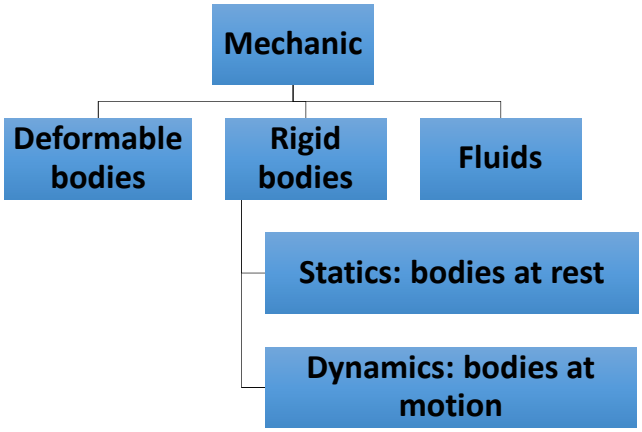
Engineering of Structures

References:

- Higdon, A. and Stiles, W. B., ''Engineering Mechanics: Statics and Dynamics''.
- Beer, F. B. and Johnston, E. R., ''Mechanics of Engineers: Statics''.
- Meriam, J. L. and Kriage, L. G., ''Engineering Mechanics: Statics''.
- Clements and Wilson, ''Analytical and Applies Mechanics''.

Definition:

Mechanic is the science which describes and predicts the conditions of rest or motion of bodies under the action of force/s. It can be divided into three parts:



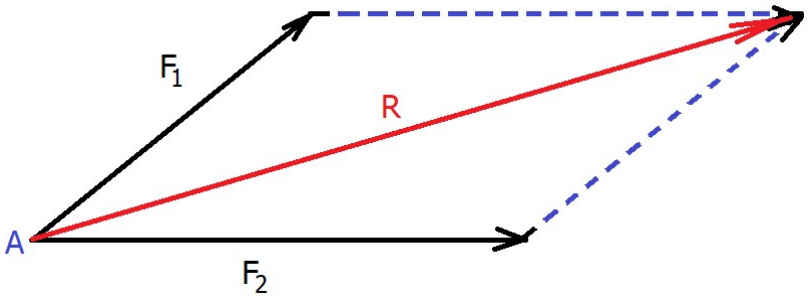
Statics of particles:

Force in a plane (two-dimensional)

- Force on particle: it represents the action of one body on another. Its characterised by its magnitude, direction and point of application.
- The sense: the direction of a force indicated by an arrow head.
- Line of action: infinite straight line along which the force acts. It characterised by an angle that forms with a fixed axis.
- The resultant: a single force acting on a particle which can be replace a number of forces acting on the same particle and has the same effect.

Parallelogram Law:

- It is a law based on experimental evidence for obtaining the resultant of two forces.
- Parallelogram is a draw using the two force on sides and the diagonal passes through the point of application. Its sides are equal to the forces given.

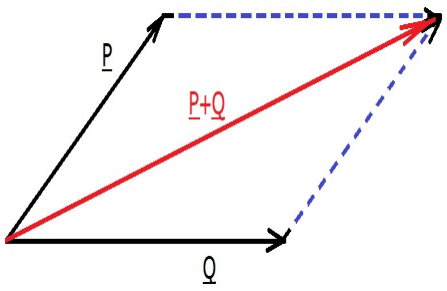


Vectors:

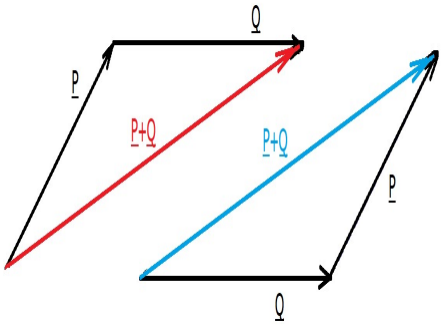
- Physical quantities possessing magnitude and direction which are added according to the parallelogram law, like forces, displacements, acceleration….etc.
- Quantities which have no direction such as volume, mass or energy are called scalars.
- Vector can be represented as P and can be divided into fixed (bound) and free (sliding).

Characteristics of vectors:
Addition:

- **Parallelogram law**

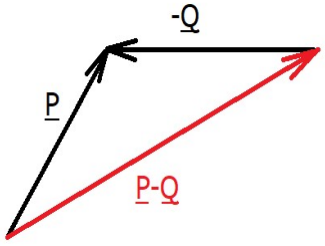


- **Triangle rule**

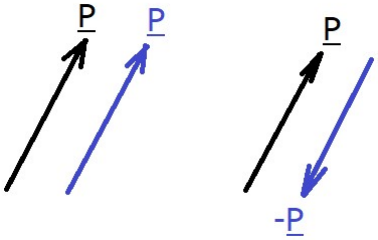


Characteristics of vectors:

- **Subtraction**



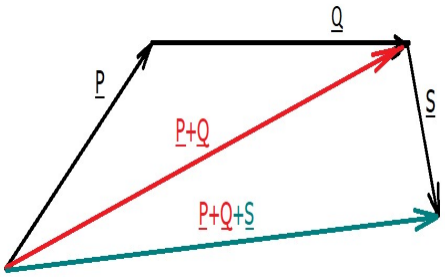
- **Equalization**



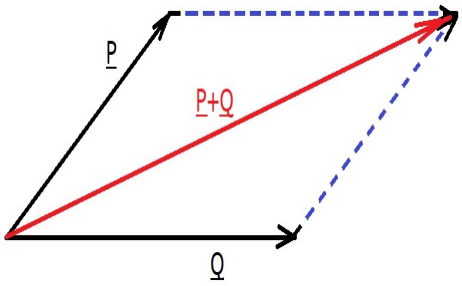
Coplanar vectors:

Vectors contained in the same plane. For addition of three or more vectors:

- **Polygon rule:**



- **Parallelogram or Tringle rule**



Vectors in commutation

Addition

$\underline{P}+\underline{Q}+\underline{S} = (\underline{P}+\underline{Q})+\underline{S}$

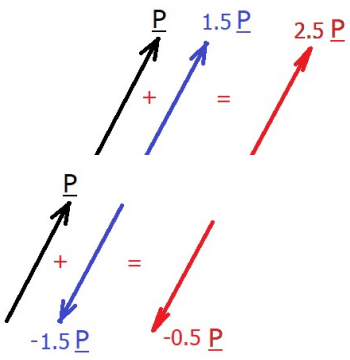
$= (\underline{Q}+\underline{S})+\underline{P}$

$= (\underline{P}+\underline{S})+\underline{Q}$

$= \underline{Q}+\underline{P}+\underline{S}$

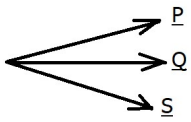
Product

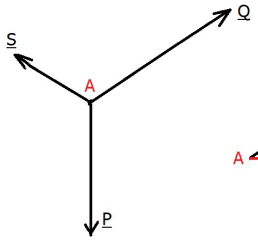
$\underline{P}+\underline{P}+\underline{P}+\underline{P}+\ldots.= n\ \underline{P}$

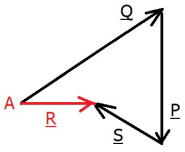


Concurrent Forces

Those passing the same point. For addition, use the polygon rule which is equivalent to the repeated application of parallelogram law.





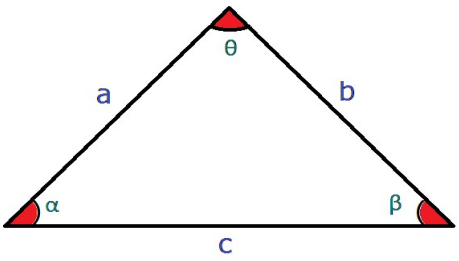


Law of sines

$$\frac{Sin\,\beta}{a} = \frac{Sin\,\alpha}{b} = \frac{Sin\,\theta}{c}$$

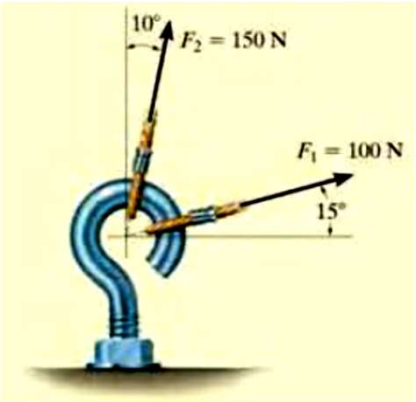
Law of cosines

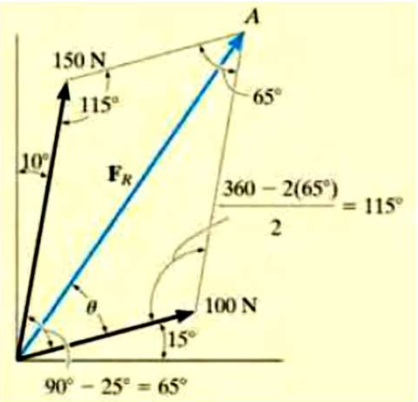
$$a^2 = b^2 + c^2 - 2bc\,Cos\beta$$



Example 1: Two forces act on a bolt, determine the resultant.

Parallelogram method





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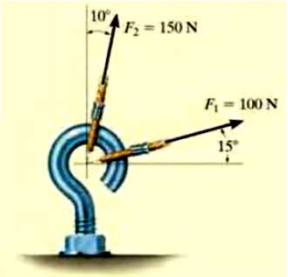


Tringle method:

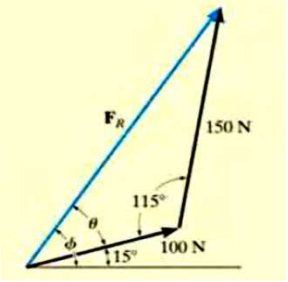
$$F_R = \sqrt{(100\text{ N})^2 + (150\text{ N})^2 - 2(100\text{ N})(150\text{ N})\cos 115°}$$
$$= \sqrt{10\,000 + 22\,500 - 30\,000(-0.4226)} = 212.6\text{ N}$$
$$= 213\text{ N} \qquad \textit{Ans.}$$

Applying the law of sines to determine θ,

$$\frac{150\text{ N}}{\sin\theta} = \frac{212.6\text{ N}}{\sin 115°} \qquad \sin\theta = \frac{150\text{ N}}{212.6\text{ N}}(\sin 115°)$$
$$\theta = 39.8°$$

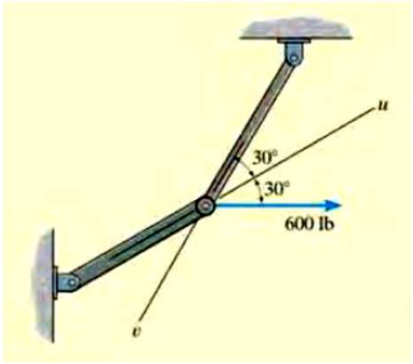
Thus, the direction ϕ (phi) of $\mathbf{F}_R$, measured from the horizontal, is

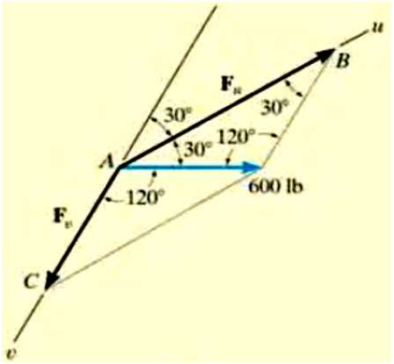
$$\phi = 39.8° + 15.0° = 54.8° \qquad \textit{Ans.}$$



Example 2: Resolve the horizontal force 600lb into two components acting along the u and v axes.

Parallelogram method





Example 2: Resolve the horizontal force 600lb into two components acting along the u and v axes.

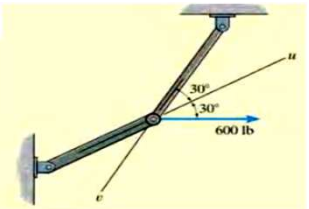
Tringle method:

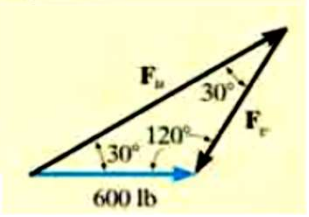
$$\frac{F_u}{\sin 120^\circ} = \frac{600\text{ lb}}{\sin 30^\circ}$$

$$F_u = 1039\text{ lb} \quad \textit{Ans.}$$

$$\frac{F_v}{\sin 30^\circ} = \frac{600\text{ lb}}{\sin 30^\circ}$$

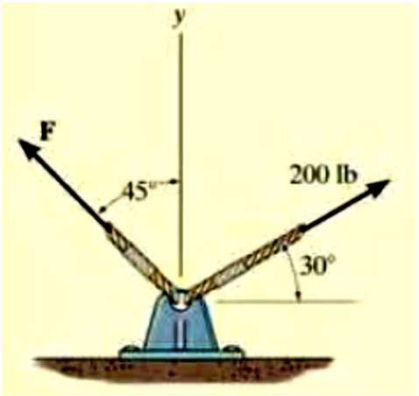
$$F_v = 600\text{ lb} \quad \textit{Ans.}$$

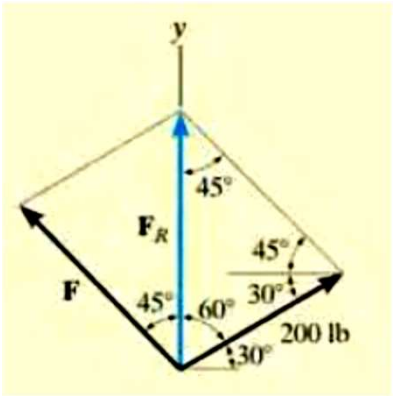




Example 3: Determine the magnitude of F and find the resultant F_R, knowing that F_R is directed along the positive y axis.

Parallelogram method





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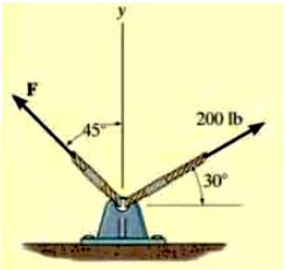
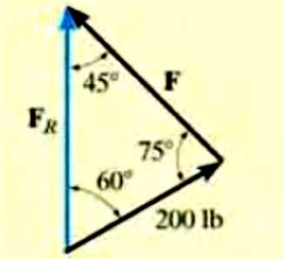


Tringle method:

$$\frac{F}{\sin 60^\circ} = \frac{200\text{ lb}}{\sin 45^\circ}$$

$$F = 245\text{ lb} \qquad \textit{Ans.}$$

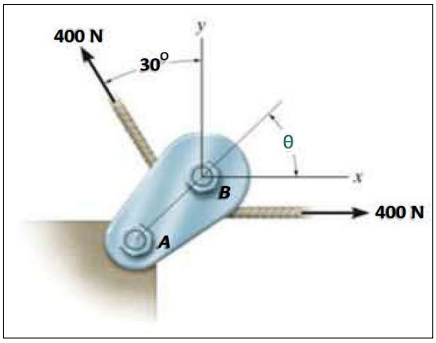


$$\frac{F_R}{\sin 75^\circ} = \frac{200\text{ lb}}{\sin 45^\circ}$$

$$F_R = 273\text{ lb} \qquad \textit{Ans.}$$

HW1:

If the tension in the cable is 400 N, determine the magnitude and the direction of the resultant force acting on the pulley using parallelogram and tringle methods. This is the same angle θ of the line AB on the tailboard block.



HW2:

If the magnitude of the resultant force is to be 9 KN directed along the positive x-axis, determine the magnitude of the force T acting on the eyebolt and its angle θ. Use parallelogram and tringle laws.