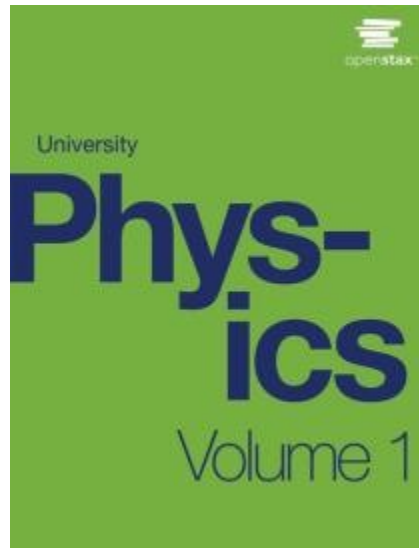


# UNIVERSITY PHYSICS

## Chapter 2 VECTORS

PowerPoint Image Slideshow



**Vectors:  
direction and  
magnitude**

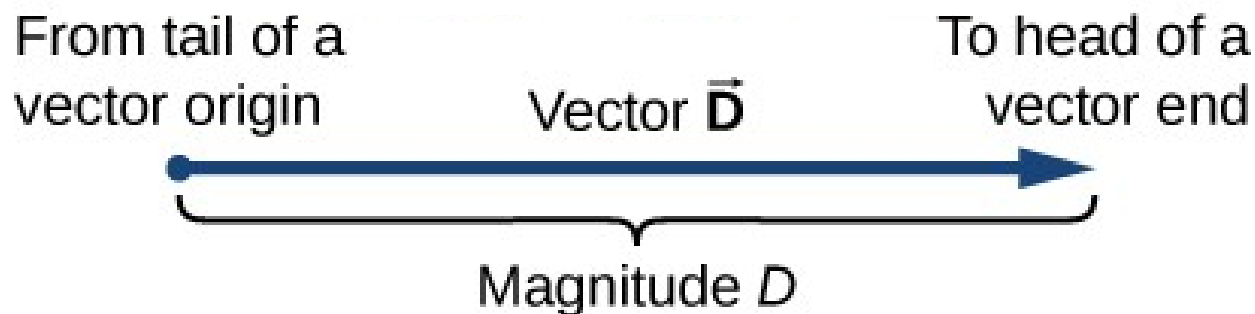
## FIGURE 2.1



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.

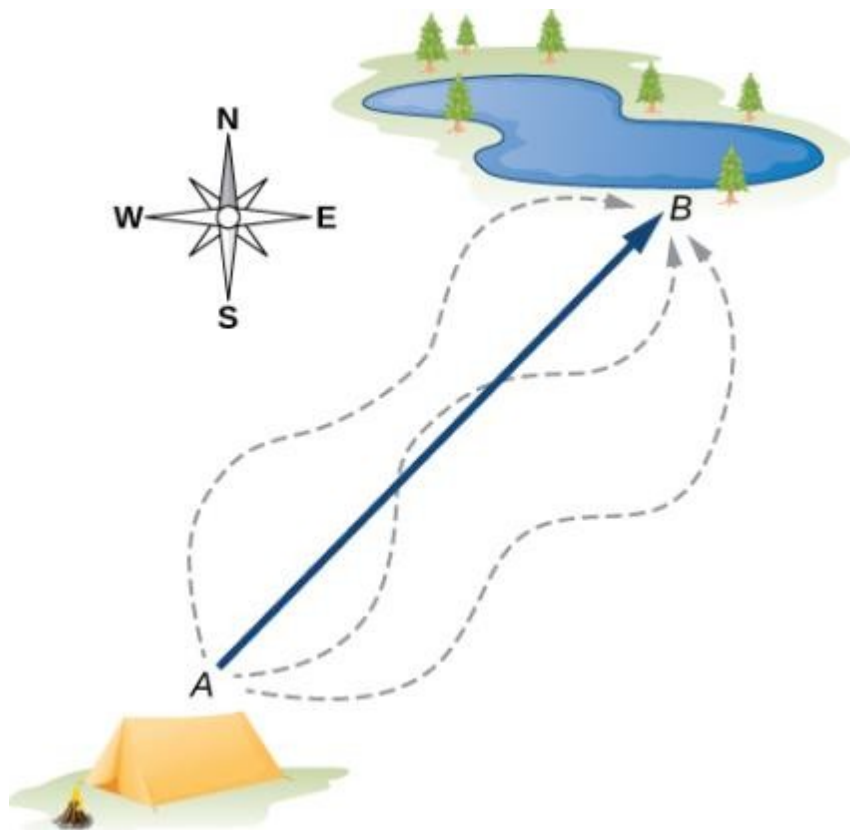
(credit: modification of work by “studio tdes”/Flickr)

## FIGURE 2.2



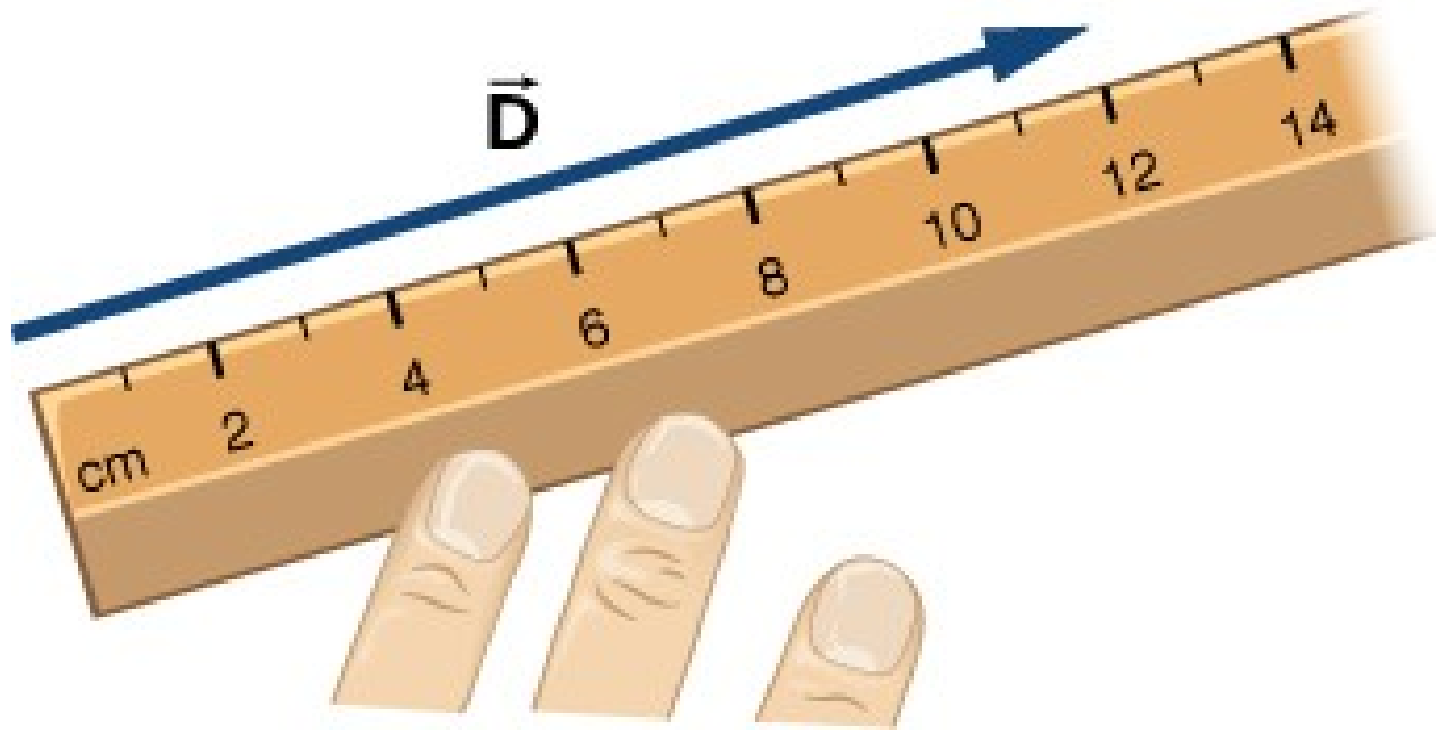
We draw a vector from the initial point or origin (called the “tail” of a vector) to the end or terminal point (called the “head” of a vector), marked by an arrowhead. Magnitude is the length of a vector and is always a positive scalar quantity. (credit: modification of work by Cate Sevilla)

## FIGURE 2.3



The displacement vector from point  $A$  (the initial position at the campsite) to point  $B$  (the final position at the fishing hole) is indicated by an arrow with origin at point  $A$  and end at point  $B$ . The displacement is the same for any of the actual paths (dashed curves) that may be taken between points  $A$  and  $B$ .

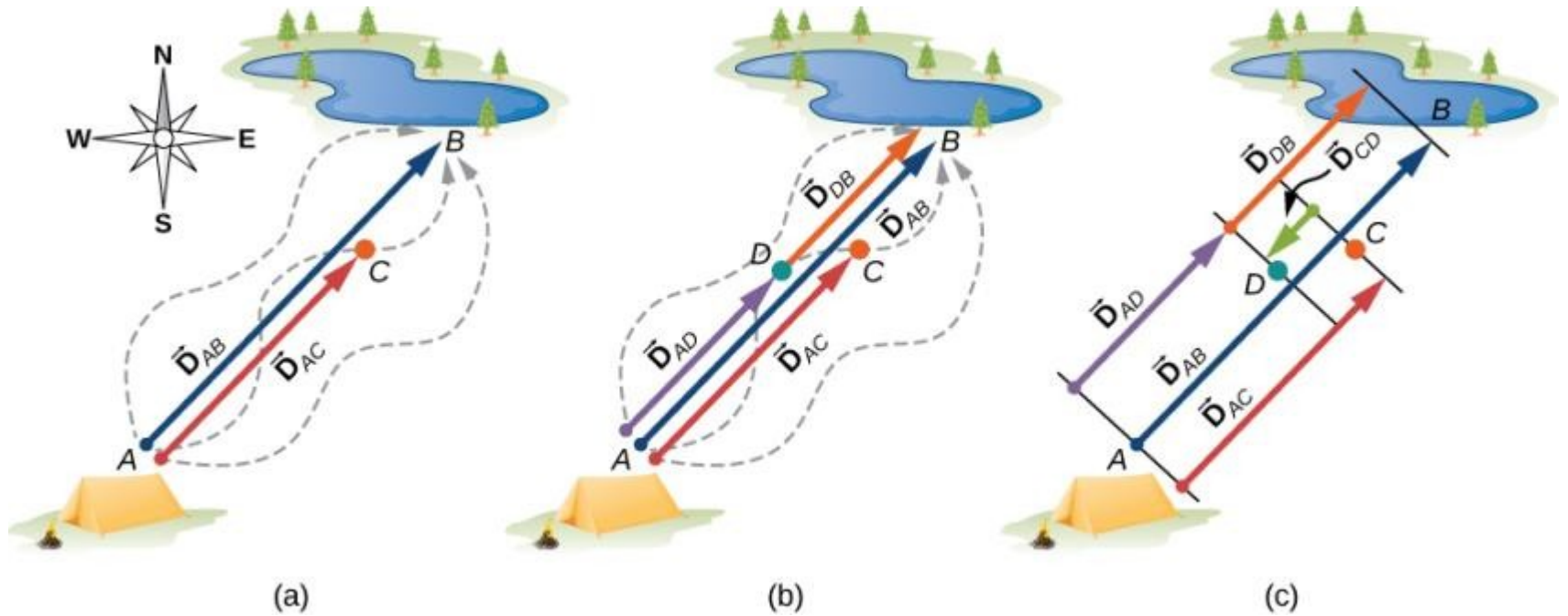
## FIGURE 2.4



A displacement of magnitude 6 km is drawn to scale as a vector of length 12 cm when the length of 2 cm represents 1 unit of displacement (which in this case is 1 km).

# Displacement Vector

# FIGURE 2.6



Displacement vectors for a fishing trip.

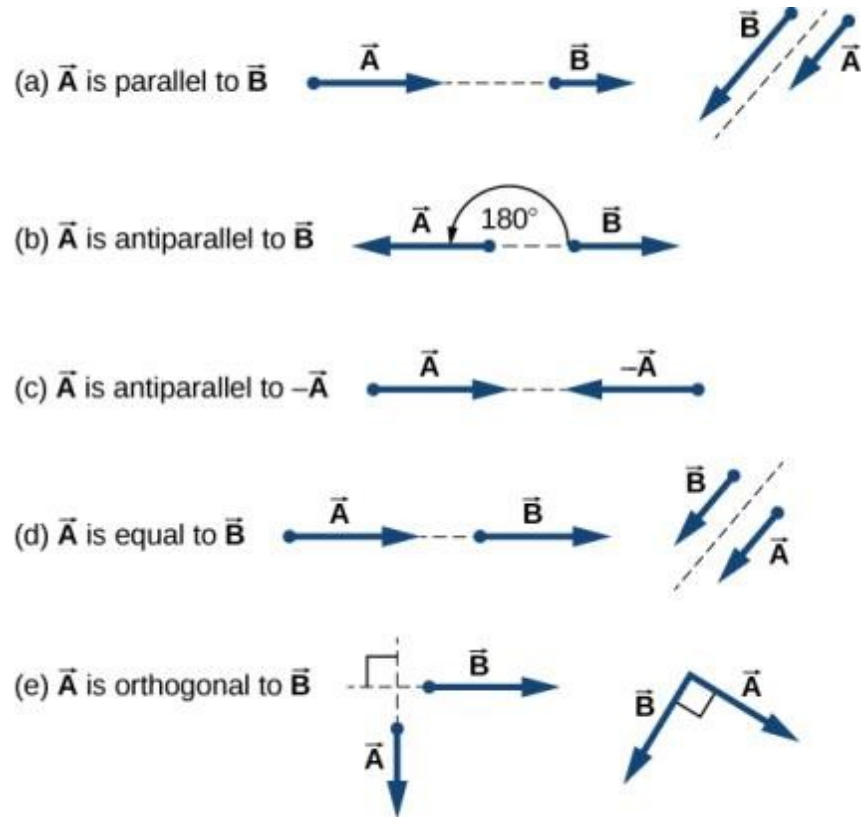
- a) Stopping to rest at point C while walking from camp (point A) to the pond (point B).
- b) Going back for the dropped tackle box (point D).
- c) Finishing up at the fishing pond.



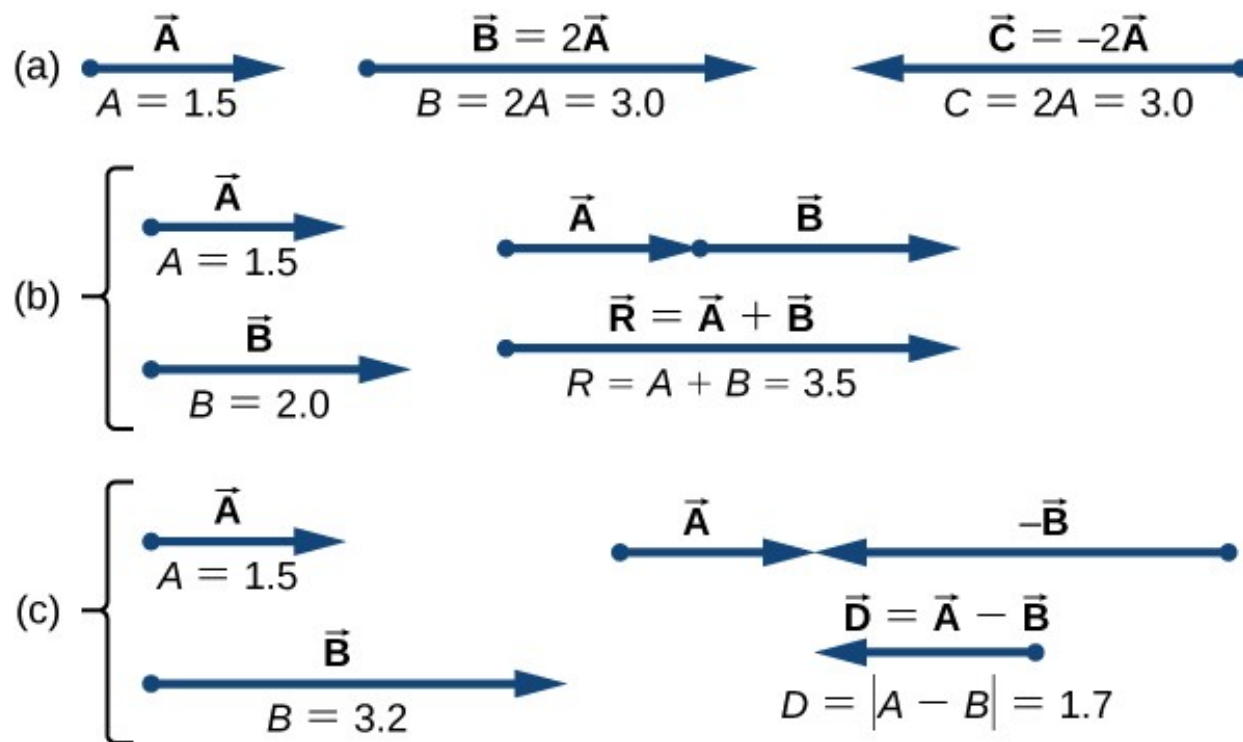
# **Mathematical Operations**

# Alternate vector notations

Various relations between two vectors **A** and **B**.



## FIGURE 2.7

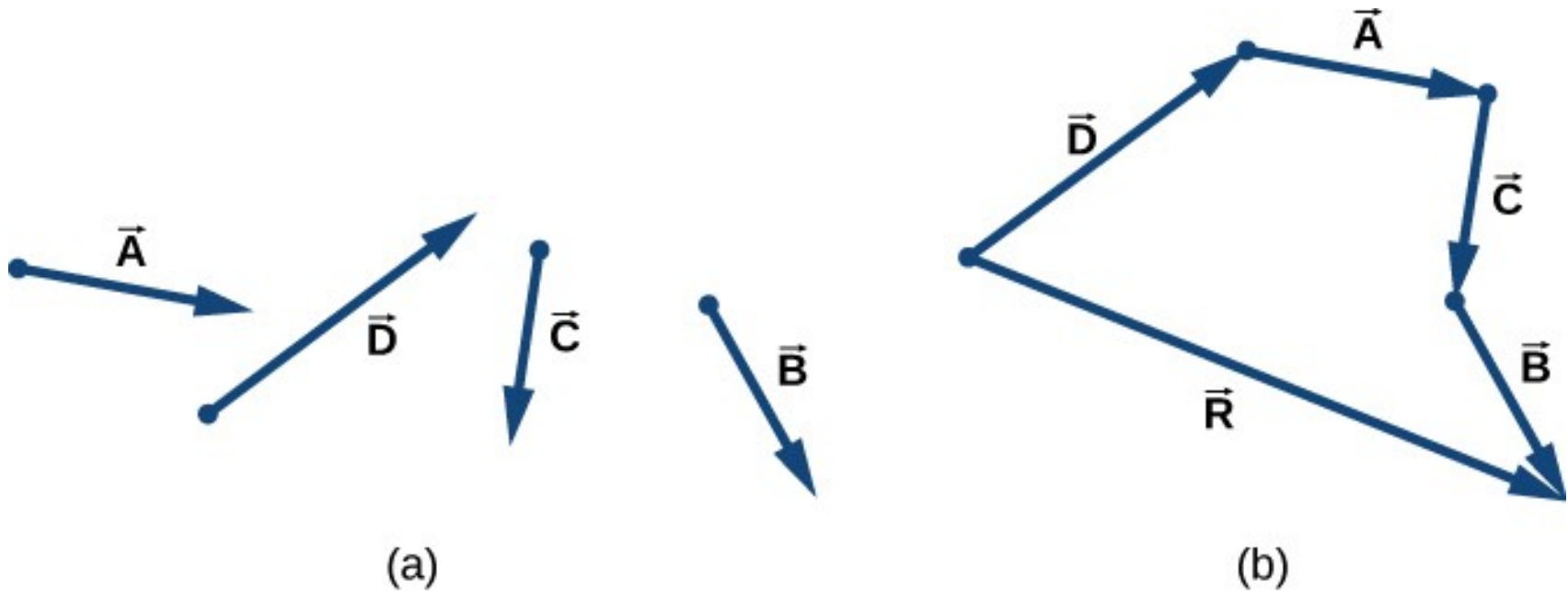


Algebra of vectors in one dimension.

- a) Multiplication by a scalar.
- b) Addition of two vectors ( is called the *resultant* of vectors and ).
- c) Subtraction of two vectors ( is the difference of vectors and ).

# Vector addition

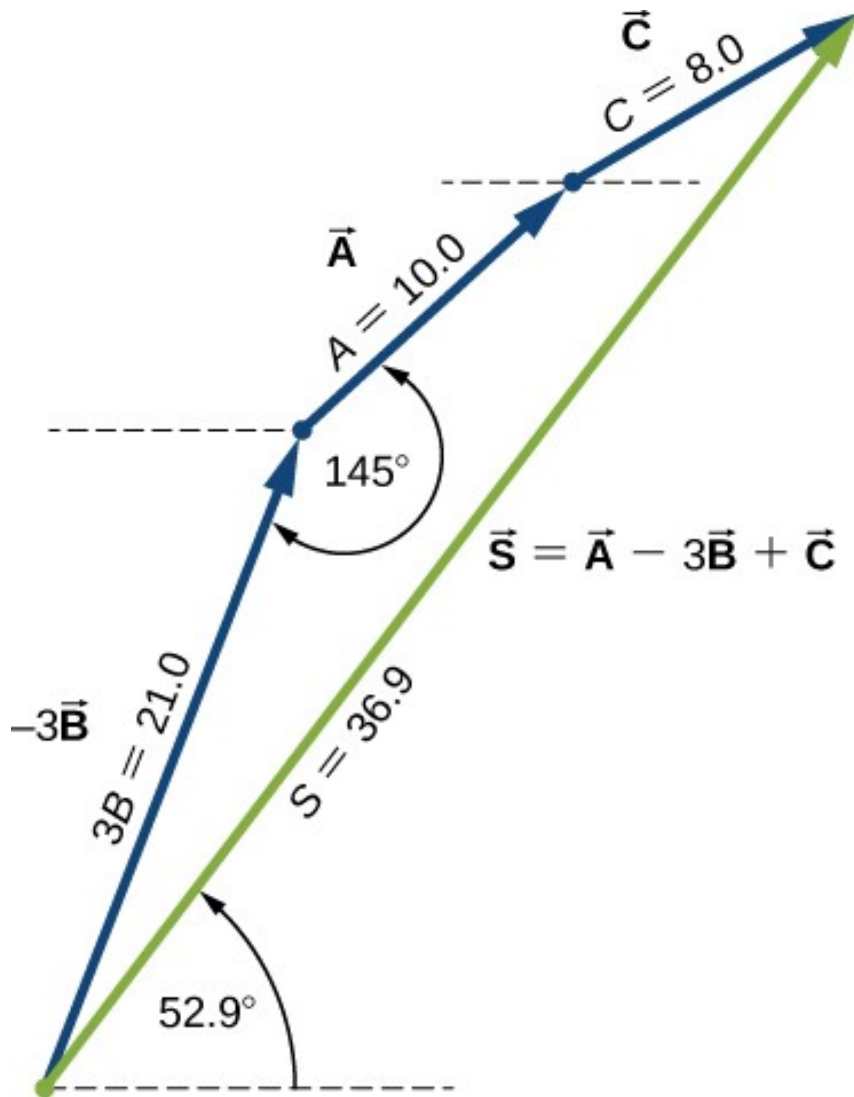
## FIGURE 2.12



Tail-to-head method for drawing the resultant vector .

- Four vectors of different magnitudes and directions.
- Vectors in (a) are translated to new positions where the origin (“tail”) of one vector is at the end (“head”) of another vector. The resultant vector is drawn from the origin (“tail”) of the first vector to the end (“head”) of the last vector in this arrangement.

**FIGURE 2.15**

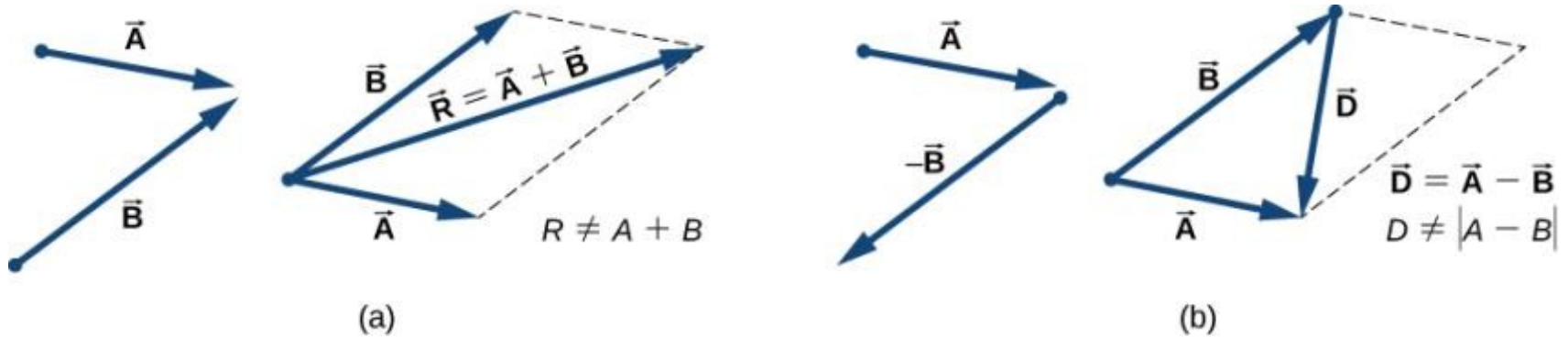


Using the tail-to-head method to solve (c)  
(finding vector  $\vec{S}$ , green).

# Parallelogram rule



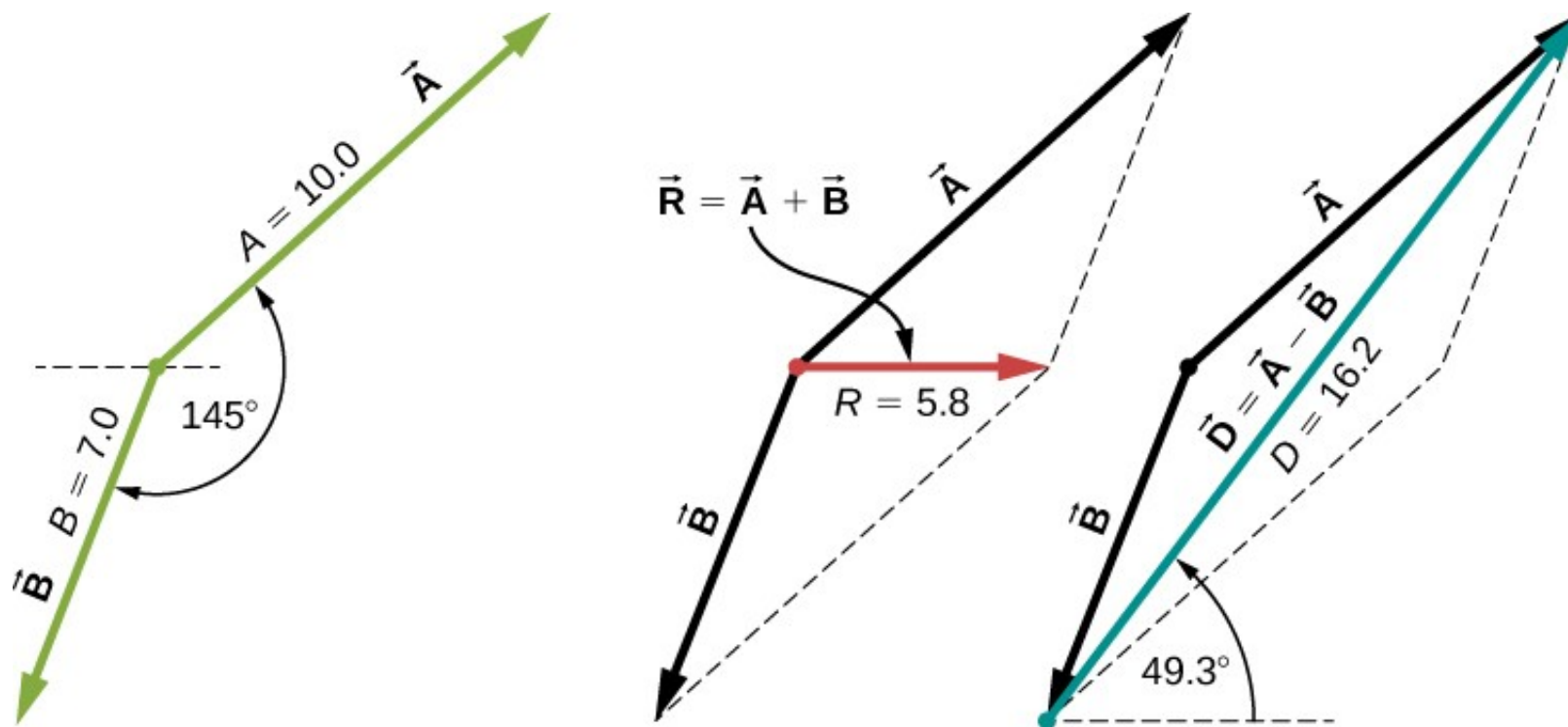
# FIGURE 2.10



The parallelogram rule for the addition of two vectors. Make the parallel translation of each vector to a point where their origins (marked by the dot) coincide and construct a parallelogram with two sides on the vectors and the other two sides (indicated by dashed lines) parallel to the vectors.

- a) Draw the resultant vector along the diagonal of the parallelogram from the common point to the opposite corner. Length of the resultant vector is not equal to the sum of the magnitudes of the two vectors.
- b) Draw the difference vector along the diagonal connecting the ends of the vectors. Place the origin of vector at the end of vector and the end (arrowhead) of vector at the end of vector . Length  $D$  of the difference vector is not equal to the difference of magnitudes of the two vectors.

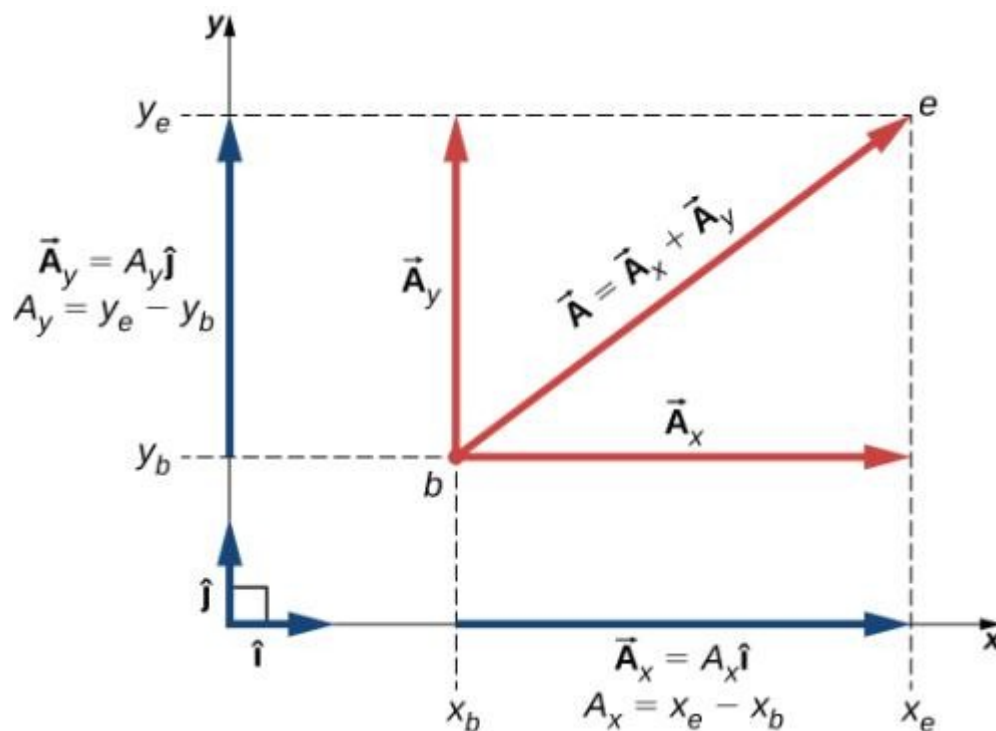
## FIGURE 2.14



Using the parallelogram rule to solve (a) (finding the resultant, red) and (b) (finding the difference, blue).

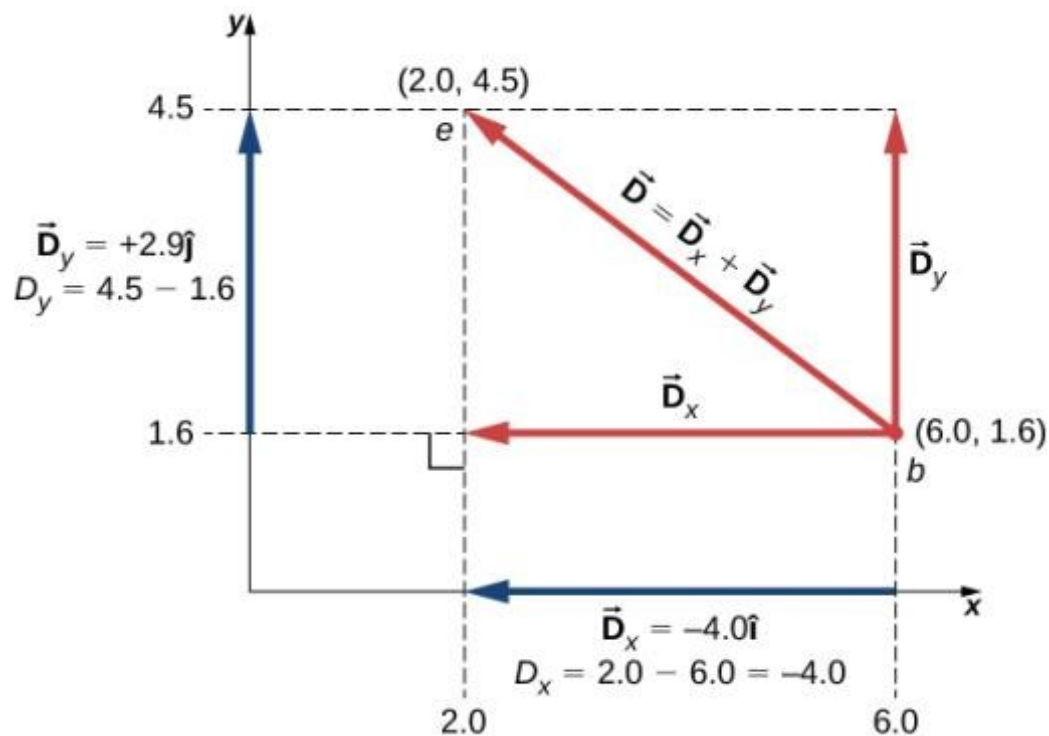
# **Cartesian Coordinates**

## FIGURE 2.16



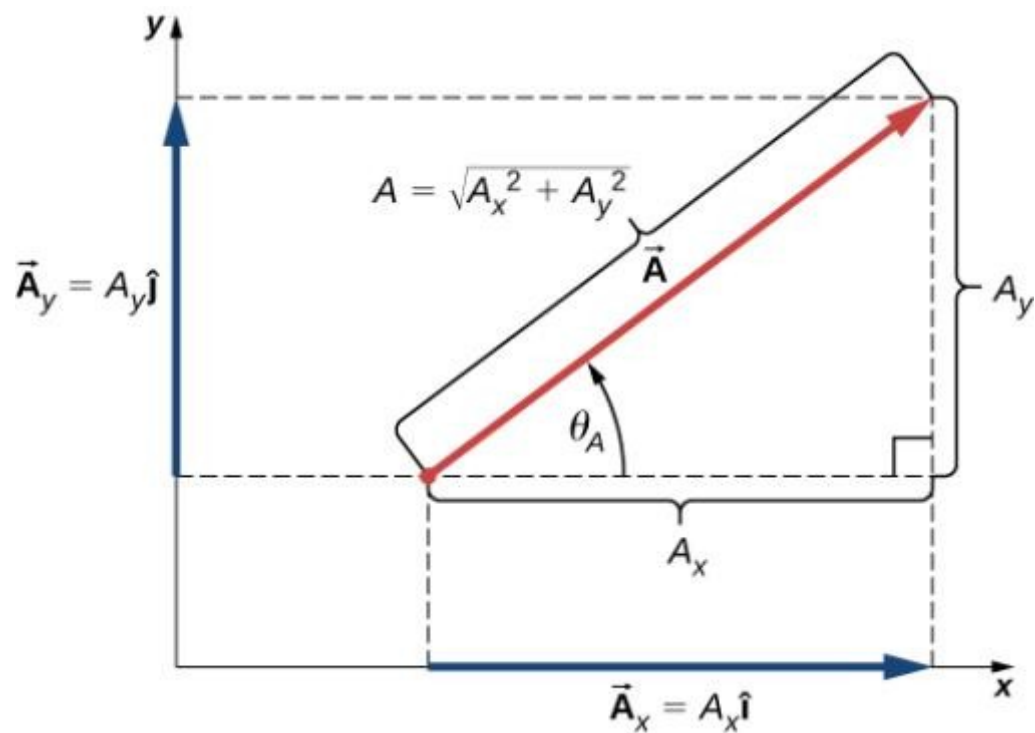
Vector in a plane in the Cartesian coordinate system is the vector sum of its vector x- and y-components. The x-vector component is the orthogonal projection of vector onto the x-axis. The y-vector component is the orthogonal projection of vector onto the y-axis. The numbers and that multiply the unit vectors are the scalar components of the vector.

# FIGURE 2.17



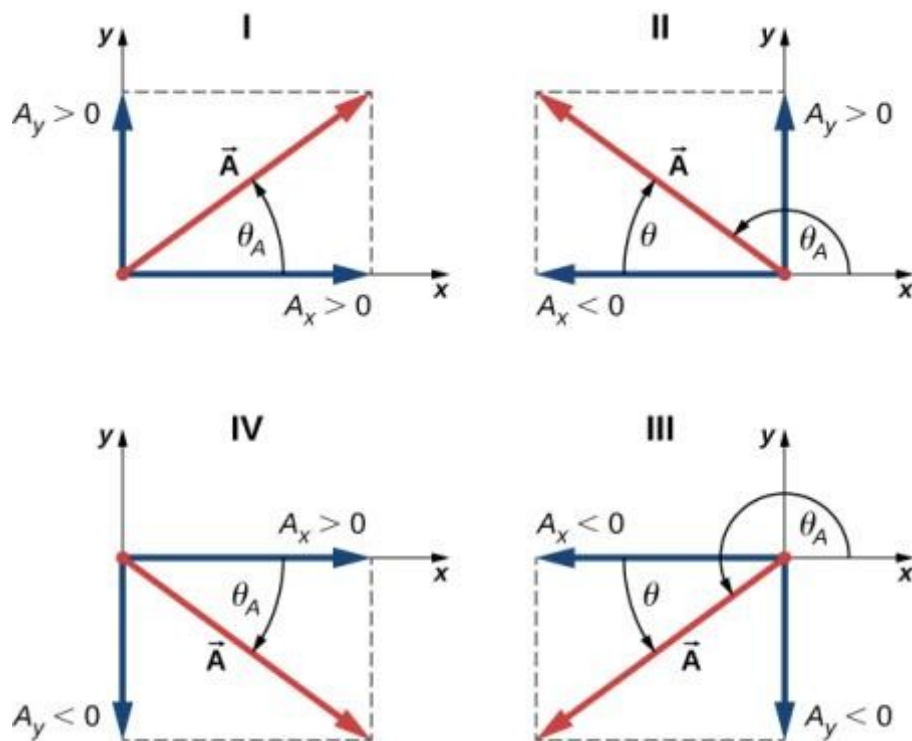
The graph of the displacement vector. The vector points from the origin point at  $b$  to the end point at  $e$ .

# FIGURE 2.18



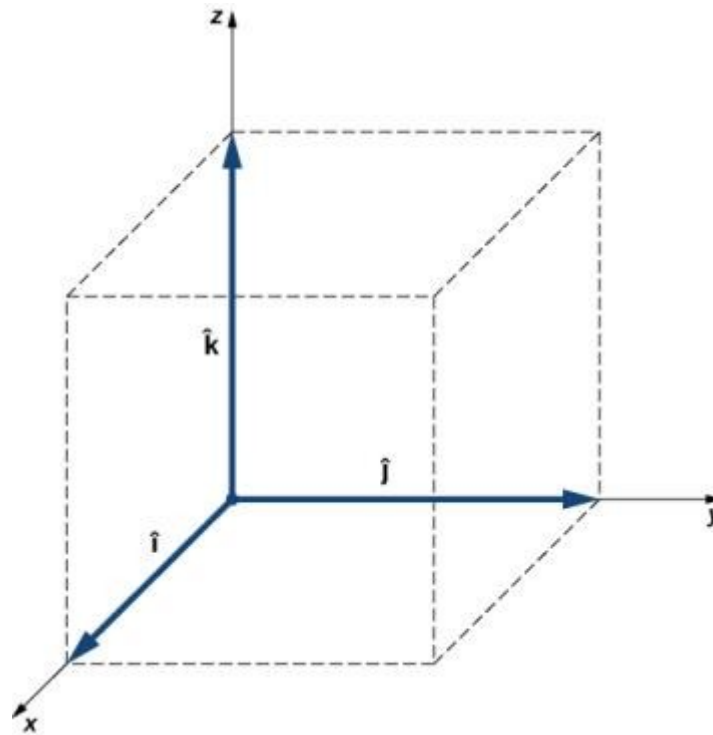
For vector  $\vec{A}$ , its magnitude  $A$  and its direction angle  $\theta_A$  are related to the magnitudes of its scalar components because  $\vec{A}_x$ ,  $\vec{A}_y$ , and  $\vec{A}$  form a right triangle.

## FIGURE 2.19



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 .

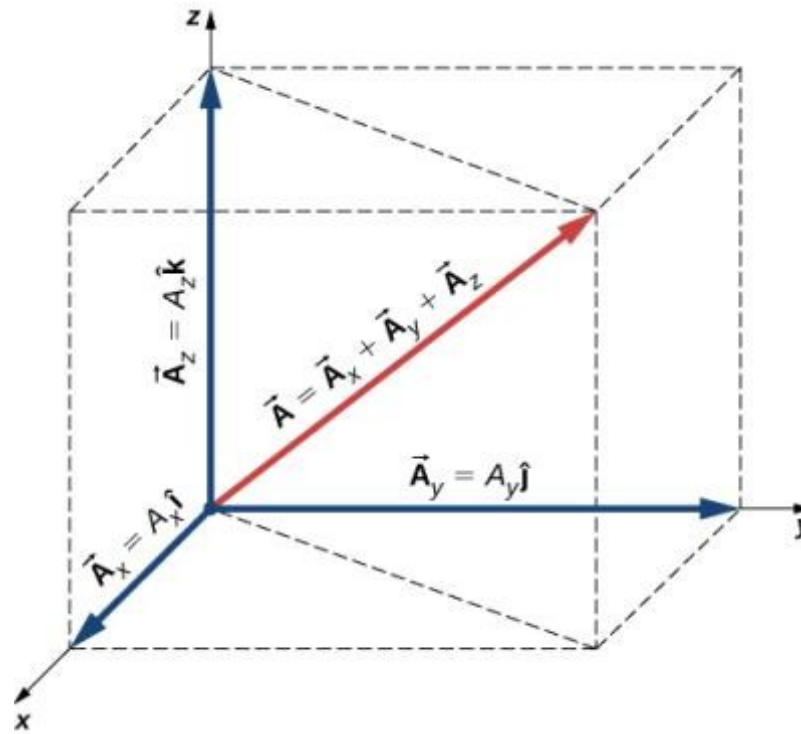
## FIGURE 2.21



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.



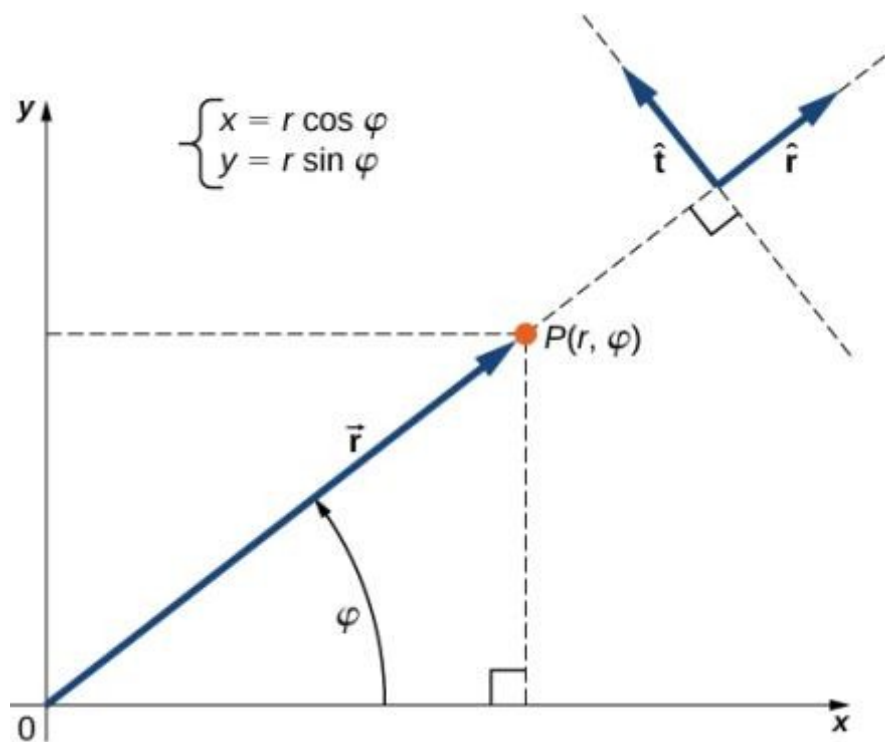
**FIGURE 2.22**



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

# **Polar Coordinates**

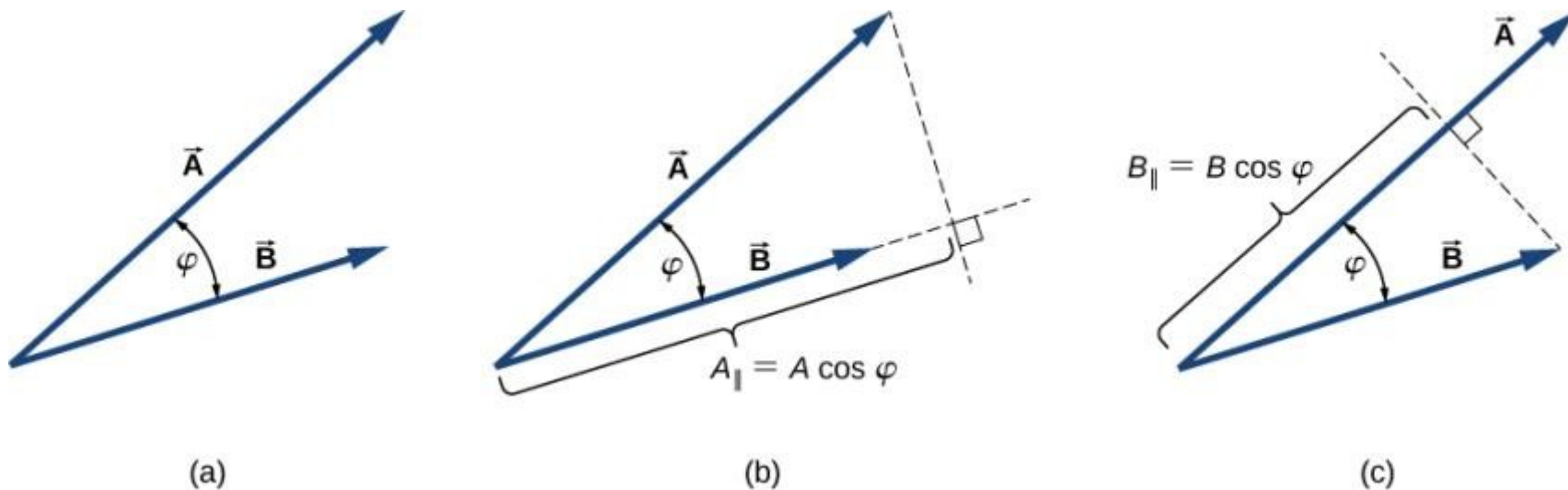
# FIGURE 2.20



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  $\varphi$ .

# Dot Product

# FIGURE 2.27

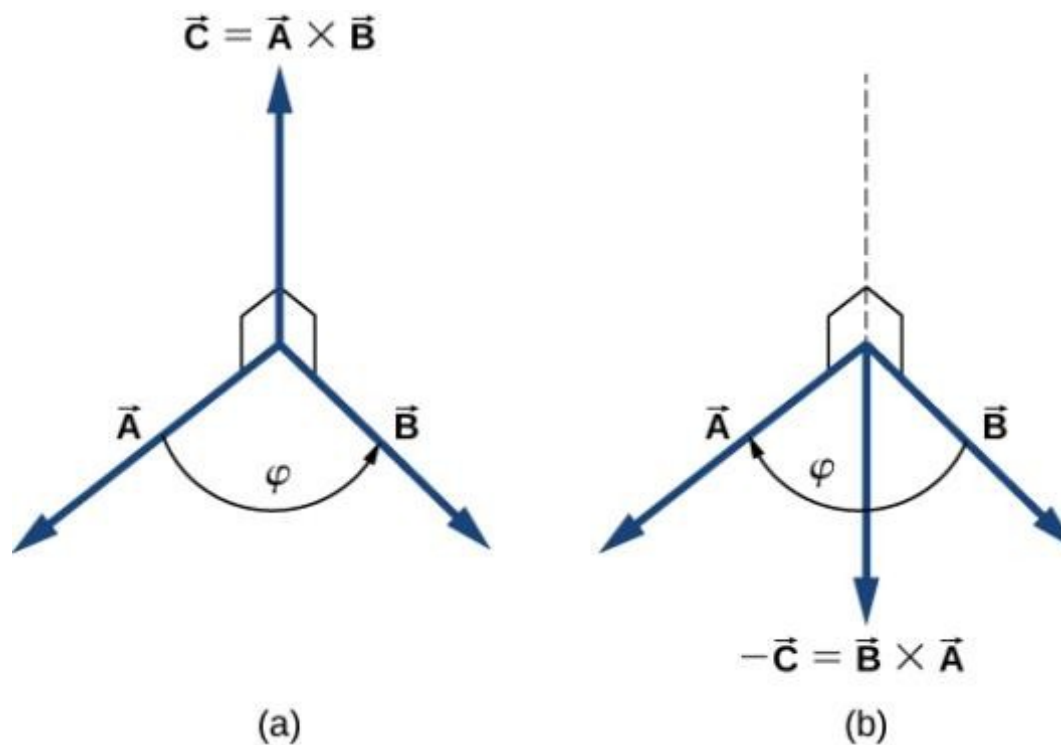


The scalar product of two vectors.

- The angle between the two vectors.
- The orthogonal projection  $A_{\parallel}$  of vector onto the direction of vector .
- The orthogonal projection  $B_{\parallel}$  of vector onto the direction of vector .

**Cross Product**

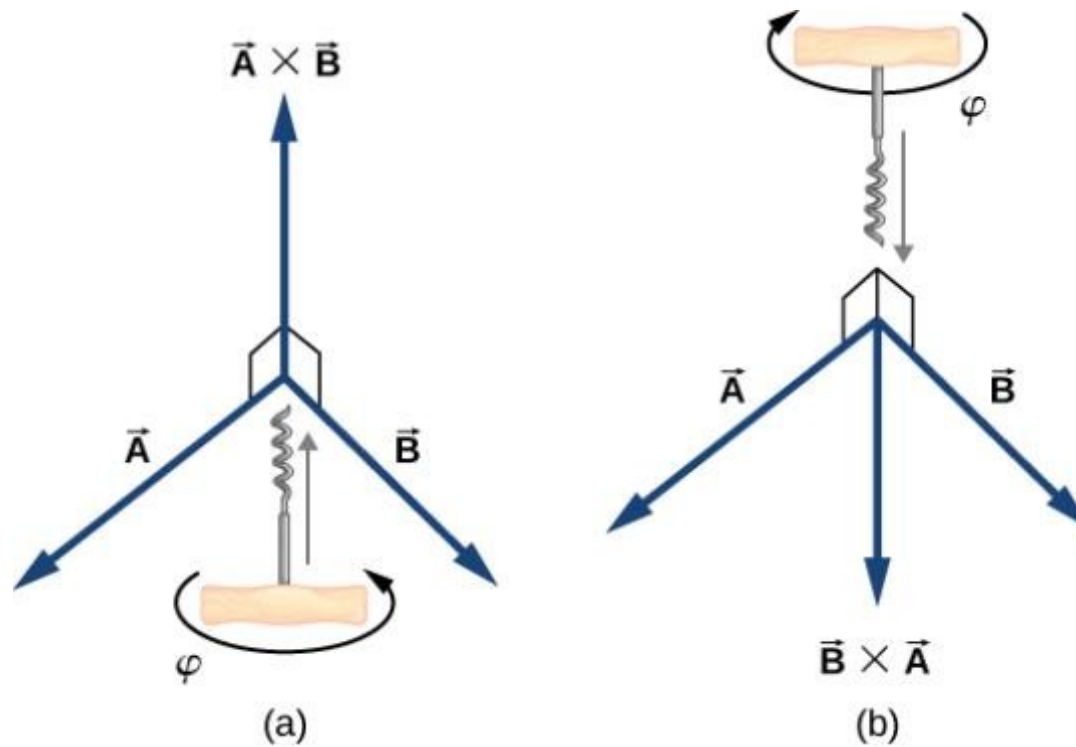
## FIGURE 2.29



The vector product of two vectors is drawn in three-dimensional space.

- The vector product  $\vec{C}$  is a vector perpendicular to the plane that contains vectors  $\vec{A}$  and  $\vec{B}$ . Small squares drawn in perspective mark right angles between  $\vec{A}$  and  $\vec{C}$ , and between  $\vec{B}$  and  $\vec{C}$  so that if  $\vec{A}$  and  $\vec{B}$  lie on the floor, vector  $\vec{C}$  points vertically upward to the ceiling.
- The vector product  $-\vec{C}$  is a vector antiparallel to vector  $\vec{C}$ .

## FIGURE 2.30

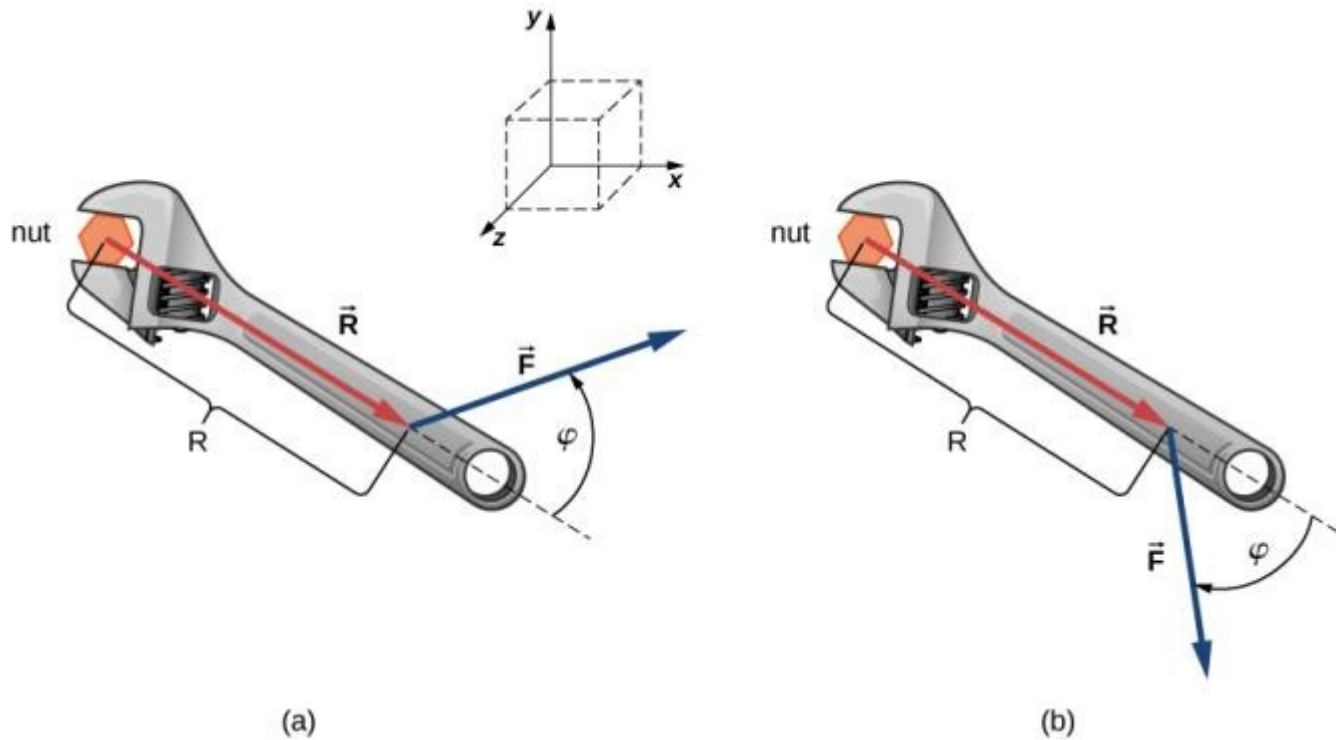


The corkscrew right-hand rule can be used to determine the direction of the cross product  $\vec{A} \times \vec{B}$ . Place a corkscrew in the direction perpendicular to the plane that contains vectors  $\vec{A}$  and  $\vec{B}$ , and turn it in the direction from the first to the second vector in the product. The direction of the cross product is given by the progression of the corkscrew.

- a) Upward movement means the cross-product vector points up.
- b) Downward movement means the cross-product vector points downward.



## FIGURE 2.31

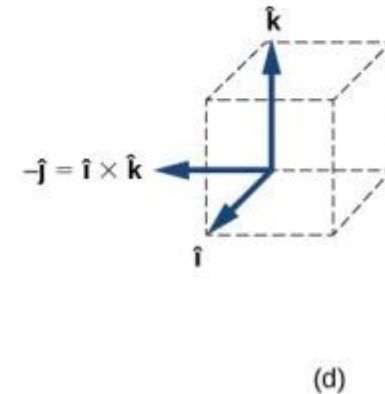
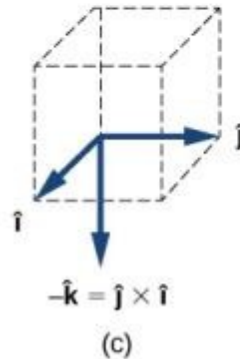
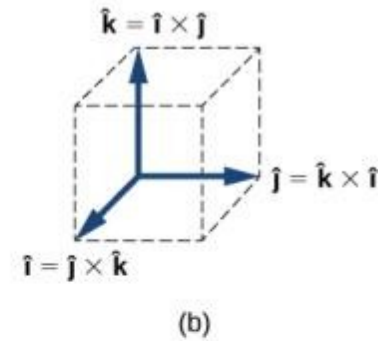
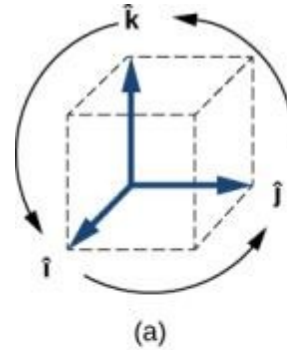


A wrench provides grip and mechanical advantage in applying torque to turn a nut.

- a) Turn counterclockwise to loosen the nut.
- b) Turn clockwise to tighten the nut.

# FIGURE 2.32

- a) The diagram of the cyclic order of the unit vectors of the axes.
- b) The only cross products where the unit vectors appear in the cyclic order. These products have the positive sign.
- c) (d) Two examples of cross products where the unit vectors do not appear in the cyclic order. These products have the negative sign.





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