Engineering Mechanics

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Lecture 1 : Introduction to the Engineering Mechanics

Mechanics is the branch of physical science that deals with rigid body or engineering mechanic is essentially a study of the effects of forces acting on bodies.

1 Classification of Engineering Mechanics

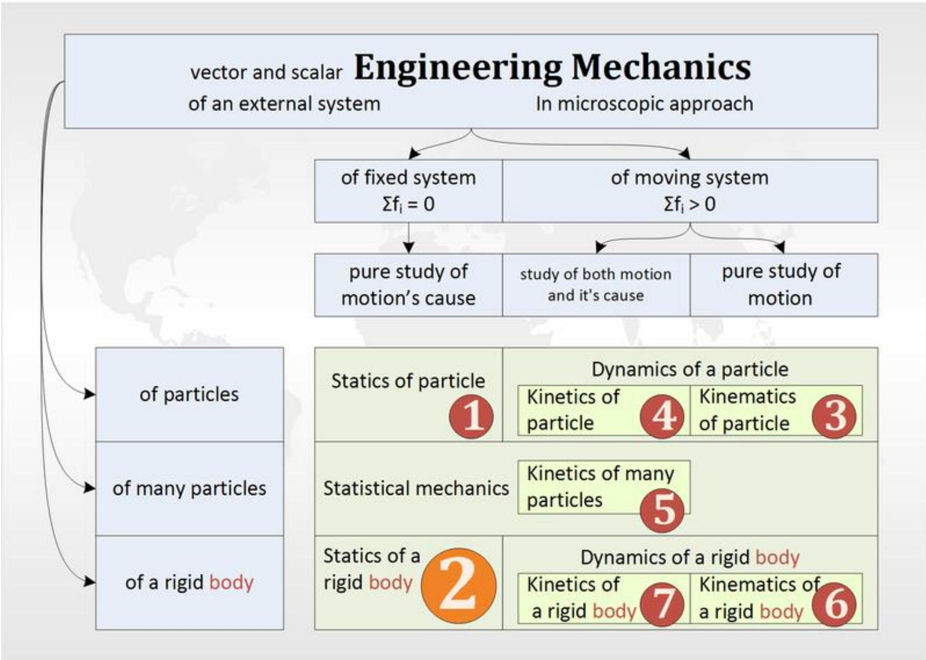
The subject of Engineering Mechanics may be divided into the following two main groups: 1. Statics, and 2. Dynamics.

1. **Static:**
   It is that branch of Engineering Mechanics in which has its body at rest while dealing with forces and there effect.

2. **Dynamics:**
   It is that branch of Engineering Mechanics in which has its body in motion while dealing with forces and there effect.The subject of Dynamics may be further sub-divided into the following two branches :
   1. Kinetics, and 2. Kinematics.

- **Kinetic:**
  It is the branch of Dynamics, which deals with the bodies in motion due to the application of forces.

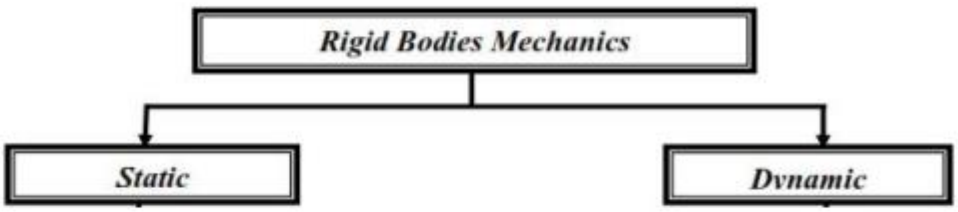
- **Kinematics:**
  It is that branch of Dynamics, which deals with the bodies in motion, without any reference to the forces which are responsible for the motion.



Rigid body is a body in all particles remains at fixed distance from each other's. No real body is absolutely rigid, but in many cases the changes in shape of the body have a negligible effect upon the acceleration produced by a forced system or upon the reactions required to maintain equilibrium. Whenever the changes in distance between the particles of a body can be neglected, the body is assumed to be rigid.

- When the force system acting on a body is equal zero (the body is in equilibrium), the branch of mechanics is called **Static**.

- When the force system acting on a body isn't equal zero (the body isn't in equilibrium), the branch of mechanics is called **Dynamic**.



2 Scalar and vector quantities

Physical quantities such as force, mass, acceleration, volume, velocity, and time used in engineering mechanics can be classified as either scalar or vector quantities.

1. **Vector quantities** are the quantities which have magnitude and direction such as: force, weight, velocity, distance, acceleration, displacement.
2. **Scalar quantities** are the quantities which have magnitude only such as: time, size, sound, density and light.

3 Force

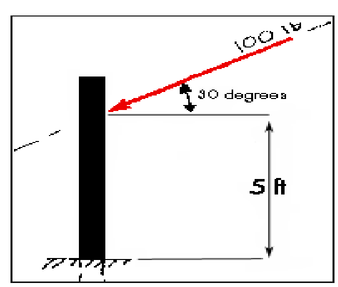
is an action that changes or tends to change the state of the motion of the body upon which it acts. It is a vector quantity that can be represented either mathematically or graphically.

A complete description of a force included:

- Magnitude.

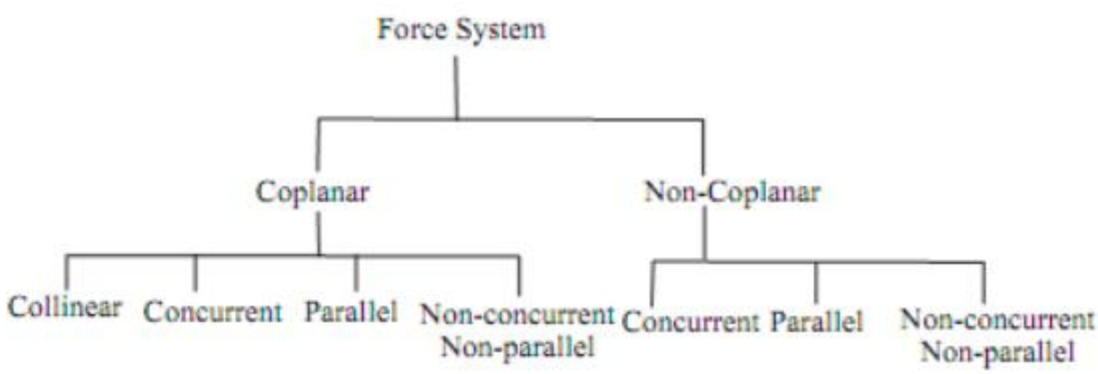
- Direction and sense.

- Point of action.



3.1 Classification of force systems

We can classify the force system by means planes as figure shown below:



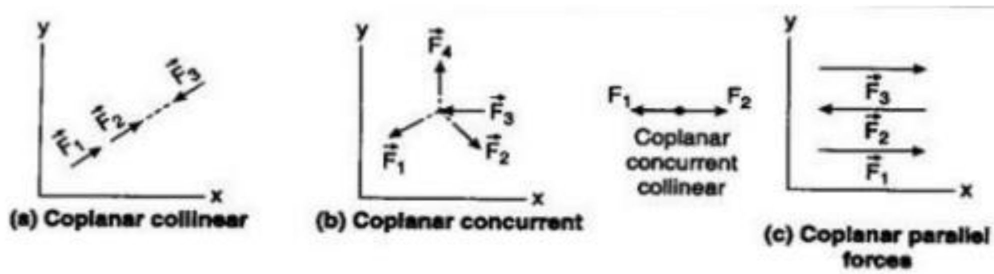
3.1.1 Coplanar system:

all the forces in same the plane.

a- Coplanar Collinear forces: the forces which lie at one line of action also lie on same the plane.

b- Coplanar concurret forces: the forces which meet at one point and line of action also lie on same the plane.

c- Coplanar parallel forces: the forces whose pareller line of action also lie on same the plane.

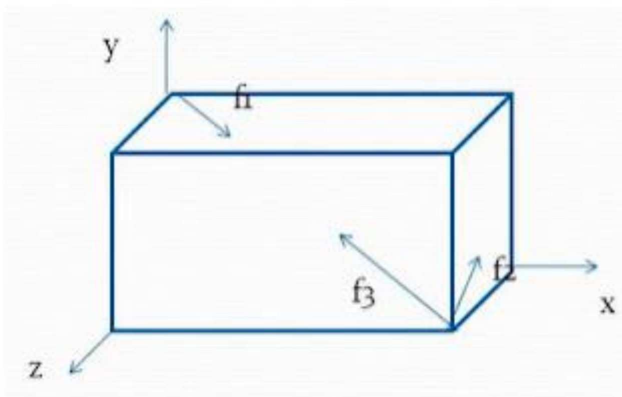


(a) Coplanar collinear (b) Coplanar concurrent (c) Coplanar parallel forces d- Coplanar non concurret non pareller forces: the forces whose line of action lie on same the plane but they do not meet at one point and non parallel.

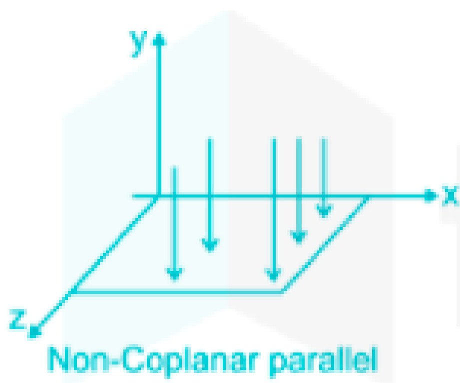
3.1.2 Non coplanar system:

The forces are not all in same the plane.

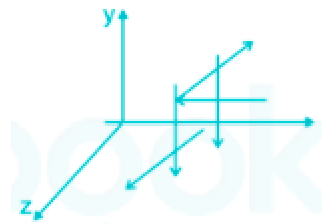
a- Non coplanar concurret forces: the forces which meet at one point but do not lie on same the plane.



b- Non coplanar parallel forces: the forces whose parallel line of action but do not lie on same the plane.



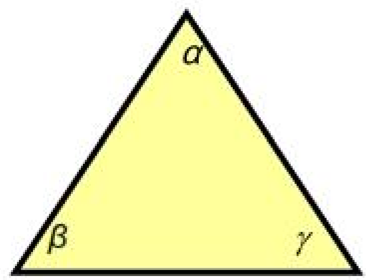
c- Non coplanar non concurret non parallel forces: the forces whose non parallel line of action and do not lie on same the plane and do not meet at one point.



Non-Coplanar non-concurrent

Symbols:

α	ALPPHA
β	BETA
γ	GAMMA
ϕ	PHI
π	PI
μ	MU



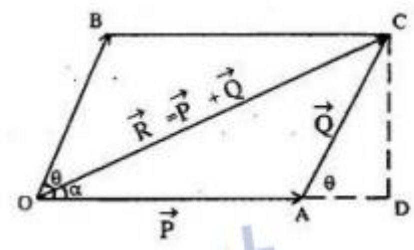
4 Composition and resolution of force

The process of replacing a force system by its resultant is called Composition. The resultant of a pair of concurrent forces can be determined by means:

- Parallelogram law: If two forces acting on a point are represented in magnitude and direction by the two sides of a parallelogram drawn from one of its angular points, their resultant is represented both in magnitude and direction by the diagonal by the parallelogram passing through that angular point.

$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

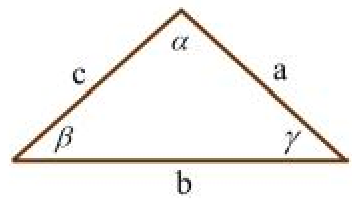
$$\alpha = \tan^{-1}\left[\frac{Q\sin\theta}{P + Q\cos\theta}\right]$$



- Trigonometric law:

a- Sine law

$$\frac{\mathbf{a}}{\sin\beta} = \frac{\mathbf{b}}{\sin\alpha} = \frac{\mathbf{c}}{\sin\gamma}$$

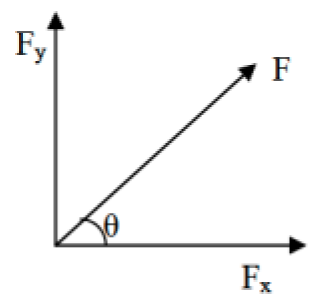


b- Cos law

$$\mathbf{a}^2 = \mathbf{b}^2 + \mathbf{c}^2 - 2\mathbf{bc}\cos\beta$$
$$\mathbf{b}^2 = \mathbf{a}^2 + \mathbf{c}^2 - 2\mathbf{ac}\cos\alpha$$
$$\mathbf{c}^2 = \mathbf{a}^2 + \mathbf{b}^2 - 2\mathbf{ab}\cos\gamma$$

5 Resolving a force components

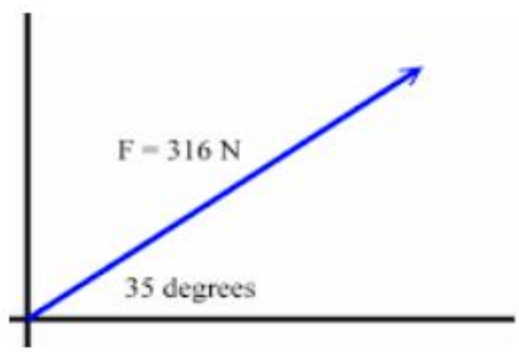
The force F can be resolved into two components F_x and F_y along the x and y axes and hence, the components are called rectangular components. Use the parallelogram law to solve this problem.



$$F_x = F * cos\theta \qquad F = \sqrt{F_x{}^2 + F_y{}^2}$$

$$F_y = F * sin\theta \qquad \theta = \tan^{-1}\frac{F_y}{F_x}$$

Example (1): Find the components F=316 N in the x and y direction with angle 35.



Sol.

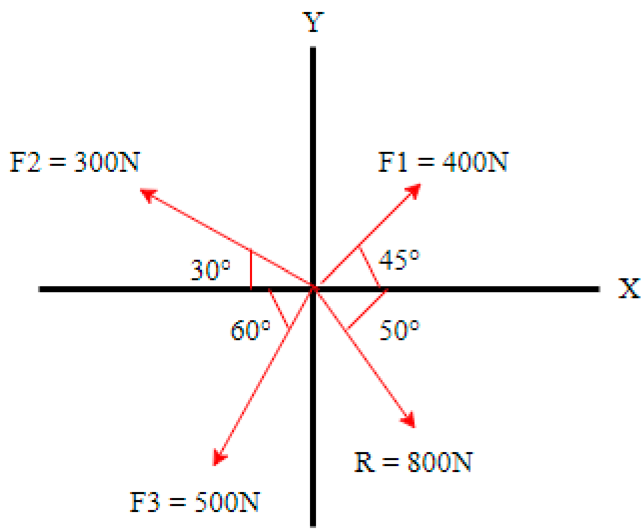
$F_x = F * cos\theta$

$F_x = 316 * cos35 = 258.85\ N$

$F_y = F * sin\theta$

$F_y = 316 * sin35 = 181.25\ N$

Example (2): Find the resultant for system forces as shown in fig. below:



Sol.

$F_x = F * cos\theta$

$F_y = F * sin\theta$

For F_1 = 400 N & $\boldsymbol{\theta} = \mathbf{45}$ °

$F_{1x} = 400 * cos45 = 282.8\ N$

$F_{1y} = 400 * sin45 = 282.8\ N$

For F_2 = 300 N & $\boldsymbol{\theta} = \mathbf{30}$ °

$F_{2x} = 300 * cos30 = 259.8\ N$

$F_{2y} = 300 * sin30 = 150\ N$

For F_3 = 500 N & $\boldsymbol{\theta} = \mathbf{60}$ °

$F_{3x} = 500 * cos60 = 250$

$F_{3y} = 500 * sin60 = 433\ N$

For R = 800 N & $\boldsymbol{\theta} = \mathbf{50}$ °

$R_x = 800 * cos50 = 514\ N$

$R_y = 800 * sin50 = 383\ N$

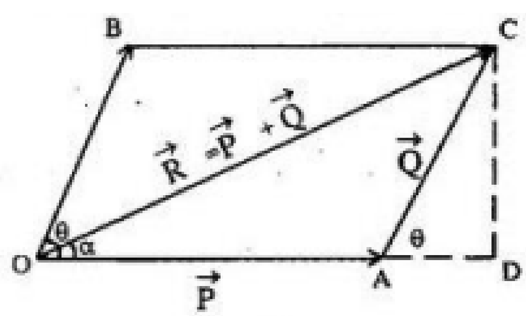
$\sum F_x = 282.8 - 259.8 - 250 + 514 = 287\ N$

$\sum F_y = 282.8 + 150 - 433 - 383 = -283.2$

$$F = \sqrt{{F_x}^2 + {F_y}^2}$$

$$F = \sqrt{(287)^2 + (-283.2)^2} = 403.2\ N$$

Example (3): In the fig. shown below, the resultant **F** is 300Ib and the angles **θ** and **β**, respectively. Resolve the force **F** into a pair of components **P** along line **OA** and **Q** along line **OB**.



Sol.

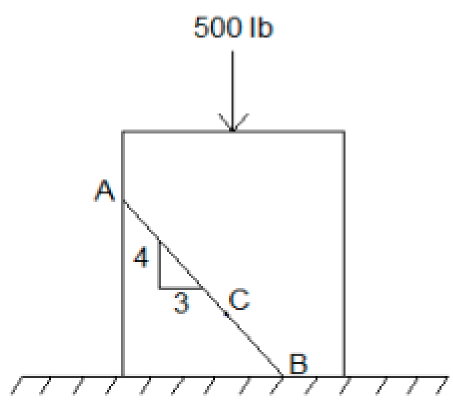
$$\frac{F}{\sin(180-\theta-\alpha)}=\frac{P}{\sin\theta}=\frac{Q}{\sin\alpha}$$

$$\frac{F}{\sin 110}=\frac{P}{\sin 45}=\frac{Q}{\sin 25}$$

$$P=\frac{F*\sin 45}{\sin 110}=\frac{F*0.707}{0.94}=225.6\,N$$

$$Q=\frac{F*\sin 25}{\sin 110}=\frac{F*0.422}{0.94}=134.6\,N$$

Example (4): In fig. shown below, Resolve the 500Ib force into components: a shearing component parallel **AB** and a normal component perpendicular **AB**.



Sol.

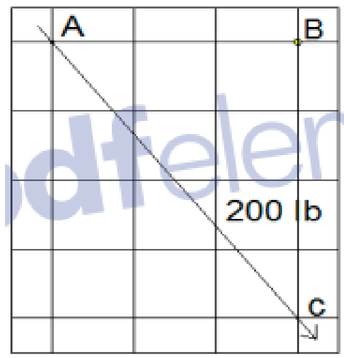
$F_x = F * cos\theta$

$F_x = 500 * cos36.87 = 400\ N$

$F_y = F * sin\theta$

$F_y = 500 * sin36.87 = 300\ N$

Example (5): In fig. shown below, Resolve the **200Ib** force into two components: one along **AB** and the other parallel to **CB**.



Sol.

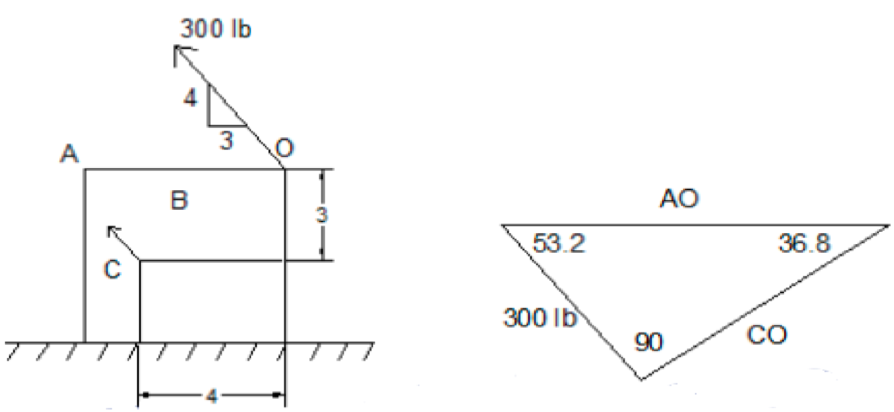
$F_{AB} = F * cos\theta$

$F_{AB} = 200 * cos53.2 = 120\ N$

$F_{BC} = F * sin\theta$

$F_{BC} = 200 * sin53.2 = 160\ N$

Example (6): In fig. shown below, the **300Ib** force acts on the box **B**, Resolve this force into two components: one along **AO** and the other through point **C**.



Sol.

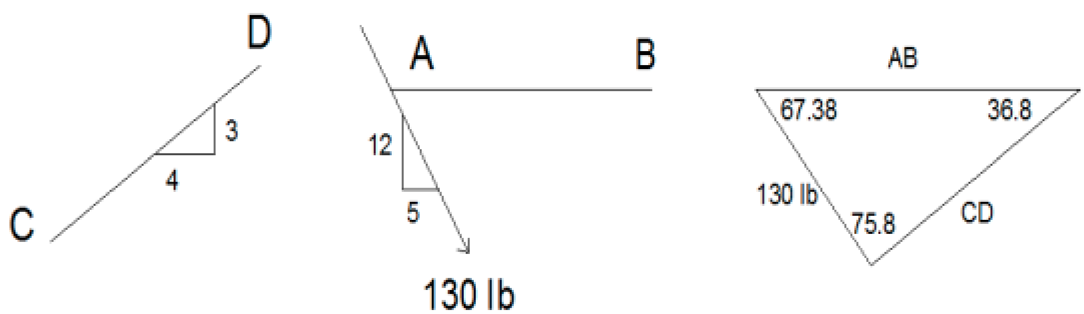
$300/\sin 36.8 = OC/\sin 53.2 = AO/\sin 90$

$300/0.6 = OC/0.8 = AO/1$

$OA = 300 * 1/0.6 = 500\ N$

$OC = 300 * 0.8/0.6 = 400\ N$

Example (7): In fig. shown below. Resolve the force **130Ib** into two nonrectangular components: one along **AB** and **CD**.



Sol.

$130/\sin 36.8 = AB/\sin 75.8 = CD/\sin 67.38$

$130/0.6 = AB/0.964 = CD/0.923$

$AB = 130 * 0.969/0.6 = 210\ N$

$CD = 130 * 0.923/0.6 = 200\ N$