Preview

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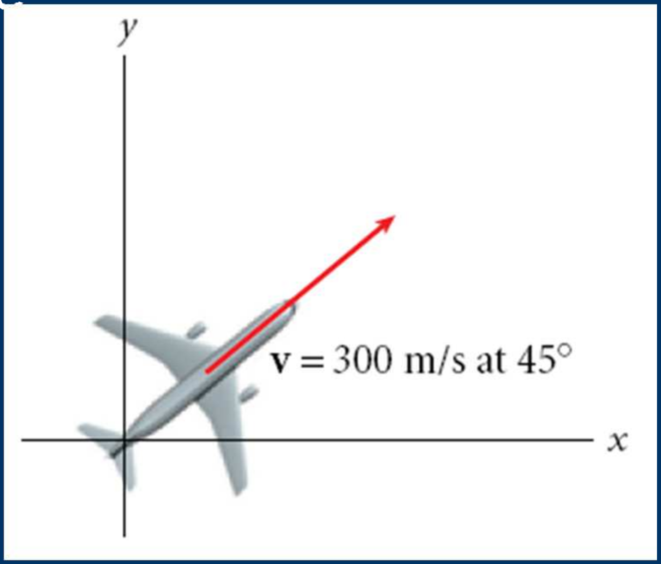
Objectives

- **Identify** appropriate coordinate systems for solving problems with vectors.
- **Apply** the Pythagorean theorem and tangent function to calculate the magnitude and direction of a resultant vector.
- **Resolve** vectors into components using the sine and cosine functions.
- **Add** vectors that are not perpendicular.

Coordinate Systems in Two Dimensions

- One method for diagraming the motion of an object employs **vectors** and the use of the ***x*- and *y*-axes**.
- Axes are often designated using **fixed directions**.
- In the figure shown here, the **positive *y*-axis** points **north** and the **positive *x*-axis** points **east**.



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Determining Resultant Magnitude and Direction

- In Section 1, the magnitude and direction of a resultant were found **graphically.**
- With this approach, the accuracy of the answer depends on how carefully the diagram is drawn and measured.
- A simpler method uses the **Pythagorean theorem** and the **tangent function.**

Determining Resultant Magnitude and Direction, *continued*

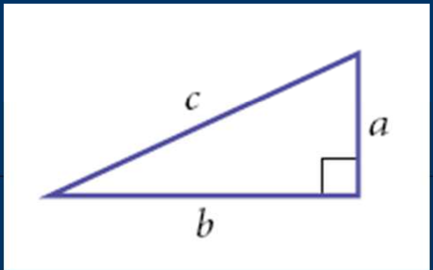
The Pythagorean Theorem

- Use the **Pythagorean theorem** to find the magnitude of the resultant vector.

- The Pythagorean theorem states that for any **right triangle,** the **square of the hypotenuse**—the side opposite the right angle—**equals the sum of the squares of the other two sides**, or legs.

$$c^2 = a^2 + b^2$$

$$(\text{hypotenuse})^2 = (\text{leg } 1)^2 + (\text{leg } 2)^2$$



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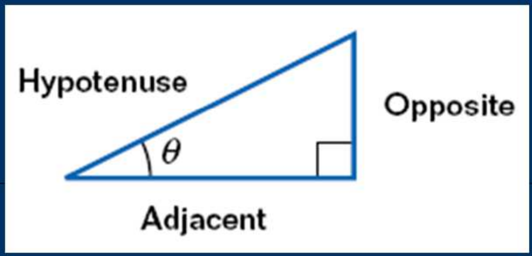
Determining Resultant Magnitude and Direction, *continued*

The Tangent Function

- Use the **tangent function** to find the direction of the resultant vector.
- For any right triangle, the **tangent** of an angle is defined as the **ratio of the opposite and adjacent legs** with respect to a **specified acute angle** of a **right triangle.**

$$\text{tangent of angle } \theta = \frac{\text{opposite leg}}{\text{adjacent leg}}$$



Sample Problem

Finding Resultant Magnitude and Direction

An archaeologist climbs the Great Pyramid in Giza, Egypt. The pyramid's height is 136 m and its width is 2.30×10^2 m. What is the magnitude and the direction of the displacement of the archaeologist after she has climbed from the bottom of the pyramid to the top?

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Sample Problem, *continued*

1. **Define**

Given:

Δy = 136 m

Δx = 1/2(width) = 115 m

Unknown:

d = ? θ = ?

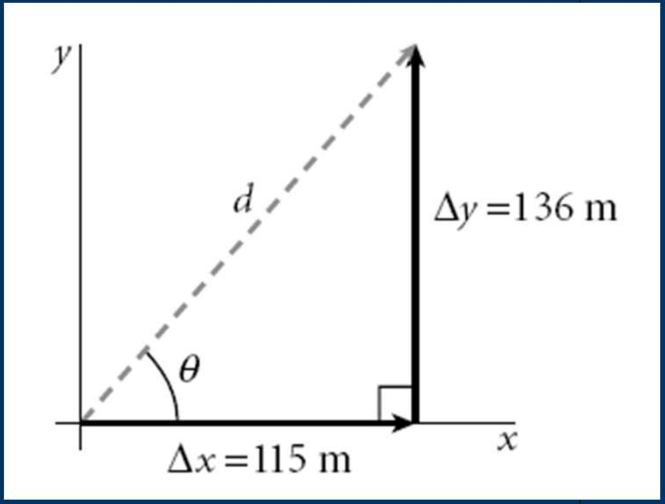

Diagram:

Choose the archaeologist's starting position as the origin of the coordinate system, as shown above.

Sample Problem, *continued*

2. Plan

Choose an equation or situation: The Pythagorean theorem can be used to find the magnitude of the archaeologist's displacement. The direction of the displacement can be found by using the inverse tangent function.

$$d^2 = \Delta x^2 + \Delta y^2 \qquad \tan\ \theta = \frac{\Delta y}{\Delta x}$$

Rearrange the equations to isolate the unknowns:

$$d = \sqrt{\Delta x^2 + \Delta y^2} \qquad \theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right)$$

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Sample Problem, *continued*

3. Calculate

$$d = \sqrt{\Delta x^2 + \Delta y^2} \qquad \theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right)$$

$$d = \sqrt{(115\ \text{m})^2 + (136\ \text{m})^2} \qquad \theta = \tan^{-1}\left(\frac{136\ \text{m}}{115}\right)$$

$$\boxed{d = 178\ \text{m}} \qquad \boxed{\theta = 49.8°}$$

4. Evaluate

Because *d* is the hypotenuse, the archaeologist's displacement should be less than the sum of the height and half of the width. The angle is expected to be more than 45° because the height is greater than half of the width.

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