You can draw here

Physics 111 - Class 2C
Vectors III

Do not draw in/on this box!

September 17, 2021

You can draw here

You can draw here

Logistics/Announcements

- Lab this week: Introduction
- HW due this week on ~~Thursday at 6 PM~~ Friday at 6PM (PL issues)
  - I released it a bit late, so I added +24 hours to the grace period
- Test/Bonus Test: No test this week!
- Learning Log 2 due on Saturday at 6 PM
- HW and LL deadlines have a 48 hour grace period

Logistics/Announcements

- Tutorials start next week !
  - Anybody can go to ANY Tutorial, all the links to the Zoom sessions are on Canvas
  - Attendance is not required in Tutorials
  - I recommend attending to meet your TA and work on stuff in groups
  - The TAs will guide you through a long problem each week

Feedback

Q1 Task 1: Active Learning and Peer Instruction
4 Points

First, Watch this video and then reflect on it

Watch this video

It's about 14 minutes long and it's pretty compelling. You can watch it at 1.5x or 2x speed if you like, but please do watch it to the end!

The speaker is Dr. Eric Mazur, and the topic is his experience in "discovering" Active Learning and Peer Instruction.

Once you're done with the video, there are a few reflection questions for you to answer below.

Q1.1 Reflection
4 Points

In 3-5 sentences, reflect on the video and think about how you can learn from Dr. Mazur's experience to succeed in this course. Here are some questions you may want to consider in your response:

- What are your thoughts on Dr. Mazur's experience?
- What is your initial reaction to the idea of students doing things, and working with their peers during class time rather than listening to an instructor talk for an hour?
- Have you ever experienced a class with active learning or peer instruction? How did it feel? What did you think?
- How do you think Active Learning and group work can work in an online environment?

Note that there are no correct or incorrect answers, this exercise is meant for you to think about your learning and your education. I will grade these based on the thoughtfulness of the

Learning Log 1 — GRADED

5 DAYS, 13 HOURS LATE

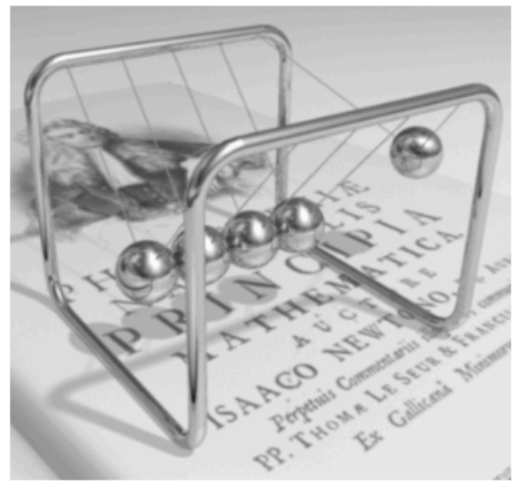
STUDENT
StudentFiras StudentMoosvi

TOTAL POINTS
6 / 10 pts

QUESTION 1	Task 1: Active Learning and Peer Instruction	**1** / 4 pts
1.1	Reflection	**1** / 4 pts
1.2	Ed Discussion	**0** / 0 pts
QUESTION 2	Goal Setting	**3** / 3 pts
QUESTION 3	Renew your vows of Academic Integrity	**0** / 1 pt
QUESTION 4	Well-being Check	**2** / 2 pts
4.1	Current Anxiety Level	**0.5** / 0.5 pts
4.2	Current Stress Level	**0.5** / 0.5 pts
4.3	Expected Anxiety Level	**0.5** / 0.5 pts
4.4	Expected Stress Level	**0.5** / 0.5 pts
QUESTION 5	Anything Else (Optional)?	**0** / 0 pts

Class Outline

- Introduction to Chapters 1 and 2
- Clicker Questions
- Problem Solving Template
- Activity:
- Debrief



Physics 111

Contents

Videos

Below are the assigned videos for this week. The videos are collapsible so once you're done with one, you can move to the next one. In the sidebar on the right, you can use the checklists to keep track of what's done.

Checklist of items

- [ ] Video 1
- [ ] Video 2
- [ ] Video 3
- [ ] Video 3
- [ ] Video 3

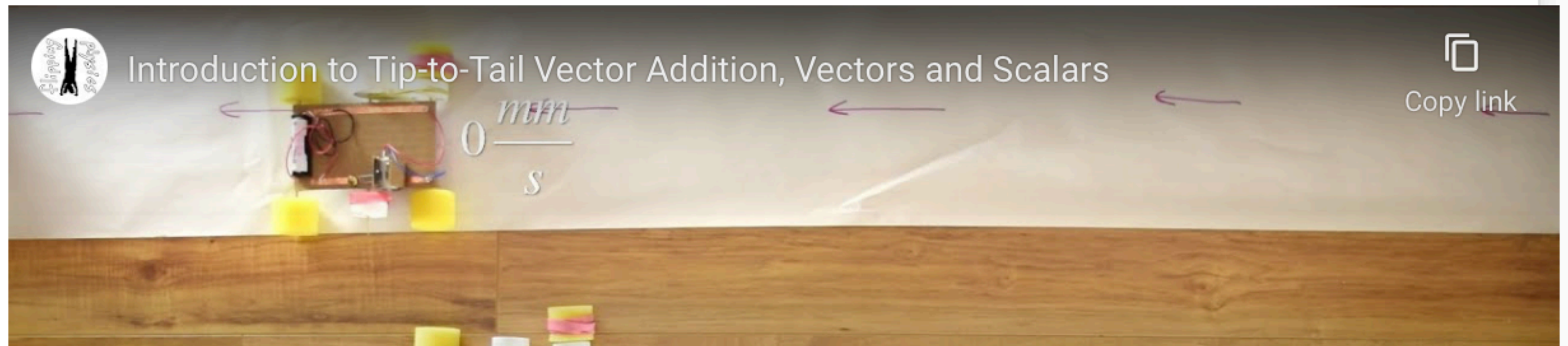
Required Videos

1. Introduction to Significant Figures

- Notes
- Direct link to Mr. P's page

2. Working with Significant Figures

3. Introduction to Tip-to-Tail Vector Addition



Introduction

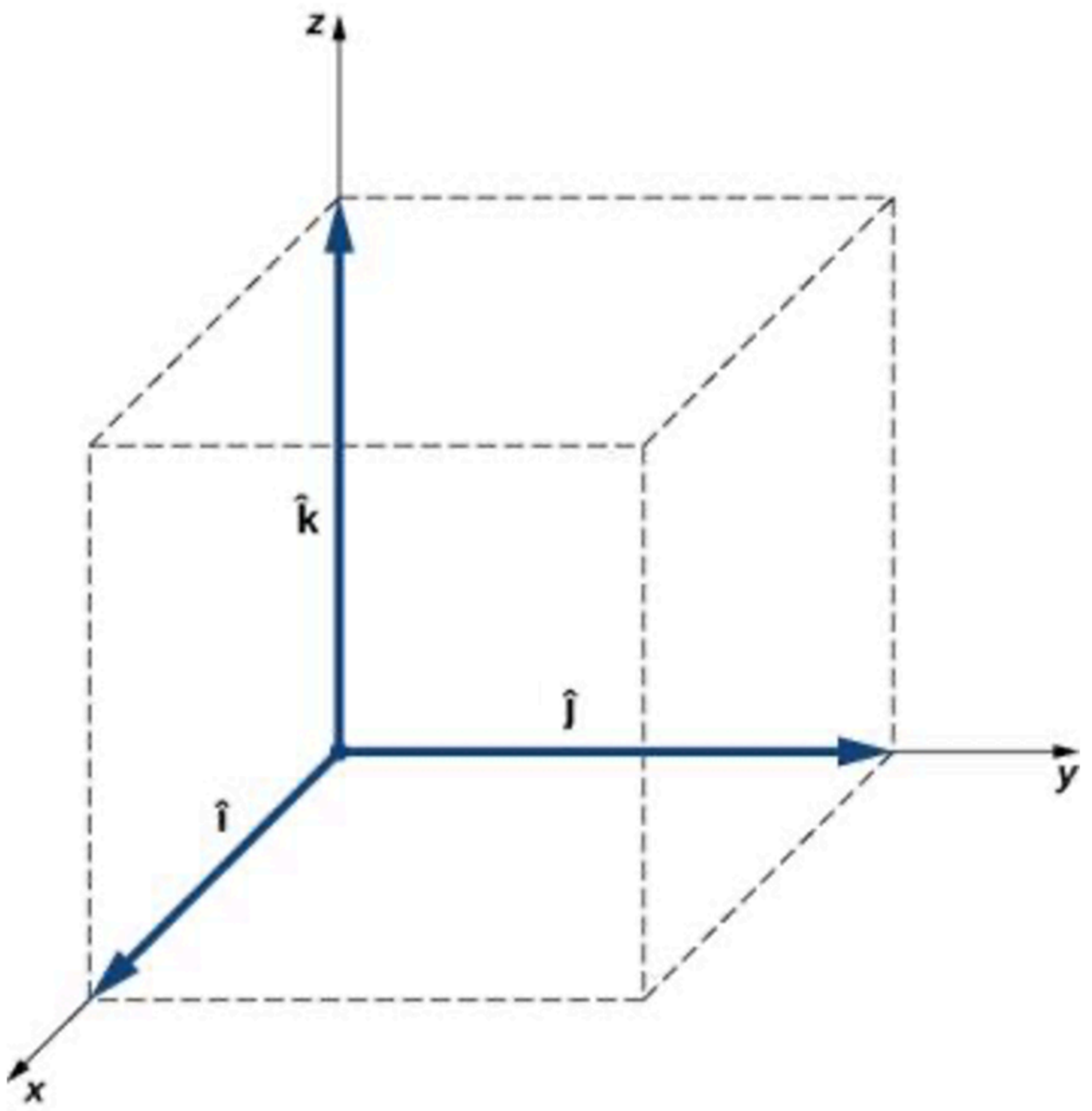
Table of contents

Search this book

My highlights

Figure 2.1 A signpost gives information about distances and directions to towns or to other locations relative to the location of the signpost. Distance is a scalar quantity. Knowing the distance alone is not enough to get to the town; we must also know the direction from the signpost to the town. The direction, together with the distance, is a vector quantity commonly called the displacement vector. A signpost, therefore, gives information about displacement vectors from the signpost to towns. (credit: modification of work by "studio tdes"/Flickr, thedailyenglishshow.com)

FIGURE 2.21 Unit Vectors



Three unit vectors define a Cartesian system in three-dimensional space. The order in which these unit vectors appear defines the orientation of the coordinate system. The order shown here defines the right-handed orientation.

Vectors

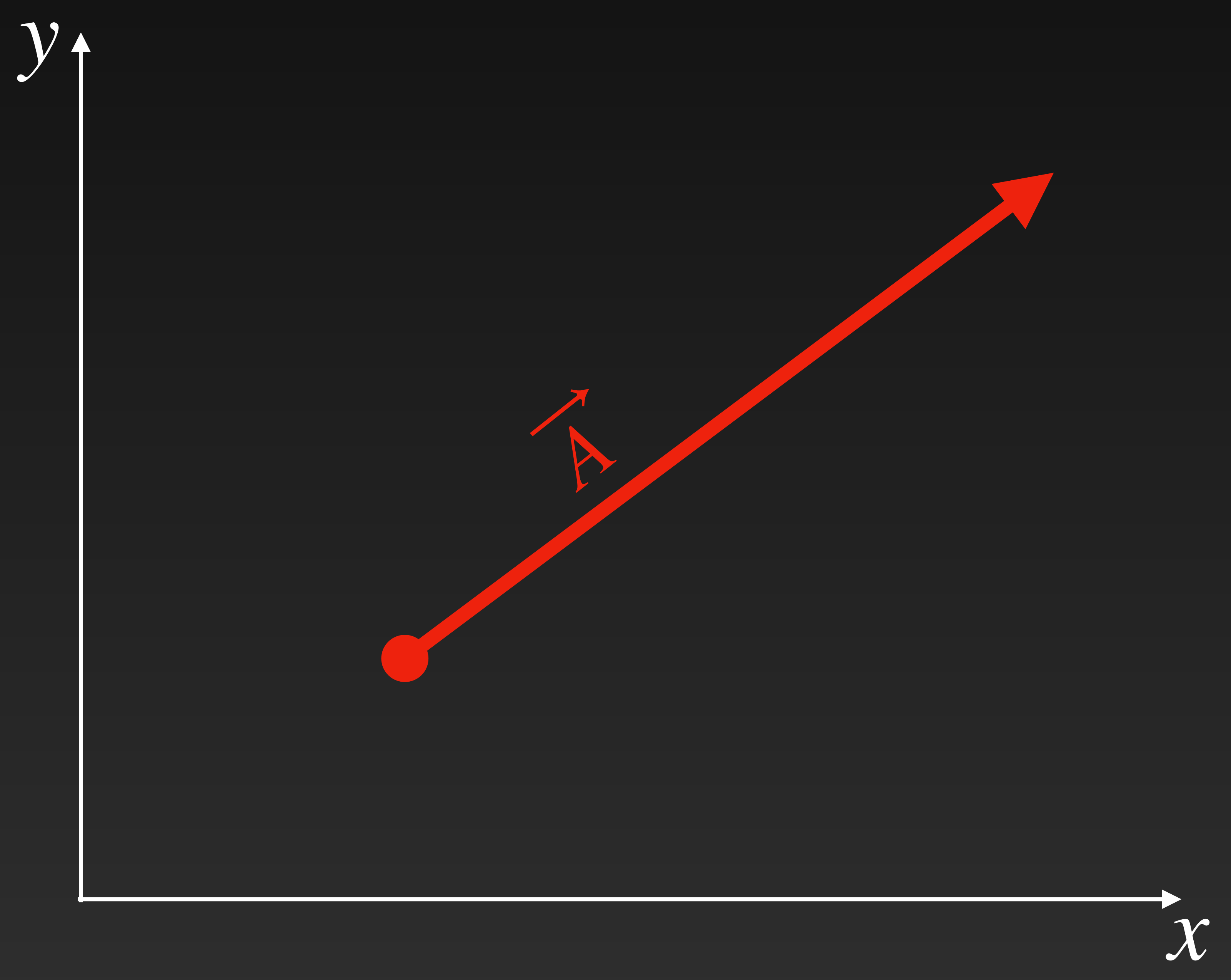
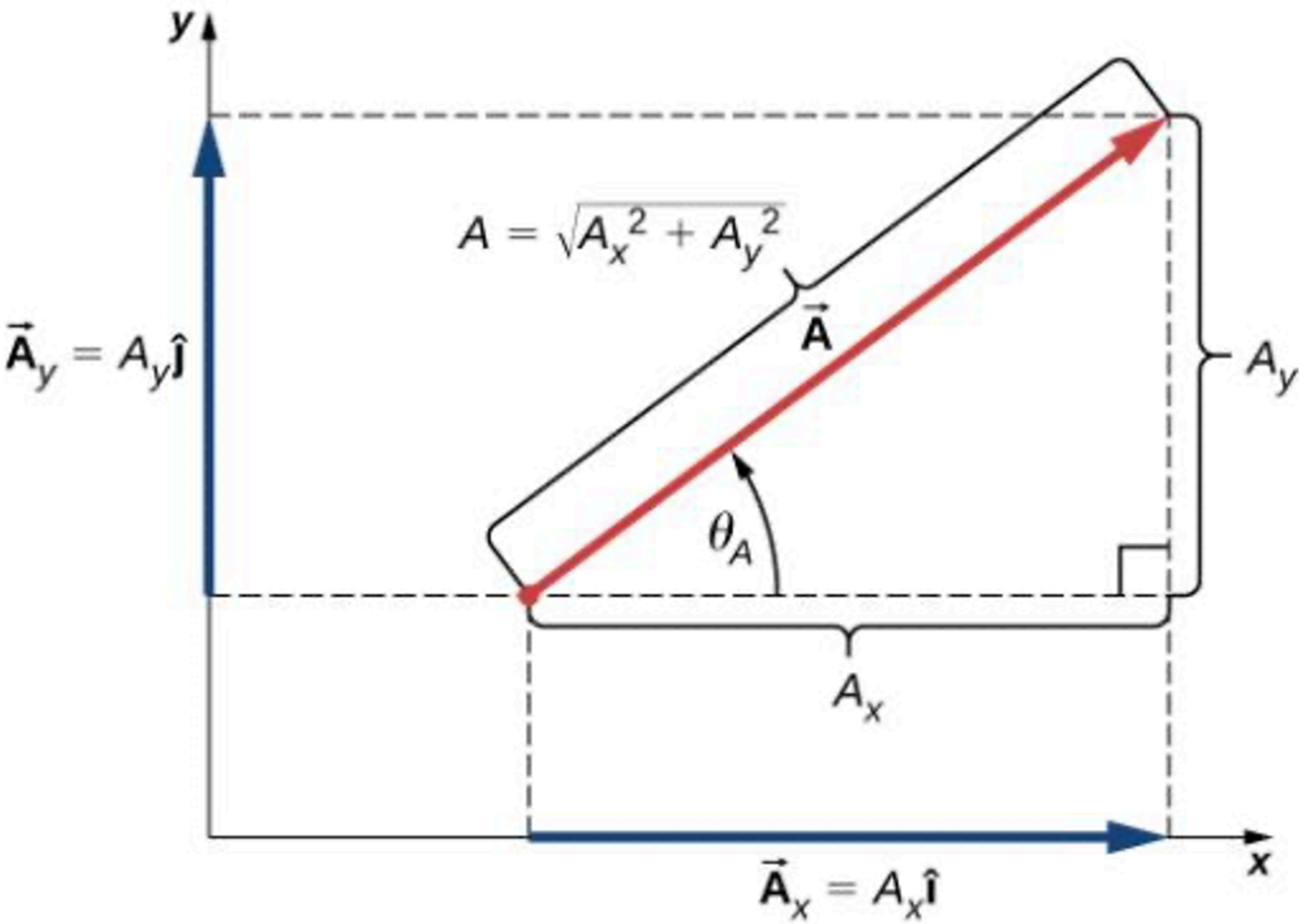


FIGURE 2.18

Vectors



For vector $\vec{\mathbf{A}}$, its magnitude A and its direction angle θ_A are related to the magnitudes of its scalar components because A, A_x, and A_y form a right triangle.

Components

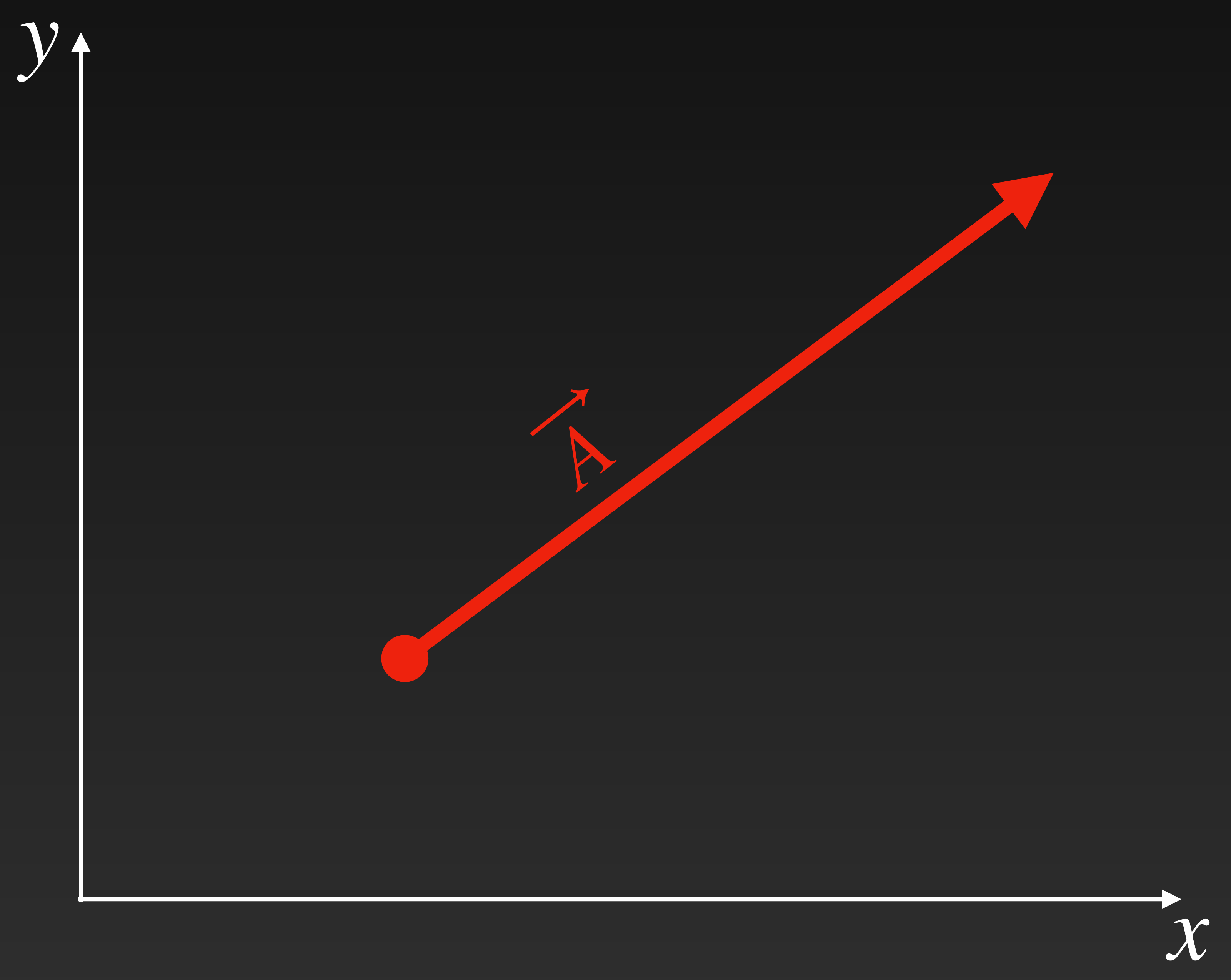
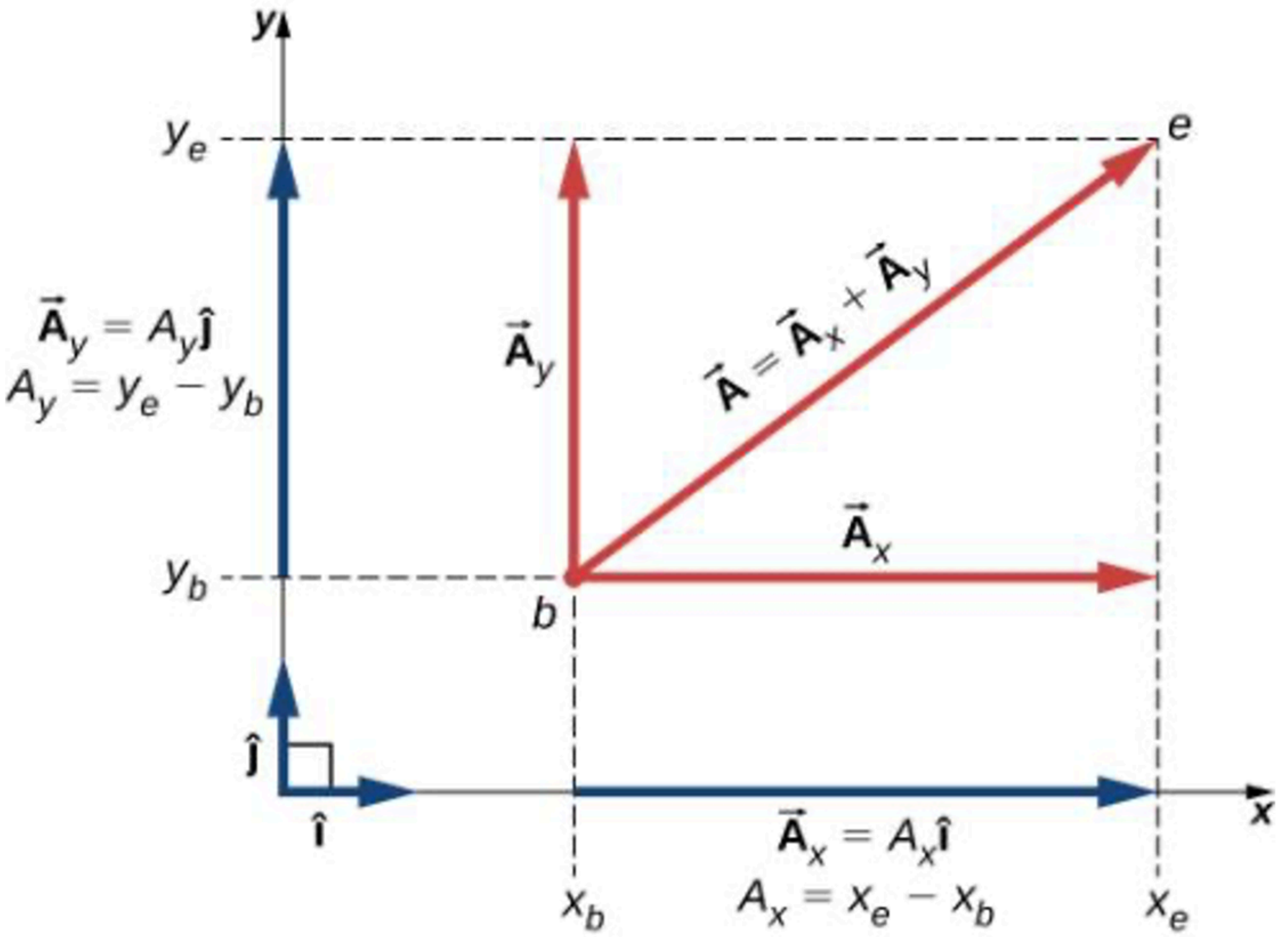


FIGURE 2.16

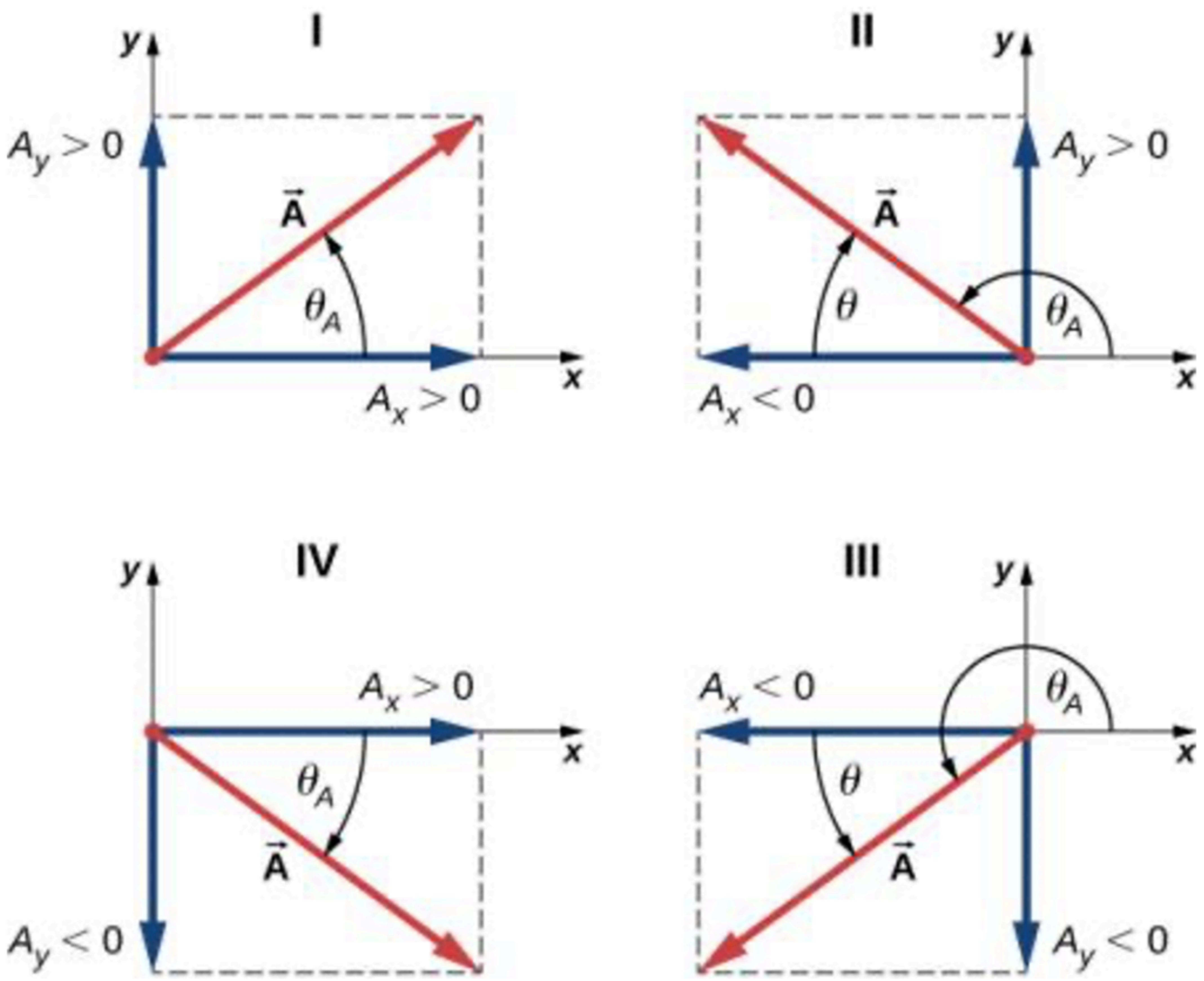
Components



Vector $\vec{\mathbf{A}}$ in a plane in the Cartesian coordinate system is the vector sum of its vector *x*- and *y*-components. The *x*-vector component $\vec{\mathbf{A}}_x$ is the orthogonal projection of vector $\vec{\mathbf{A}}$ onto the *x*-axis. The *y*-vector component $\vec{\mathbf{A}}_y$ is the orthogonal projection of vector onto the *y*-axis. The numbers A_x and A_y that multiply the unit vectors are the scalar components of the vector.

FIGURE 2.19

Quadrants



Scalar components of a vector may be positive or negative. Vectors in the first quadrant (I) have both scalar components positive and vectors in the third quadrant have both scalar components negative. For vectors in quadrants II and III, the direction angle of a vector is $\theta_A = \theta + 180°$.

FIGURE 2.19

Quadrants

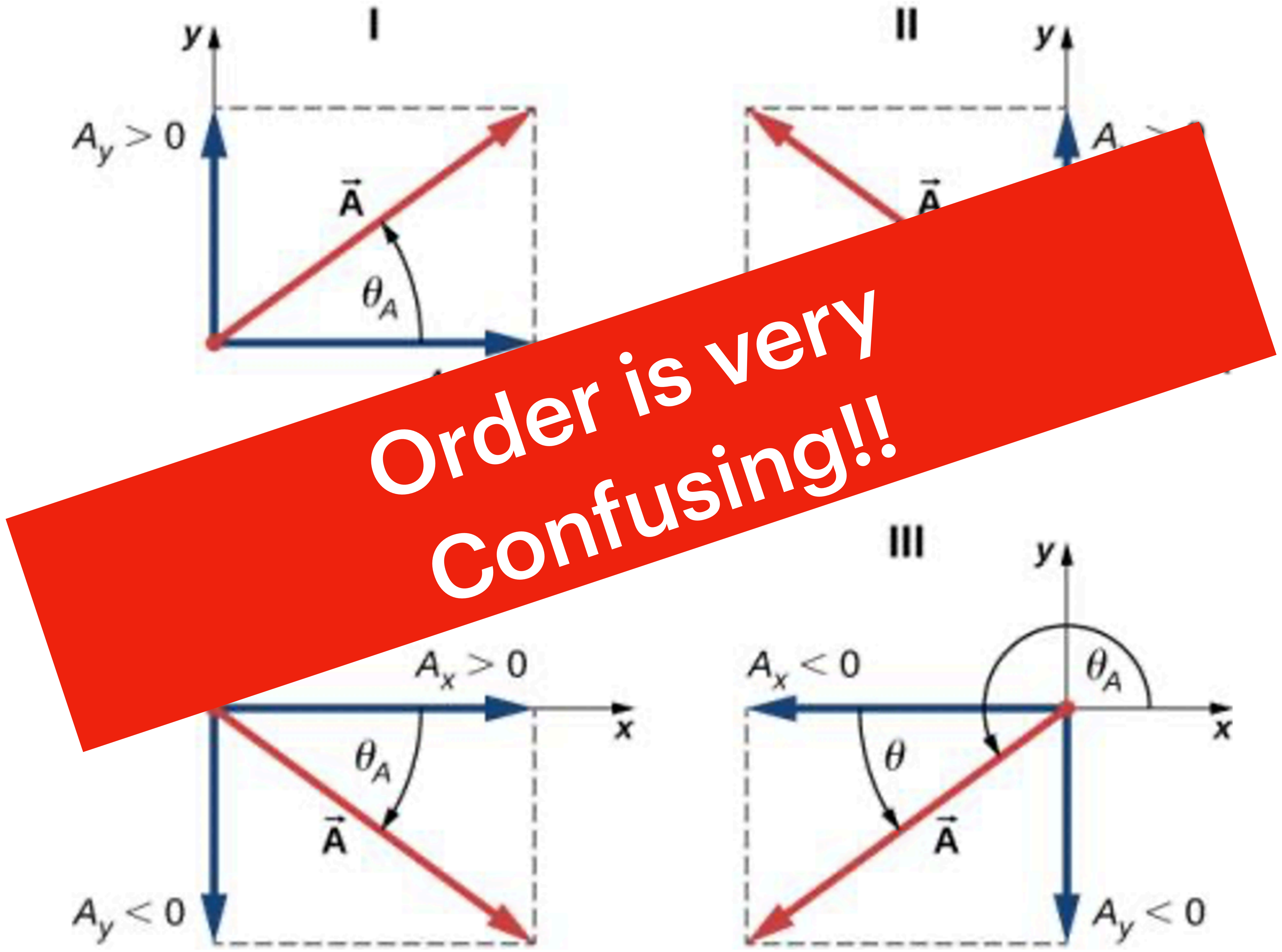


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FIGURE 2.19

Quadrants

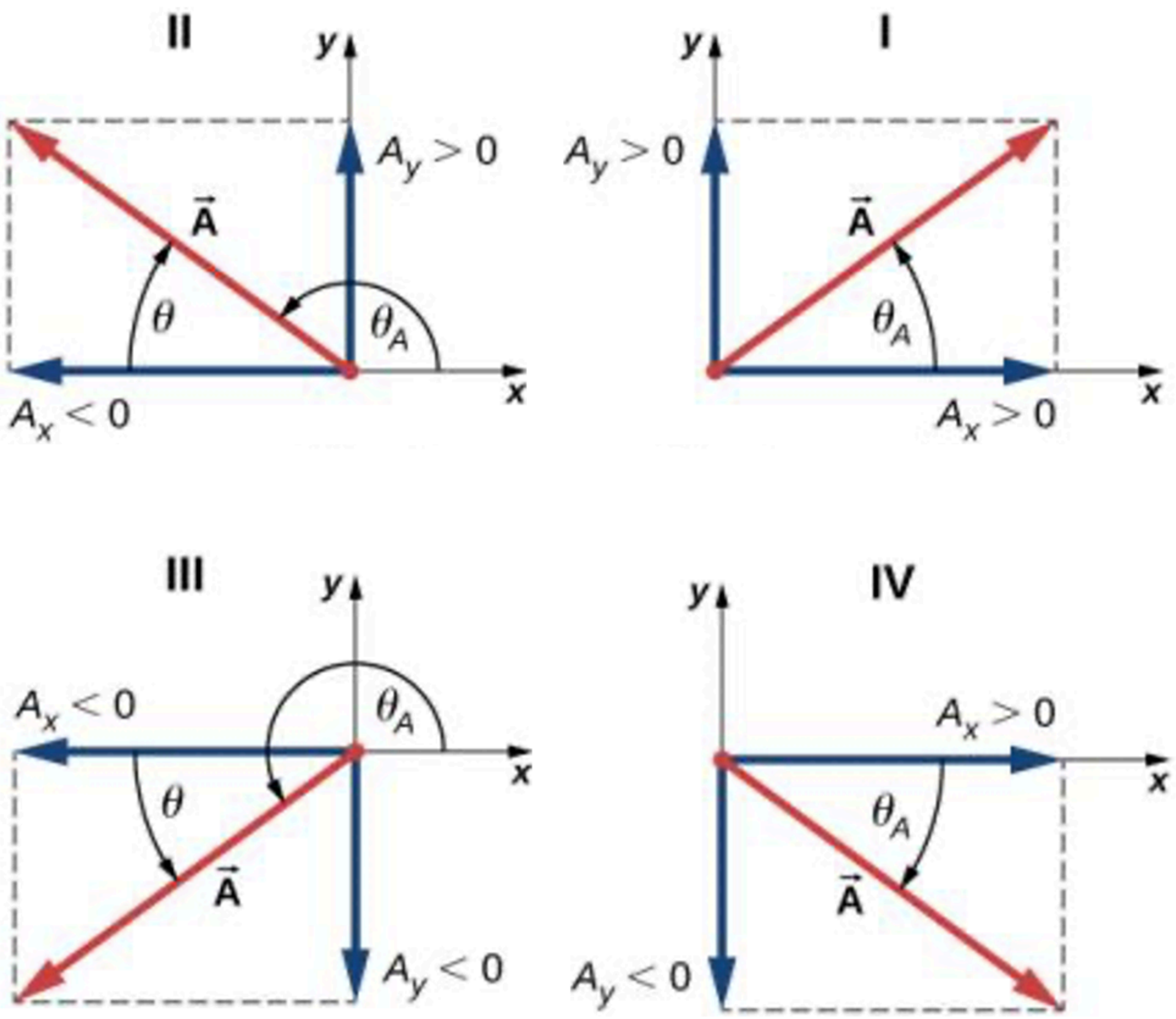

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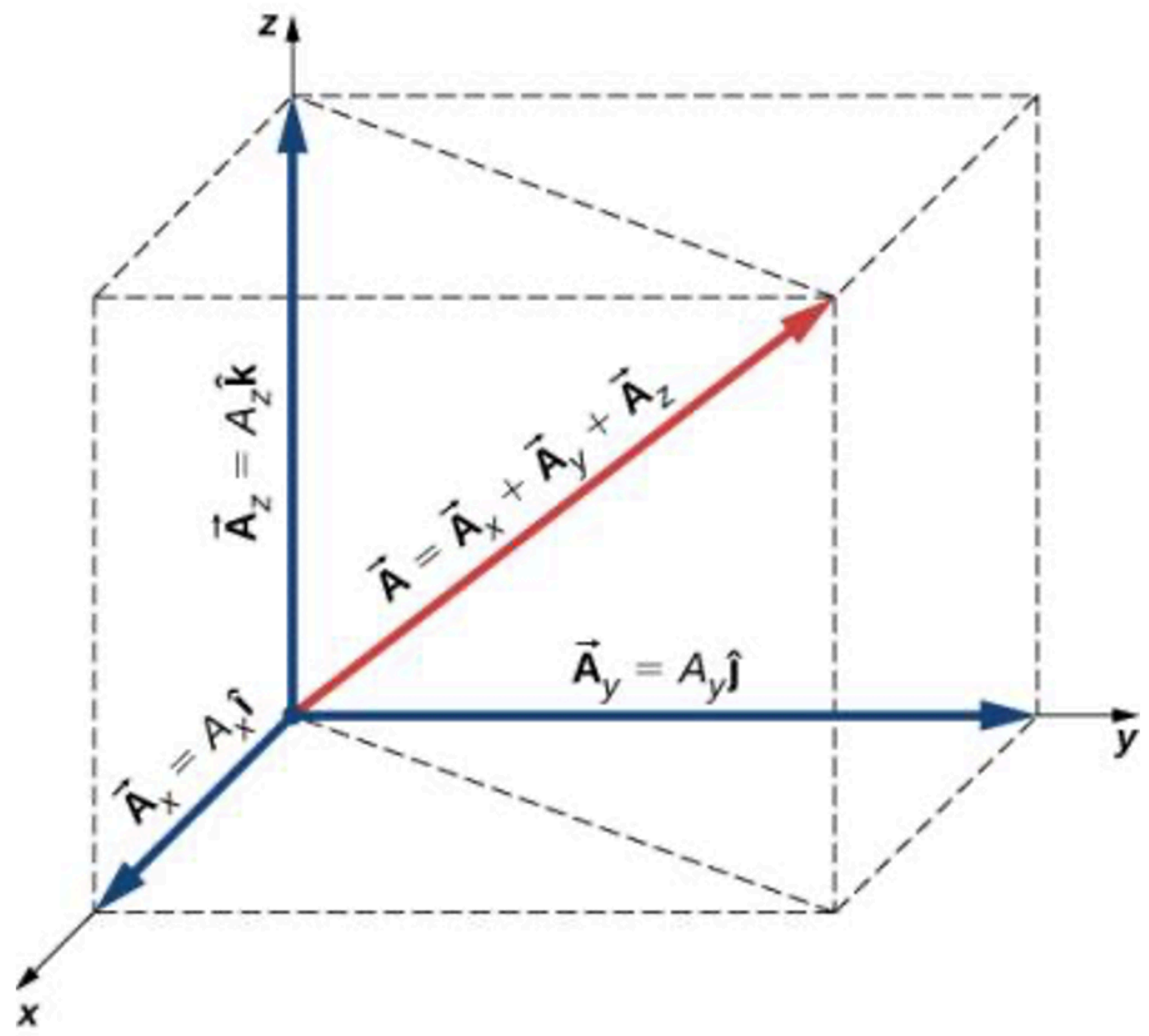
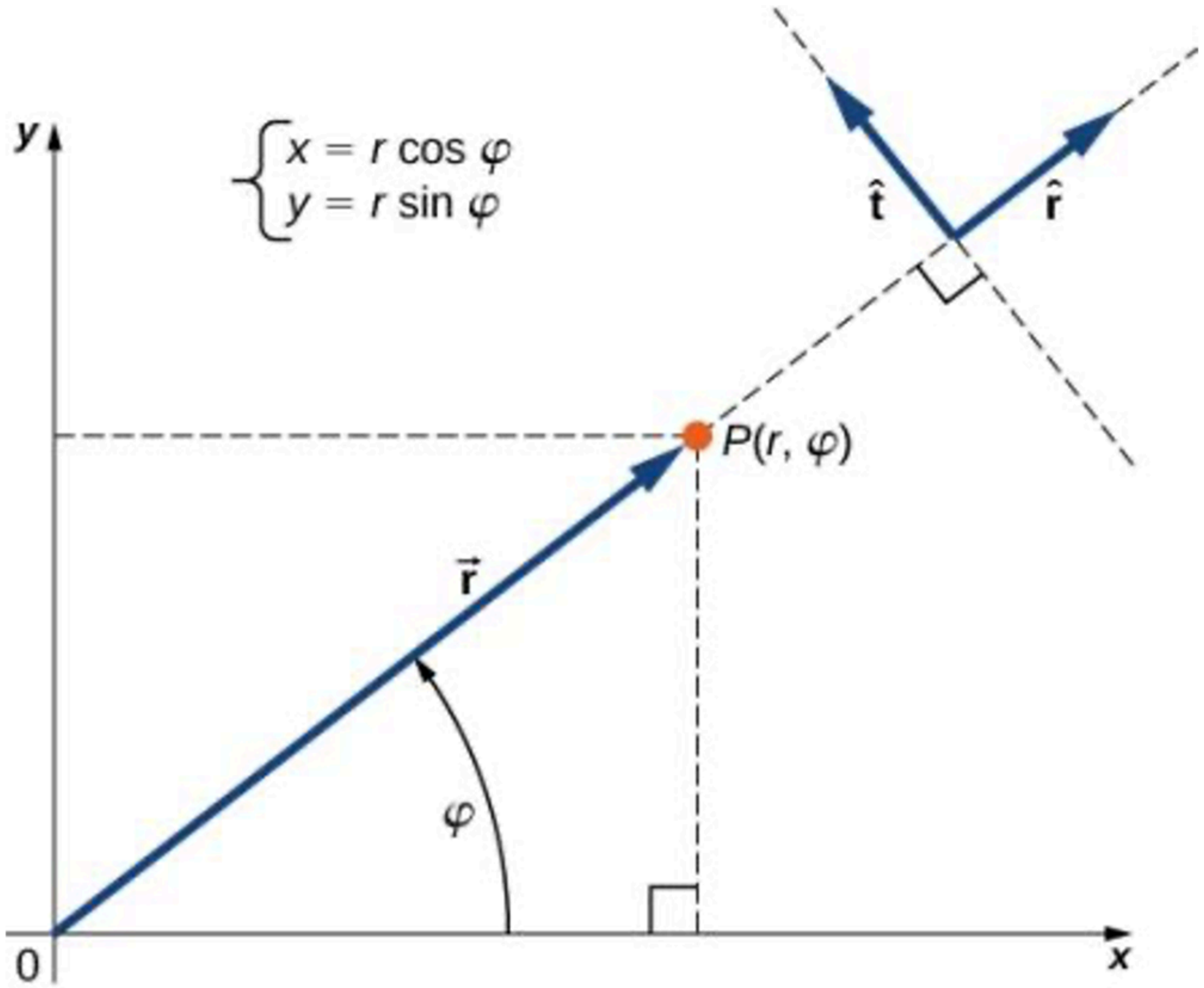
FIGURE 2.22

3D Vectors



A vector in three-dimensional space is the vector sum of its three vector components.

FIGURE 2.20 Polar Coordinates



Using polar coordinates, the unit vector $\hat{r}$ defines the positive direction along the radius r (radial direction) and, orthogonal to it, the unit vector $\hat{t}$ defines the positive direction of rotation by the angle φ.

Key Equations

Multiplication by a scalar (vector equation)	$\vec{\mathbf{B}} = \alpha\vec{\mathbf{A}}$
Multiplication by a scalar (scalar equation for magnitudes)	$B = \lvert\alpha\rvert A$
Resultant of two vectors	$\vec{\mathbf{D}}_{AD} = \vec{\mathbf{D}}_{AC} + \vec{\mathbf{D}}_{CD}$
Commutative law	$\vec{\mathbf{A}} + \vec{\mathbf{B}} = \vec{\mathbf{B}} + \vec{\mathbf{A}}$
Associative law	$(\vec{\mathbf{A}} + \vec{\mathbf{B}}) + \vec{\mathbf{C}} = \vec{\mathbf{A}} + (\vec{\mathbf{B}} + \vec{\mathbf{C}})$
Distributive law	$\alpha_1\vec{\mathbf{A}} + \alpha_2\vec{\mathbf{A}} = (\alpha_1 + \alpha_2)\vec{\mathbf{A}}$
The component form of a vector in two dimensions	$\vec{\mathbf{A}} = A_x\hat{\mathbf{i}} + A_y\hat{\mathbf{j}}$
Scalar components of a vector in two dimensions	$\begin{cases} A_x = x_e - x_b \\ A_y = y_e - y_b \end{cases}$
Magnitude of a vector in a plane	$A = \sqrt{A_x^2 + A_y^2}$
The direction angle of a vector in a plane	$\theta_A = \tan^{-1}\left(\frac{A_y}{A_x}\right)$

Key Equations

Scalar components of a vector in a plane	$\begin{cases} A_x = A\cos\theta_A \\ A_y = A\sin\theta_A \end{cases}$
Polar coordinates in a plane	$\begin{cases} x = r\cos\varphi \\ y = r\sin\varphi \end{cases}$
The component form of a vector in three dimensions	$\vec{\mathbf{A}} = A_x\hat{\mathbf{i}} + A_y\hat{\mathbf{j}} + A_z\hat{\mathbf{k}}$
The scalar z-component of a vector in three dimensions	$A_z = z_e - z_b$
Magnitude of a vector in three dimensions	$A = \sqrt{A_x^2 + A_y^2 + A_z^2}$
Distributive property	$\alpha(\vec{\mathbf{A}} + \vec{\mathbf{B}}) = \alpha\vec{\mathbf{A}} + \alpha\vec{\mathbf{B}}$
Antiparallel vector to $\vec{\mathbf{A}}$	$-\vec{\mathbf{A}} = -A_x\hat{\mathbf{i}} - A_y\hat{\mathbf{j}} - A_z\hat{\mathbf{k}}$
Equal vectors	$\vec{\mathbf{A}} = \vec{\mathbf{B}} \Leftrightarrow \begin{cases} A_x = B_x \\ A_y = B_y \\ A_z = B_z \end{cases}$
Components of the resultant of N vectors	$\begin{cases} F_{Rx} = \sum_{k=1}^{N} F_{kx} = F_{1x} + F_{2x} + \ldots + F_{Nx} \\ F_{Ry} = \sum_{k=1}^{N} F_{ky} = F_{1y} + F_{2y} + \ldots + F_{Ny} \\ F_{Rz} = \sum_{k=1}^{N} F_{kz} = F_{1z} + F_{2z} + \ldots + F_{Nz} \end{cases}$
General unit vector	$\widehat{\mathbf{V}} = \frac{\vec{\mathbf{V}}}{V}$

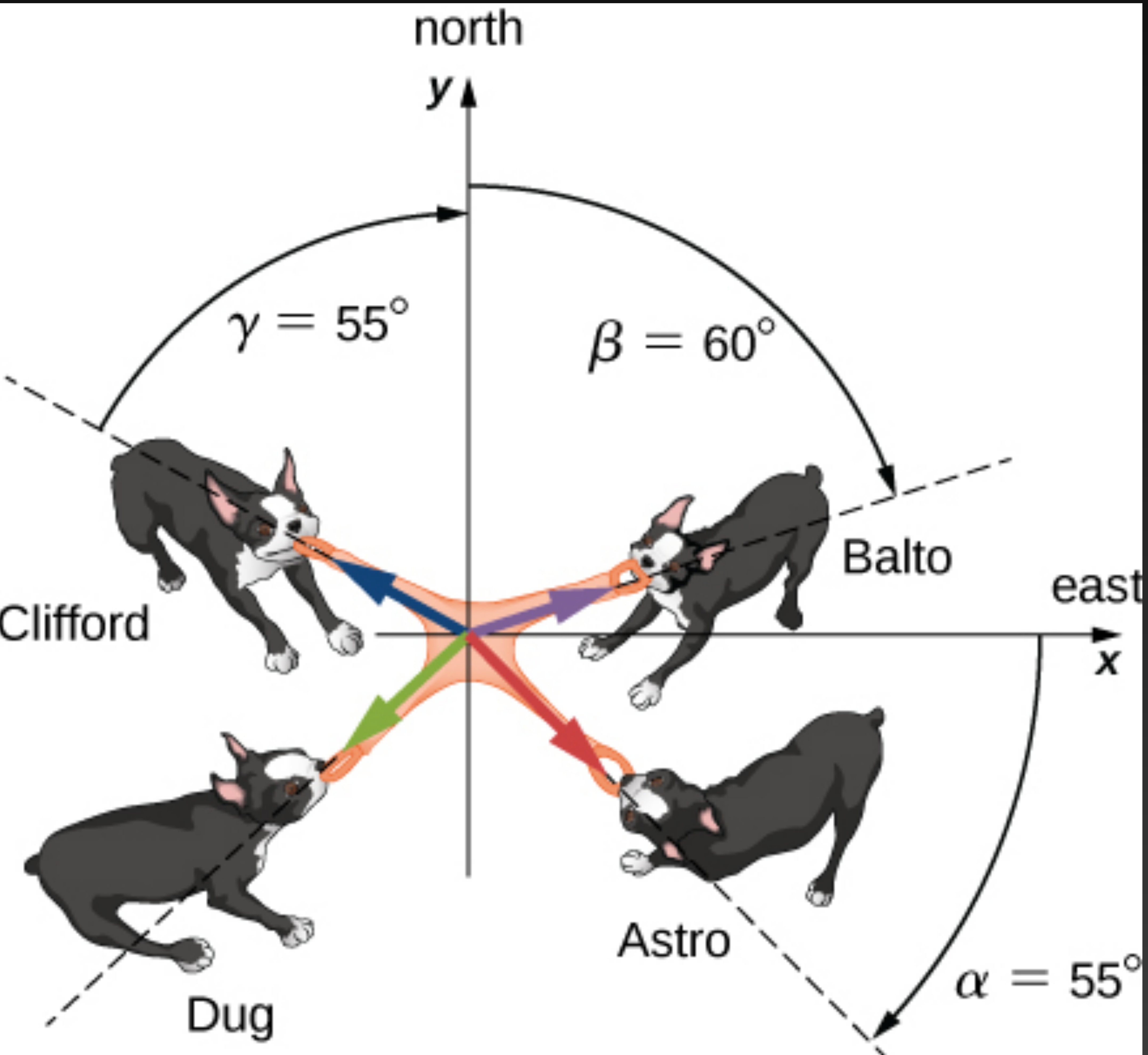
Key Equations

Definition of the scalar product	$\vec{\mathbf{A}} \cdot \vec{\mathbf{B}} = AB\cos\varphi$
Commutative property of the scalar product	$\vec{\mathbf{A}} \cdot \vec{\mathbf{B}} = \vec{\mathbf{B}} \cdot \vec{\mathbf{A}}$
Distributive property of the scalar product	$\vec{\mathbf{A}} \cdot (\vec{\mathbf{B}} + \vec{\mathbf{C}}) = \vec{\mathbf{A}} \cdot \vec{\mathbf{B}} + \vec{\mathbf{A}} \cdot \vec{\mathbf{C}}$
Scalar product in terms of scalar components of vectors	$\vec{\mathbf{A}} \cdot \vec{\mathbf{B}} = A_x B_x + A_y B_y + A_z B_z$
Cosine of the angle between two vectors	$\cos\varphi = \frac{\vec{\mathbf{A}} \cdot \vec{\mathbf{B}}}{AB}$
Dot products of unit vectors	$\hat{\mathbf{i}} \cdot \hat{\mathbf{j}} = \hat{\mathbf{j}} \cdot \hat{\mathbf{k}} = \hat{\mathbf{k}} \cdot \hat{\mathbf{i}} = 0$
Magnitude of the vector product (definition)	$\left\lvert \vec{\mathbf{A}} \times \vec{\mathbf{B}} \right\rvert = AB\sin\varphi$
Anticommutative property of the vector product	$\vec{\mathbf{A}} \times \vec{\mathbf{B}} = -\vec{\mathbf{B}} \times \vec{\mathbf{A}}$
Distributive property of the vector product	$\vec{\mathbf{A}} \times (\vec{\mathbf{B}} + \vec{\mathbf{C}}) = \vec{\mathbf{A}} \times \vec{\mathbf{B}} + \vec{\mathbf{A}} \times \vec{\mathbf{C}}$
Cross products of unit vectors	$\begin{cases} \hat{\mathbf{i}} \times \hat{\mathbf{j}} = +\hat{\mathbf{k}}, \\ \hat{\mathbf{j}} \times \hat{\mathbf{k}} = +\hat{\mathbf{i}}, \\ \hat{\mathbf{k}} \times \hat{\mathbf{i}} = +\hat{\mathbf{j}}. \end{cases}$
The cross product in terms of scalar components of vectors	$\vec{\mathbf{A}} \times \vec{\mathbf{B}} = (A_y B_z - A_z B_y)\hat{\mathbf{i}} + (A_z B_x - A_x B_z)\hat{\mathbf{j}} + (A_x B_y - A_y B_x)\hat{\mathbf{k}}$

No Clicker Questions today

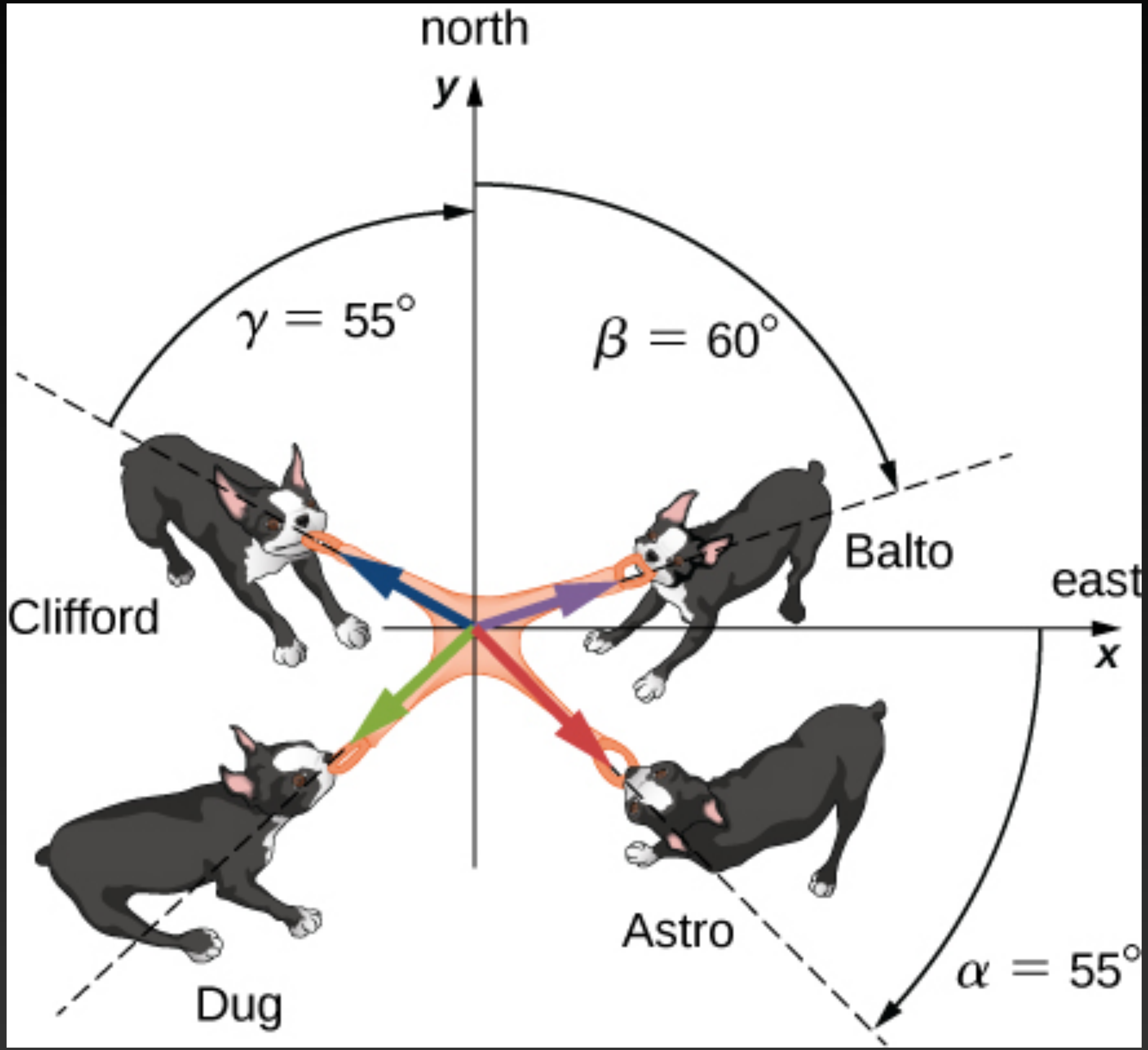
Tug of War

Activity



Tug of War

Activity



Four dogs (Astro, Balto, Clifford, Dug) are playing tug of war with a toy.

- Astro pulls with 160.0 N of force with angle α
- Balto pulls with 200.0 N of force with angle β
- Clifford pulls with 140.0 N of force with angle γ
- Dug pulls with a force so overall, the toy does not move.

What is the magnitude and direction of the Force Dug pulls the toy at?

Problem Solving Template

PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH **16**, 010123 (2020)

Template for teaching and assessment of problem solving in introductory physics

E. W. Burkholder,[1,*] J. K. Miles,[2] T. J. Layden,[2] K. D. Wang,[3]
A. V. Fritz,[4] and C. E. Wieman[1,3]

Reference: Template for teaching and assessment of problem solving in introductory physics

1. Framing

- Visual Representation
- Assumptions and Simplifications
- Relevant Concepts
- Information Needed
- Similar Problems

2. Planning

- Solution Plan
- Rough Estimate

3. Execution

Carry-out Plan for solving
- Work in algebra/symbols until the BITTER end
- Plug in numbers at the LAST step

4. Answer Checking

- Compare to Estimate
- Units Check
- Limits Test
- Getting (UnStuck)

Reference: Template for teaching and assessment of problem solving in introductory physics

1. Framing

2. Planning

3. Execution

4. Answer Checking

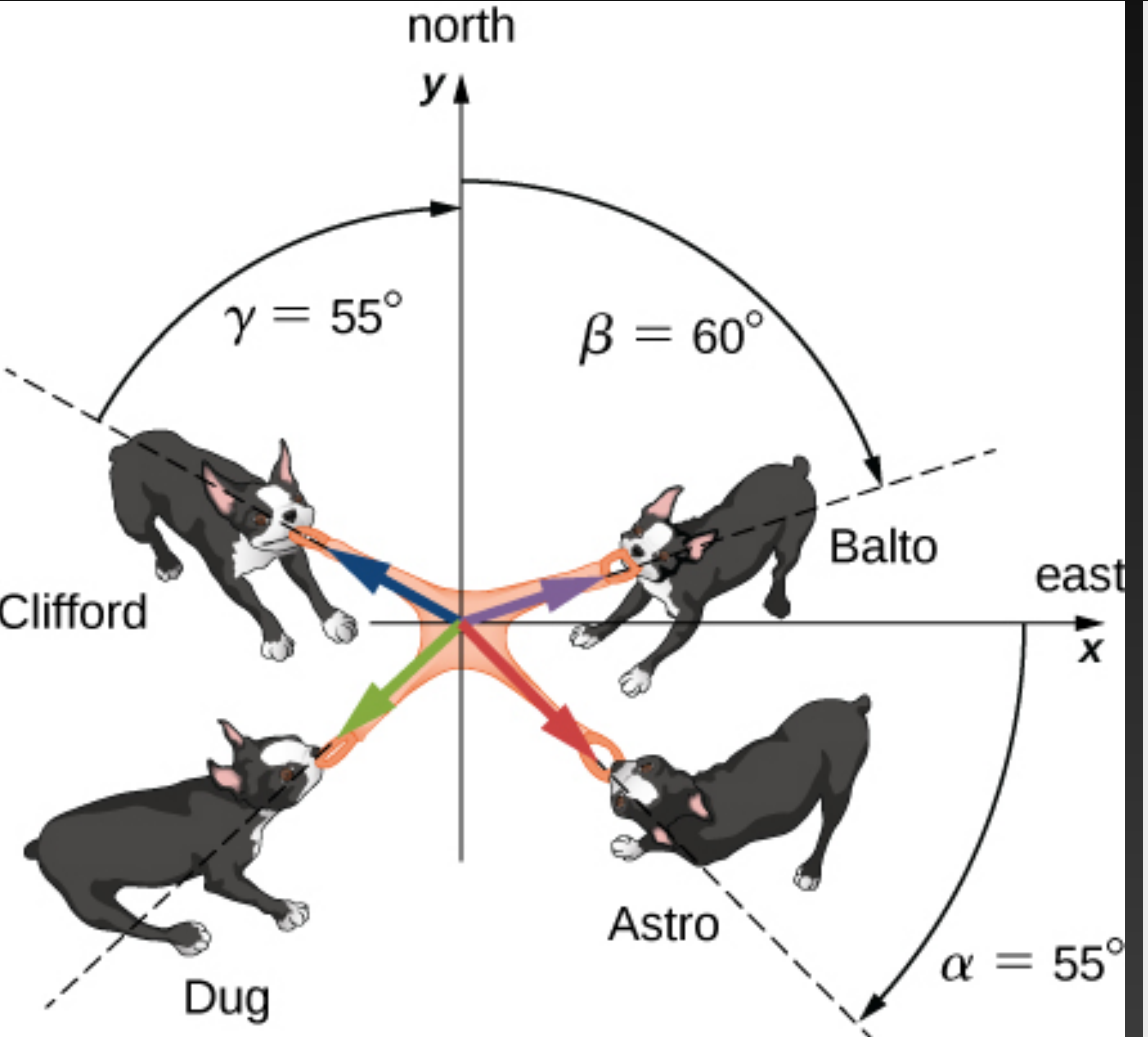
The direction angles are $\theta_A = -\alpha = -55°$, $\theta_B = 90° - \beta = 30°$, and $\theta_C = 90° + \gamma = 145°$, and substituting them into Equation 2.17 gives the scalar components of the three given forces:

$$\begin{cases} A_x = A\cos\theta_A = (160.0\text{ N})\cos(-55°) = +91.8\text{ N} \\ A_y = A\sin\theta_A = (160.0\text{ N})\sin(-55°) = -131.1\text{ N} \end{cases}$$

$$\begin{cases} B_x = B\cos\theta_B = (200.0\text{ N})\cos 30° = +173.2\text{ N} \\ B_y = B\sin\theta_B = (200.0\text{ N})\sin 30° = +100.0\text{ N} \end{cases}.$$

$$\begin{cases} C_x = C\cos\theta_C = (140.0\text{ N})\cos 145° = -114.7\text{ N} \\ C_y = C\sin\theta_C = (140.0\text{ N})\sin 145° = +80.3\text{ N} \end{cases}$$

Debrief



Now we compute scalar components of the resultant vector $\vec{\mathbf{R}} = \vec{\mathbf{A}} + \vec{\mathbf{B}} + \vec{\mathbf{C}}$:

$$\begin{cases} R_x = A_x + B_x + C_x = +91.8\text{ N} + 173.2\text{ N} - 114.7\text{ N} = +150.3\text{ N} \\ R_y = A_y + B_y + C_y = -131.1\text{ N} + 100.0\text{ N} + 80.3\text{ N} = +49.2\text{ N} \end{cases}.$$

The antiparallel vector to the resultant $\vec{\mathbf{R}}$ is

$$\vec{\mathbf{D}} = -\vec{\mathbf{R}} = -R_x\hat{\mathbf{i}} - R_y\hat{\mathbf{j}} = (-150.3\hat{\mathbf{i}} - 49.2\hat{\mathbf{j}})\text{ N}.$$

The magnitude of Dug's pulling force is

$$D = \sqrt{D_x^2 + D_y^2} = \sqrt{(-150.3)^2 + (-49.2)^2}\text{ N} = 158.1\text{ N}.$$

The direction of Dug's pulling force is

$$\theta = \tan^{-1}\left(\frac{D_y}{D_x}\right) = \tan^{-1}\left(\frac{-49.2\text{ N}}{-150.3\text{ N}}\right) = \tan^{-1}\left(\frac{49.2}{150.3}\right) = 18.1°.$$

Dug pulls in the direction $18.1°$ south of west because both components are negative, which means the pull vector lies in the third quadrant (Figure 2.19).

See you next class!

Attribution