Learning unit 1

Force System

Essence

Force is the essence of engineering mechanics. Knowledge of force systems is a necessary basis for further advanced studies of mechanics, such as structural analysis. Stress analysis Force is a type of vector. which must determine both size and direction The combination of forces cannot therefore be done in ordinary algebra. In this unit, we study the nature of various combinations of forces. Both in the plane and in the spatial system.

Learning substance

1. Scalar and vector quantities
2. Combination of forces in a plane
3. Separation force
4. Combining the x-axis and y-axis forces
5. Space force system

Unit performance

1. Shows finding the force in the axial direction x axial y of the given
2. ForceCalculate the net force of a given force.

Learning objectives

1. Explain the meaning of scalars and vectors.
2. Find the total force in the plane.
3. Calculate the force by components the force.
4. Calculate the total force from the sub-forces in the x-y plane.
5. Calculate forces in spatial systems.

Scalar and vector quantities

There are two types of quantities involved in statistics: scalar quantities and vector quantities.

Scalars are quantities that have specific dimensions, such as length, mass, and time.

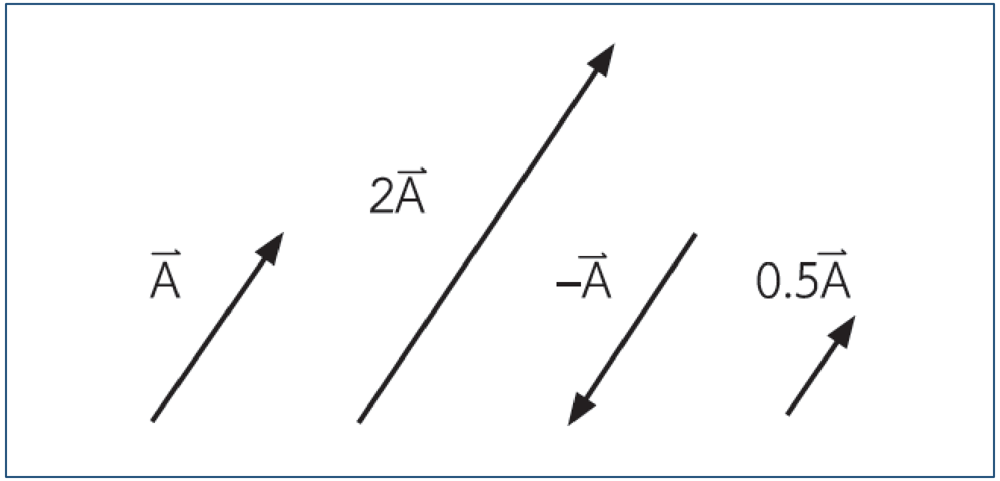
A vector **is a quantity that has both magnitude and direction, such as force, acceleration, and moment.**

Vector quantities can be divided into 3 types:

- Free vector (Free Vector) is a vector that tells the size and direction.
- Sliding Vector is a vector that is horizontal along a stationary line.
- A fixed vector (Fixed Vector) is a vector whose magnitude and direction are determined. Including t exact point of action

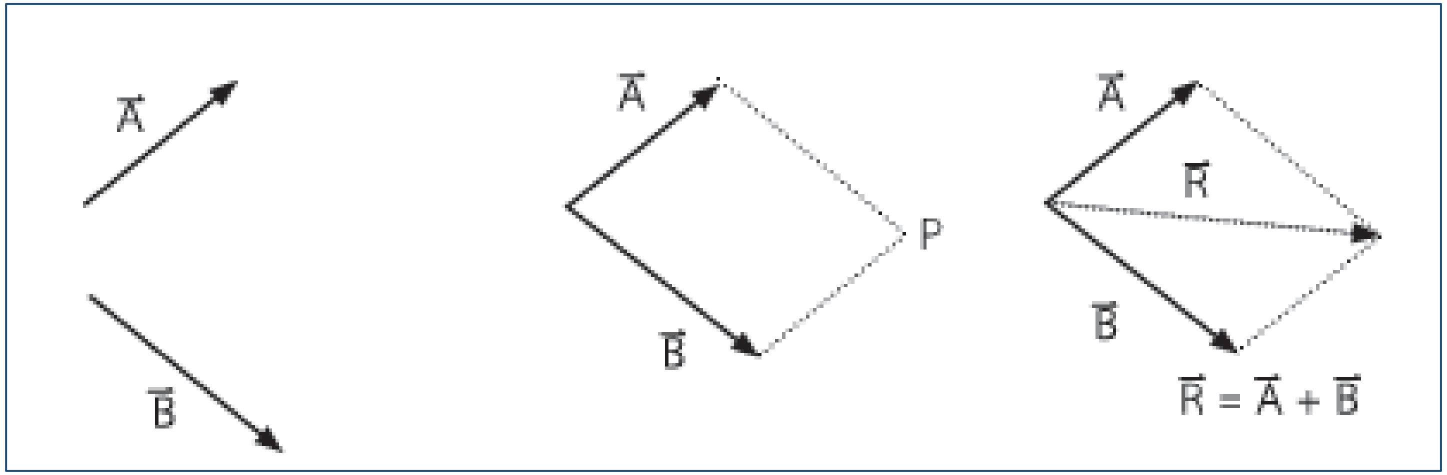
Vector basic knowledge

1. Vectors can be written with arrow signs. The arrowhead indicates the direction of the vector.
2. Multiplying or dividing vectors by scalars A vector increases or decreases in size by the scalar quantity multiplied by the vector. The vector remains in the same direction when the scalar quantity is positive and switches directions when the scalar quantity is negative.



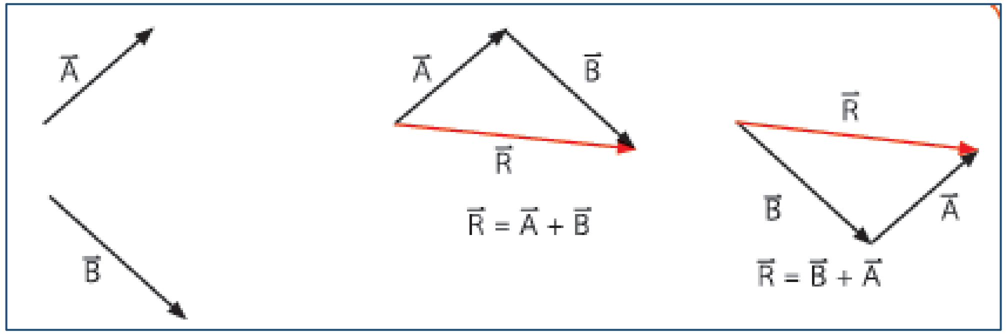
Vector basic knowledge

3. Vector integration begins by joining the tails of the two vectors together. Then draw a line parallel to the two forces. The intersection point of the parallel lines is at the point P The resultant vector R is formed by drawing a line from the connecting point of the two vectors to the point P, that is, $\vec{R}=\vec{A}+\vec{B}$.

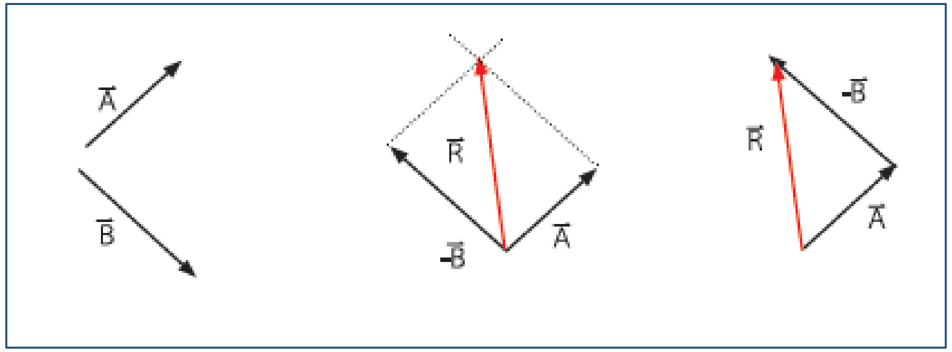


Vector basic knowledge

Additionally, vectors can be combined using the triangle rule. It is a vector B combined with vector A According to the principle of "Head-to-Tail”In conclusion, it can be concluded that $\vec{R}=\vec{A}+\vec{B}=\vec{B}+\vec{A}$



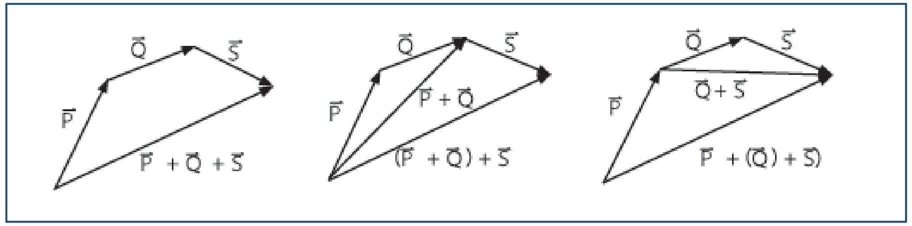
Vector subtraction section The same method applies to combining normal vectors. different that change the direction of the vector $\vec{R}=\vec{A}=\vec{B}=\vec{A}+(-\vec{B})$



Vector basic knowledge

In the case of wanting to combine 3 or more vectors. For example, there is a vector P Q and S Combine the first two vectors first, then add the result to the next vector.

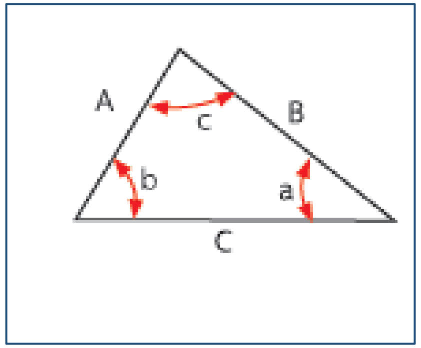
$$\vec{P}+\vec{Q}+\vec{S}=(\vec{P}+\vec{Q})+\vec{S}=\vec{P}+(\vec{Q}+\vec{S})$$



Force is a vector quantity. The result of the action of a force depends on both the size and the direction in which the force acts on the object. Force tries to cause an object to change or move.

- Magnitude indicates the amount of force. Its unit is Newton (N).
- Direction describes the direction of the applied force by measuring the line of force with a reference axis.

Combination of forces in a plane

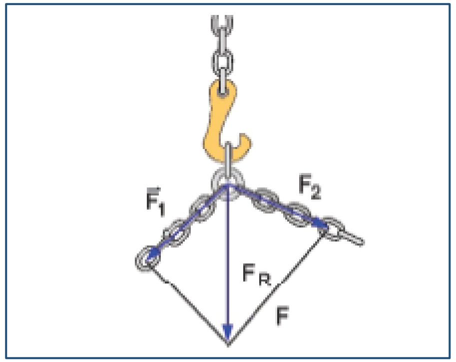


Law of Cosines

C= $\sqrt{A^2 + B^2 - 2ABcos\ c}$

Law of sines

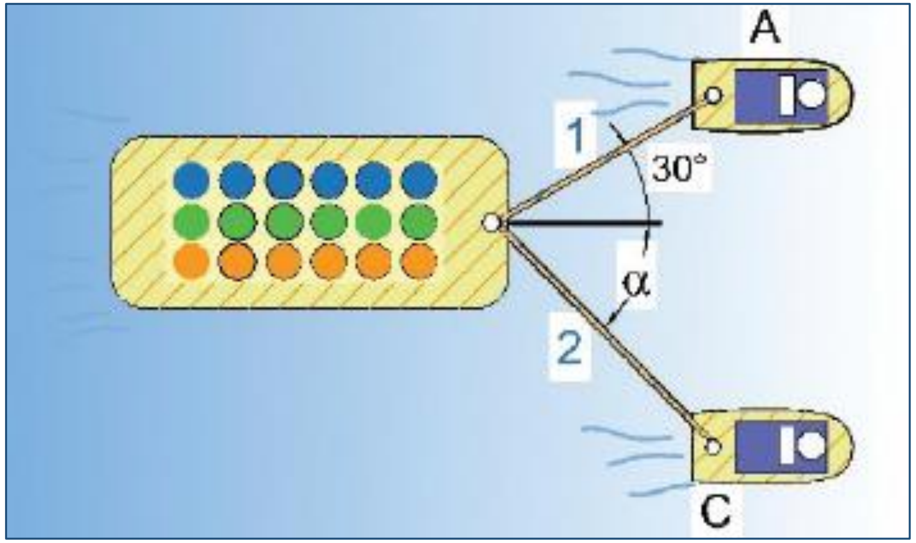
$\frac{A}{sine\ a} = \frac{B}{sine\ b} = \frac{C}{sine\ c}$

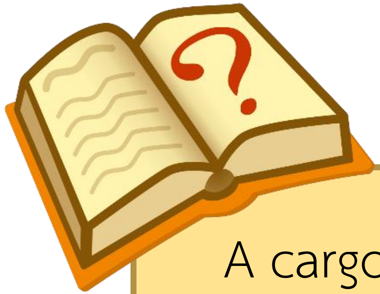


An example image is a force acting.Connect the hook to lift weights.

Force is considered a vector. This is because forces have both magnitude and direction.Calculation of net force follows the law of vector integration.

Sample Problem





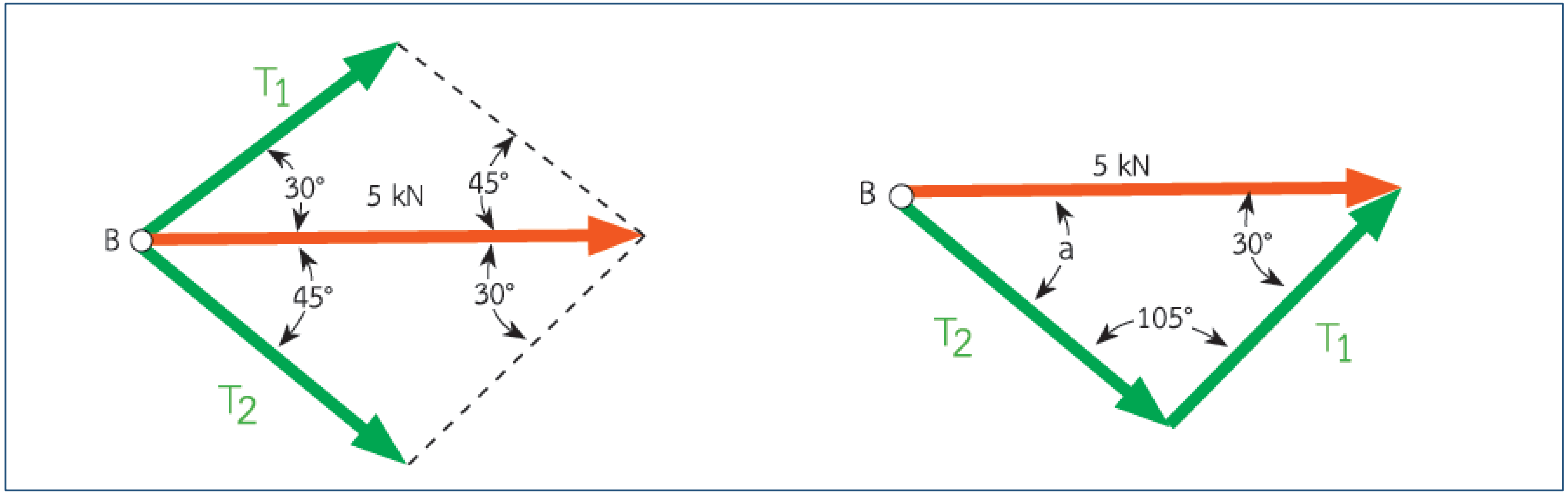
A cargo ship has 2 tug boats as shown. If the net force of these 2 boats is 5 kilonewtons and has the same direction as the cargo ship, calculate.

a) The tensile force in both ropes when α = 45°

b) The value of α When the tensile force in the second rope is the least.

Solution

a) Finding the tension in a rope This can be done by drawing a figure using the parallelogram rule and calculating from trigonometry as follows.

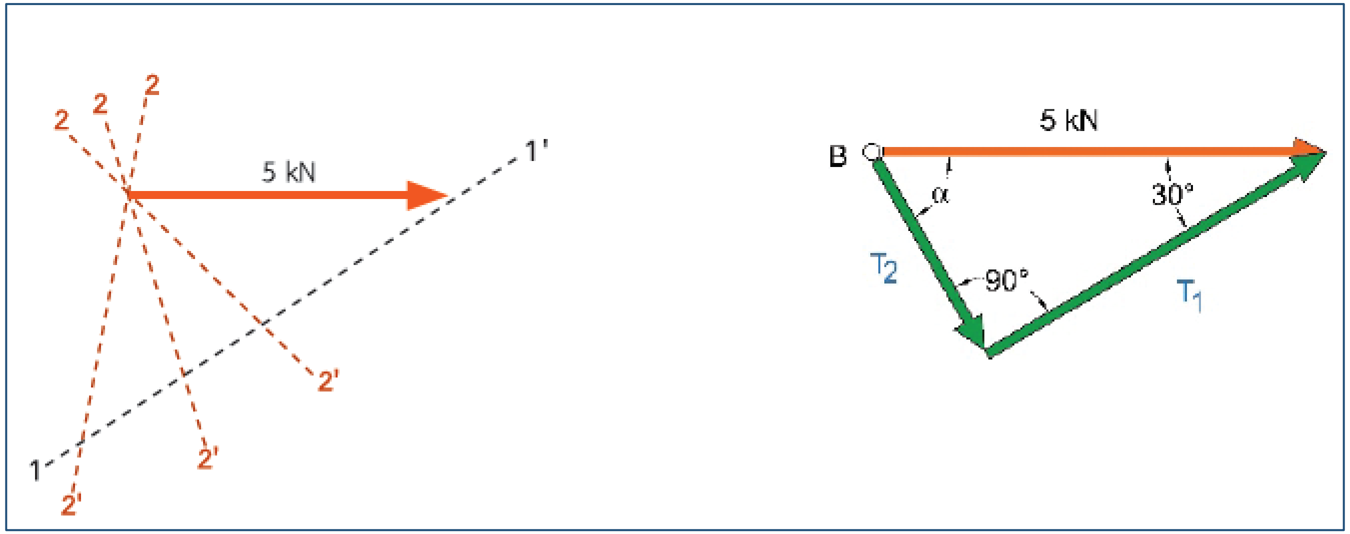


$$\frac{T_1}{\text{Sin } 45^\circ} = \frac{T_2}{\text{Sin } 30^\circ} = \frac{5\text{kN}}{\text{Sin } 105^\circ}$$

$\therefore$ T_1 = 3.66 kN $\quad$ T_2 = 2.59 kN

Solution

b) Fine α When the tension on the second rope is the least using the triangle rule. Start by drawing lines 1-1 represents the line of tension in the rope1 (T_1) Line of tension in a rope T_2 (2-2) There can be many lines. But the shortest line is The line that creates the minimum pulling force. That's the line.1-1 กับ 2-2 Perpendicular to each other, so T_2 Can be calculated as follows:

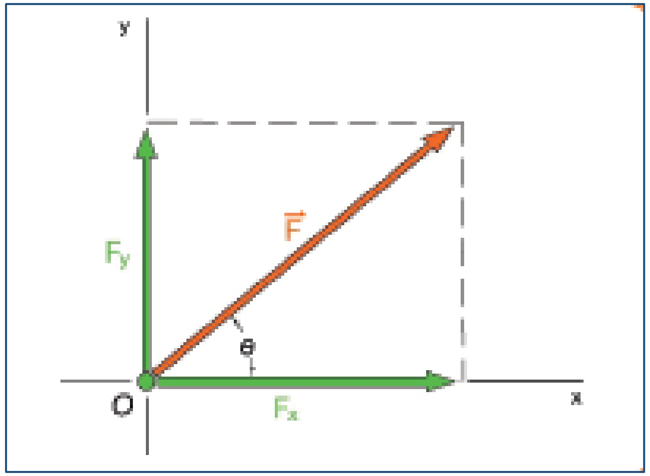


T_2 = (5 kN) sin 30° = 2.5 kN

T_1 = (5 kN) cos 30° = 4.33 kN

α = 90°-30° = 60°

Rectangle components



In solving problems in some cases, it is necessary to use the rectangle components. method. Force F resolved into a component x-y axis It is called the Rectangle components in the x-y axis. (F_x) , (F_y) Accordingly, this force break is drawn using a ectangular drawing

Where θ is the angle that force F acts on the x-axis.

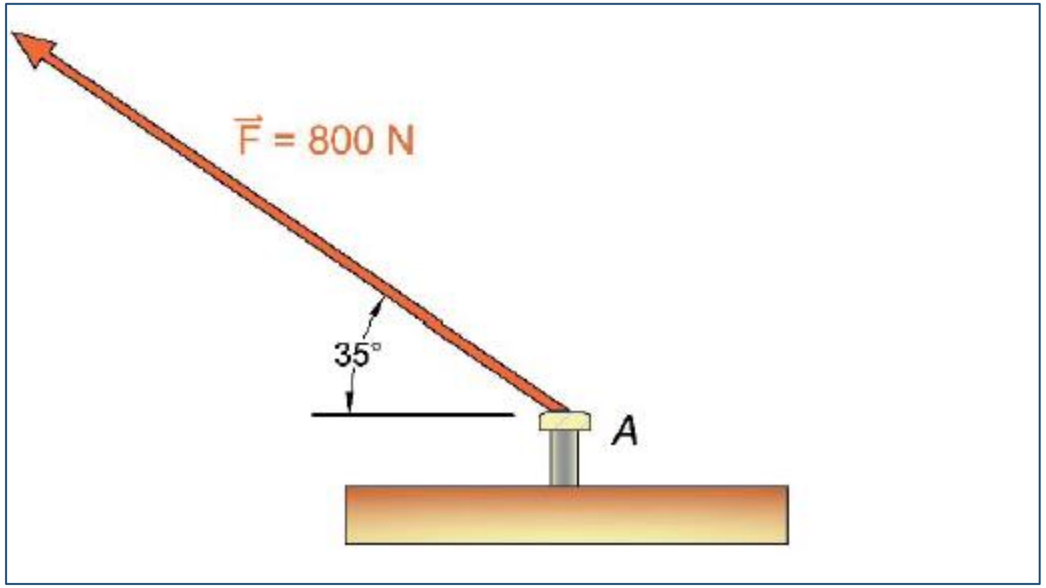
$$F_x = F \cos \theta$$

$$F_y = F \sin \theta$$

$$\tan \theta = \frac{F_x}{F_y}$$

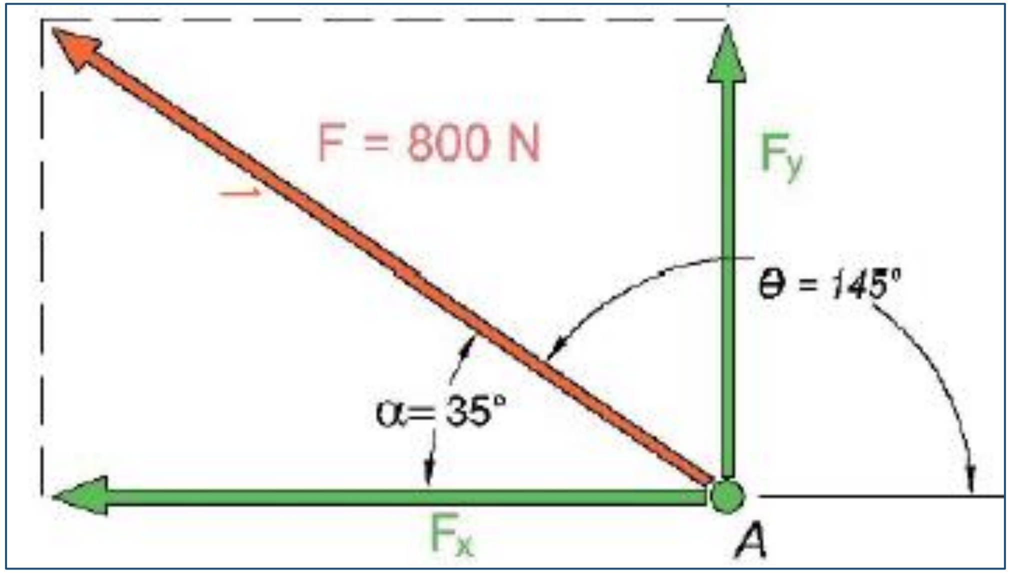
$$F = \sqrt{F_x^2 + F_y^2}$$

Sample Problem



There is a force of 800 newtons acting on pin A as shown. Calculate the force in the x-axis and y-axis

Solution

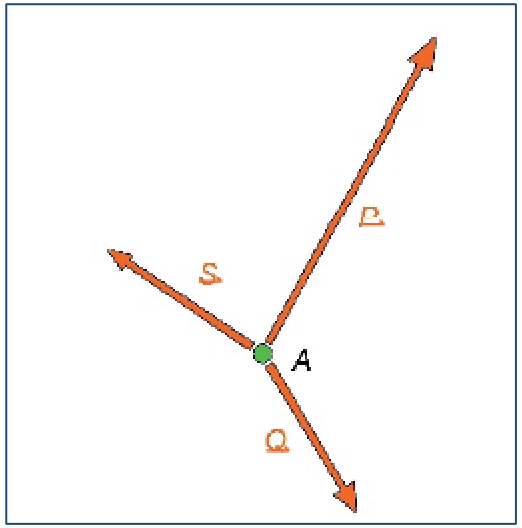


$$F_x = -\,F\cos\alpha$$
$$= -(800N)\cos 35^{\circ}$$
$$= -655\ N$$

$$F_y = +\,F\sin\alpha$$
$$= +(800N)\sin 35^{\circ}$$
$$= +459\ N$$

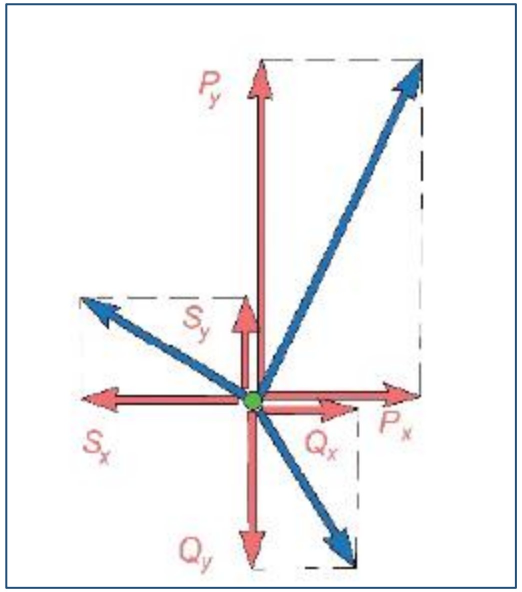
Addition the x-axis and y-axis forces

There are 3 forces, P Q S, acting on point A (a). To combine these 3 forces, start by breaking each force. It is released as a force in the x-axis and y-axis (b).



$$\vec{R}=\vec{P}+\vec{Q}+\vec{S}$$

(a)



(b)

$$R_x = P_x + Q_x + S_x$$

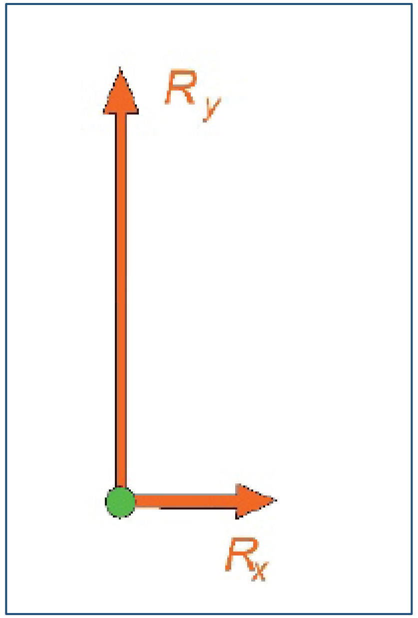
$$R_y = P_y + Q_y + S_y$$

Or it can be written that

$$R_x = \sum F_x$$

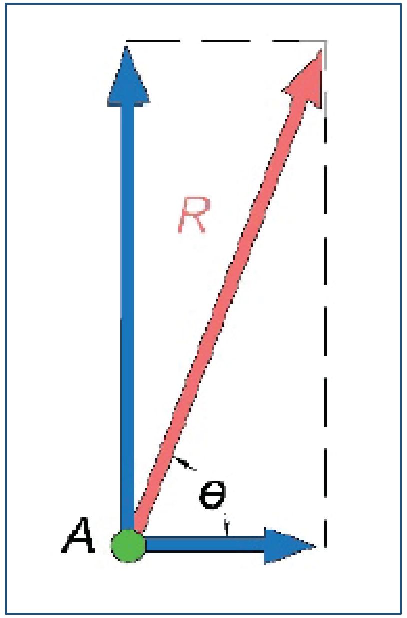
$$R_y = \sum F_y$$

Rectangular components the x-axis and y-axis forces



(c)

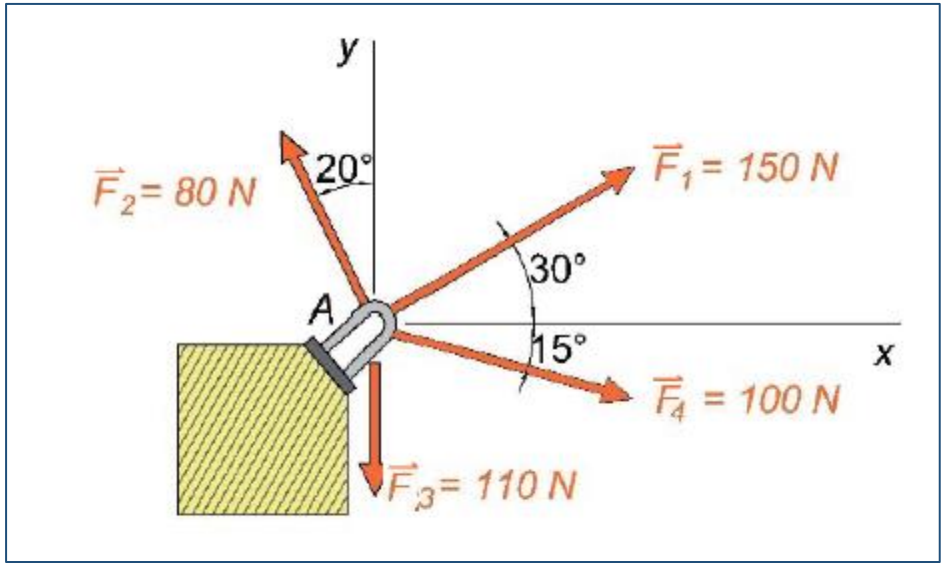
Total force in the x axis and the y axis as shown (c).



(d)

Find the total force R using the parallelogram rule. The total force R is shown in figure (d).

Sample Problem

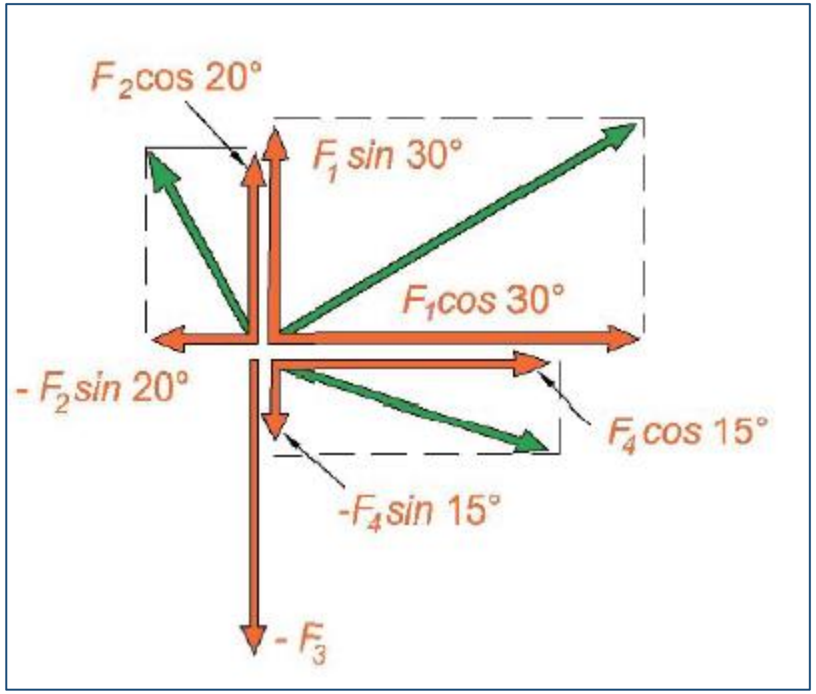


There are 4 forces acting on pin A as shown. Divide the net force acting on pin A.

Solution

Calculate the partial force along the x-axis and y-axis of each force. The force is positive or negative depending on the axial direction.

That is, the force along the x axis is positive when the force is directed to the right. The force along the y axis is positive in the upward direction.

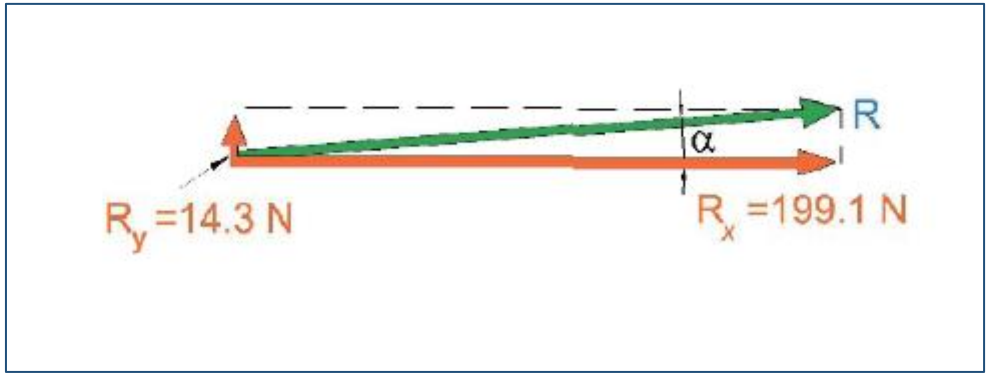


Sample Problem

The component forces of each force are shown in the table.

Force	Magnitude (N)	x Component (N)	y Component (N)
F_1	150	+129.9	+75.0
F_2	80	-27.4	+75.2
F_3	110	0	-110.0
F_4	100	+96.6	-25.9
		R_x = +199.1	R_y = +14.3

Solution



Resultant R $= \sqrt{R_x^2 + R_y^2}$

$= \sqrt{(+199.1)^2 + (+14.3)^2}$

= 199.6 N

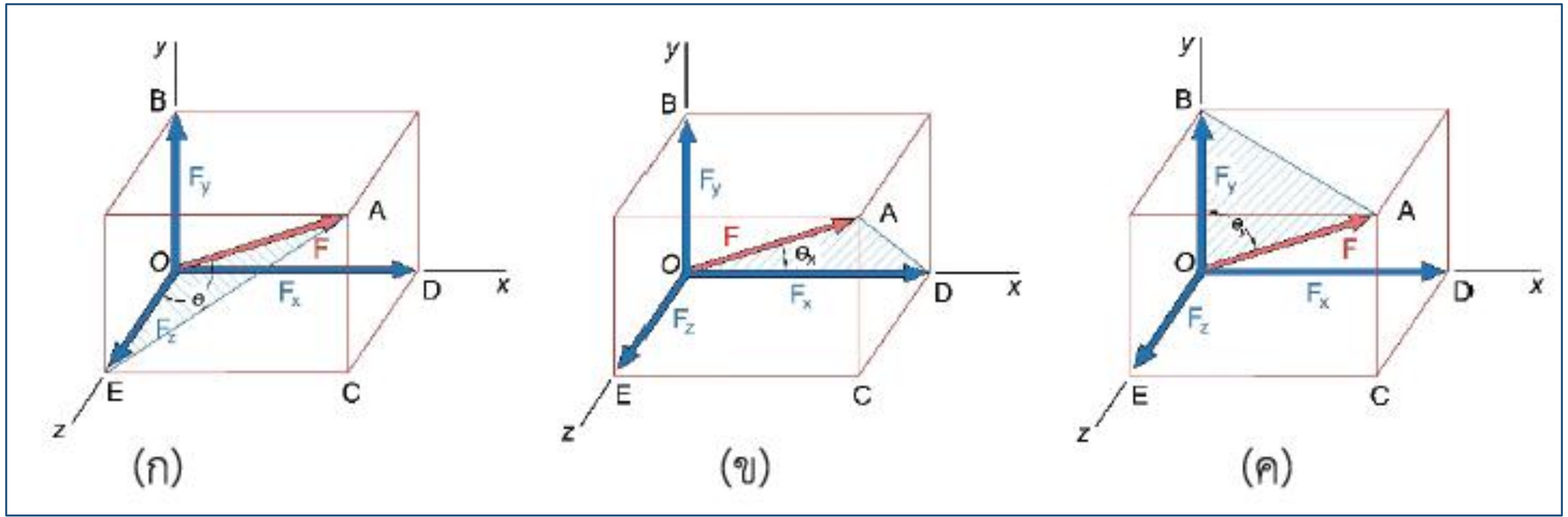
tan θ $= \frac{R_y}{R_x} = \frac{14.3\ N}{199.1\ N}$

α = 4.1°

∴ result of force 199.6 N ∡ 4 °

Force in three dimensional space

A force F resolved into retangular components F_x F_y and F_z we have



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

$$F_x = F\cos\theta_x \qquad F_y = F\cos\theta_y$$

$$\cos^2\theta_x + \cos^2\theta_y + \cos^2\theta_z = 1$$

When the angle θ_x θ_y และ θ_z is the angle that the force F acts on the x, y, and z axes, respectively.

Sample poblem

Force F magnitude 500 N act angle 60 ° 45° and 120 ° with the axis x and the axisz y and the axis z In order, calculate F_x F_y *and* F_z

Solution

From the question, know that F= 500 N

and θ_x = 60 ° θ_y = 45° *and* θ_z = 120 °

F_x = (500 N) cos 60 ° = +250 N

F_y = (500 N) cos 45 ° = +354 N

F_z = (500 N) cos 120 ° = -250 N