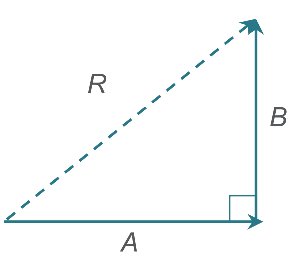
6

Magnitude of the Resultant Vector

EXAMPLE

If the two vectors are added at a [right] angle, the magnitude of the resultant vector can be found using the Pythagorean theorem:

$$R^2 = A^2 + [\ B^2\ ]$$



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Instruction | Vectors

Slide 6

Magnitude of the Resultant Vector

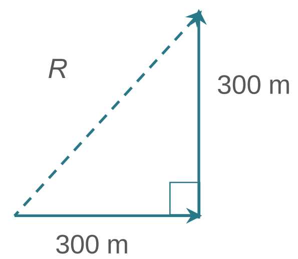
$R^2 = A^2 + B^2$

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

$R^2 = 300^2 + \boxed{300}^2$

$R^2 = 180{,}000$

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

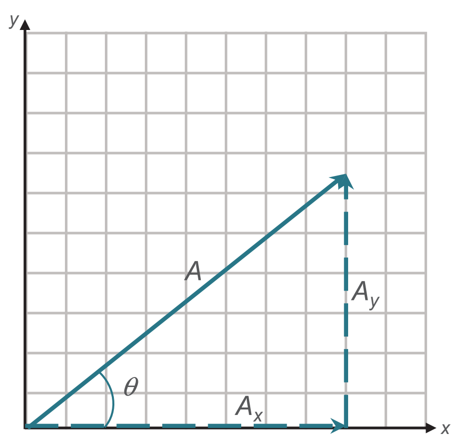


Slide 10

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.
  - $A_x = A\cos\theta \qquad \cos\theta = \frac{A_x}{A}$
  - $A_y = A\sin\theta \qquad \sin\theta = \frac{A_y}{A}$
- **Vector resolution** is the process by which the components of a vector are determined.



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Instruction | Vectors

Slide 10

The Sign of a Component

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

Second quadrant

$A_x < 0$ (−)

$A_y > 0$ (+)

First quadrant

$A_x > 0$ (+)

$A_y > 0$ (+)

Third quadrant

$A_x < 0$ (−)

$A_y < 0$ (−)

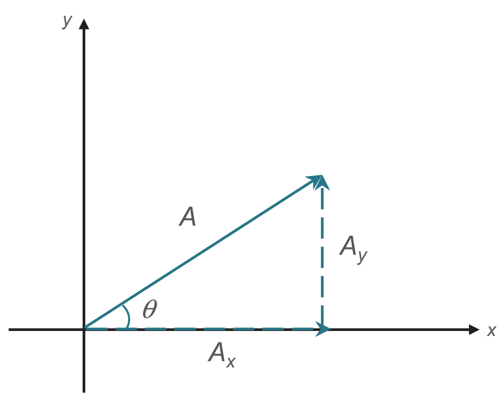
Fourth quadrant

$A_x > 0$ (+)

$A_y < 0$ (−)

The Components of Vectors

A truck travels 16.0 km on a straight road that is 40° north of east. What are the east and north components of the truck's displacement?



$A = 16.0\,\text{km}$ $\quad A_x = A\cos\theta$

$\theta = 40°$ $\quad A_y = A\sin\theta$

$A_x = (16.0\,\text{km})\cos 40° =$ 12.3 km

$A_y = (16.0\,\text{km})\sin 40° =$ 10.3 km

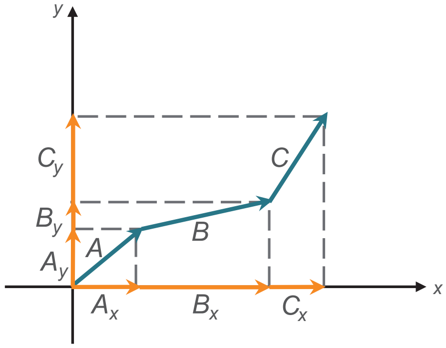
Instruction | Vectors

Slide 12

Algebraic Addition of Vectors

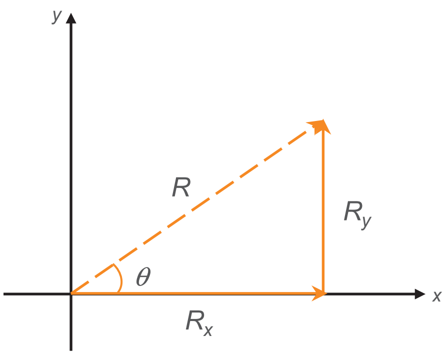
EXAMPLE

- Two or more vectors that are not perpendicular to each other may be added by resolving each vector into its *x* and *y* components.
- The components are then added together along each axis.
- The sum along each axis is a component of the resultant vector.



EXAMPLE

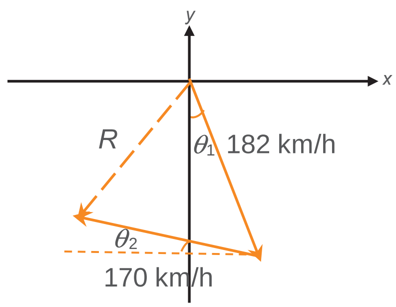
- Use the Pythagorean theorem to find the magnitude of the resultant vector.
  - $R^2 = [R_x^{\,2} + R_y^{\,2}]$
- Use the tangent to find the angle or direction of the resultant.
  - $\tan\theta = \dfrac{R_y}{R_x}$



Slide 12

Algebraic Vector Addition

A plane flies 25° east of south at 182 km/h for an hour. It then turns and flies 10° north of west at 170 km/h for another hour. What is the magnitude and direction of the plane's resultant velocity?



$\theta_1 = 295° \qquad \theta_2 = 170°$

$A_x = A\cos\theta_1$

$A_x = 182(\cos 295°) =$ 76.917

$A_y = A\sin\theta_1$

$A_y = 182(\sin 295°) =$ – 164.948

$B_x = B\cos\theta_2 \quad B_x = 170(\cos 170°) =$ – 167.417

$B_y = B\cos\theta_2 \quad B_y = 170(\sin 170°) =$ 29.520

$A_x + B_x = R_x$

$76.917 +$ – 167.417 $= -90.5$

$A_y + B_y = R_y$

$-164.948 + 29.520 =$ – 135.428

Instruction | Vectors

Slide 12

Then we're going to use the Pythagorean Theorem and solve for *R*. Remember the equation:

$$R^2 = R_x^2 + R_y^2$$

$$R^2 = (-90.5)^2 + (-135.428)^2$$

$$R^2 = 26530.993$$

$$R = \boxed{162.9\text{ km / h}}$$

Then, to find the direction of *R*, use tangent θ equals R_y over R_x.

$$\tan\theta = \frac{R_y}{R_x}$$

$$= \frac{-135.428}{-90.5}$$

$$= \boxed{1.49644}$$

$$\theta = \boxed{56^\circ} \text{ south of west}$$

Summary | Vectors

Lesson Question

How can vectors be used to describe and analyze motion in two dimensions?

Answer

(Sample answer) Vectors can be used to describe and analyze motion in two dimensions by showing the horizontal and vertical components of velocity, acceleration, and so on.

Slide 2

Review: key concepts

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	$\tan\theta = \frac{R_y}{R_x}$

Summary | Vectors

Use this space to write any questions or thoughts about this lesson.