King Saud University
College of Science
Physics & Astronomy Dept.

PHYS 111 (GENERAL PHYSICS 2)

CHAPTER 3: Vectors

LECTURE NO. 1

Presented by Nouf Saad Alkathran

3.2 Vector and Scalar Quantities

Scalar quantity: is completely specified by a single value with an appropriate unit and has no direction. Such as volume, mass, speed, and time intervals.

Vector quantity is completely specified by a number and appropriate units plus a direction. Such as displacement, velocity, and forces.

- a vector quantity can be presented as A, $|\mathbf{A}|$, $\vec{\mathbf{A}}$.

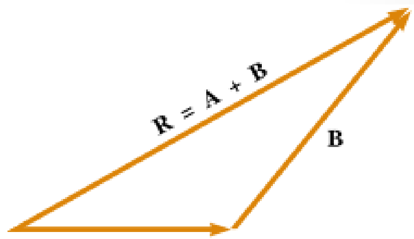
Quick Quiz 3.1 Which of the following are vector quantities and which are scalar quantities? (a) your age (b) acceleration (c) velocity (d) speed (e) mass

أ. نوف الخضران

3.3 Some Properties of Vectors

- **Equality of Two Vectors**

if they have the same magnitude and point in the same direction. A = B

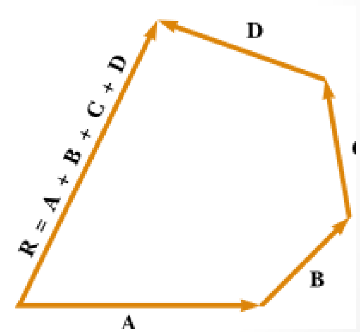


- **Adding Vectors**
- Graphical methods

  A+B=R

- Geometric construction

  A+B+C+D= R



R is the vector drawn from the tail

of the first vector to the tip of the last vector.

أ. نوف الخضران

3.3 Some Properties of Vectors

- Commutative law of addition:

$$\mathbf{A} + \mathbf{B} = \mathbf{B} + \mathbf{A}$$

- Associative law of addition:

$$\mathbf{A} + (\mathbf{B} + \mathbf{C}) = (\mathbf{A} + \mathbf{B}) + \mathbf{C}$$

Negative of a Vector

The negative of the vector A is defined as the vector that when added to A gives zero for the vector sum. That is, A + (- A) =0.

أ. نوف الخضران

3.3 Some Properties of Vectors

Subtracting Vectors

A - B as vector **- B** added to vector **A**

$$\mathbf{A} - \mathbf{B} = \mathbf{A} + (-\mathbf{B})$$

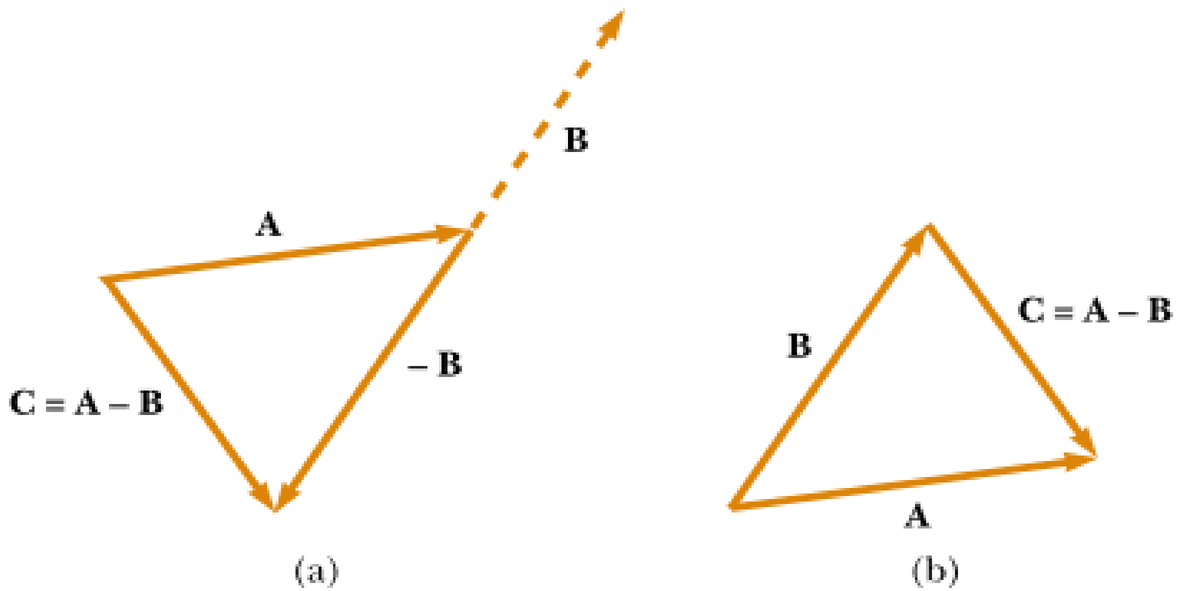


Figure 3.11 (a) This construction shows how to subtract vector **B** from vector **A**. The vector $-\mathbf{B}$ is equal in magnitude to vector **B** and points in the opposite direction. To subtract **B** from **A**, apply the rule of vector addition to the combination of **A** and $-\mathbf{B}$: Draw **A** along some convenient axis, place the tail of $-\mathbf{B}$ at the tip of **A**, and **C** is the difference $\mathbf{A} - \mathbf{B}$. (b) A second way of looking at vector subtraction. The difference vector $\mathbf{C} = \mathbf{A} - \mathbf{B}$ is the vector that we must add to **B** to obtain **A**.

3.3 Some Properties of Vectors

- To find resultant (R) resulting from two vectors A, B, we use this equation:

$$R = \sqrt{A^2 + B^2 - 2AB\cos\theta}$$

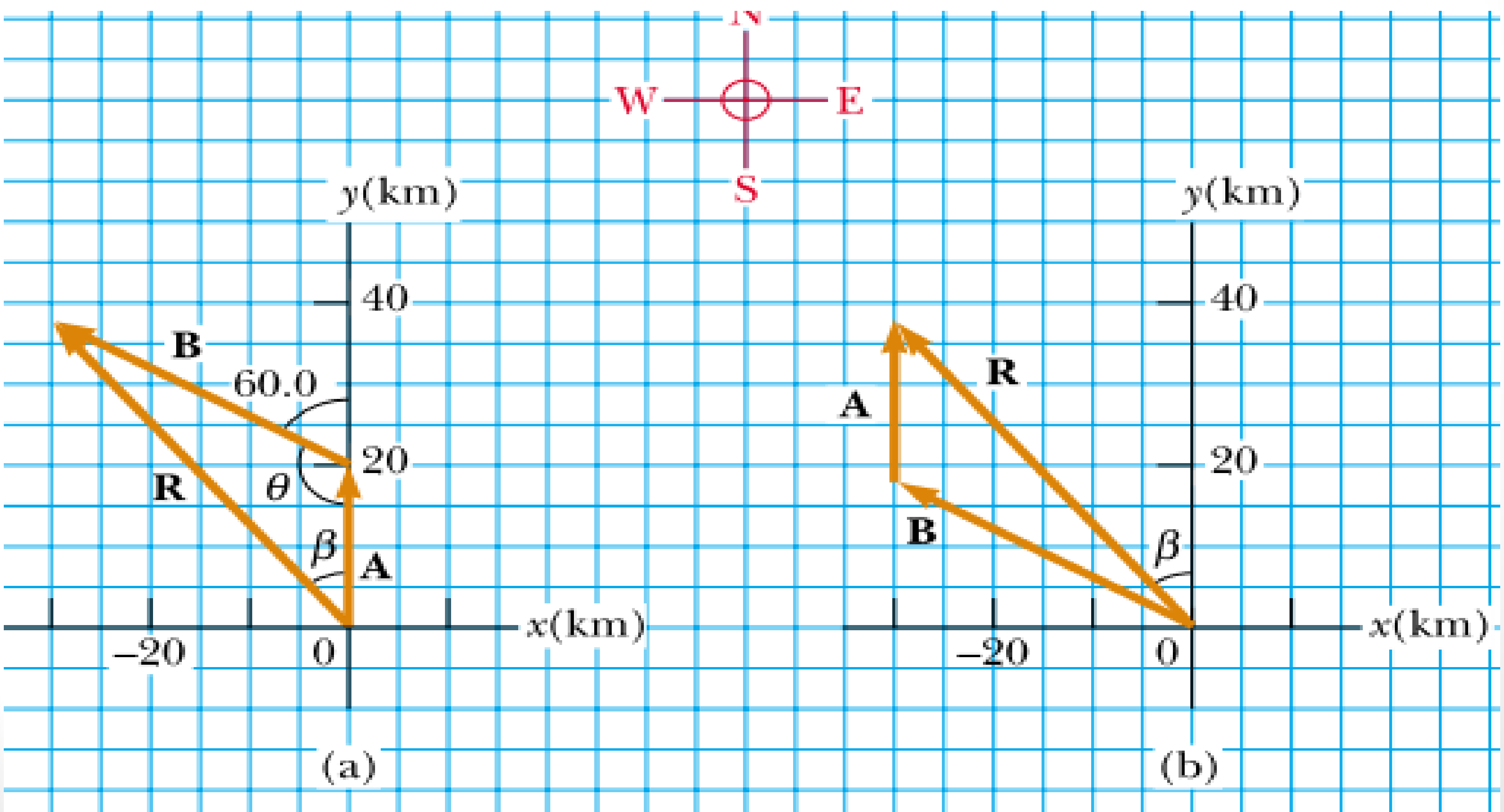
Where ϴ is the angle between A and B.

- To find the angle β of the resultant R, we use this equation:

$$\frac{\sin\beta}{B} = \frac{\sin\theta}{R}$$

Example 3.2

- A car travels 20.0 km due north and then 35.0 km in a direction 60.0° west of north, as shown in Figure 3.12a. Find the magnitude and direction of the car’s resultant displacement.



Solution 3.2

$$R = \sqrt{A^2 + B^2 - 2AB\cos\theta}$$

With $\theta = 180° - 60° = 120°$

$$= \sqrt{(20.0\text{ km})^2 + (35.0\text{ km})^2 - 2(20.0\text{ km})(35.0\text{ km})\cos 120°}$$

$$= 48.2\text{ km}$$

$$\frac{\sin\beta}{B} = \frac{\sin\theta}{R}$$

$$\sin\beta = \frac{B}{R}\sin\theta = \frac{35.0\text{ km}}{48.2\text{ km}}\sin 120° = 0.629$$

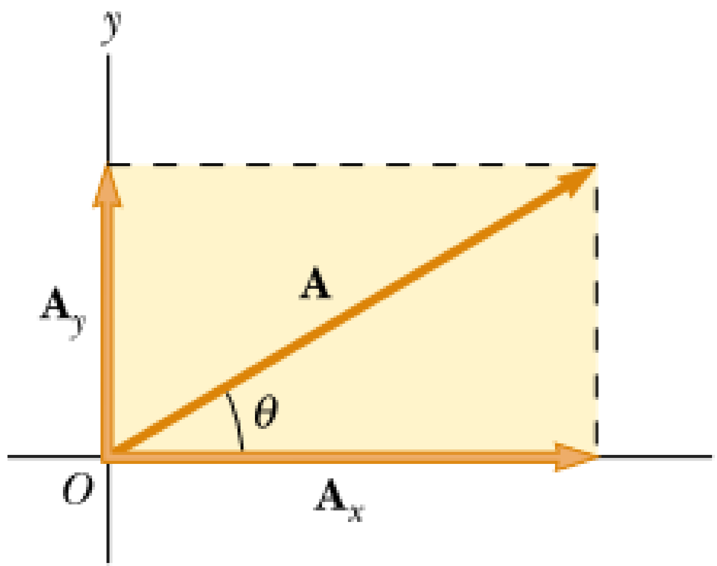
$$\beta = 39.0°$$

Quick Quiz

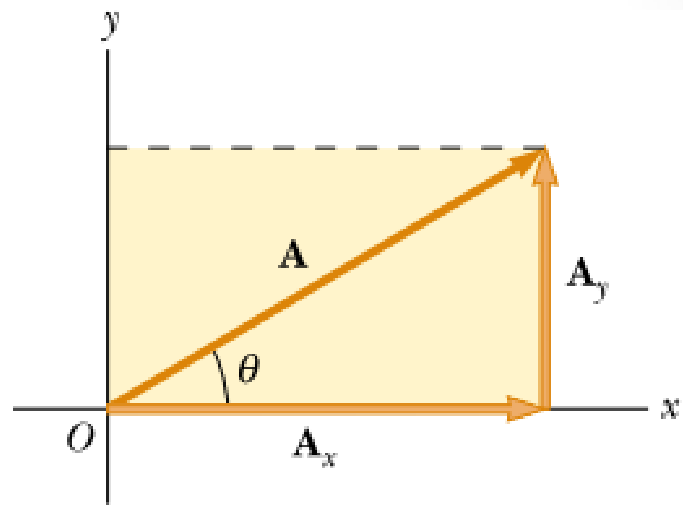
Quick Quiz 3.2 The magnitudes of two vectors **A** and **B** are $A = 12$ units and $B = 8$ units. Which of the following pairs of numbers represents the *largest* and *smallest* possible values for the magnitude of the resultant vector $\mathbf{R} = \mathbf{A} + \mathbf{B}$? (a) 14.4 units, 4 units (b) 12 units, 8 units (c) 20 units, 4 units (d) none of these answers.

Quick Quiz 3.4 If vector **B** is added to vector **A**, which *two* of the following choices must be true in order for the resultant vector to be equal to zero? (a) **A** and **B** are parallel and in the same direction. (b) **A** and **B** are parallel and in opposite directions. (c) **A** and **B** have the same magnitude. (d) **A** and **B** are perpendicular.

3.4 Components of a Vector and Unit Vectors



(a)



(b)

$$\mathbf{A} = \mathbf{A}_x + \mathbf{A}_y.$$

$$A_x = A\cos\theta$$

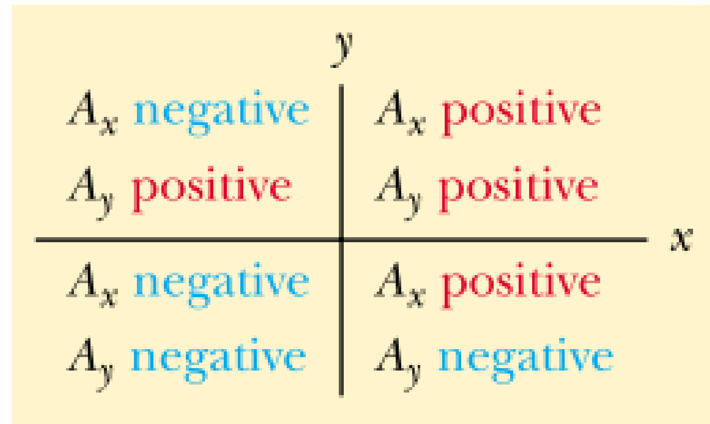
$$A_y = A\sin\theta$$

$$A = \sqrt{A_x^2 + A_y^2}$$

$$\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$$

أ. نوف الخضران

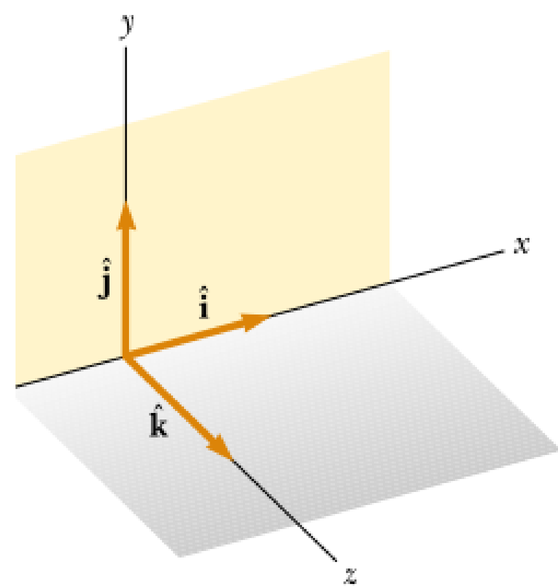
3.4 Components of a Vector and Unit Vectors



Unit Vectors

$$|\hat{\mathbf{i}}| = |\hat{\mathbf{j}}| = |\hat{\mathbf{k}}| = 1.$$

$$\mathbf{A} = A_x\hat{\mathbf{i}} + A_y\hat{\mathbf{j}}$$



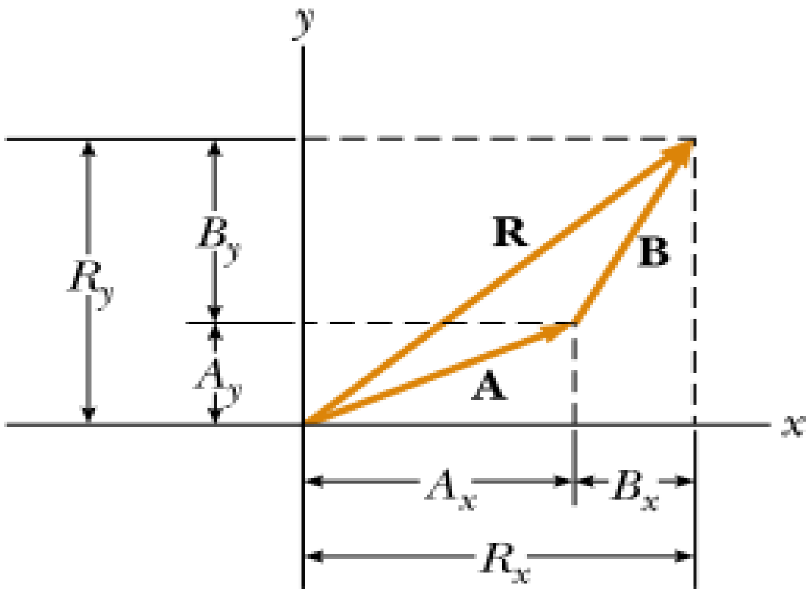
The resultant vector $\mathbf{R} = \mathbf{A} + \mathbf{B}$ is therefore

$$\mathbf{R} = (A_x\hat{\mathbf{i}} + A_y\hat{\mathbf{j}}) + (B_x\hat{\mathbf{i}} + B_y\hat{\mathbf{j}})$$

$$\mathbf{R} = (A_x + B_x)\hat{\mathbf{i}} + (A_y + B_y)\hat{\mathbf{j}}$$

$$R_x = A_x + B_x$$

$$R_y = A_y + B_y$$



$$\mathbf{R} = R_x\hat{\mathbf{i}} + R_y\hat{\mathbf{j}},$$

We obtain the magnitude of **R** and the angle

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(A_x + B_x)^2 + (A_y + B_y)^2}$$

$$\tan\theta = \frac{R_y}{R_x} = \frac{A_y + B_y}{A_x + B_x}$$

Example 3.3

Find the sum of two vectors **A** and **B** lying in the *xy* plane and given by

$$\mathbf{A} = (2.0\hat{\mathbf{i}} + 2.0\hat{\mathbf{j}})\ \text{m} \qquad \text{and} \qquad \mathbf{B} = (2.0\hat{\mathbf{i}} - 4.0\hat{\mathbf{j}})\ \text{m}$$

Example 3.4

A particle undergoes three consecutive displacements: $\mathbf{d}_1 = (15\hat{\mathbf{i}} + 30\hat{\mathbf{j}} + 12\hat{\mathbf{k}})$ cm, $\mathbf{d}_2 = (23\hat{\mathbf{i}} - 14\hat{\mathbf{j}} - 5.0\hat{\mathbf{k}})$ cm and $\mathbf{d}_3 = (-13\hat{\mathbf{i}} + 15\hat{\mathbf{j}})$ cm. Find the components of the resultant displacement and its magnitude.