

Phys 111

General Physics (2)

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Lecture 1

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Vector and Scalar Quantities

A scalar quantity:

is completely specified by a single value with an appropriate unit and has no direction.

Examples: volume, mass, speed, and time intervals.

A vector quantity

is completely specified by a number and appropriate units plus a direction.

Examples: displacement, velocity, and force.

Some Properties of Vectors

Equality of Two Vectors

- $\mathbf{A} = \mathbf{B}$ only if $A = B$ and if \mathbf{A} and \mathbf{B} point in the same direction along parallel lines.

- **Adding Vectors**

- The **resultant vector** $\mathbf{R} = \mathbf{A} + \mathbf{B}$ is the vector drawn from the tail of \mathbf{A} to the tip of \mathbf{B} .

- The **commutative law of addition**: $\mathbf{A} + \mathbf{B} = \mathbf{B} + \mathbf{A}$

- The **associative law of addition**: $\mathbf{A} + (\mathbf{B} + \mathbf{C}) = (\mathbf{A} + \mathbf{B}) + \mathbf{C}$

- **Negative of a Vector**

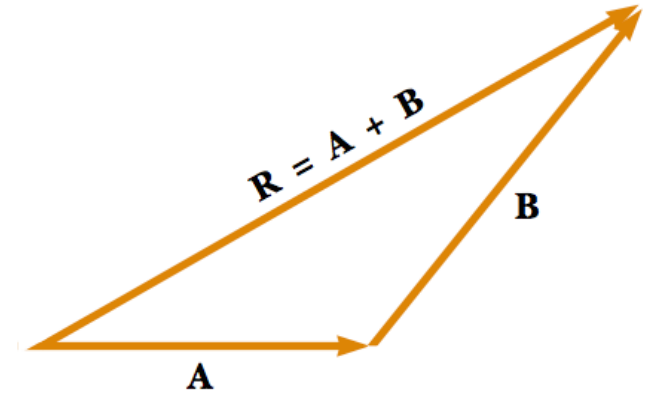
- $\mathbf{A} + (-\mathbf{A}) = 0$. The vectors \mathbf{A} and $-\mathbf{A}$ have the same magnitude but point in opposite directions.

- **Subtracting Vectors**

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

- **Multiplying a Vector by a Scalar**

- The product $m\mathbf{A}$ is a vector that has the same direction as \mathbf{A} and magnitude mA .

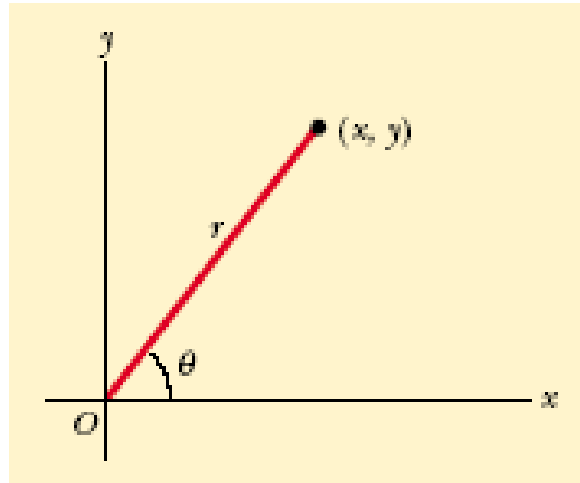


- نظم الإحداثيات (Coordinate Systems)

- المتجهات : (Vectors)

نحتاج في حياتنا العملية إلى تحديد موقع جسم ما في الفراغ سواءً كان ساكناً أم متحركاً، ولتحديد موقع هذا الجسم فإننا نستعين بما يعرف بالإحداثيات **Coordinates**، وهناك نوعان من الإحداثيات التي سوف نستخدمها وهما **Rectangular coordinates** و **polar coordinates**.

الإحداثيات القطبية (r, θ)



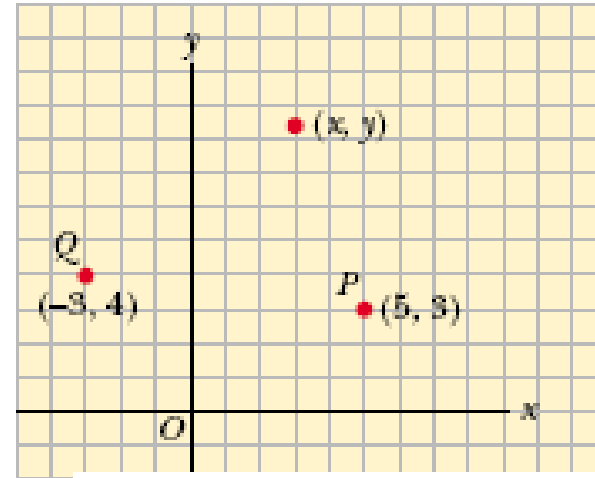
$$\tan \theta = y/x$$

$$x = r \cos \theta$$

$$r = \sqrt{x^2 + y^2}$$

$$y = r \sin \theta$$

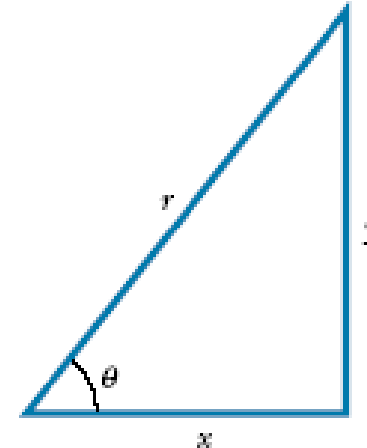
الإحداثيات الكارتيزية (X, Y)



$$\sin \theta = \frac{y}{r}$$

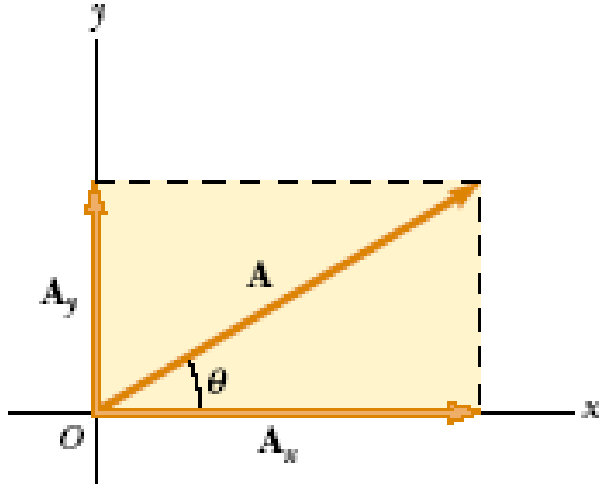
$$\cos \theta = \frac{x}{r}$$

$$\tan \theta = \frac{y}{x}$$



- مكونات (مركبات) المتجه و متجه الوحدة:

Components of a vector and unit vector



- يمكن تحليل أي متجه (A) إلى مركبة سينية (A_x) على المحور السيني (x) ومركبة صادية (A_y) على المحور الصادي (y) حيث؛

$$A_x = A \cos \theta \quad \& \quad A_y = A \sin \theta$$

$$A = \sqrt{A_x^2 + A_y^2} \quad \& \quad \theta = \tan^{-1} \frac{A_y}{A_x}$$

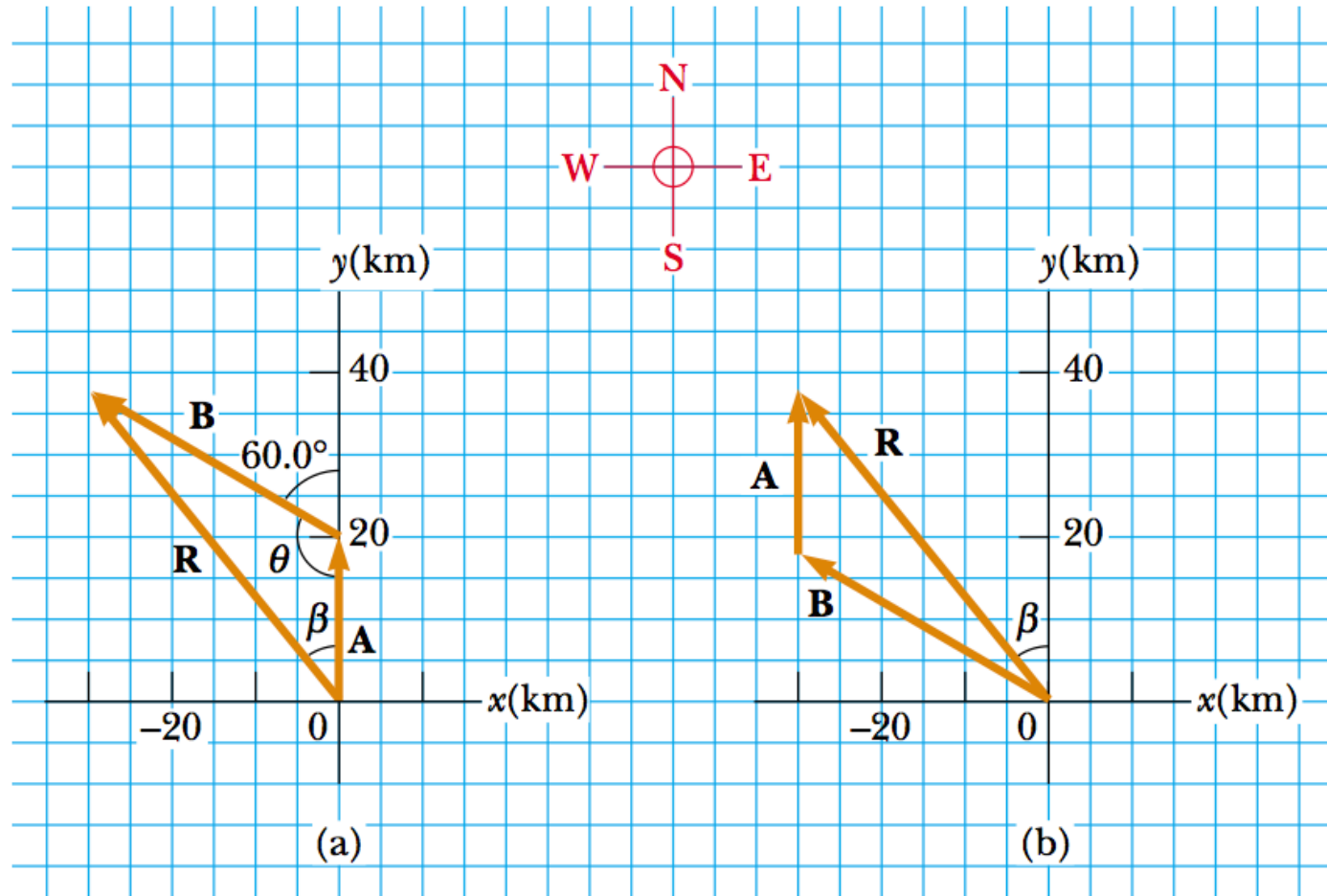
A_x negative	A_x positive
A_y positive	A_y positive
A_x negative	A_x positive
A_y negative	A_y negative

- تعتمد إشارة المركبات السينية والصادية على الزاوية θ ، كما هو موضح بالرسم

- ملحوظة هامة: للتعويض بالمعادلات السابقة لحساب المركبة السينية أو الصادية دائماً تؤخذ قيمة الزاوية بين المتجه والمحور السيني الموجب

Example : A Vacation Trip

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, Find the magnitude and direction of the car's resultant displacement.



Use $R^2 = A^2 + B^2 - 2AB \cos \theta$ from the law of cosines to find R :

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

Substitute numerical values, noting that $\theta = 180^\circ - 60^\circ = 120^\circ$:

$$\begin{aligned} R &= \sqrt{(20.0 \text{ km})^2 + (35.0 \text{ km})^2 - 2(20.0 \text{ km})(35.0 \text{ km}) \cos 120^\circ} \\ &= 48.2 \text{ km} \end{aligned}$$

Use the law of sines (Appendix B.4) to find the direction of $\vec{\mathbf{R}}$ measured from the northerly direction:

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

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

$$\beta = 38.9^\circ$$

The resultant displacement of the car is 48.2 km in a direction 38.9° west of north.

3.4 Components of a Vector and Unit Vectors

- Unit Vectors

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

- The unit vector notation for the vector \mathbf{A} is

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

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

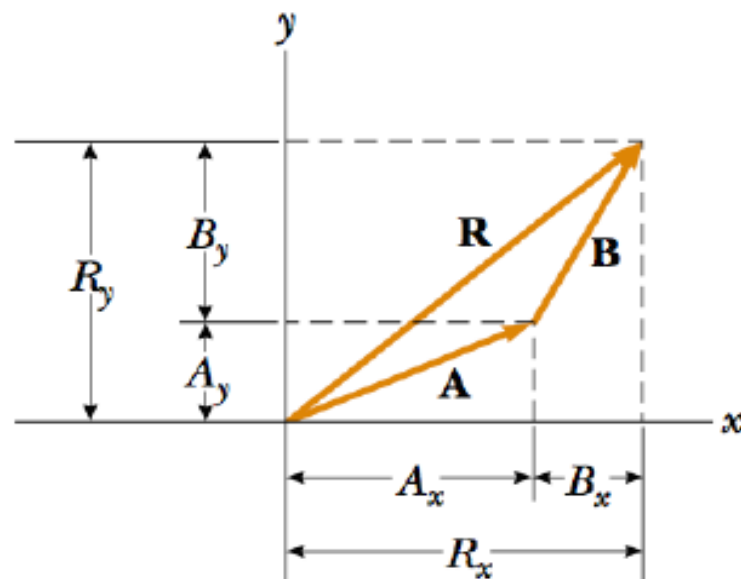
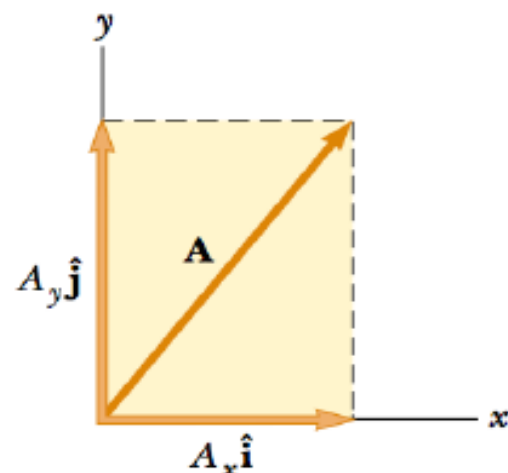
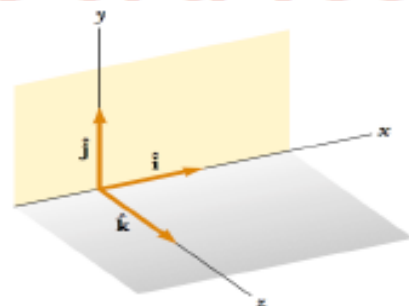
$$\mathbf{R} = (A_x \hat{\mathbf{i}} + A_y \hat{\mathbf{j}}) + (B_x \hat{\mathbf{i}} + B_y \hat{\mathbf{j}})$$

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

- The magnitude of \mathbf{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 The Sum of Two Vectors

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

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

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

$$R_x = 4.0 \text{ m} \quad R_y = -2.0 \text{ m}$$

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(4.0 \text{ m})^2 + (-2.0 \text{ m})^2} = \sqrt{20} \text{ m} = 4.5 \text{ m}$$

$$\tan \theta = \frac{R_y}{R_x} = \frac{-2.0 \text{ m}}{4.0 \text{ m}} = -0.50$$