National University of Computer & Emerging Sciences – FAST

Department of Computer Science

Course Code : EE 117

Course Title : Applied Physics

Instructor: Muhammad Adeel

Fall Semester 2020

An Introduction & a Short Review of Physics

Definition of Physics:

Branch of science deals with the study of matter and energy along with the interaction between them.

Application of Physics:

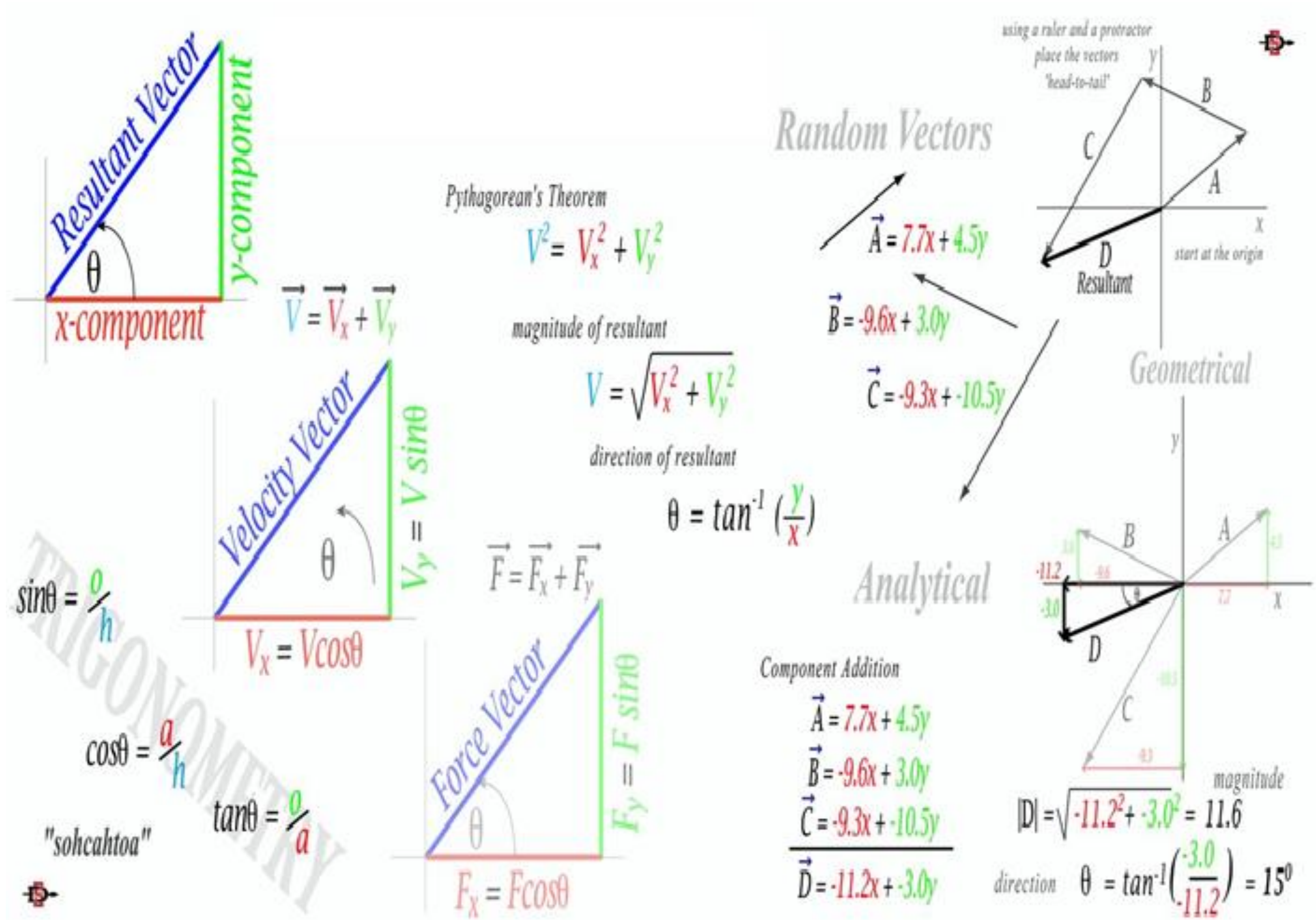
Why Applied Physics?

Difference of Pure Physics and Applied Physics:

- **Physics** is field of study of the natural phenomenon, whereas **Applied Physics** is a field of study under **Physics**.

Need to study Applied Physics:

- It is the physics for Engineers, because it develops connection between physical laws and principles to Engineering.


Resultant Vector
y-component
x-component
θ
Pythagorean's Theorem
magnitude of resultant
direction of resultant
Velocity Vector
Force Vector
TRIGONOMETRY
"sohcahtoa"
Random Vectors
Geometrical
Analytical
Component Addition
using a ruler and a protractor
place the vectors
"head-to-tail"
start at the origin
Resultant
magnitude
direction

VECTORS

Contents

Introduction

Definition of Vectors & Scalars

Physical quantities can be classified under two main headings,

- Scalars
- Vectors
- A Scalar quantity that has magnitude only, while direction is not taken into account.

Examples: Speed, Pressure, Temperature, Energy etc.

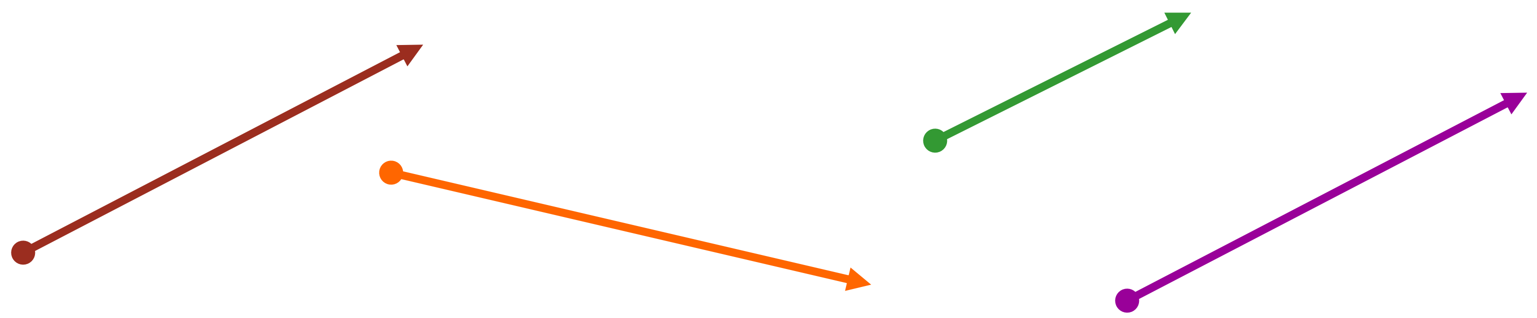
- A quantity that has both magnitude and direction and obeys certain algebraic laws is called a Vector quantity.

Examples: Velocity, Acceleration, Force, Displacement etc.

Graphical Realization of Vector

Vector is represented by an arrow.

The length of the vector represents the magnitude and the arrow indicates the direction of the vector.



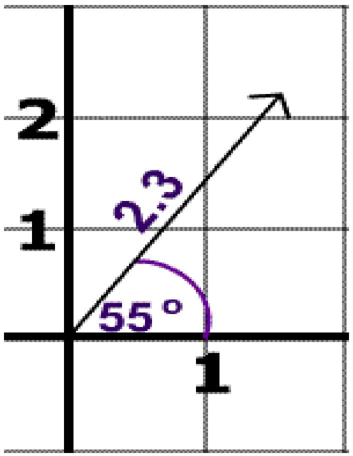
Brown and orange vectors have same magnitude but different direction.

Brown and purple vectors have same magnitude and direction so they are equal.

Brown and green vectors have same direction but different magnitude.

Two vectors are equal if they have the same direction and magnitude (length).

Graphical Realization of Vector



- The **direction** of the vector is 55° North of East
- The **magnitude** of the vector is 2.3.

In order to distinguish vector and scalar quantities, different conventions are used.

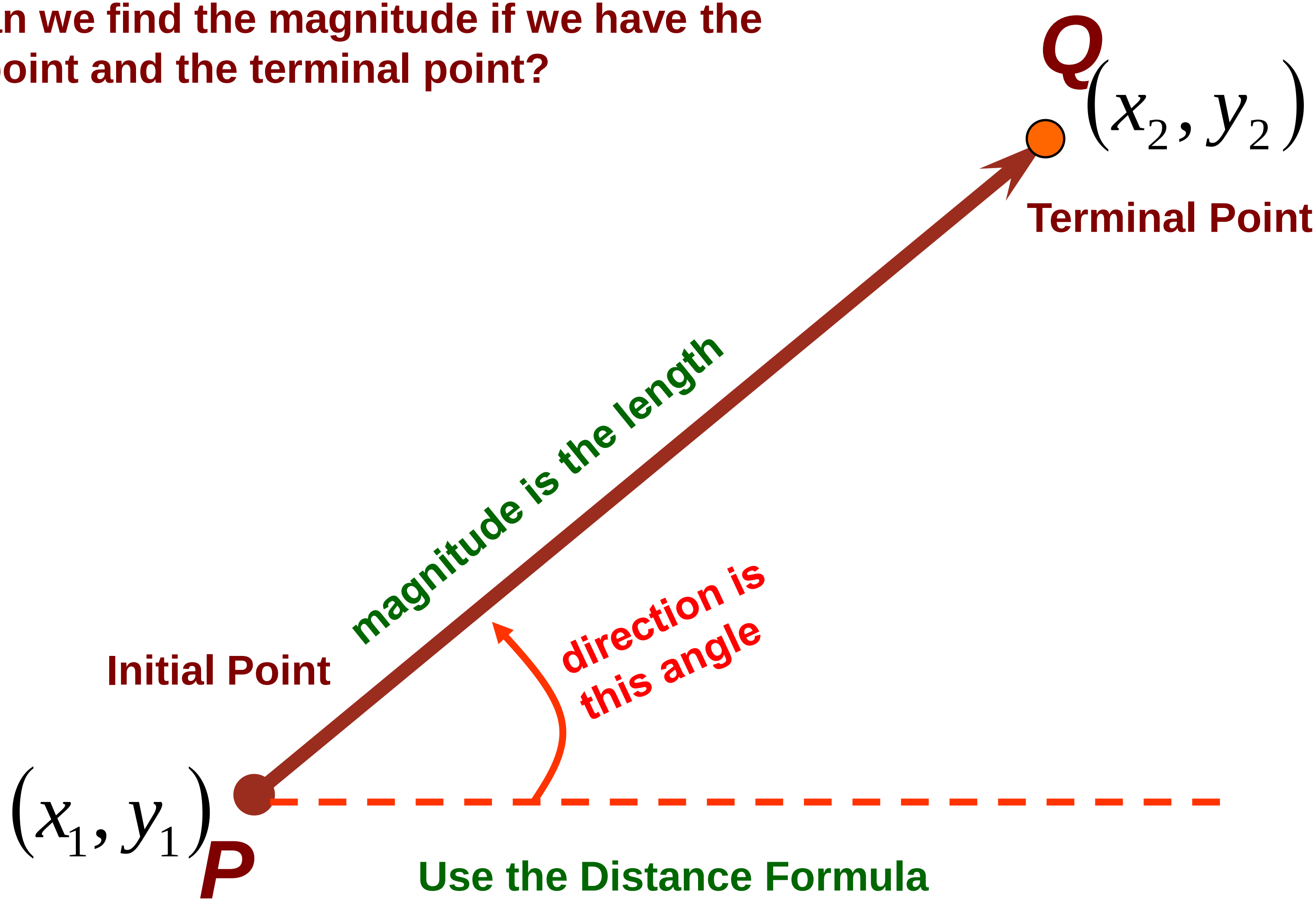
An arrow over a letter: $\vec{V}$ or a letter with bold face ***V***

An arrow over two letters, the initial and terminal points $\overrightarrow{AB}$

or both letters in bold face ***AB***

The magnitude (length) of a vector is notated with double vertical lines $\|\vec{V}\|$ $\|\overrightarrow{AB}\|$

How can we find the magnitude if we have the initial point and the terminal point?



Use the Distance Formula

or the

Pythagorean Theorem

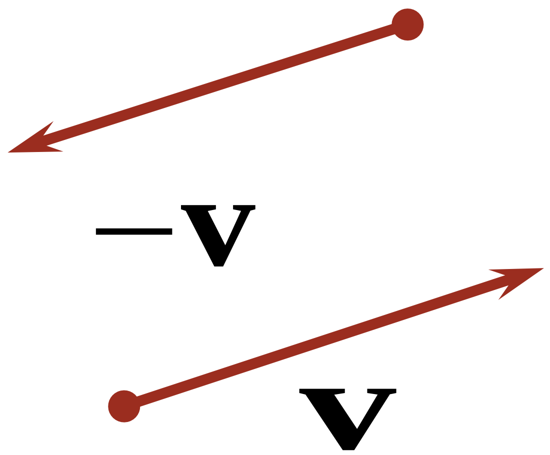
Mathematical Realization of Vector & Vector Components

- Negative of a Vector
- Vector Components and Resolution of Vector
- Vector Addition, Subtraction
- Multiplication of Vector
- Unit Vector and Coordinate system
- Dot Product and Cross Product

Negative of a Vector

The Negative of A Vector is just a vector

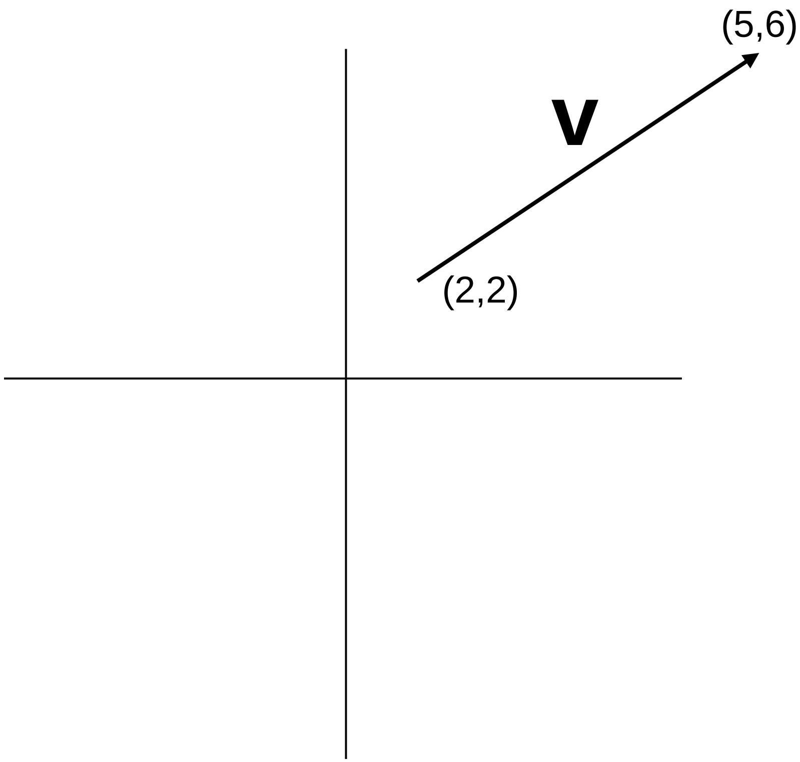
going the opposite way.



- The negative of a vector when added to the original vector, gives a resultant of zero ! Represented as **"– V"**
- **V + (– V) = 0**

Components of a Vector

- To do computations with vectors, we place them in the plane and find their **components**.
- The initial point is the **tail**, the **head** is the terminal point. The components are obtained by subtracting coordinates of the initial point from those of the terminal point.

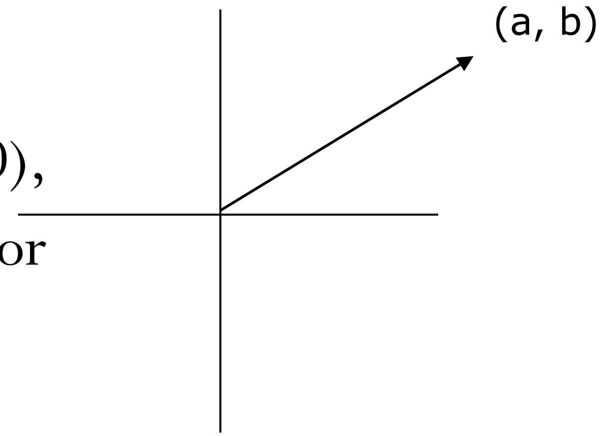


Components of a Vector

Vector is shown by angle brackets <a, b>

Example: Let a vector with Initial point at (0,0), Terminal point at (a, b) then the resultant vector will be **v** = <a-0,b-0>

v = <a,b>

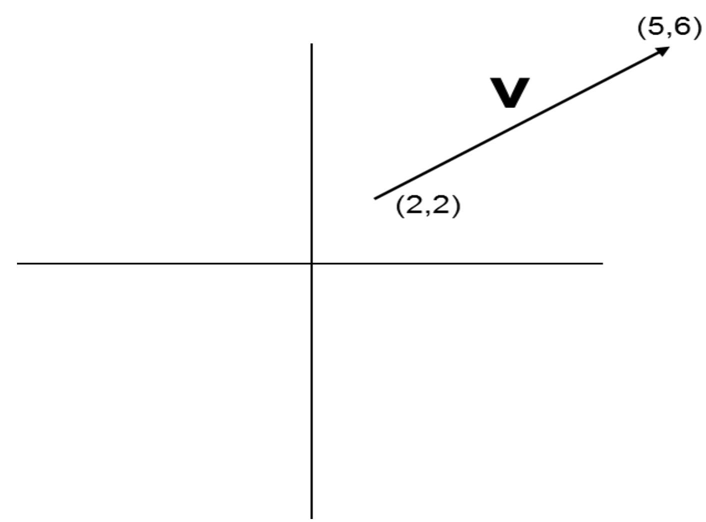


Mathematically ,

The first component of v is 5 -2 = 3.

The second is 6 -2 = 4.

We write **v** = <3,4>

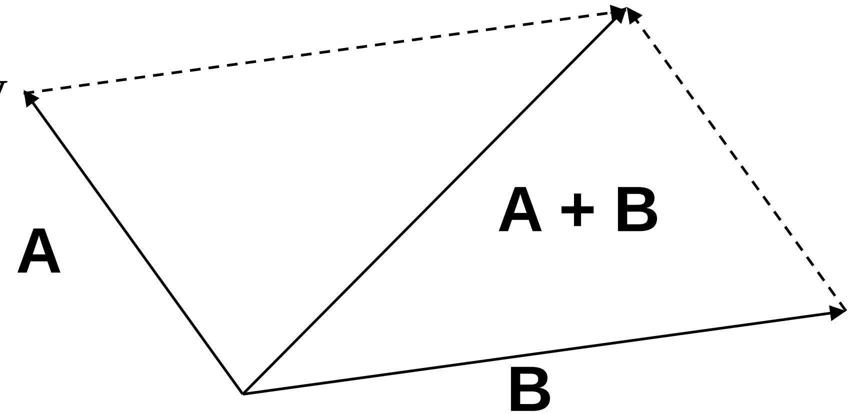


Vector Resolution

- Vectors that are acting at an angle can be broken down into the horizontal and vertical parts which make them up.
- Any vector can be broken down into a horizontal component and a vertical component.
- The sum of the two components should give you back your original vector.
- What is nice about vector components is that they form right triangle, since one acts vertically and the other acts horizontally. Thus, the original vector forms the hypotenuse of the right triangle formed by its components. The process of breaking a vector down into its components is called VECTOR RESOLUTION

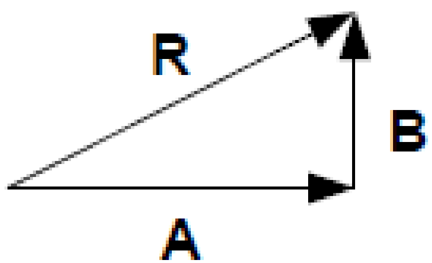
Addition of Vectors

- Graphically vectors are added by using famous head to tail rule



- Two vectors can be added using the **Parallelogram Law.**
- Considering vectors **A** & **B,** add them by using head to tail rule

Mathematically, the vector sum is found to be **R** = **A** + **B**



The resultant vector **R** = **A** + **B**

Addition of Vectors

- Considering Fig 1(a), move **B** so that its tail coincides with the tail of **A**.
- The resultant **R** is seen to lie along the diagonal of the parallelogram formed by **A** and **B**, with the tails of all three vectors coinciding as in Fig1(b).
- Finally shift **A** such that its tail coincides with the head of the shifted **B** as shown in Fig 1(c).
- It is now obvious from Fig 1(c) that **R** =**A** + **B** = **B** + **A**,

showing that the *commutative law* holds for vector addition

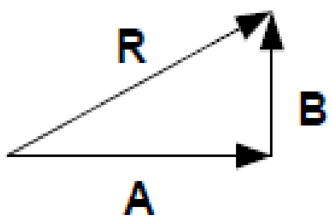


Fig 1(a)

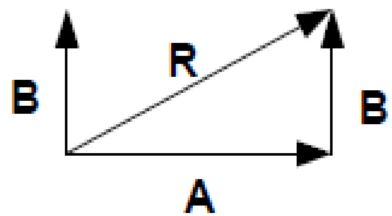


Fig 1(b)

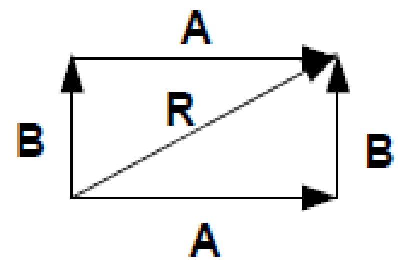


Fig 1(c)

Addition of Vectors

- The sum of more than two vectors can be found by continuing to place the tail of succeeding vectors at the head of the preceding vector, as shown in Fig. 2(c) . The resultant vector **D** = **A** + **B** + **C** is shown in Fig 2(d).

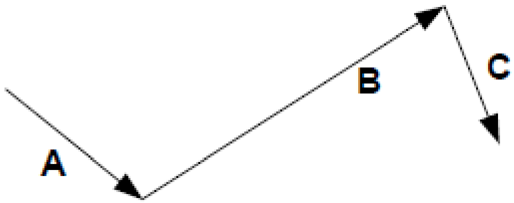


Fig 2(a)

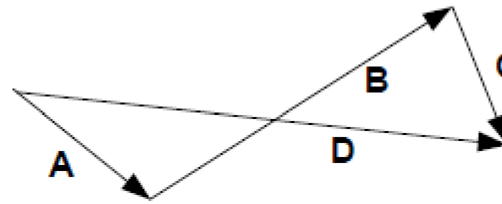


Fig 2(b)

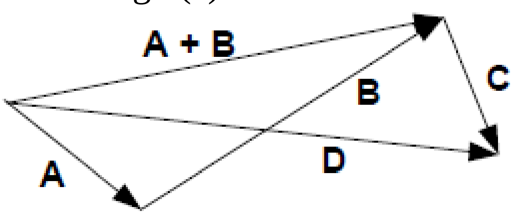


Fig 2(c)

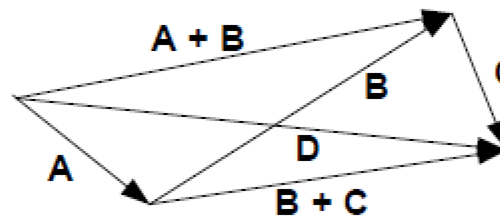


Fig 2(d)

- Draw the vector sum (**A** + **B**) in Fig. 2(b). The result is shown in Fig. 2(c).
- Finally, draw the vector sum (**B** + **C**) in Fig.2(c). The result is shown in Fig.2(d) . It is now clear from Fig. 2(d) that ,

D = **A** + **B** + **C** = (**A** + **B**) + **C** = **A** + (**B** + **C**), showing that

the associative law holds for vector addition.

Subtraction of a Vector

- Two vectors **A** and **B** are shown Fig.3(a). The vector **–A** is a vector with the same magnitude as **A** but with the opposite direction.
- Draw **–A** in Fig.3(a). The result is shown in Fig.3(b).
- Draw the resultant vector **R** = **A** + **B** in Fig. 3(b) Since **R** = **A** + **B.**
- Verify that **R** – **A** = **B** by showing that **R** + (**–A**) = **B** in Fig 3(b).

The result is shown in Fig. 3(c).

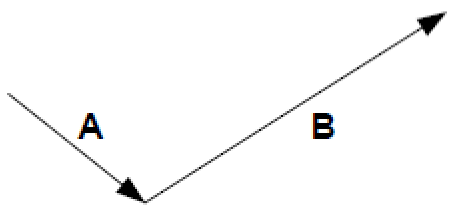


Fig 3(a)

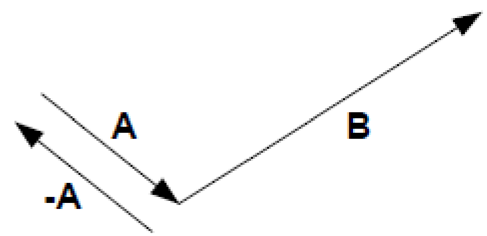


Fig 3(b)

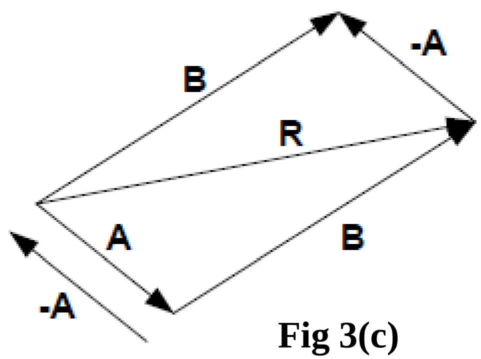


Fig 3(c)

Subtraction of a Vector

- TASK # --:

Fig.3(d) shows two vectors **A** and **B**. Draw the resultant vector **R** = **A** + **B** and the difference vector **D** = **A - B**. Note that the difference vector **D** can be drawn by connecting the head of **A** with the head of **B** and locating the head of **D** at the head of **A** as shown in Fig. 3(e).

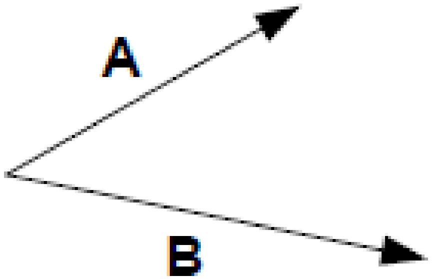


Fig 3(d)

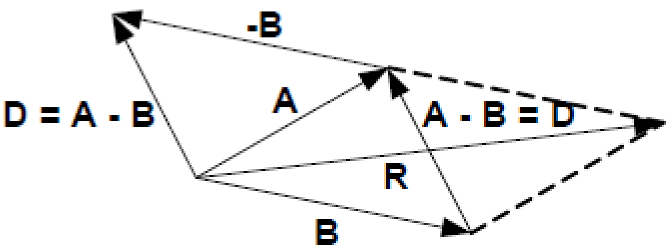


Fig 3(e)

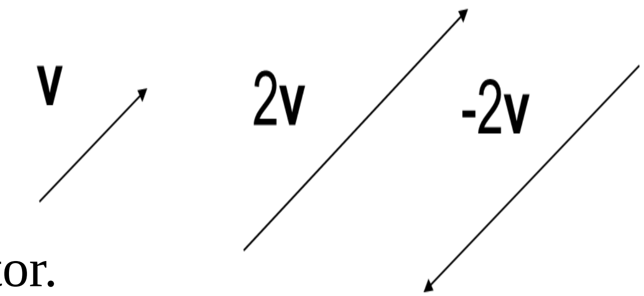
Scalar Multiplication of a Vector

We can multiply a vector by a real number c

That means multiplying its magnitude by c:

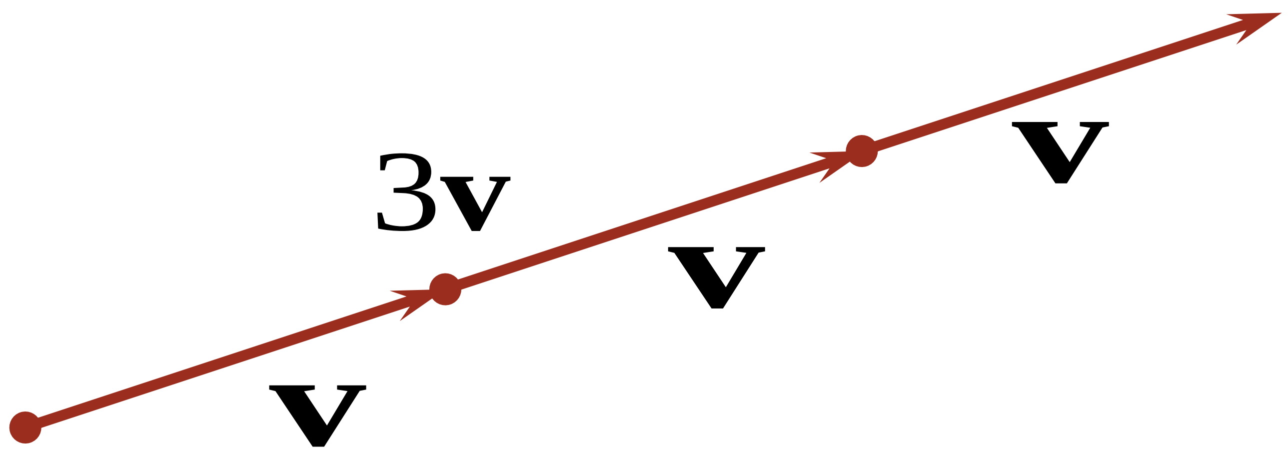
Notice that multiplying a vector by a

negative real number **reverses the direction** of vector.



A number multiplied in front of a vector is called a **SCALAR**.

It means to take the vector and add together that many times.



Properties of Multiplication of a vector by a number

- Commutative Law:

$$m\vec{A}=\vec{A}m$$

- Associative Law:

$$m(\mathrm{n}\,\vec{A})=\vec{A}(m\,\mathrm{n})$$

- Distributive Law:

$$(m+\mathrm{n})\,\vec{A}=m\vec{A}+\mathrm{n}\vec{A}$$

$$m(\vec{A}+\vec{B})=m\vec{A}+m\vec{B}$$

Unit Vectors

- A **unit vector** is a vector with magnitude 1.
- Given a vector $\mathbf{v}$, we can form a unit vector by multiplying the vector by $1 / |\mathbf{v}|$.
- A vector such as $<3,4>$ can be written as

$$3<1,0> + 4<0,1>.$$

For this reason, these vectors are given special names:

$$\mathbf{i} = <1,0> \text{ and } \mathbf{j} = <0,1>.$$

A vector in component form $\mathbf{v} = <a,b>$ can be written as $a\mathbf{i} + b\mathbf{j}$.

Muhammad Adeel

Unit Vectors and Coordinate Systems

- If a vector **A** is multiplied by a scalar *m*, the resulting product *m***A** is a vector whose magnitude is equal to $|m|$ times the magnitude of **A**. The direction of *m***A** is the same as that of **A** if *m* is positive and opposite to that of **A** if *m* is negative. If λ is a vector having a magnitude of unity, then *m*λ is a vector whose magnitude is $|m|$.
- The magnitude of the vector **A** is written as $|\mathbf{A}| = A$.
- In Fig. 4(a) the unit vector $A\ \boldsymbol{\lambda}$, which has a magnitude of unity, is in the same direction as **A**. We can therefore write the vector **A** as the magnitude of **A** multiplied by the unit vector $A\ \boldsymbol{\lambda}$.

  That is, $A\ \mathbf{A} = A\boldsymbol{\lambda}$.

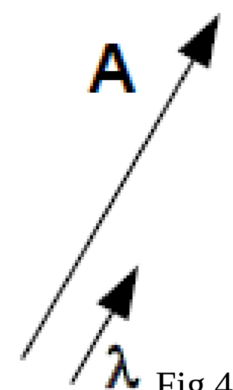


Fig 4(a)

- The unit vector $A\ \boldsymbol{\lambda}$ in the direction of **A**

  can then be written as $\boldsymbol{\lambda} = \dfrac{\boldsymbol{A}}{A}$

Unit Vectors and Coordinate Systems

- Fig. 4(b) shows $\mathbf{A}$ to be the vector sum of $\mathbf{A}_x$ and $\mathbf{A}_y$. That is,

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

- The vectors $\mathbf{A}_x$ and $\mathbf{A}_y$ lie along the x and y axes; therefore, we say that the vector $\mathbf{A}$ has been resolved into its x and y components.
- The unit vectors $\mathbf{i}$ and $\mathbf{j}$ are directed along the x and y axes as shown in Fig. 4(b).
- Using the technique of Fig. 4(a), we can therefore write

$$\mathbf{A}_x = A_x\mathbf{i} \text{ and } \mathbf{A}_y = A_y\mathbf{j}$$

- We can then write $\mathbf{A}$ in terms of the unit vectors as the vector sum $\mathbf{A} = A_x\mathbf{i} + A_y\mathbf{j}$.

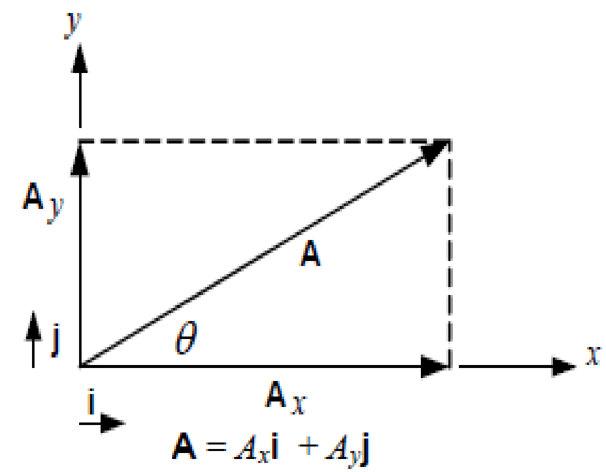


Fig 4(b)

Unit Vectors and Coordinate Systems

- In the previous frame we saw that a vector **A** lying in the *x*-*y* plane can be written as **A** = *Ax***i** + *Ay***j**.
- From the figure we see that the magnitudes are related by

$$Ax = A \cos \theta \qquad Ay = A \sin \theta$$

$$A_x^2 + A_y^2 = A^2\left(\cos^2\theta + \sin^2\theta\right) = A^2$$

from which the ratio $$\frac{A_y}{A_x} = \frac{\sin\theta}{\cos\theta} = \tan\theta$$

Square *Ax* and *Ay* and add the results to obtain

$$A_x^2 + A_y^2 = A^2\left(\cos^2\theta + \sin^2\theta\right) = A^2$$

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

Addition of Vectors by Components

To illustrate the addition of vectors by components, consider the vector sum **R** = **A** + **B** shown in Fig 5(a) By resolving **A** and **B** into x and y components, we can write

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

$$= A_x\mathbf{i} + A_y\mathbf{j} + B_x\mathbf{i} + B_y\mathbf{j}$$

from which

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

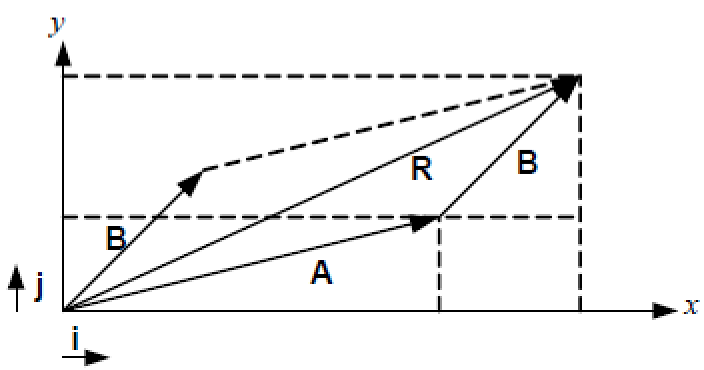


Fig 5(a) $\mathbf{R} = (A_x + B_x)\mathbf{i} + (A_y + B_y)\mathbf{j}$

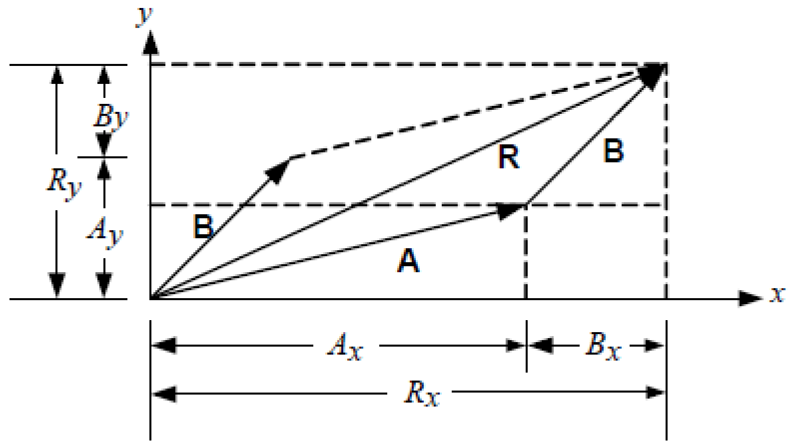
Addition of Vectors by Components

But in **Fig 5(a)** **R** can be written as $\mathbf{R} = R_x\mathbf{i} + R_y\mathbf{j}$. Therefore

$$R_x = A_x + B_x$$

$$R_y = A_y + B_y$$

These results are summarized in **figure below.**



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