Statics SKMM1203
Introduction to Statics and Resultant (2D)

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Brief introduction to Statics

Brief Concept:
Definition of Mechanics as a subject of study: Mechanics is the science that describes and predicts the conditions of rest or motion of bodies under the action of forces. It is the foundation of most engineering sciences and is an indispensable prerequisite to their study.

The foundation of the mechanics is Statics. A subject that deals with Equilibrium of bodies with either:

- •Stationary
- •Move with constant velocity

The idealizations throughout this course are:

- •Particles ➔has a mass and size can be neglected
- •Rigid Body ➔ a combination of a large number of particles that do not deform
- •Concentrated Force ➔ the effect of a loading

Brief introduction to Statics

Fundamental Laws:

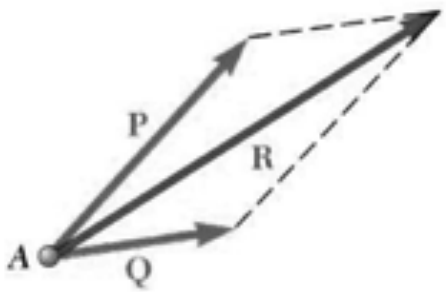
Newton's First Law: If the resultant force on a particle is zero, the particle will remain at rest or continue to move in a straight line.

Newton's Second Law: A particle will have an acceleration proportional to a nonzero resultant applied force.

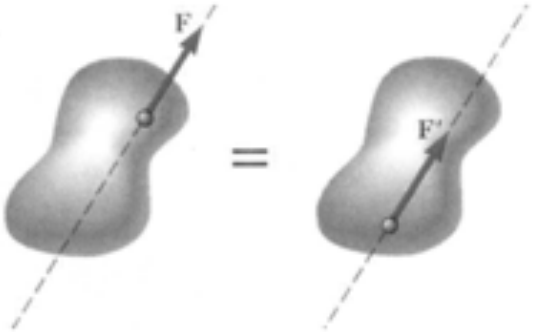
Newton's Third Law: The forces of action and reaction between two particles have the same magnitude and line of action with opposite sense.

2D-Vector

Basic 2D Vector:



- *Parallelogram Law*



- *Principle of Transmissibility*

Cosine Law:

$$R^2 = P^2 + Q^2 - 2PQ\cos B$$

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

Sine Law:

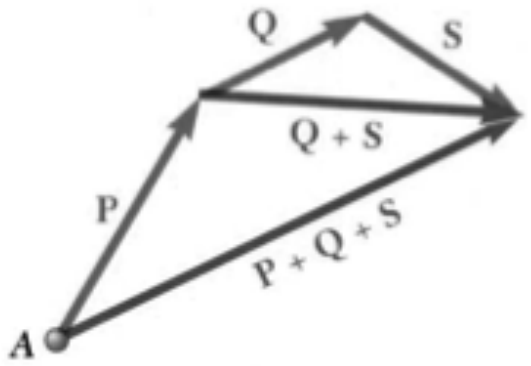
$$\frac{\sin A}{Q} = \frac{\sin B}{R} = \frac{\sin C}{A}$$

2D-Vector

Commutative, Associative.

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

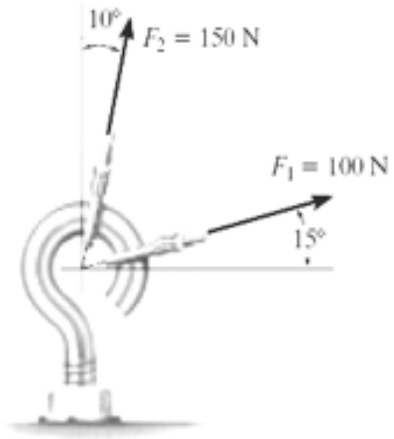
$$\vec{P} + \vec{Q} + \vec{S} = (\vec{P} + \vec{Q}) + \vec{S} = \vec{P} + (\vec{Q} + \vec{S})$$



2D-Vector

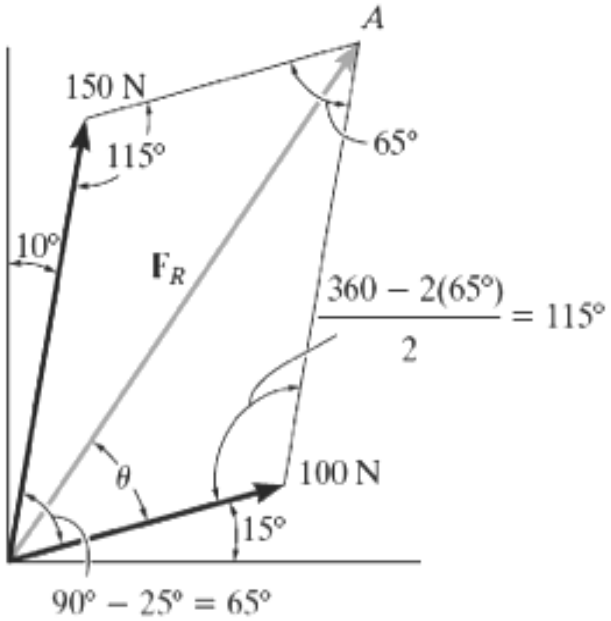
Example:

Q1. Determine the magnitude and direction of the resultant force.



A1:

a. Parallelogram



2D-Vector

Apply Cosine Law:

$$F_R = \sqrt{(100N)^2 + (150N)^2 - 2(100N)(150N)\cos 115^\circ}$$

$$= \sqrt{10000 + 22500 - 30000(-0.4226)} = 212.6N = 213N$$

Apply Sine Law:

$$\frac{150N}{\sin\theta} = \frac{212.6N}{\sin 115^\circ}$$

$$\sin\theta = \frac{150N}{212.6N}(0.9063)$$

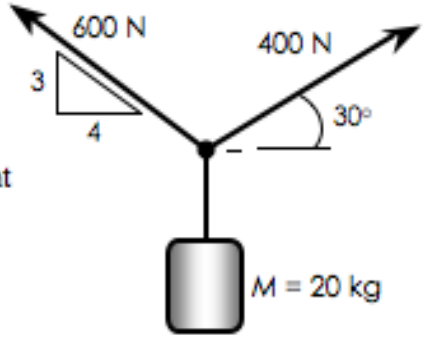
$$\theta = 39.8^\circ$$

2D-Vector

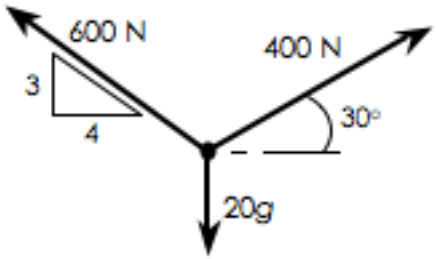
Q2.

a. Determine the resultant force for the system shown.

b. Determine the change in the mass M if the resultant force is horizontal.



A2:



a.

$(+\rightarrow)\Sigma F_x = R_x$

$R_x = 400\cos 30^\circ - 600\cos\theta$

$R_x = 346.4 - 480 = -133.6$

$\therefore \quad R_x = 133.6 \text{ N} \leftarrow$

$(+\uparrow)\Sigma F_y = R_y$

$R_y = 400\sin 30^\circ + 600\sin\theta - 20g$

$R_y = 200 + 360 - 196.2$

$R_y = 363.8 \text{ N} \uparrow$

$R = \sqrt{363.8^2 + 133.6^2} = 387.6 \text{ N}$

$\theta = \tan^{-1}(363.8/133.6) = 69.8^\circ$

b.

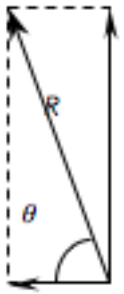
$(+\uparrow)\Sigma F_y = 0$

$400\sin 30^\circ + 600\sin\theta - Mg = 0$

$Mg = 200 + 360$

$M = 57.1 \text{ kg}$

mass added: $57.1 - 20 = 37.1 \text{ kg}$

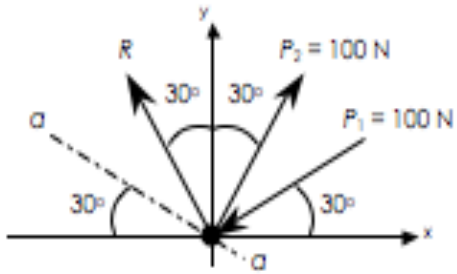


2D-Vector

Q 3

a. R is the resultant of three forces P_1, P_2 and P_3 (P_3 acts on the line aa). Determine the force P_3 and R.

b. Determine the two components of the force P_1 along the aa and x axes.



A3

a.

$(+\rightarrow)$

$-100\cos 30^\circ + 100\sin 30^\circ - P_3\cos 30^\circ = -R\sin 30^\circ$

$-86.6 + 50 - 0.866\,P_3 = -0.5\,R$

$-36.6 - 0.866\,P_3 = -0.5\,R$

$36.6 + 0.866\,P_3 = 0.5\,R$ (1)

$(+\uparrow)$

$-100\sin 30^\circ + 100\cos 30^\circ + P_3\sin 30^\circ = R\cos 30$

$-50 + 86.6 + 0.5\,P_3 = 0.866\,R$

$36.6 + 0.5\,P_3 = 0.866\,R$ (2)

(1) × 0.866 $42.3 + P_3 = 0.577\,R$ (3)

(2) × 0.5 $73.2 + P_3 = 1.732\,R$ (4)

$-30.9 = -1.155\,R$

$R = 26.8$ N

input $R = 26.8$ N into (3)

$42.3 + P_3 = 0.577(26.8)$

$P_3 = -26.8$ N

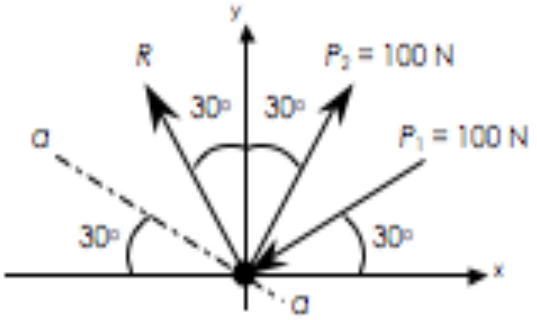
$\therefore \quad P_3 = 26.8$ N $\searrow 30^\circ$

2D-Vector

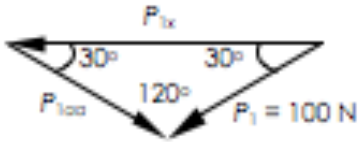
Q 3

a. R is the resultant of three forces P_1, P_2 and P_3 (P_3 acts on the line aa). Determine the force P_3 and R.

b. Determine the two components of the force P_1 along the aa and x axes.



b.



sin rule $$\frac{100}{\sin 30^\circ} = \frac{P_{1aa}}{\sin 30^\circ} = \frac{P_{1x}}{\sin 120^\circ}$$

30°

$P_{1aa} = 100$ N

$P_{1x} = 173.2$ N ←

2D-Vector

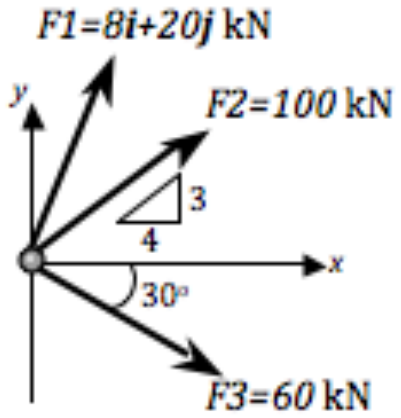
Q 4

Four forces; *F1,F2,F3* and F_4 (not shown) are applied onto a stationary particle.

a. Find the force F_4 for the particle to remain stationary.

b. Find the vertical component of F_4 to start moving the particle along the *x*-axis.

c. Explain the condition of force F_4 to start moving the particle along the *y*-axis.



2D-Vector

A4

a. $\rightarrow F1+\square F2+\square F3+\square F4=\square R=0$

$(+\rightarrow)$ $8+10045+60\cos 30o+F4x=0$

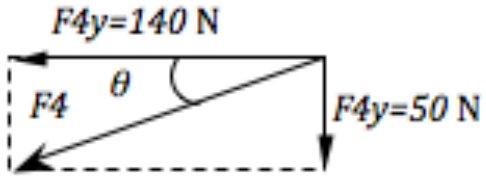
$F4x=-140$ N

$\therefore$ $F4x=140$ N $(\leftarrow)$

$(+\uparrow)$ $20+10035-60\sin 30o+F4y=0$

$F4y=-50$ N

$\therefore$ $F4y=50$ N $(\downarrow)$



$F4=1402+502=148.7$ N

$\theta=\tan-150140=19.65o$

b.

$(+\uparrow)$ $20+10035-60\sin 30o+F4y=0$

$F4y=-50$ N

$\therefore$ $F4y=50$ N $(\downarrow)$

c.

$(+\rightarrow)$ $8+10045+60\cos 30o+F4x=0$

$F4x=-140$ N

$\therefore$ $F4x=140$ N $(\leftarrow)$

and

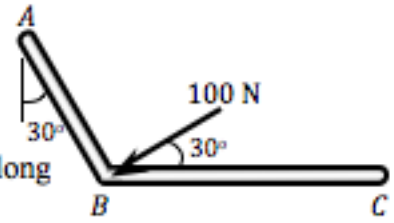
$F4y\neq+50$ N

2D-Vector Practice Problems

Practice:

PQ1.

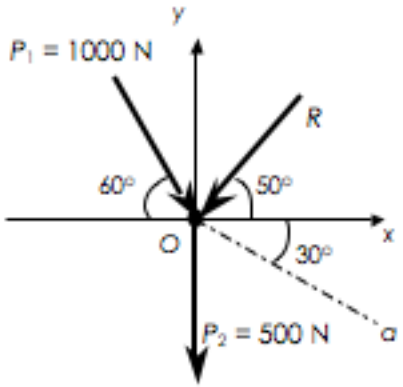
Determine components of the 100 N force along *AB* and *BC* axes.



PQ 2

a. *R* is the resultant of three forces P_1, P_2 and P_3 (P_3 acts on the line *Oa*). Determine the forces P_3 and *R*.

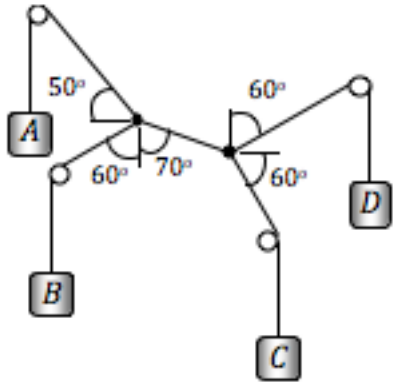
b. Determine the two components of the force P_1 along the *Oa* and *x* axes.



2D-Vector Practice Problems

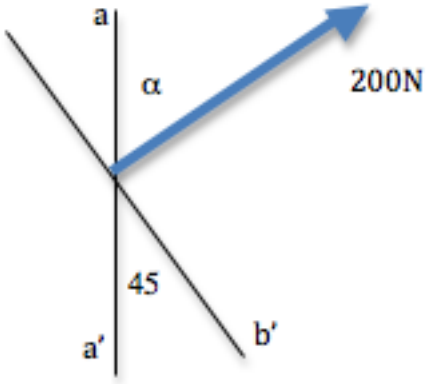
PQ 3

If m_D = 100 kg determine m_B, m_C and m_D so that the system is in equilibrium.



PQ 4

200N force is to be resolved into components along a-a' and b-b'. Determine the angle a knowing that along b-b' is 120N. Also compute the a-a'

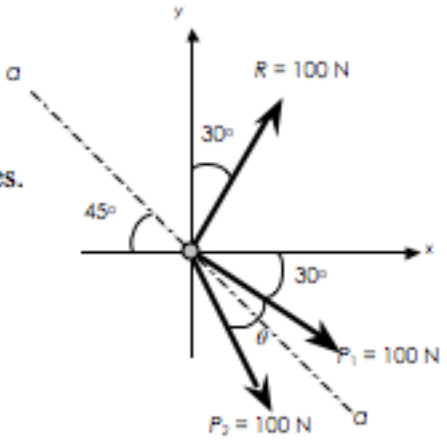


2D-Vector Practice Problems

PQ 5

$R = 100$ N is the resultant of three forces P_1, P_2 and P_3 (acts on the line aa). Determine the angle θ and the force P_3.

Determine components of the resultant along the x and aa axes.

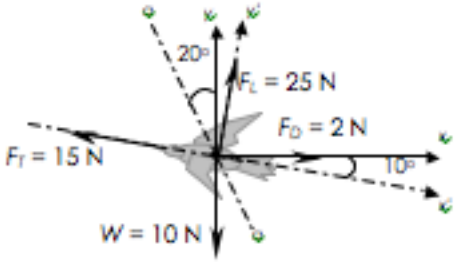


PQ 6

Four forces act on a bird in flight, as shown in the figure; its weight, the thrust F_T, the lift F_L provided by the wings, and the drag F_D resulting from its motion through air. Determine

a. the resultant of the four forces and its line of action with respect to the $x-$axis.

b. the components of the resultant in the aa and $x'x'$ directions.



2D-Vector Practice Problems

PQ 7

A 6 kg mass at E is supported as shown. Determine tension in the spring and cable AB.