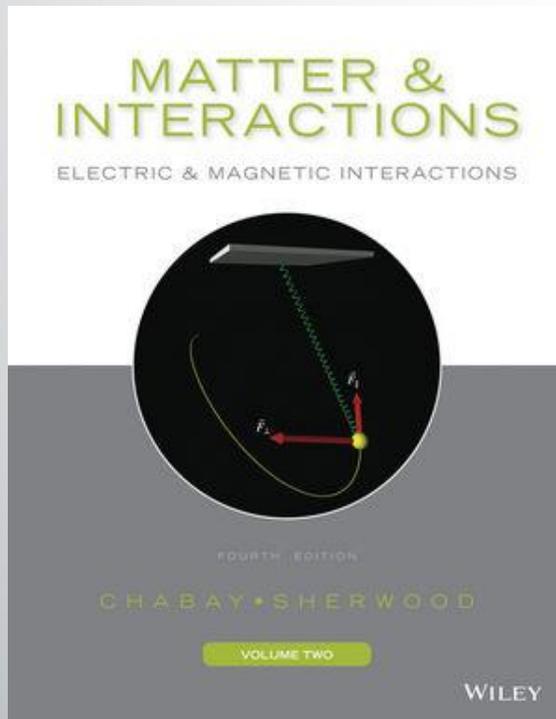**American University Of The Middle East**

Electric and Magnetic Interactions, [PHYS 272]

College of Engineering and Technology

Science Department

Course: Electric and Magnetic Interactions,

[PHYS 272]

Book: Matter and Interactions, Volume II:

Electric and Magnetic Interactions,

Edition: 4th edition

Authors: Ruth W. Chabay, Bruce A. Sherwood

1. Moodle links

2. Assessments & grade distribution

Category	Assessment Name	Weight
attendance		5%
In Class Assignment	ICA 1 (individual)	10 % each
	ICA 2 (individual)	
Labs	Lab 1 (individual)	7 %
	Lab 2 (individual)	7 %
	Lab 3 (individual)	7 %
	Lab 4 (individual)	7 %
	Lab 5 (individual)	5 %
	Lab 6 (individual)	7 %
Pop Quiz	Pop Quiz 1 (individual)	2.5 % each
	Pop Quiz 2 (individual)	
Class Assignment	Assignment (individual)	10 %
Final Assessment	Final (individual)	20 %
Total		**100%**

PHYS 272

Course Introduction and Math Review

- Any branch of physics (mechanics, electromagnetism, optics, thermodynamics, etc.) is described in terms of a number of laws or principles.

- In PHYS 172, you studied mechanics. Mechanics is based on several laws e.g. Newton's first law, Newton's second law (or Momentum Principle), Newton's third law, Newton's law for gravitation, and the Energy Principle.

- In PHYS 272, you will study Electromagnetism. Electromagnetism is mainly based on 5 laws: Coulomb's law, Biot-Savart law, Gauss's law, Ampere's law and Faraday's Law.

Charles-Augustin de Coulomb
1736 - 1806

Johann Carl Friedrich Gauss
1777 - 1855

André-Marie Ampère
1775 - 1836

Michael Faraday
1791 - 1867

- In this course, you will understand how charged particles (or systems) interact.

- You will also understand the concepts of electric field, electric force, magnetic field, and magnetic force and learn how to calculate these quantities using more than one method.

- The math required for this course is: elementary vector calculus + rare use of simple derivatives and integrations.

- Determine the unit vector for $\vec{B} = \langle 3, -1.5, 2 \rangle \, m$.

$$B = \left|\vec{B}\right| = \sqrt{x^2 + y^2 + z^2} = \sqrt{3^2 + (-1.5)^2 + 2^2} = \sqrt{15.25} = 3.9 \, m$$

$$\hat{B} = \frac{\vec{B}}{B} = \frac{\langle 3, -1.5, 2 \rangle}{3.9} = \langle 0.77, -0.38, 0.51 \rangle$$

- Calculate the **scalar product** of the two vectors $\vec{A} = \langle -2, 0, 1 \rangle \, N$ and $\vec{B} = \langle 3, -1.5, 2 \rangle \, m$.

$$\vec{A}.\vec{B} = A_x B_x + A_y B_y + A_z B_z = (-2) * 3 + 0 * (-1.5) + 1 * 2 = -4 \, N.m$$

Determine the angle between them.

$$\vec{A}.\vec{B} = \left|\vec{A}\right| * \left|\vec{B}\right| * \cos(\theta)$$

$$\left|\vec{A}\right| = \sqrt{x^2 + y^2 + z^2} = \sqrt{(-2)^2 + 0^2 + 1^2} = \sqrt{5} = 2.24 \, N$$

$$\left|\vec{B}\right| = \sqrt{x^2 + y^2 + z^2} = \sqrt{3^2 + (-1.5)^2 + 2^2} = \sqrt{15.25} = 3.9 \, m$$

$$\cos(\theta) = \frac{\vec{A}.\vec{B}}{\left|\vec{A}\right| * \left|\vec{B}\right|} = \frac{-4}{2.24 * 3.9} = -0.457 \quad \rightarrow \quad \theta = \cos^{-1}(-0.457) = 117.2\,°$$

The following vectors all have length 5m. Write them as vectors.
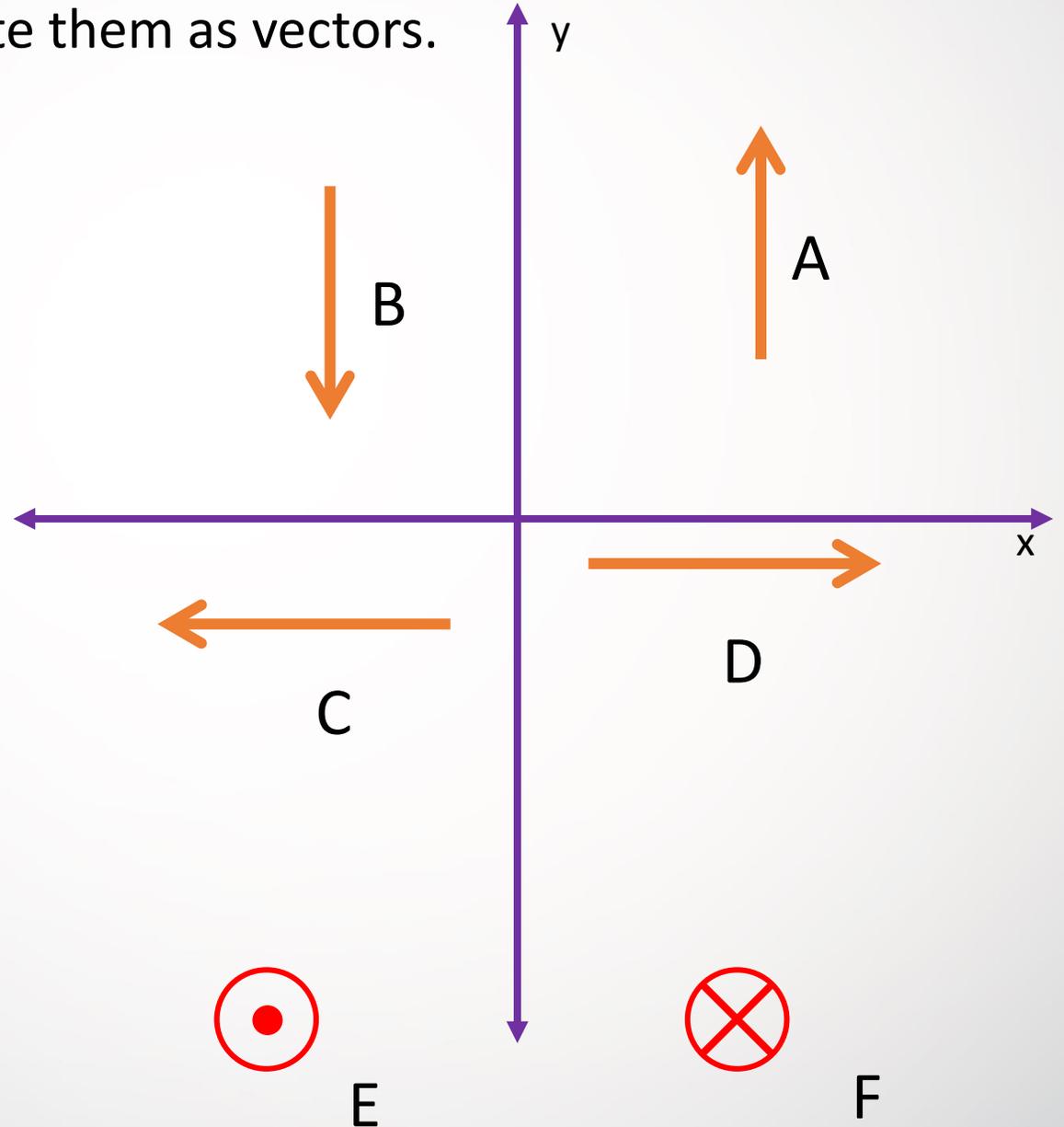
$\vec{A} =$

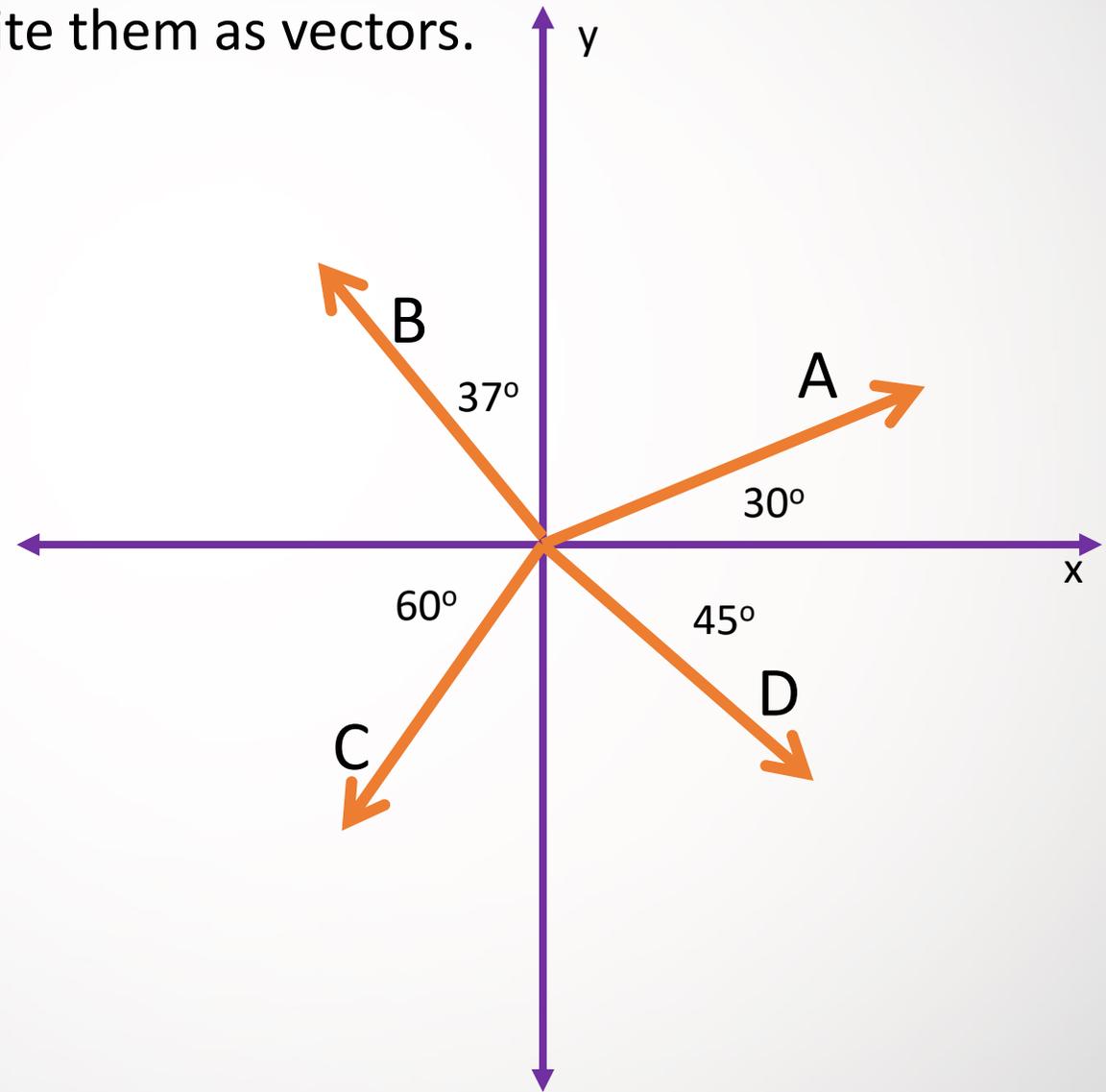$\vec{B} =$

$\vec{C} =$

$\vec{D} =$

$\vec{E} =$

$\vec{F} =$

The following vectors all have length 5m. Write them as vectors.

$\vec{A} =$

$\vec{B} =$

$\vec{C} =$

$\vec{D} =$

A is at $\langle 3, 2, 0 \rangle$ m

B is at $\langle 5, 2, 0 \rangle$ m

C is at $\langle 5, -2, 0 \rangle$ m

$$\vec{E} = \langle 0, -400, 0 \rangle \text{ N/C}$$

$A_{\times}$ $\times^{B}$

$\overrightarrow{E}$

$\times C$

- From A to B, calculate $\Delta V = \vec{E}.\Delta\vec{l}$

$$\Delta\vec{l} = \vec{l}_f - \vec{l}_i = \langle 5, \ 2, 0 \rangle - \langle 3, \ 2, 0 \rangle$$
$$= \langle 2, 0, 0 \rangle \, m$$

$$\Delta V = \vec{E}.\Delta\vec{l} = 0 * 2 + (-400) * 0 + 0 * 0 = 0 \, V$$

- From B to C, calculate $\Delta V = \vec{E}.\Delta\vec{l}$

$$\Delta\vec{l} = \vec{l}_f - \vec{l}_i = \langle 5, \ -2, 0 \rangle - \langle 5, \ 2, 0 \rangle$$
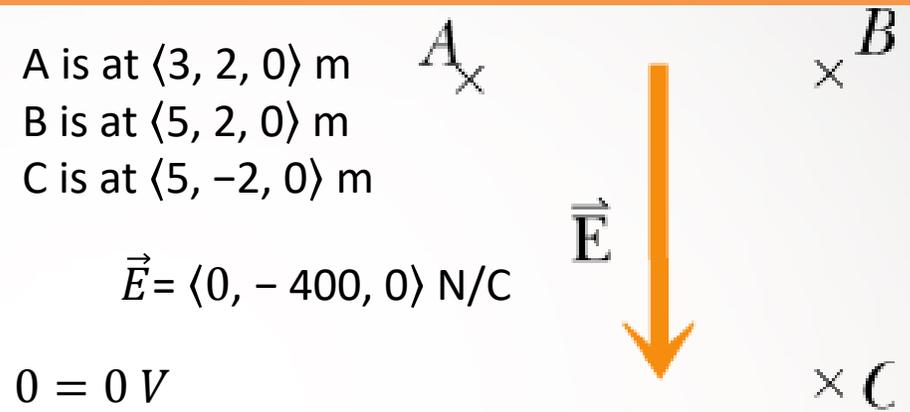$$= \langle 0, \ -4, 0 \rangle \, m$$

$$\Delta V = \vec{E}.\Delta\vec{l} = 0 * 0 + (-400) * (-4) + 0 * 0 = 1600 \, V$$

- From A to C, calculate $\Delta V = \vec{E}.\Delta\vec{l}$

$$\Delta\vec{l} = \vec{l}_f - \vec{l}_i = \langle 5, \ -2, 0 \rangle - \langle 3, \ 2, 0 \rangle$$
$$= \langle 2, \ -4, 0 \rangle \, m$$

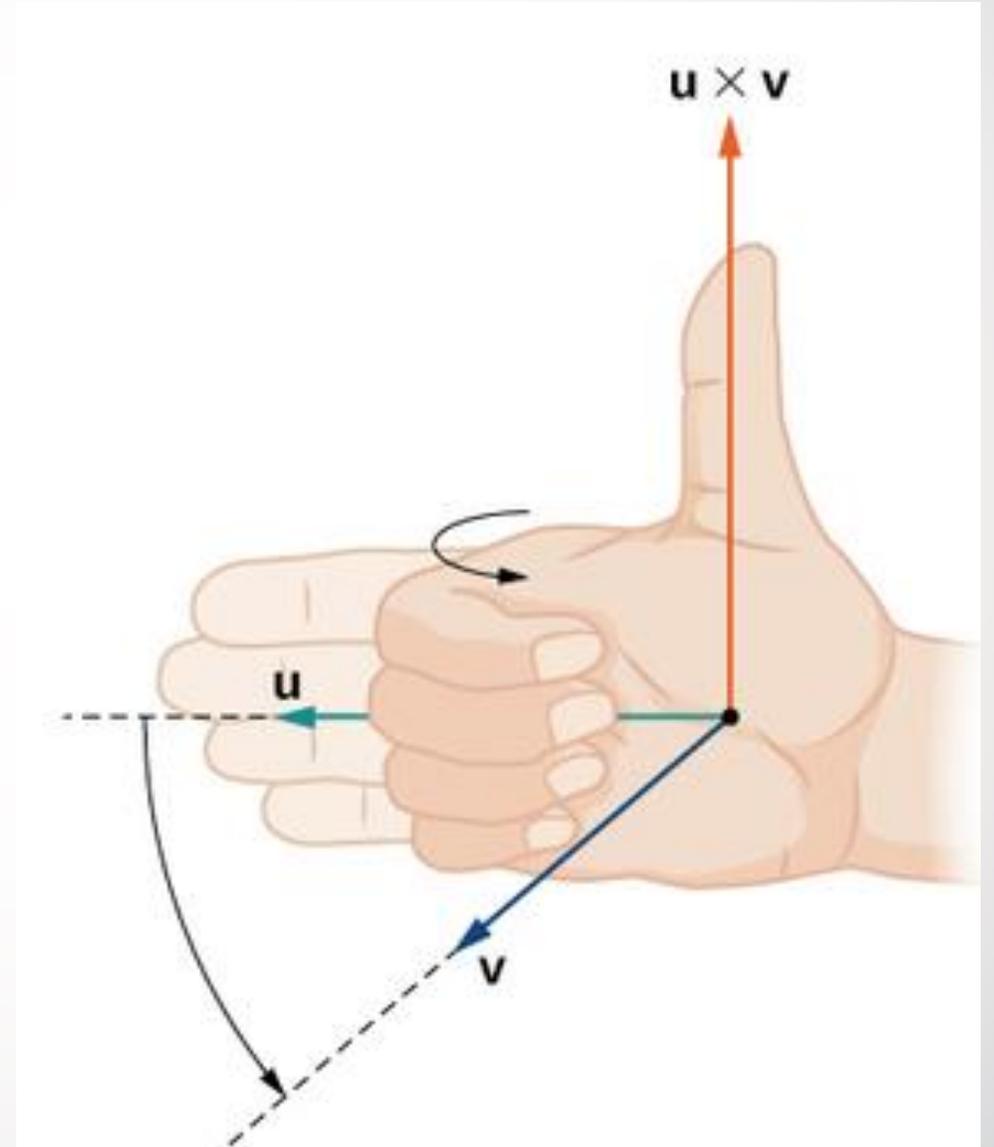$$\Delta V = \vec{E}.\Delta\vec{l} = 0 * 2 + (-400) * (-4) + 0 * 0 = 1600 \, V$$

- The **cross product** of two vectors $\vec{A}$ and $\vec{B}$ is a vector and can be calculated using the rule

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix} = \langle A_y B_z - A_z B_y , \; A_z B_x - A_x B_z , \; A_x B_y - A_y B_x \rangle$$

- Note also that $\quad \left| \vec{A} \times \vec{B} \right| = \left| \vec{A} \right| \left| \vec{B} \right| \boldsymbol{sin(\theta)}$

- Calculate $\vec{A} \times \vec{B}$ if $\vec{A} = \langle -2, 0, 1 \rangle$ and $\vec{B} = \langle 3, -1.5, 2 \rangle$.

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ -2 & 0 & 1 \\ 3 & -1.5 & 2 \end{vmatrix}$$

$$= \langle 0 * 2 - 1 * (-1.5), \; 1 * 3 - (-2) * 2, \; (-2) * (-1.5) - 0 * 3 \rangle$$

$$= \langle 0 + 1.5, \; 3 + 4, \; 3 - 0 \rangle = \langle 1.5, \; 7, \; 3 \rangle$$

The direction of $\vec{u} \times \vec{v}$: Right-hand rule

Example

Given the vectors $\vec{E} = \langle 0, 10, 0 \rangle \ (N/C)$, $\vec{B} = \langle 0, 0, -5 \rangle \ (T)$ and $\vec{v} = \langle 0, 2, 0 \rangle \ (m/s)$.

Given the scalar $q = 1.6 \times 10^{-19}$. Calculate the vector

$$\vec{F} = q \, \vec{v} \times \vec{B} + q\vec{E} = q \, (\vec{v} \times \vec{B} + \vec{E})$$

- $\vec{v} \times \vec{B} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 0 & 2 & 0 \\ 0 & 0 & -5 \end{vmatrix} = \langle 2*(-5) - 0*0, 0*0 - 0*(-5), 0*0 - 2*0 \rangle$

$$= \langle -10 - 0, \ 0 - 0, \ 0 - 0 \rangle = \langle -10, \ 0, \ 0 \rangle \ (T.m/s)$$

- $\vec{v} \times \vec{B} + \vec{E} = \langle -10, \ 0, \ 0 \rangle + \langle 0, \ 10, \ 0 \rangle = \langle -10, \ 10, \ 0 \rangle$

- $\vec{F} = q \, (\vec{v} \times \vec{B} + \vec{E}) = 1.6 \times 10^{-19} * \langle -10, \ 10, \ 0 \rangle = \langle -1.6 \times 10^{-18}, 1.6 \times 10^{-18},$

  $0 \rangle \ (N)$

- In this course, some integrals will be evaluated on a circular path.

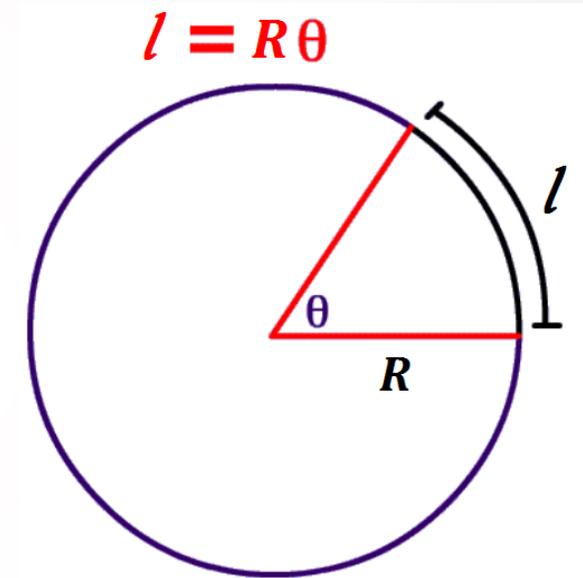- For a circle, the length of an arc is related to the facing angle and the radius via the simple relation
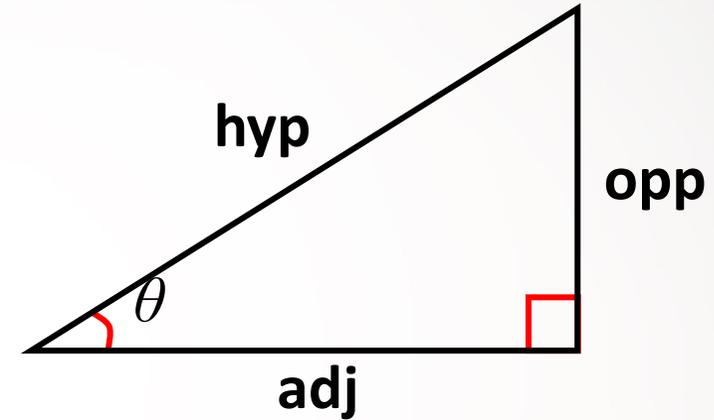
$$l = R\theta$$

- For a very small arc (infinitesimal), the relation is written as

$$dl = Rd\theta$$

Example: The perimeter L of a circle can be calculated using integrations as follows

$$L = \int_{l\_min}^{l\_max} dl = \int_0^{2\pi} Rd\theta = R \int_0^{2\pi} d\theta = 2\pi R$$
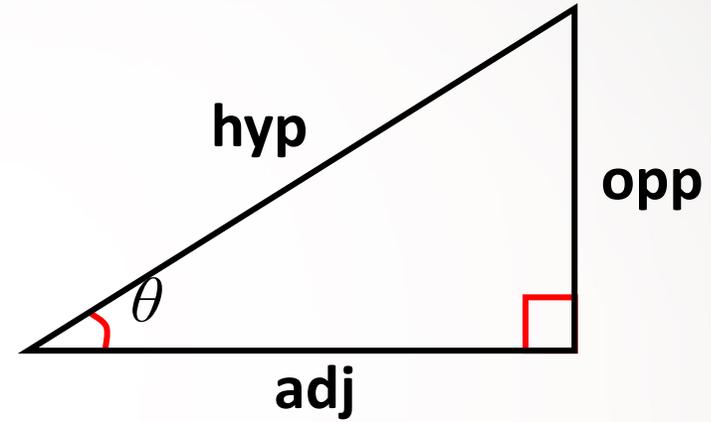
$$l = R\,\theta$$

The sides of the right triangle are:

- The side **opposite to** the acute angle θ

- The side **adjacent** to the acute angle θ

- The **hypotenuse** of the right triangle.

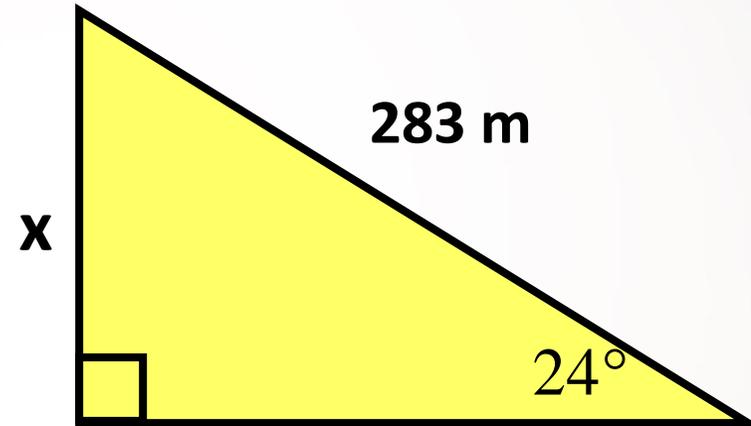Remember that: $hyp^2 = opp^2 + adj^2$

The basic trigonometric functions are:
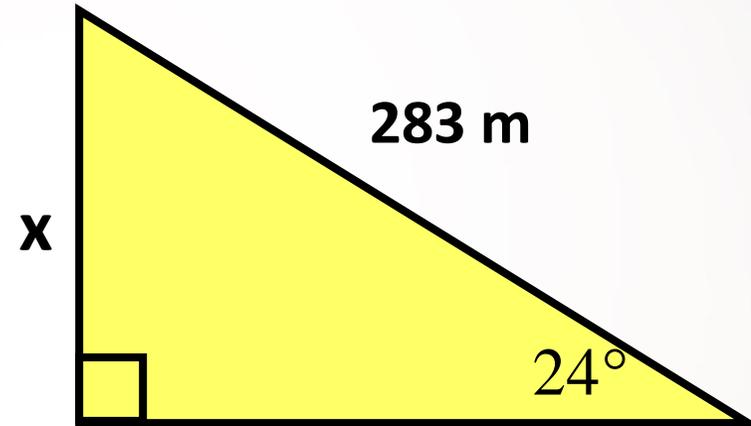
$$\sin \theta = \frac{\text{opp}}{\text{hyp}}$$

$$\cos \theta = \frac{\text{adj}}{\text{hyp}}$$

$$\tan \theta = \frac{\text{opp}}{\text{adj}}$$
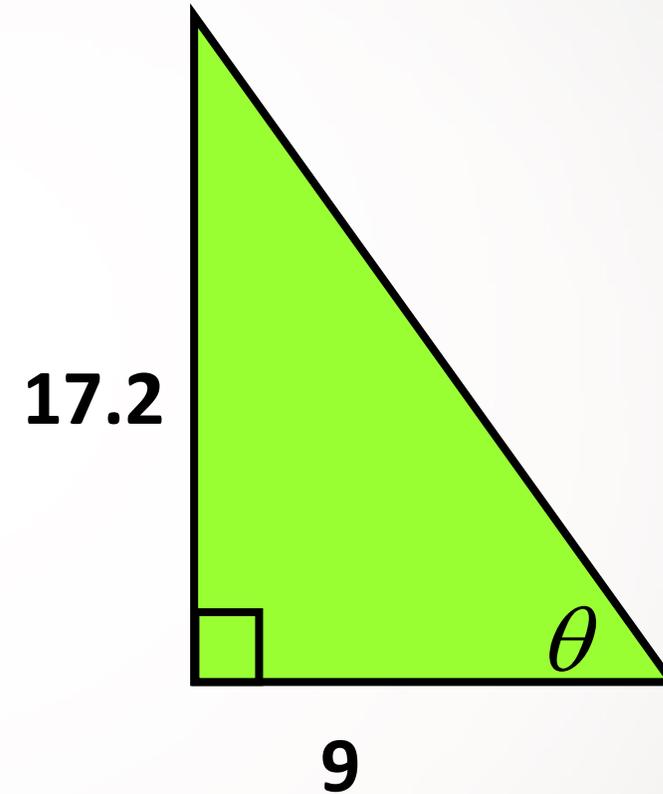
Find the missing side

Find the missing side

$$\sin\left(24^\circ\right)=\frac{x}{283}$$

$$x=283\sin\left(24^\circ\right)=115.11m$$

Find the missing angle θ

Find the missing angle θ

$$\tan\theta = \frac{17.2}{9} = 1.91$$

$$\theta = \tan^{-1}(1.91) = 62.36°$$