LECTURE # 2

In this lecture you will learn about:

- Force
- Force Systems
- Head To Tail Rule
- Resolution of Force

Course Name:

"Applied Mechanics"

Course Code: CT-144

Credit Hours: 3

Semester: Summer 2020

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FORCE

The external agency, which **tends to change the state of a body** is known as force.

A force is completely defined only when the following four characteristics are specified:

- Magnitude
- Point of application
- Line of action
- Direction

FORCE

A force (F) is a **vector quantity** which is represented graphically by a straight line say ‘ab’ whose length is proportional to the magnitude of force and the arrow shows the direction of force ‘ab’ as shown in Figure. Unit of force is **Newton (N).**

EFFECT OF A FORCE

A force acting on body may have the following effects on the body:

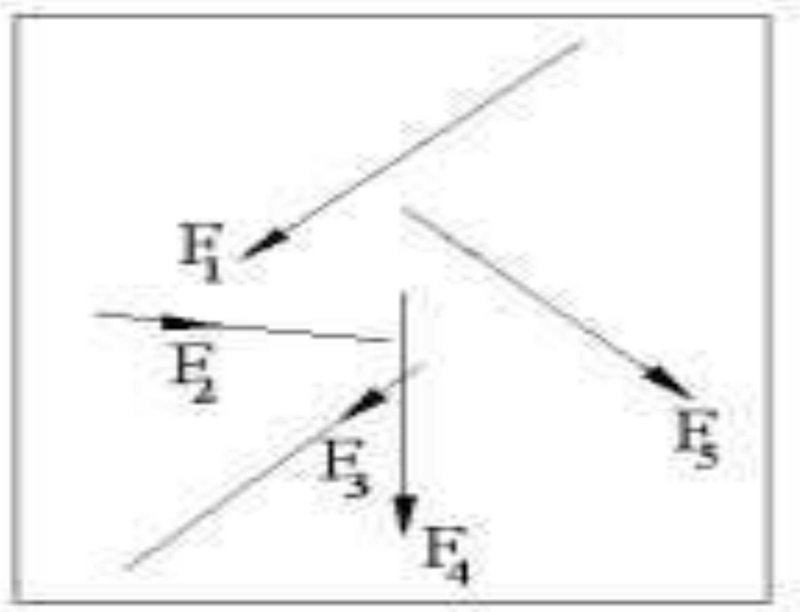
- It may change the state of rest or of uniform motion of a body.
- It may change the direction of motion of a moving body.
- It may change the shape internal stresses in the body.
- It may produce internal stresses in the body.

FORCE SYSTEM

When **several forces** of different magnitude and direction act upon a body, they constitute a system of forces.

COPLANAR FORCE SYSTEM

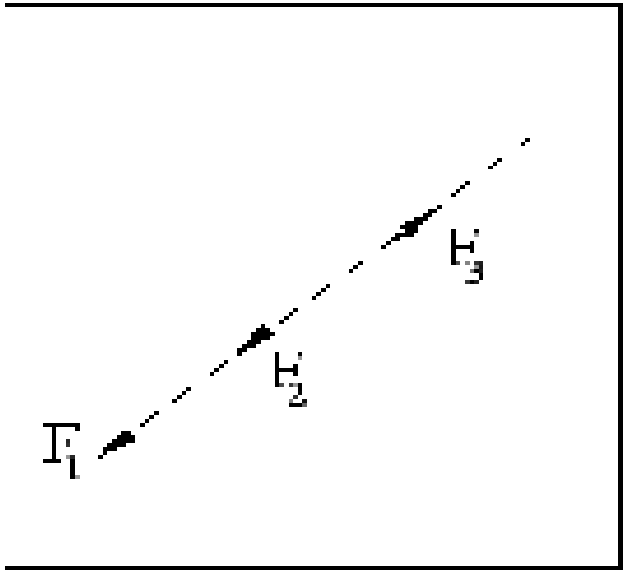
Lines of action of all the forces lie in the same plane in this system as shown in Fig. (A).



A) Coplanar, Non-concurrent, Non-parallel

COLLINEAR FORCE SYSTEM

Lines of action of all the forces lie in the same straight line in this system as shown in Fig.(B).



B) Co-llinear

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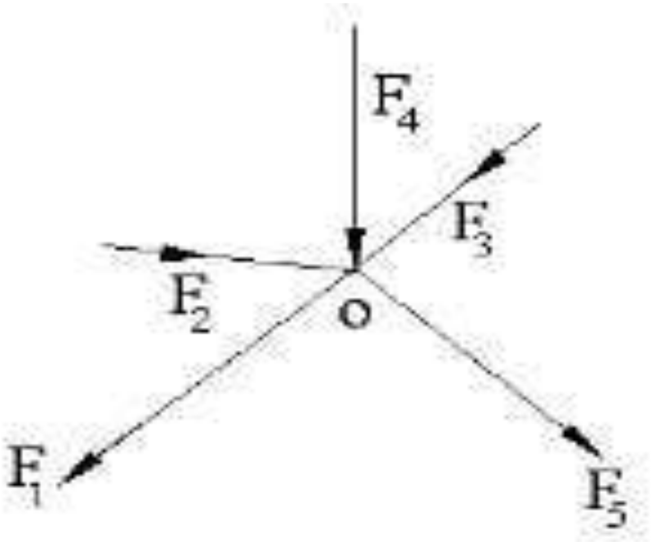
CONCURRENT FORCE SYSTEM

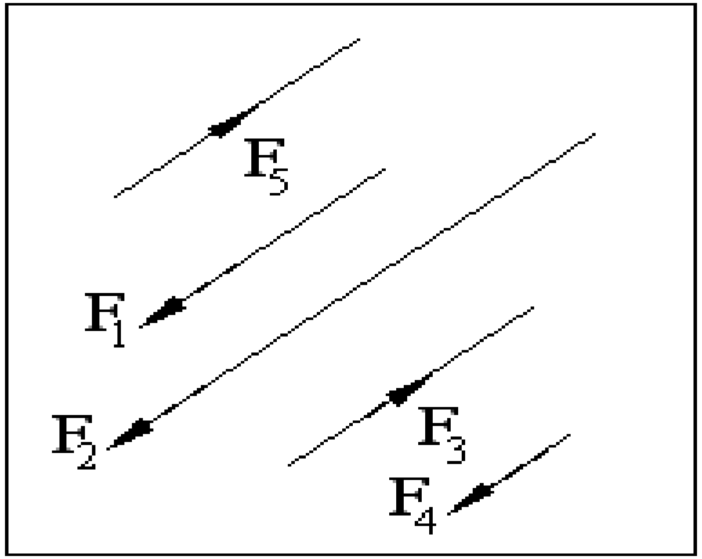
Lines of action of all the forces meet at a point in this system. The concurrent forces may not be collinear or coplanar as shown in Fig. (C)



C) Concurrent

PARALLEL FORCE SYSTEM

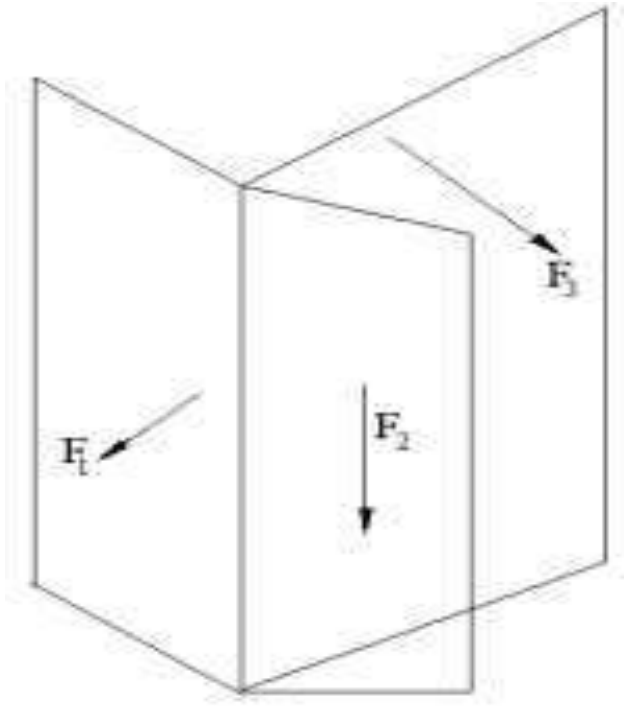
Lines of action of all the forces are in parallel as shown in Fig. (D)



D) Co-planar, parallel

NON- COPLANAR FORCE SYSTEM

Lines of action of all the forces does not lie in the same plane as shown in Fig. (E)



E) Non-Coplanar,
Non-concurrent

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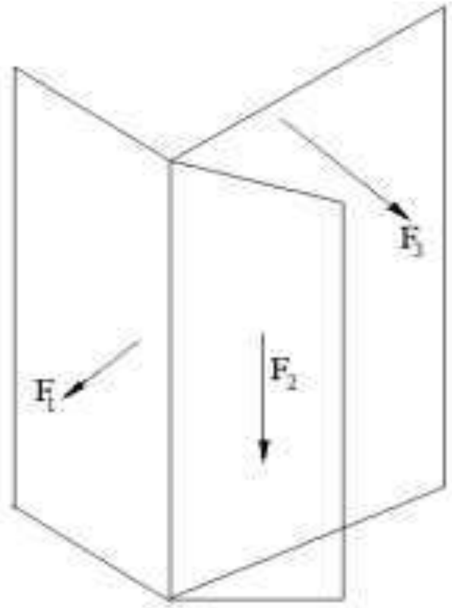
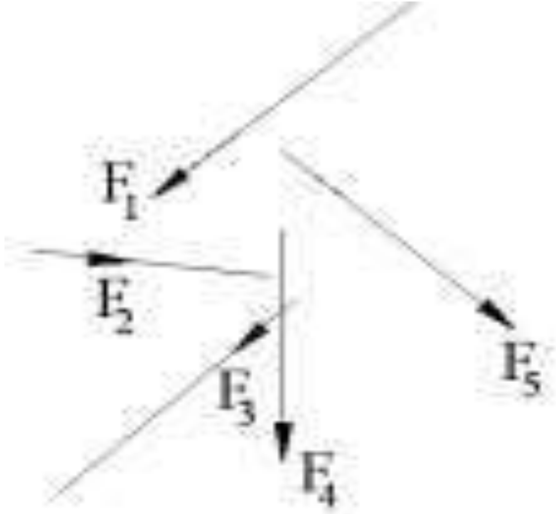
NON- CONCURRENT FORCE SYSTEM

Lines of action of all the forces do not meet at a point in this system as shown in Fig. (E &F)



E) Non-Coplanar,
Non-concurrent



F) Non-concurrent

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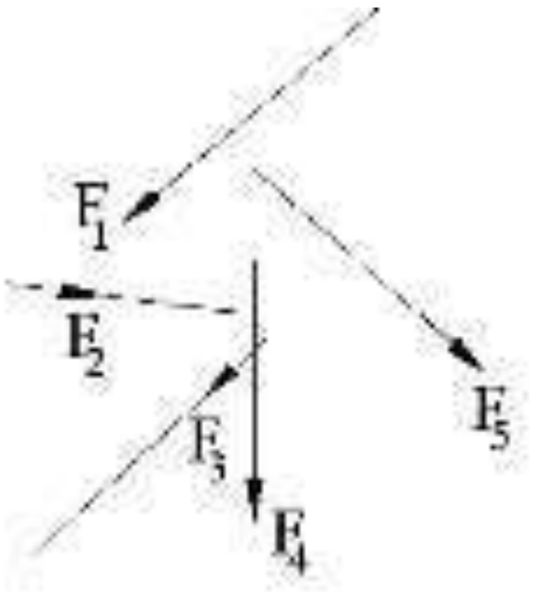
NON-PARALLEL FORCE SYSTEM

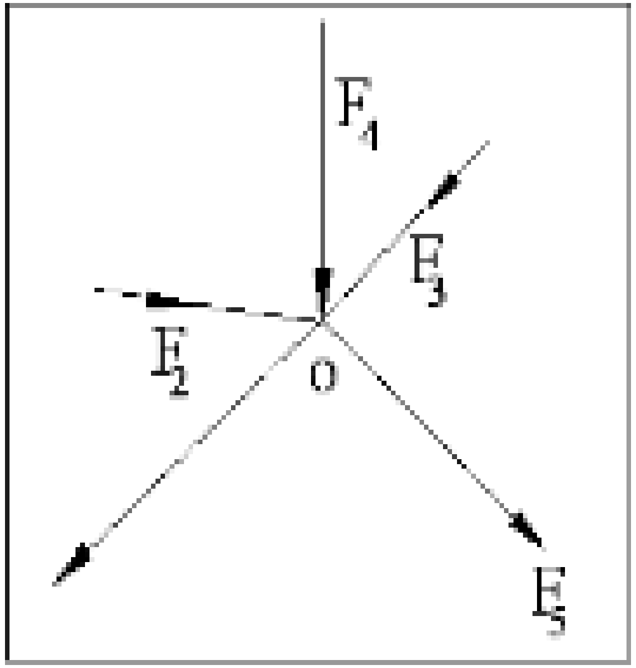
Lines of action of all the forces are not in parallel as shown in Fig. (H) above.



H) Non-parallel

COPLANAR CONCURRENT FORCE SYSTEM

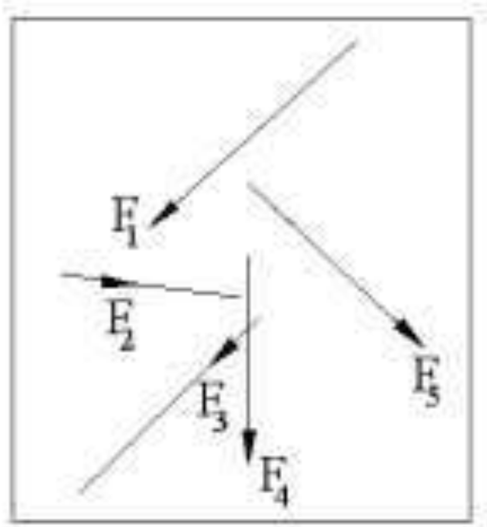
Lines of action of all the forces lie in the same plane and meet at a point shown in Fig. (G)



G) Concurrent

COPLANAR NON-CONCURRENT FORCE SYSTEM

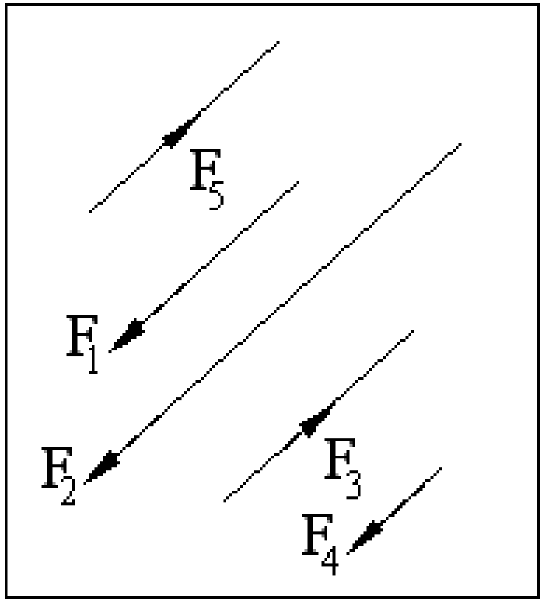
Lines of action of all the forces lie in the same plane, but do not meet at a point as shown in Fig. (A) above. They may be in parallel.



A) Coplanar, Non-concurrent, Non-parallel

COPLANAR PARALLEL FORCE SYSTEM

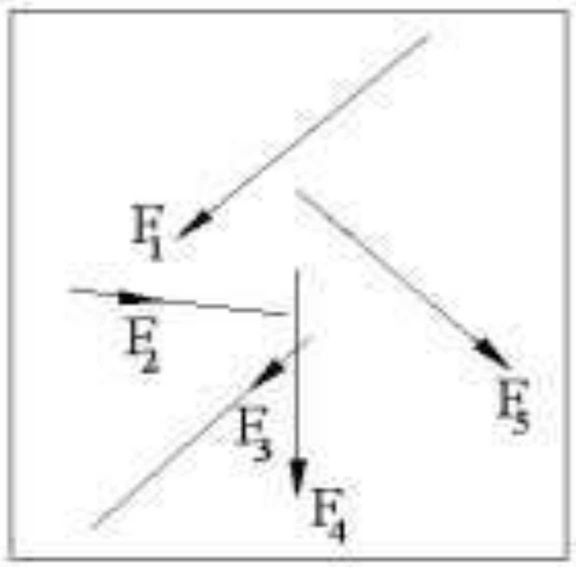
Lines of action of all the forces are in parallel in the same plane shown in Fig. (D) above.



D) Co-planar, parallel

COPLANAR, NON-CONCURRENT, NON-PARALLEL FORCE SYSTEM

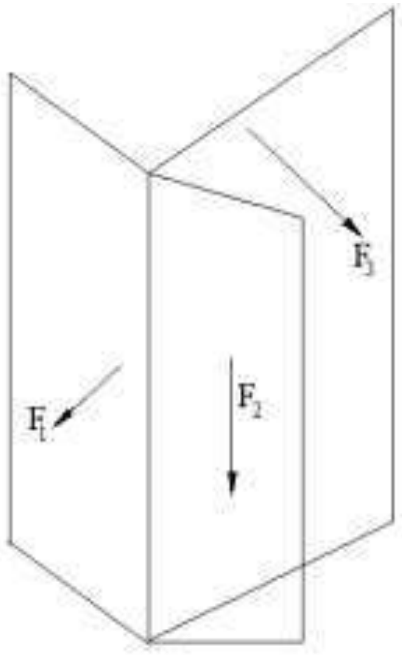
The lines of action of all the forces are not in parallel, they do not meet at a point but they are in the same plane as shown in Fig. (A)



A) Coplanar, Non-concurrent, Non-parallel

NON- COPLANAR, NON-CONCURRENT FORCE SYSTEM

The lines of action of all the forces do not lie in the same plane and do not meet at a point as shown in Fig. (E)

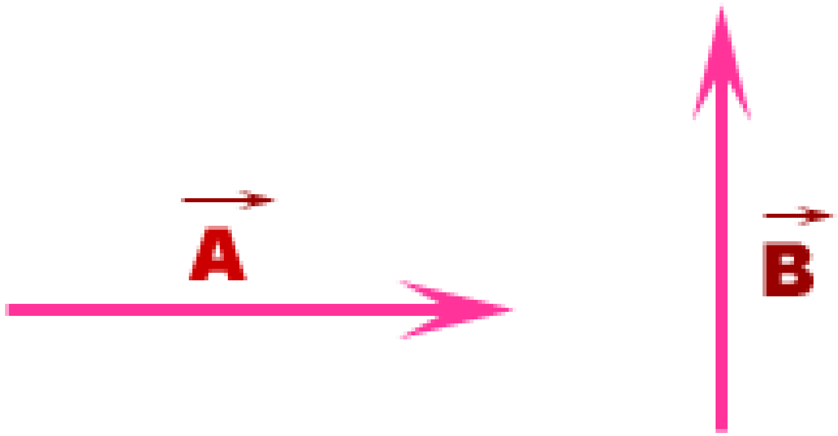


E) Non-Coplanar, Non-concurrent

HEAD TO TAIL RULE

Head to Tail method or graphical method is one of the easiest method used to find the resultant vector of two of more than two vectors.

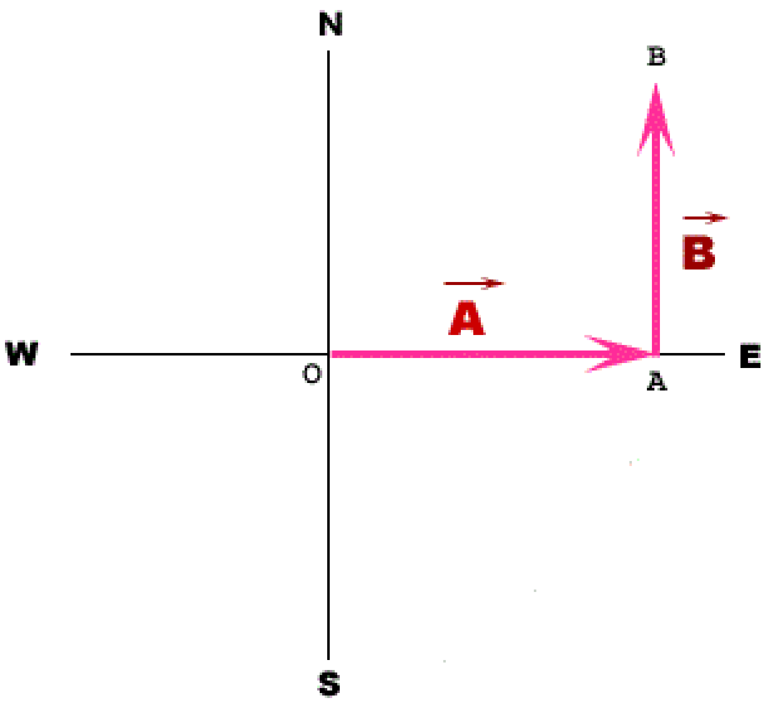
Consider two vectors $\vec{A}$ and $\vec{B}$ acting in the directions as shown below.



METHOD

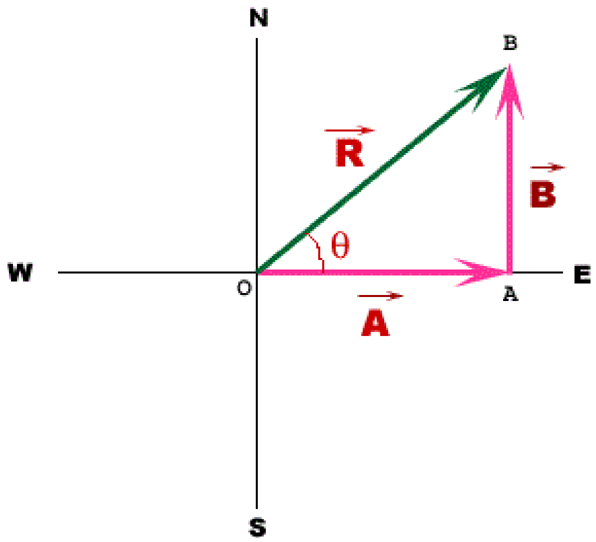
In order to get their resultant vector by head to tail method we must follow the following steps

- Choose a suitable scale for the vectors so that they can be plotted on the paper.
- Draw representative line $\overline{OA}$ of vector $\vec{A}$.
- Draw representative line $\overline{AB}$ of vector $\vec{B}$ such that the tail of $\vec{B}$ coincides with the head of vector $\vec{A}$.



METHOD

- Join 'O' and 'B'.
- $\overline{OB}$ represents resultant vector of given vectors $\vec{A}$ and $\vec{B}$ i.e.



$$\overline{OB} = \overline{OA} + \overline{AB}$$

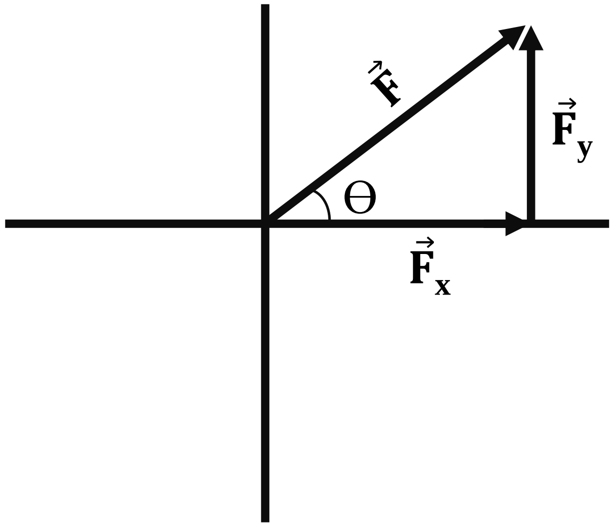
$$\vec{R} = \vec{A} + \vec{B}$$

METHOD

- Measure the length of line segment $\overline{OB}$ and multiply it with the scale choosen initially to get the magnitude of resultant vector.
- The direction of the resultant vector is directed from the tail of vector $\vec{A}$ to the head of $\vec{B}$.

RESOLUTION OF FORCE

Any force $\vec{\mathbf{F}}$ acting in a direction ϴ above the horizontal can be replaced by two forces, $\vec{\mathbf{F}}_\mathbf{x}$ and $\vec{\mathbf{F}}_\mathbf{y}$ which act at right angles to each other; $\vec{\mathbf{F}}_\mathbf{x}$ is the horizontal component and $\vec{\mathbf{F}}_\mathbf{y}$ is the vertical component. The two forces add vectorially to make , $\vec{\mathbf{F}}$ (resultant).



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HORIZONTAL COMPONENT

$$\text{Cos}\Theta = \frac{\text{BASE}}{\text{HYPOTENUSE}}$$

$$\text{Cos}\Theta = \frac{\vec{\mathbf{F}}_{\mathbf{x}}}{\vec{\boldsymbol{F}}} \quad \vec{\text{F}}$$

$$\vec{\text{F}}_{\text{x}} = \vec{\text{F}} \ \text{x} \ \text{Cos}\Theta$$

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VERTICAL COMPONENT

$$\text{Sin}\Theta = \frac{\text{PERPENDICULAR}}{\text{HYPOTENUSE}}$$

$$\text{Sin}\Theta = \frac{\vec{\mathbf{F}}_{\mathbf{y}}}{\vec{\mathbf{F}}}$$

$$\vec{F}_y = \vec{F} \times \text{Sin}\Theta$$

RESULTANT

By using Pythagoras Theorem

$$HYPOTENUSE^2 = BASE^2 + PERPENDICULAR^2$$

$$HYPOTENUSE^2 = \sqrt{BASE^2 + PERPENDICULAR^2}$$

$$\vec{F} = \sqrt{\vec{F}_x{}^2 + \vec{F}_y{}^2}$$

DIRECTION

$$\tan\Theta = \frac{\text{PERPENDICULAR}}{\text{BASE}}$$

$$\tan\Theta = \frac{\vec{F}_y}{\vec{F}_x}$$

$$\Theta = \tan^{-1}\left(\frac{\vec{F}_y}{\vec{F}_x}\right)$$

Thank You