Chapter 3
Kinematics in Two Dimensions; Vectors

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- Subtraction of Vectors, and Multiplication of a Vector by a Scalar
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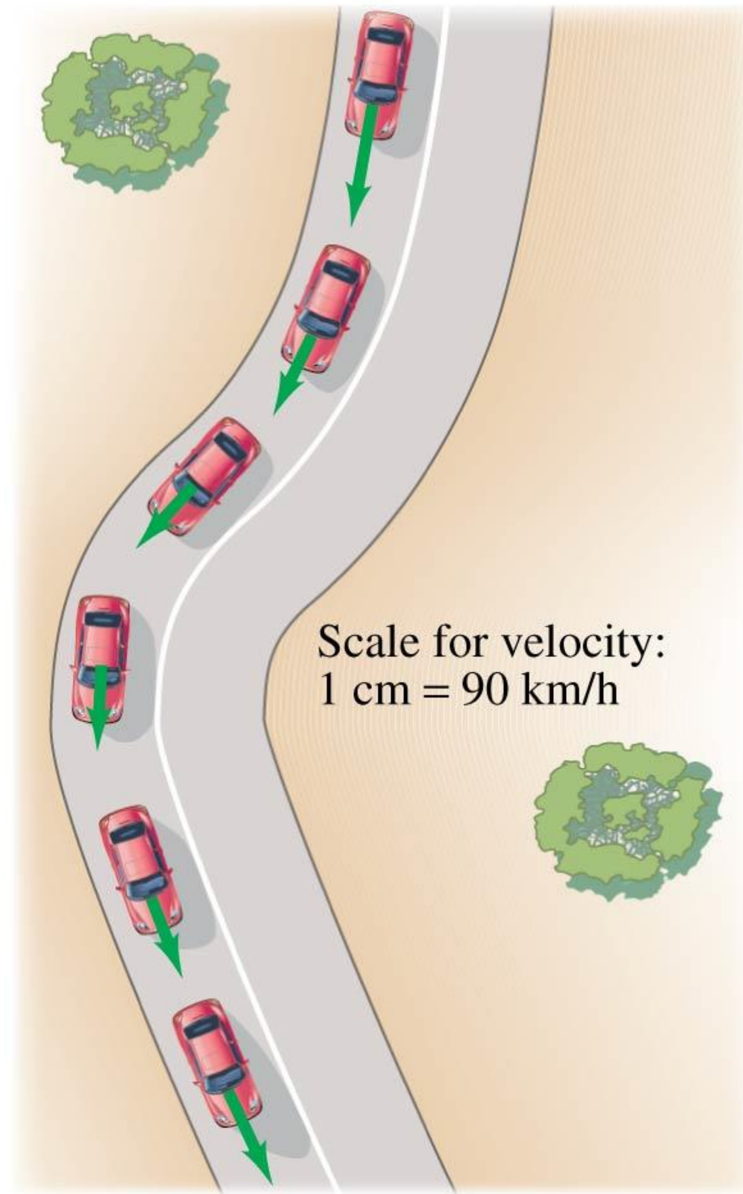
3-1 Vectors and Scalars

A vector has magnitude as well as direction.

Some vector quantities: displacement, velocity, force, momentum

A scalar has only a magnitude.

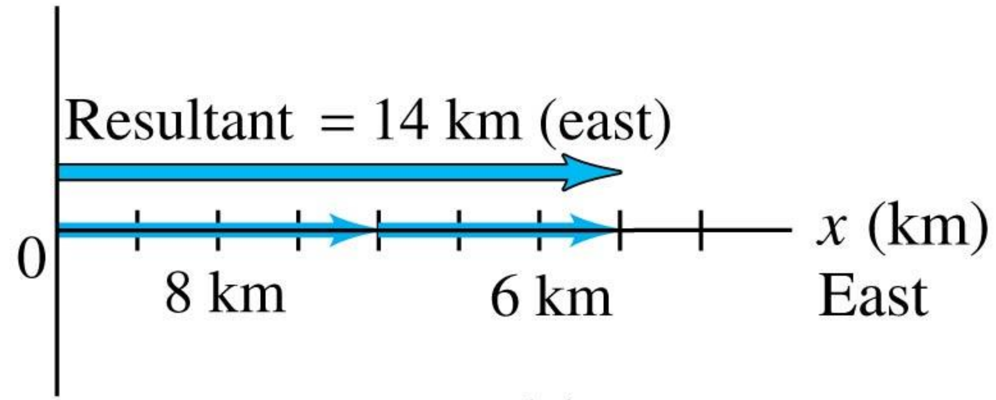
Some scalar quantities: mass, time, temperature



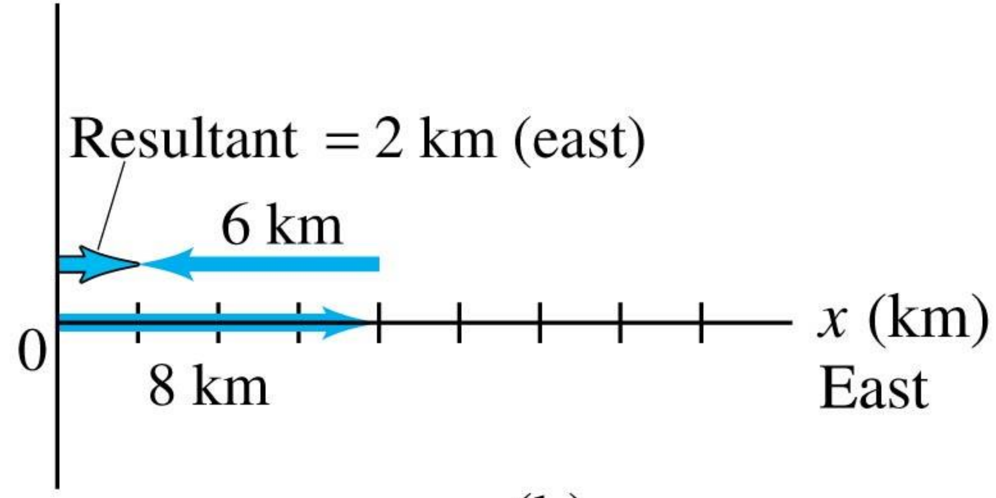
3-2 Addition of Vectors—Graphical Methods

For vectors in one dimension, simple addition and subtraction are all that is needed.

You do need to be careful about the signs, as the figure indicates.



(a)

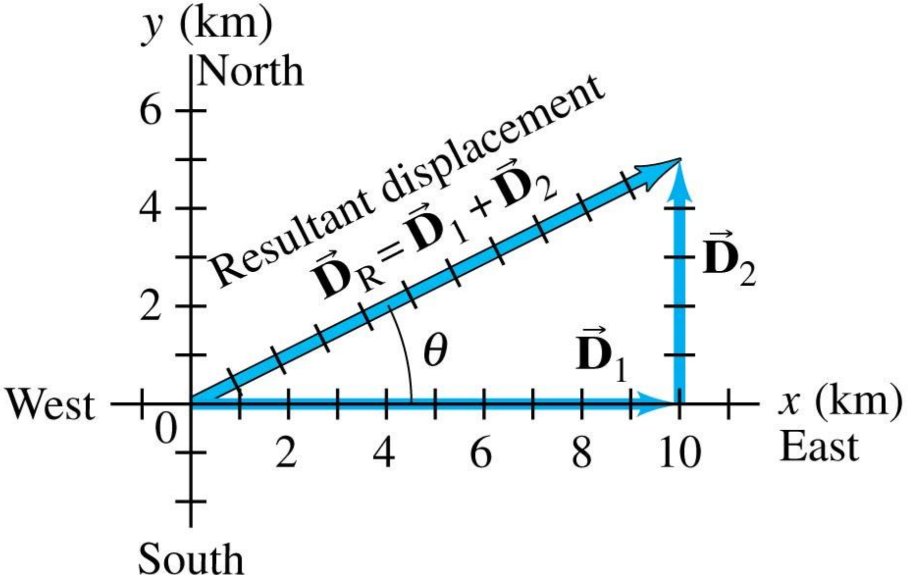


(b)

3-2 Addition of Vectors—Graphical Methods

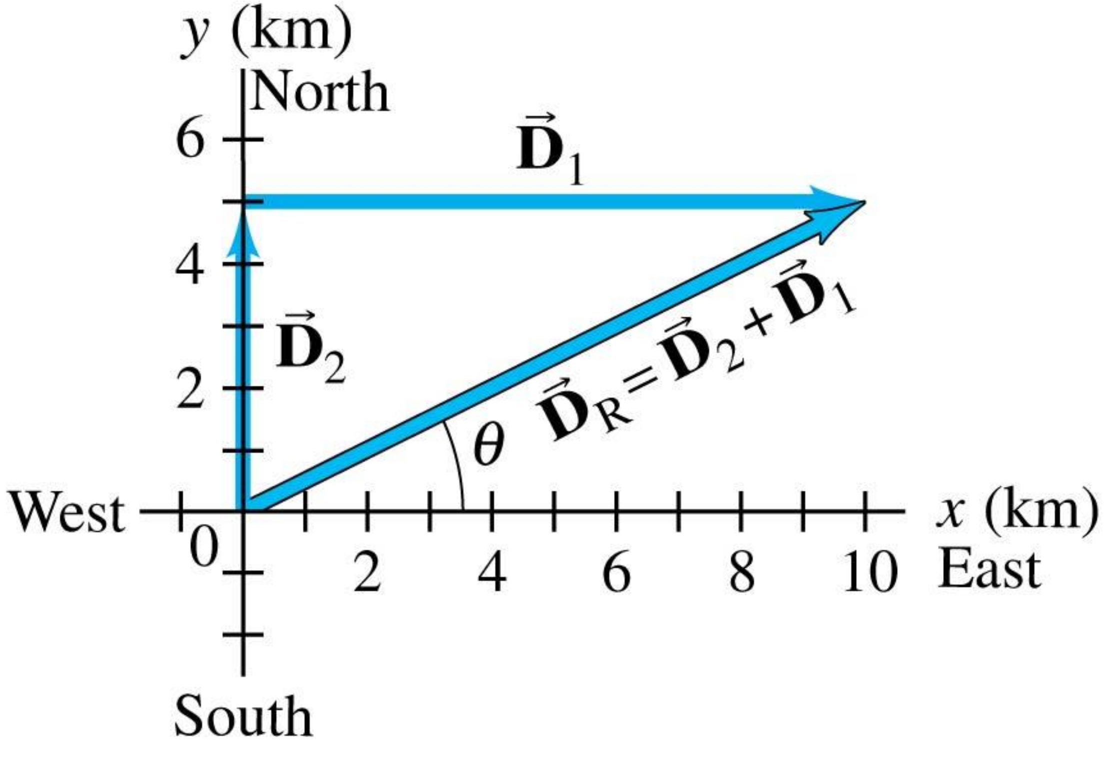
If the motion is in two dimensions, the situation is somewhat more complicated.

Here, the actual travel paths are at right angles to one another; we can find the displacement by using the Pythagorean Theorem.



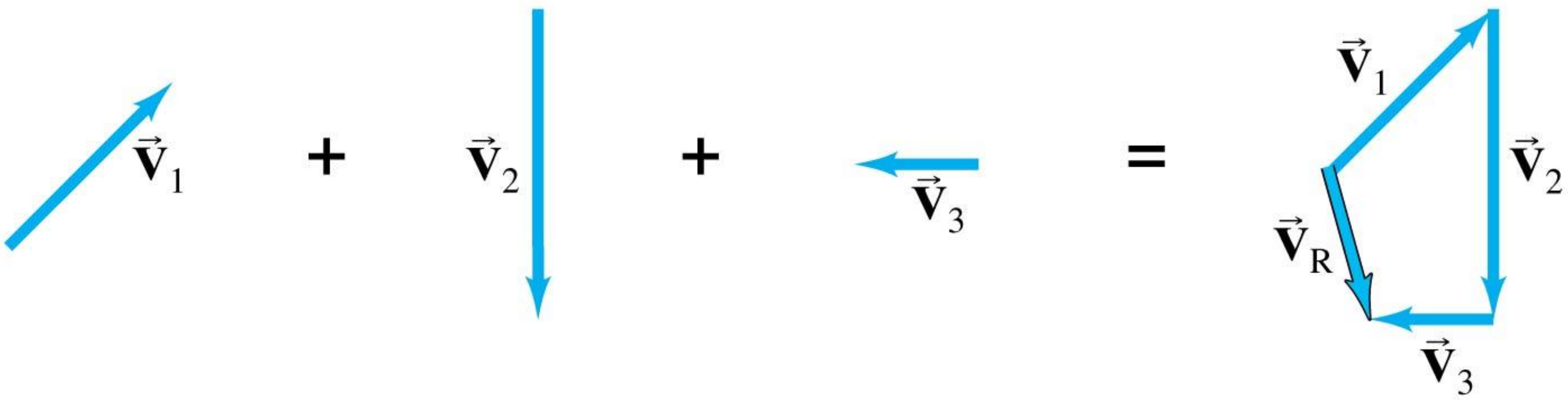
3-2 Addition of Vectors—Graphical Methods

Adding the vectors in the opposite order gives the same result:



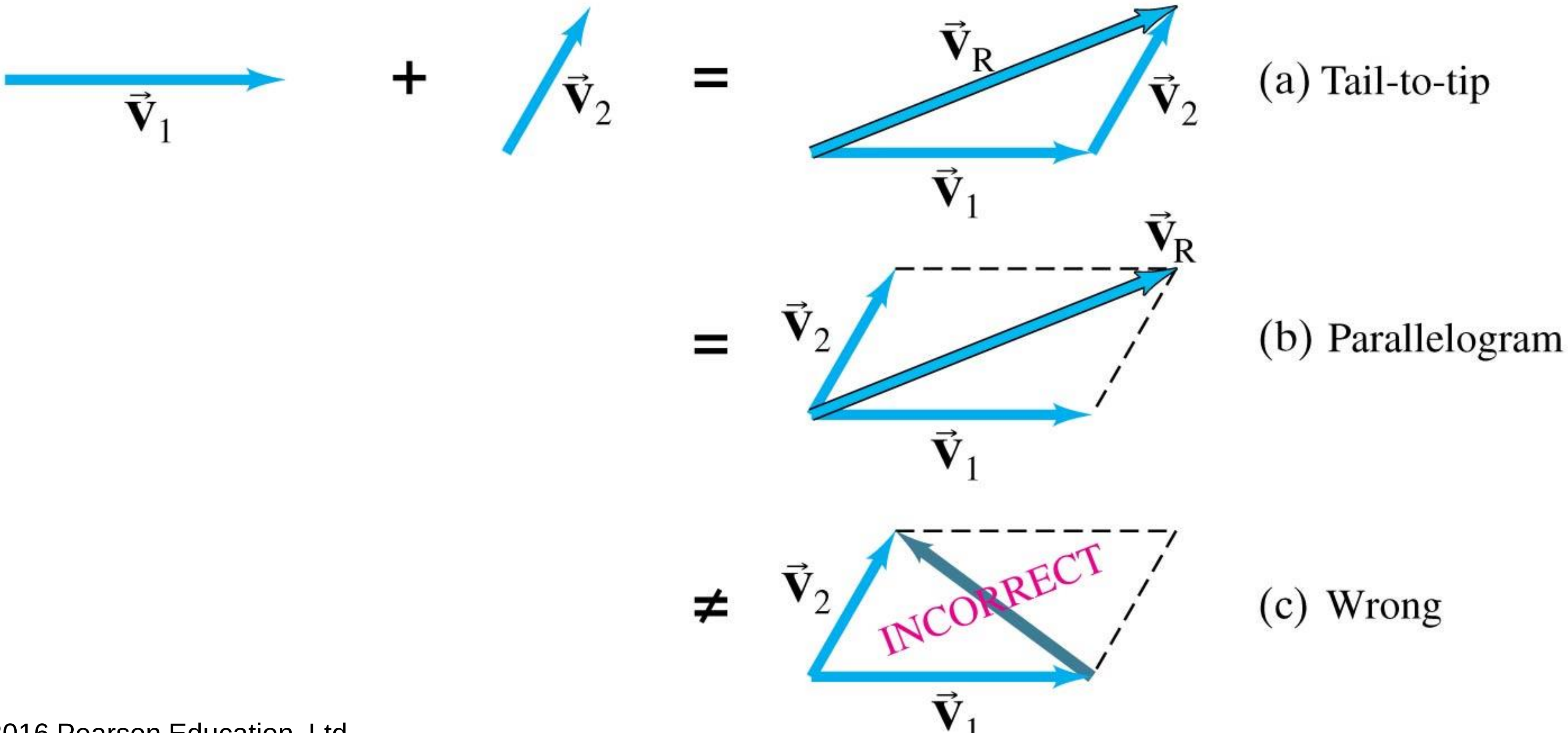
3-2 Addition of Vectors—Graphical Methods

Even if the vectors are not at right angles, they can be added graphically by using the "tail-to-tip" method.



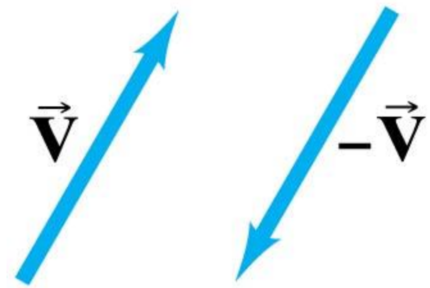
3-2 Addition of Vectors—Graphical Methods

The parallelogram method may also be used; here again the vectors must be "tail-to-tip."

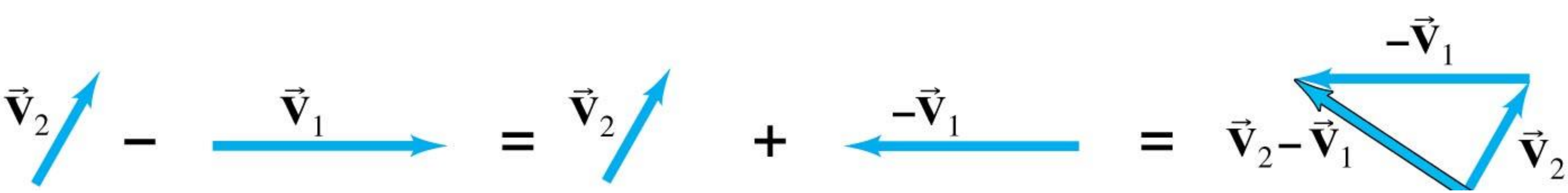


3-3 Subtraction of Vectors, and Multiplication of a Vector by a Scalar

In order to subtract vectors, we define the negative of a vector, which has the same magnitude but points in the opposite direction.

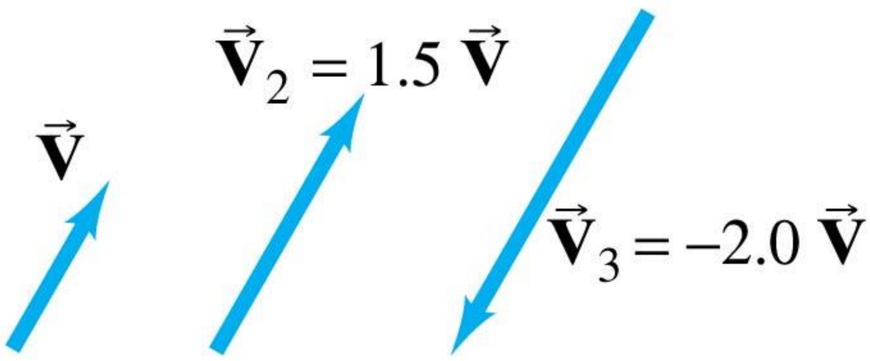


Then we add the negative vector:



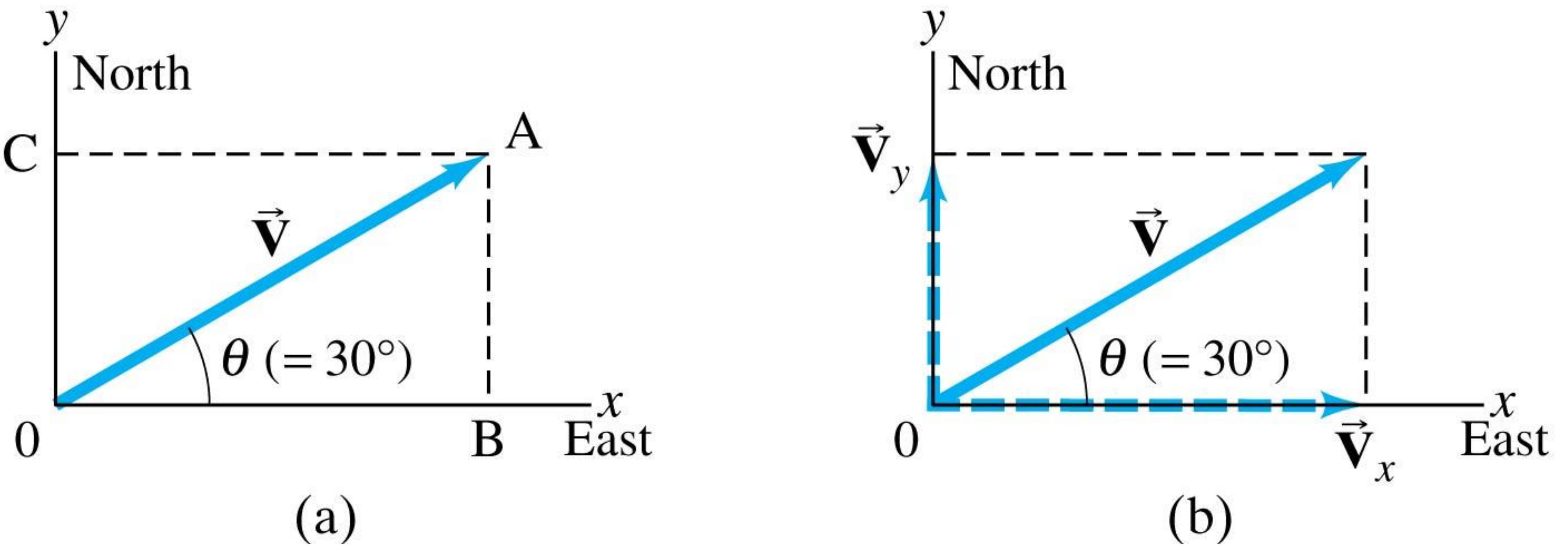
3-3 Subtraction of Vectors, and Multiplication of a Vector by a Scalar

A vector V can be multiplied by a scalar *c*; the result is a vector *c*V that has the same direction but a magnitude *cV*. If *c* is negative, the resultant vector points in the opposite direction.



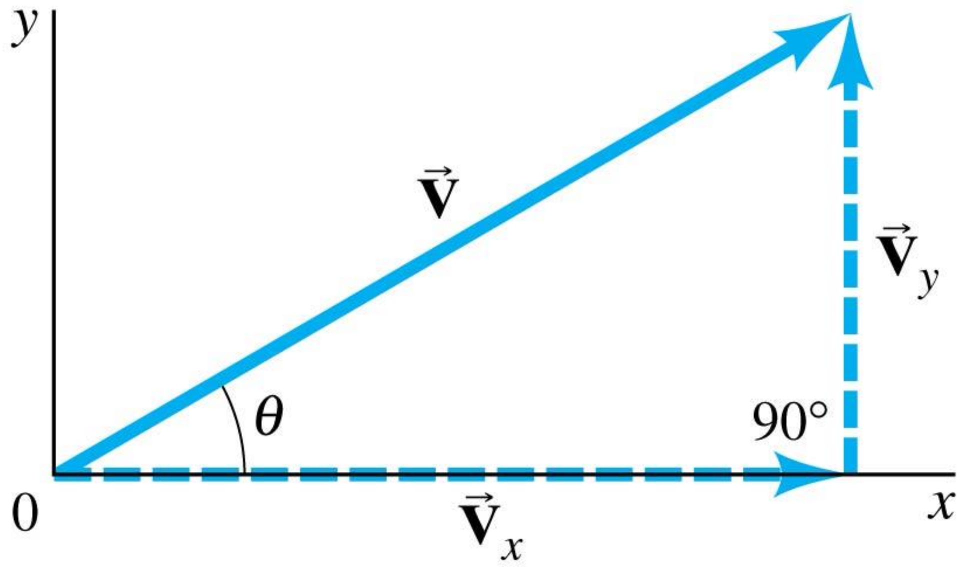
3-4 Adding Vectors by Components

Any vector can be expressed as the sum of two other vectors, which are called its components. Usually the other vectors are chosen so they are perpendicular to each other.



3-4 Adding Vectors by Components

If the components are perpendicular, they can be found using trigonometric functions.



$$\sin\theta = \frac{V_y}{V}$$

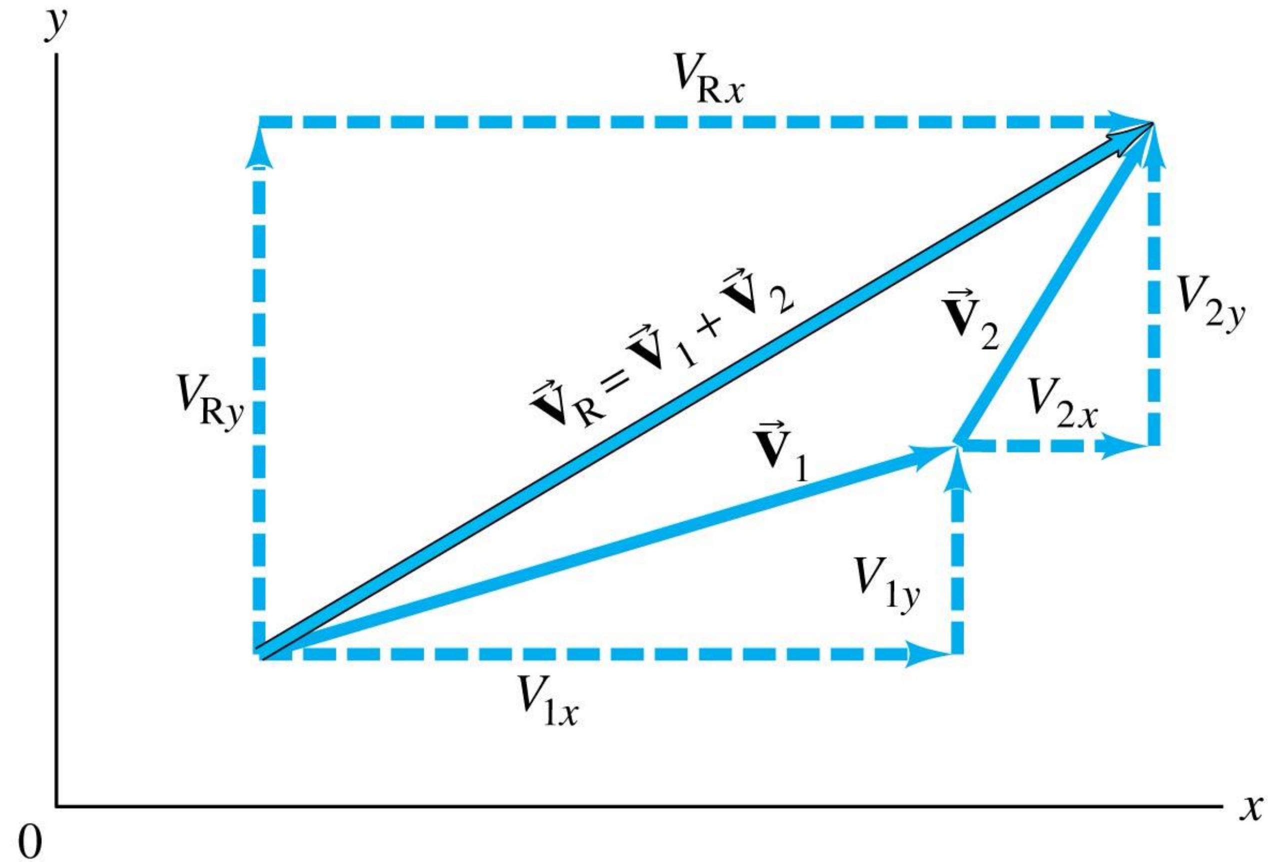
$$\cos\theta = \frac{V_x}{V}$$

$$\tan\theta = \frac{V_y}{V_x}$$

$$V^2 = V_x^2 + V_y^2$$

3-4 Adding Vectors by Components

The components are effectively one-dimensional, so they can be added arithmetically:



3-4 Adding Vectors by Components

Adding vectors:

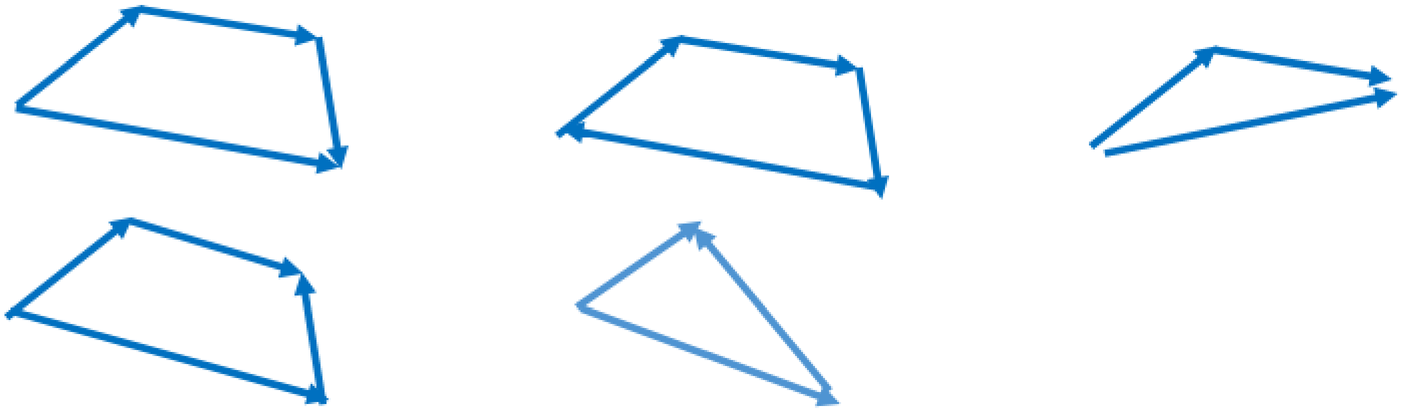
1. Draw a diagram; add the vectors graphically.
2. Choose x and y axes.
3. Resolve each vector into x and y components.
4. Calculate each component using sines and cosines.
5. Add the components in each direction.
6. To find the length and direction of the vector, use:

$$V = \sqrt{V_x^2 + V_y^2} \quad (3\text{-}4a) \qquad \tan\theta = \frac{V_y}{V_x} \quad (3\text{-}4b)$$

- Find the magnitude and direction of -5A + B, where

$A = [23, 60^0]$, $B = [90, -150^0]$.

What set of the following sets of forces acting on an object keeps the state of motion of the object unchanged



A car is driving east at 40 mile/h for 2.0 h, then north at 50 mile/h for 1.0 h, and finally east at 20 mile/h for 0.50 h. The car's average speed (in km/h) during the whole trip? Hint: 1 mile = 1600 m.

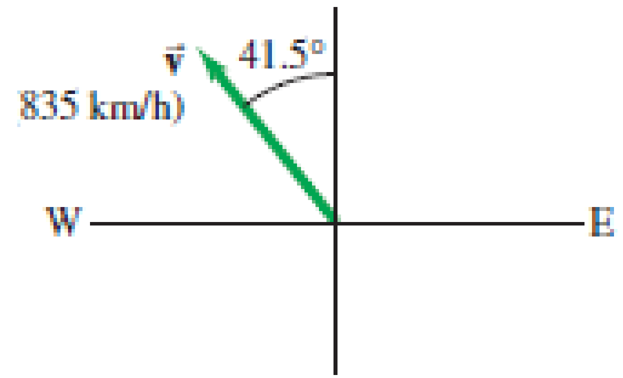
Example

A car is driven 225 km west and then 98 km southwest (45°). What is the displacement of the car from the point of origin (magnitude and direction)? Draw a diagram.

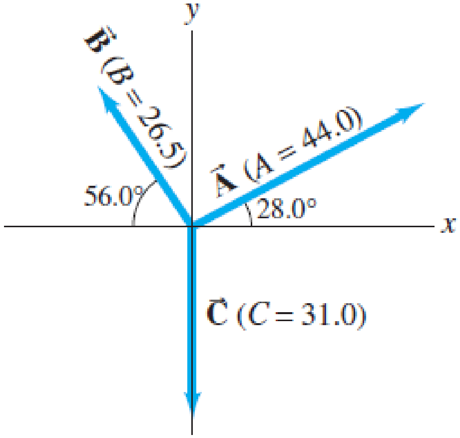
Example

3. (I) If $V_x = 9.80$ units and $V_y = -6.40$ units, determine the magnitude and direction of $\vec{\mathbf{V}}$.

(II) An airplane is traveling 835 km/h in a direction 41.5° west of north
(*a*) Find the components of the velocity vector in the northerly and westerly directions.
(*b*) How far north and how far west has the plane traveled after 1.75 h?



12. (II) For the vectors shown in Fig. 3–35, determine (*a*) $\vec{\mathbf{B}} - 3\vec{\mathbf{A}}$, (*b*) $2\vec{\mathbf{A}} - 3\vec{\mathbf{B}} + 2\vec{\mathbf{C}}$.



Summary of Chapter 3

- A quantity with magnitude and direction is a vector.
- A quantity with magnitude but no direction is a scalar.
- Vector addition can be done either graphically or using components.
- The sum is called the resultant vector.