ME 1211: Basic Mechanical Engineering

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Course Outline

Academic Week No.	Description	Assessment Method(s)
1	Fundamental concepts (system, property, path and process, pressure	
2	Concepts of Heat and Work, Zeroth Law	Quiz 1
3	1st Law of Thermodynamics	
4	2nd Law of Thermodynamics	
5	Flow and Non-flow processes	Quiz 2
6	Gas power cycle	
7	Refrigeration cycle	
8	Introduction to Mechanics: Statics Statics of Particles	
9	Equilibrium of a Particle	
10	Equilibrium of Rigid Bodies	
11	Analysis of Structures	Quiz 3
12	Introduction to Dynamics: Kinematics of Particles	
13	Kinetics of Particles: Newton's Second Law	Quiz 4
14	Introduction to Robotics	

Mark Distribution

Marks distribution for ME 1211 (Carry same weight for both part)

Attendance	= 10
Class test	= 20
Final exam	= 70
Total	= 100

Reference Books

A Textbook of Thermal Engineering by R.S Khurmi and J.K Guptas

Vector Mechanics for Engineers by Beer, Johnston, Mazurek, Cornwell & Sanghi, Tenth Edition (2013)

Engineering Mechanics: Statics by R.C Hibbeler (12th Edition)

Automobile Engineering (Volume 2) by Dr. Kirpal Singh (12th Edition)

A Textbook of Refrigeration and Air Conditioning by R.S Khurmi

Robotics by Wikibooks (https://en.wikibooks.org/wiki/Robotics)

Reference Books (Recommended)

Fundamentals of Thermal-Fluid Sciences by Çengel, Cimbala, & Turner, Fifth Edition (2017)

Introduction to Robotics: Analysis, Control, Applications by Saeed B, Niku 2nd Edition.

Department of Energy, Fundamentals Handbook: THERMODYNAMICS,

Heat Transfer, And Fluid Flow, Module 1 – Thermodynamics.

https://www.steamtablesonline.com/pdf/Thermodynamics- Volume1.pdf

MIT, Lecture Notes on "Internal Combustion Engines",

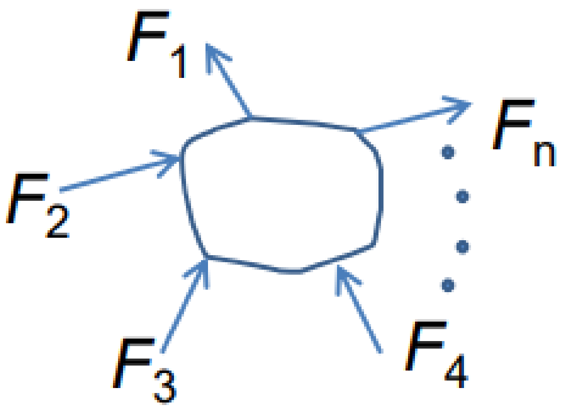
https://ocw.mit.edu/courses/mechanical-engineering/2-61-internal-combustion-engines-spring-2017/lecture-notes/

Prof. Mihir Kumar Sutar, Lectures notes on Engineering Mechanics

http://www.vssut.ac.in/lecture_notes/lecture1423904717.pdf

Chapter 1

Mechanics: It is that branch of science which describes and predicts the conditions of rest or motion of bodies under the action of forces.



- What is the condition for which the body will be in motion or at rest?

- The study of mechanics gives the Answer.

Classification of Mechanics

Mechanics is divided into three classes

1. Mechanics of rigid bodies: The bodies that do not deform under the action of forces are called rigid bodies

It has two subdivisions:

(a) Statics: It deals with the bodies at rest.

(b) Dynamics: It deals with the bodies in motion.

2. Mechanics of deformable bodies: Deformable bodies are those bodies that deform under the action of forces. Strength of material and Elasticity are concerned with deformable bodies.

Classification of Mechanics

3. Mechanics of fluid:

(a) Incompressible fluid: Volume or density does not change under the action of forces. Ex.: Liquid

(b) Compressible fluid: Volume or density does change under the action of forces. Ex.: Gas, air, etc.

Fundamental Concepts

The basic concepts used in mechanics are **space**, **time, mass,** and **force.**

Space: Associated with the notion of the position of a point P with respect to a frame of reference.

Time: To define an event, it is not sufficient to indicate its position in space. The time of the event should also be given.

Mass: Used to characterize and compare bodies on the basis of certain fundamental mechanical experiments.

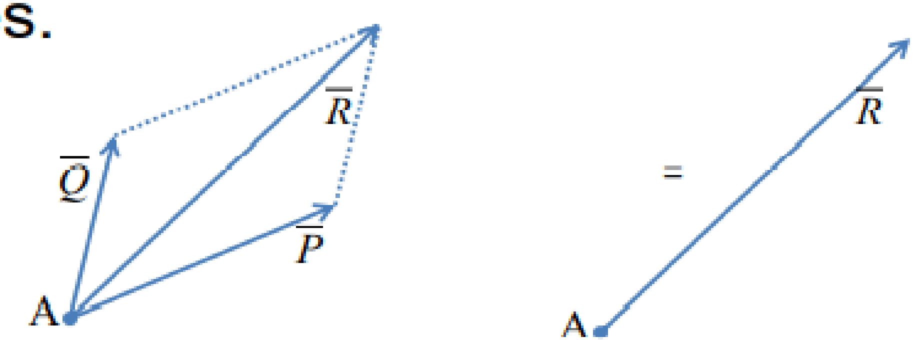
Force: A force represents the action of one body on another. It is characterized by its (i) point of application, (ii) its magnitude, and (iii) its direction ; a force is represented by a vector

Fundamental Principles

The study of elementary mechanics rests on six fundamental principles based on experimental evidence.

1. Parallelogram law for the addition of forces:

- ❑ Two forces acting on a particle may be replaced by a single force, called their resultant.
- ❑ The resultant is obtained by drawing a diagonal of the parallelogram with sides equal to the given forces.

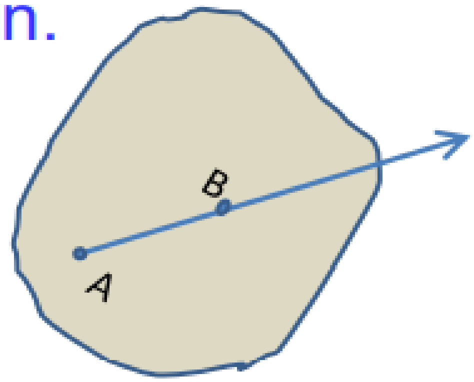


- ❑ Same effect on the particle A

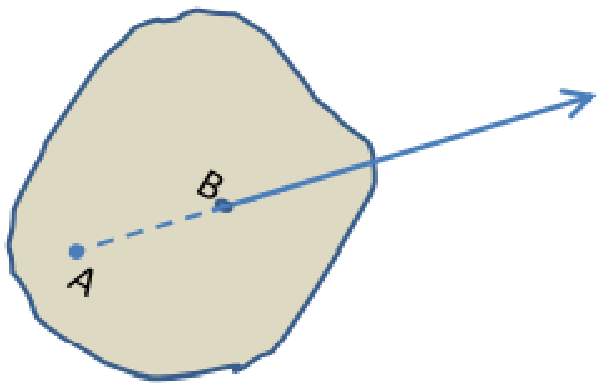
Fundamental Principles

2. The principle of transmissibility:

- States that the conditions of equilibrium or of motion of a rigid body will remain unchanged if a force acting at a given point of the rigid body is replaced by a force of the same magnitude and same direction, but acting at a different point, provided that the two forces have the same line of action.



Acting at point A



Acting at point B

- Two forces have the same effect on the body.

Fundamental Principles

3. Newton's first law:

If the resultant force acting on a particle is zero, the particle will remain at rest (if originally at rest) or will move with constant speed in a straight line (if originally in motion).

4. Newton's 2nd law:

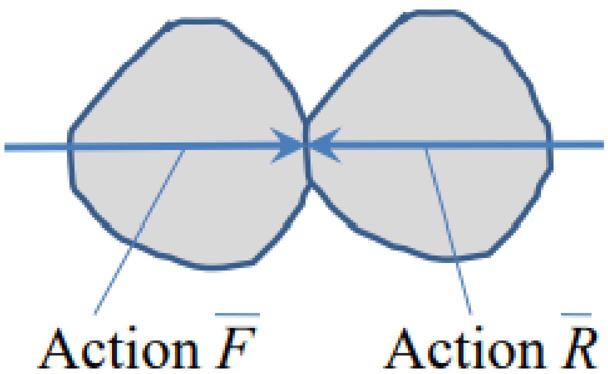
If the resultant force acting on a particle is not zero, the particle will have an acceleration proportional to the magnitude of the resultant and in the direction of this resultant force.

$$\overline{F} = m\overline{a}$$

Fundamental Principles

5. Newton’s third law:

The forces of action and reaction between bodies in contact have the (i) same magnitude, (ii) same line of action, and (iii) opposite sense.



(i) $F = R$ (same magnitude)

(ii) Same line of action

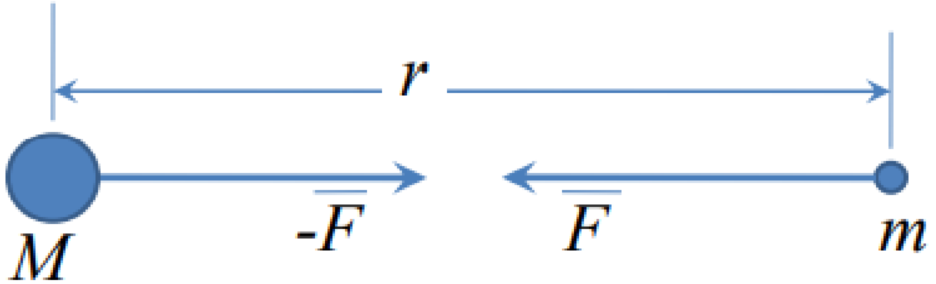
(iii) Opposite sense

Fundamental Principles

6. Newton's law of gravitation:

This states that two particles of mass M and m are mutually attracted with equal and opposite forces $\overline{F}$ and $-\overline{F}$ of magnitude F given by the formula

$$F = G\frac{Mm}{r^2}$$



G = constant of gravitation

System of Units

•*International System of Units* (SI) or Metric System :
The basic units of length, time, and mass which are defined as meter (m), second (s), and kilogram (kg).

•The unit of Force is derived as below,

$$F = ma$$

$$1\,\mathrm{N} = (1\,\mathrm{kg})\left(1\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)$$

$W = mg$ $\quad g = 9.81\ \mathrm{m/s^2} = 32.2\ \mathrm{ft/s^2}$

QUANTITY	DIMENSIONAL SYMBOL	SI UNITS: UNIT		SI UNITS: SYMBOL
Mass	M	Base units	kilogram	kg
Length	L	Base units	meter	m
Time	T	Base units	second	s
Force	F		newton	N

U. S. Customary UNITS

U.S. Customary units (or foot-pound-second (FPS) units):

- Mass : slugs (*No symbol*)
- Length: foot (symbol ft)
- Time: second (symbol sec)
- Force: pound (symbol lb)

Note: In U.S. units the pound is also used on occasion as a unit of mass. When distinction between the two units is necessary, the force unit is frequently written as lbf and the mass unit as lbm.

Other units of force in the U.S. system which are in frequent use, are the *kilopound* (= 1000 lb), and the *ton* (= 2000 lb)

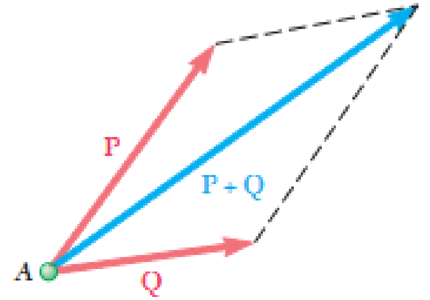
Chapter 2

- As mentioned earlier, a force is characterized by its (i) point of application, (ii) its magnitude, and (iii) its direction.
- Forces acting on a given particle have the same point of application. Thus, each force in this chapter will be defined by its (i) magnitude and (ii) its direction.

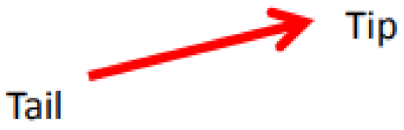
Addition of Vectors

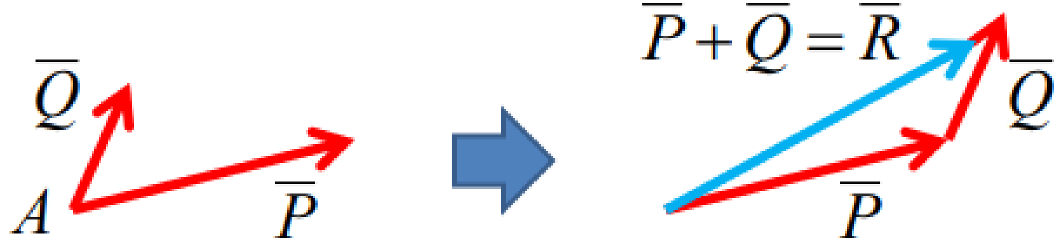
$$\overline{P}+\overline{Q}=\overline{R}$$

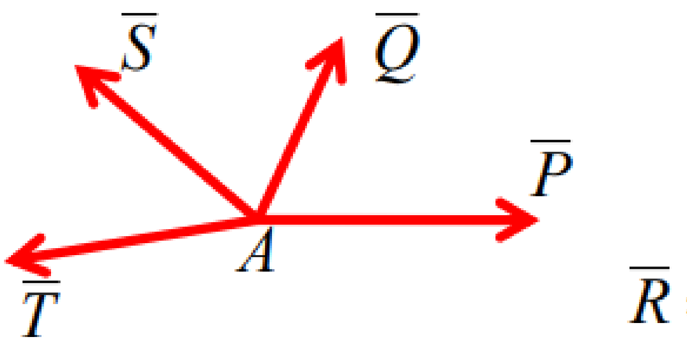
(a) Parallelogram Law:



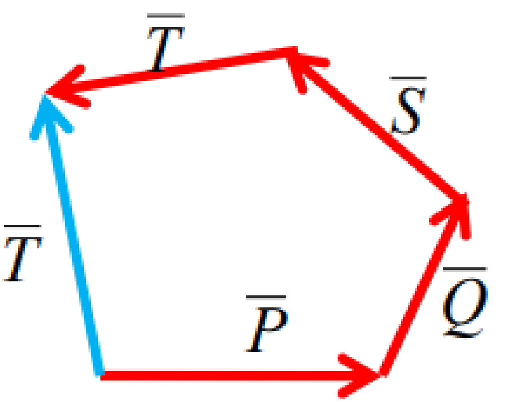
(b) Tip-to-Tail fashion:







$$\overline{R}=\overline{P}+\overline{Q}+\overline{S}+\overline{T}$$

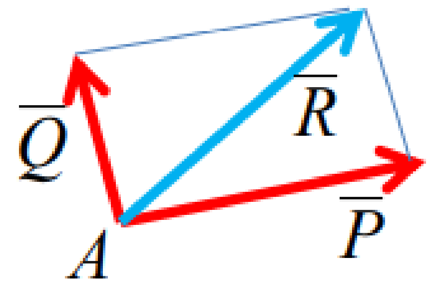


Resolution of a Force into Components

(a) One component is completely known (magnitude and direction)

Resultant $\overline{R}$ is known

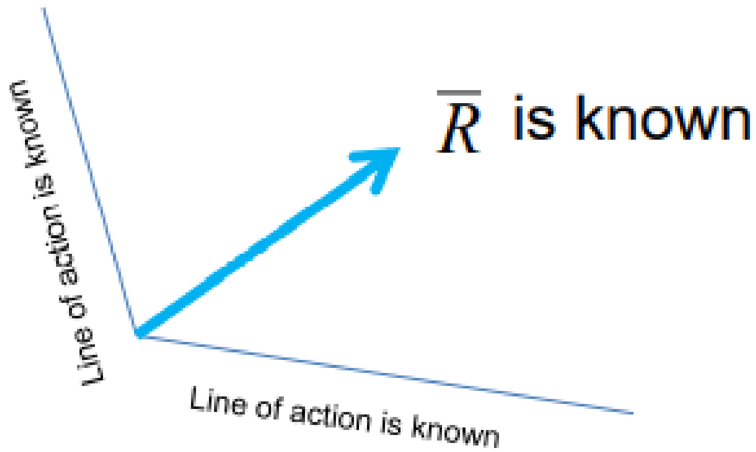
Component $\overline{P}$ is known

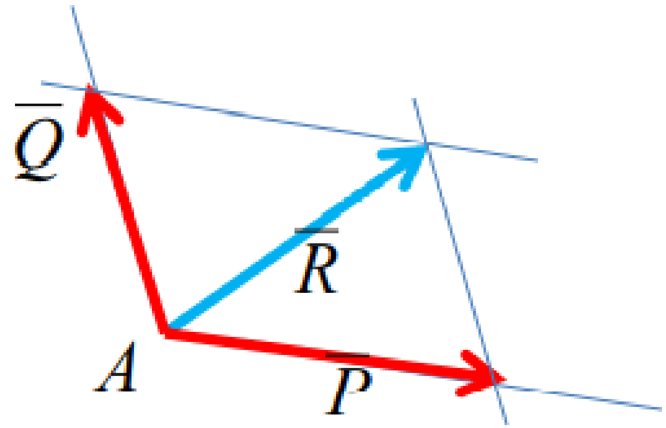


The second component $\overline{Q}$ is determined by drawing the parallelogram with sides $\overline{P}$ and $\overline{Q}$ and diagonal $\overline{R}$.

Resolution of a Force into Components

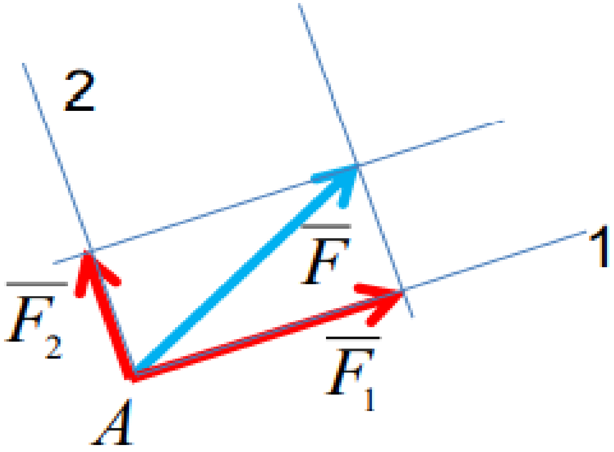
(a) Line of action of each component is known

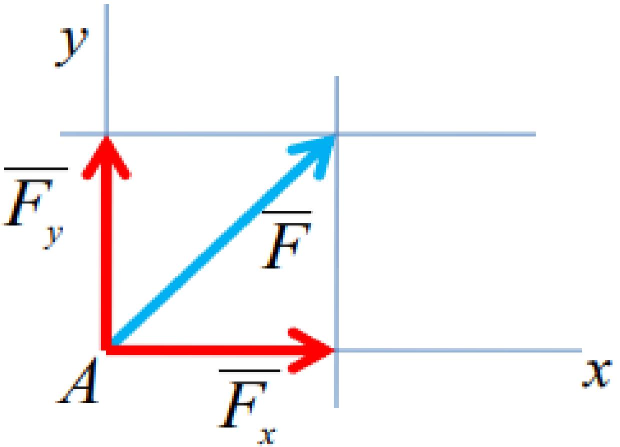




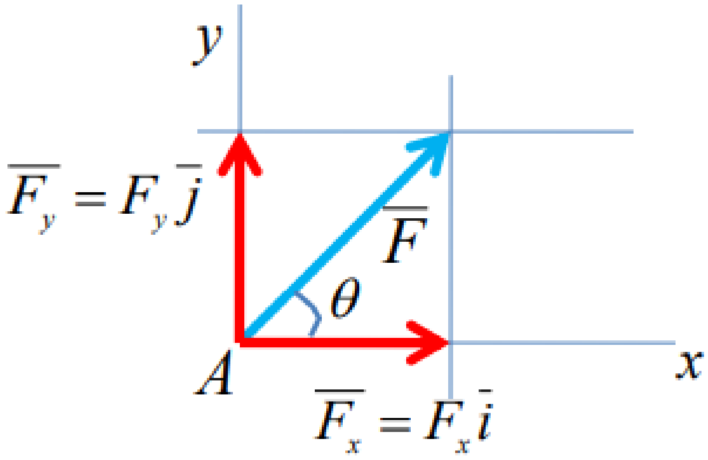
Rectangular Component of a Force

- Sometimes it is very helpful to resolve a force into its rectangular components.
- The components perpendicular to each other are called rectangular components.
- A force can be resolved into rectangular components in different orientation as shown below.





Rectangular Component of a Force



$\overline{F}$ = resultant force

$\overline{F}_x, \overline{F}_y$ = components of $\overline{F}$

$\overline{i}, \overline{j}$ = unit vectors of magnitude 1

$$\overline{F} = \overline{F}_x + \overline{F}_y$$

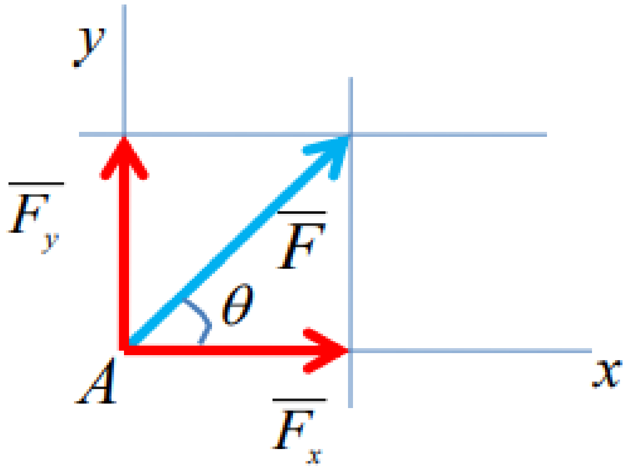
$$\Rightarrow \overline{F} = F_x \overline{i} + F_y \overline{j}$$; F_x , F_y =magnitude of components

$$\Rightarrow \overline{F} = (F\cos\theta)\overline{i} + (F\sin\theta)\overline{j}$$; F =magnitude of the resultant force

$$F_x = F\cos\theta \qquad (1a)$$
$$F_y = F\sin\theta \qquad (1b)$$

Equations (1a) and (1b) are used to determine the components of a force if its direction and magnitude are known.

Rectangular Component of a Force



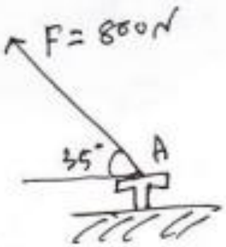
Conversely, if the components are known, the magnitude and direction of the resultant force are determined from the following equations

$$F = \sqrt{F_x^2 + F_y^2} \qquad (2a)$$; magnitude of the resultant force

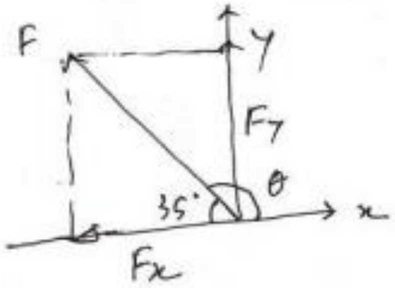
$$\tan\theta = \frac{F_y}{F_x} \Rightarrow \theta = \tan^{-1}\frac{F_y}{F_x} \qquad (2b)$$; direction of the resultant force

- Note that θ is measured from the +ve x-axis towards the resultant in CCW direction.
- A rectangular component is considered to be +ve if it is directed to a +ve direction of an axis; otherwise it is negative.

Ex:



Find components



Here $\theta = 180 - 35 = 145^0$

$F_x = F\cos\theta = 800\cos 145 = \boxed{-655N}$

$F_y = F\sin\theta = 800\sin 145 = \boxed{459\ N}$

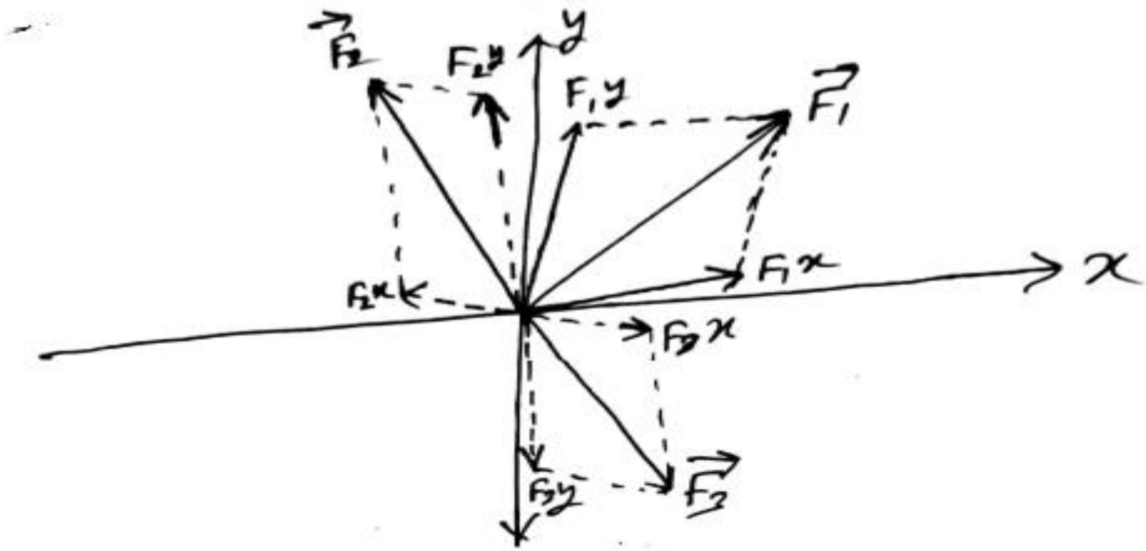
It can be solved by physically observing the sign of the components by taking the given angle of 35° betn -ve axis and the resultant.

It is seen that F_x is -ve.

Thus, $F_x = -F\cos 35 = \boxed{-655N}$

$F_y = F\sin 35 = \boxed{459\ N}$

Resultant of Concurrent Force



using cartesian vector notation →

$$\vec{F_1} = F_1x\,\hat{i} + F_1y\,\hat{j}$$

$$\vec{F_2} = -F_2x\,\hat{i} + F_2y\,\hat{j}$$

$$\vec{F_3} = F_3x\,i - F_3y\,\hat{j}$$

So the resultant vector is therefore.

Resultant of Concurrent Force

$$\vec{R} = \vec{F_1} + \vec{F_2} + \vec{F_3}$$

$$= F_{1x}\hat{i} + F_{1y}\hat{j} + (-F_{2x}\hat{i} + F_{2y}\hat{j}) + (F_{3x}\hat{i} - F_{3y}\hat{j})$$

$$= \hat{i}(F_{1x} - F_{2x} + F_{3x}) + \hat{j}(F_{1y} + F_{2y} - F_{3y})$$

$$\therefore \vec{R} = R_x\hat{i} + R_y\hat{j}$$

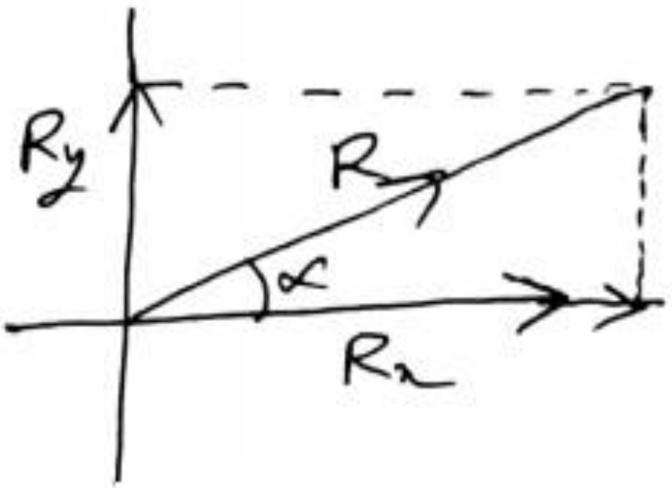
Resultant of Concurrent Force (Scaler Component)

$$\left(\xrightarrow{+}\right) \quad R_x = F_{1x} - F_{2x} + F_{3x}$$

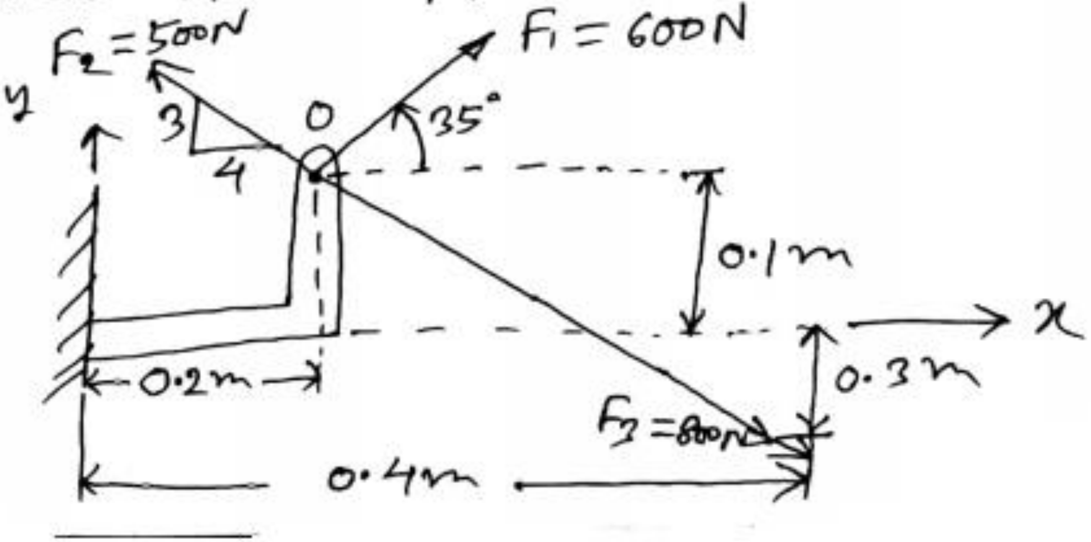
$$(+\uparrow) \quad R_y = F_{1y} + F_{2y} - F_{3y}$$

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

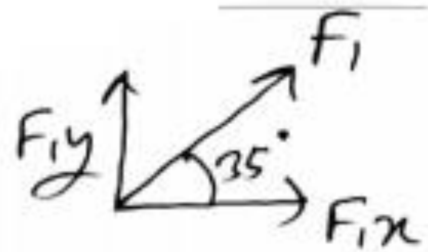
$$\& \quad \alpha = \tan^{-1}\left(\frac{R_y}{R_x}\right)$$



$\boxed{\text{Problem}}$ The forces $\vec{F_1}$, $\vec{F_2}$ & $\vec{F_3}$ all of which act on a point A of the bracket are specified in three different ways. Determine the x & y scalar components of each of the three forces. Find the resultant forces.



Scalar component of $\vec{F_1}$:



$$\cos 35^\circ = \frac{F_{1x}}{F_1}$$

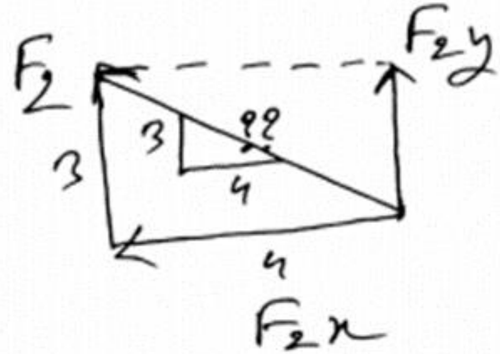
$$\therefore F_{1x} = F_1 \cos 35^\circ = 600 \cos 35^\circ$$

$$\therefore F_{1x} = 491.49\ N$$

$$\therefore F_{1y} = F_1 \sin 35^\circ = 344.15\ N$$

Scalar component of $\vec{F_2}$:

$$F_{2x} = -F_2 \times \boxed{\frac{4}{5}}$$ → component of cosine



$$\sqrt{4^2+3^2} = \sqrt{25}$$
$$\boxed{=5}$$

$$\therefore \quad F_{2x} = -500 \times \frac{4}{5}$$

$$F_{2x} = -400\,N$$

$$\& \quad F_{2y} = F_2 \times \frac{3}{5} = 500 \times \frac{3}{5}$$

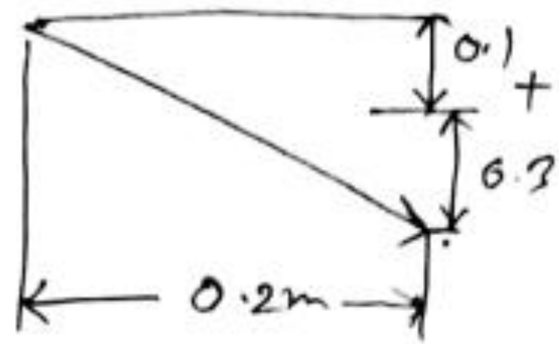
$$= 300\,N$$

for Component of $\vec{F_3}$:

$$F_{3x} = F_3 \times \frac{0.2}{0.447}$$

$$\therefore F_{3x} = 800 \times \frac{0.2}{0.447}$$

$$F_{3x} = 357.94\ N$$



$$\sqrt{0.4^2 + 0.2^2} = 0.447$$

$$\& \quad F_{3y} = -F_3 \times \frac{0.4}{0.447}$$

$$= -715.88\ N$$

Now Resultant Force:

$$R_x = \sum F_x = F_{1x} + F_{2x} + F_{3x}$$

$$= 491.49 - 400 + 357.94$$

$$R_x = 449.43 \text{ N}$$

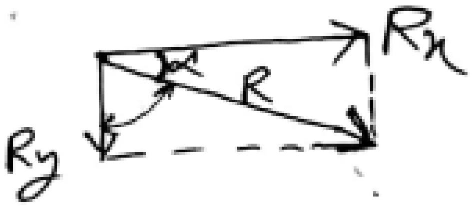
$$\& \quad R_y = \sum F_y = F_{1y} + F_{2y} + F_{3y}$$

$$= 344.15 + 300 - 715.88$$

$$= -71.73 \text{ N}$$

$$R = \sqrt{R_x^2 + R_y^2} = 455.11 \text{ N}$$

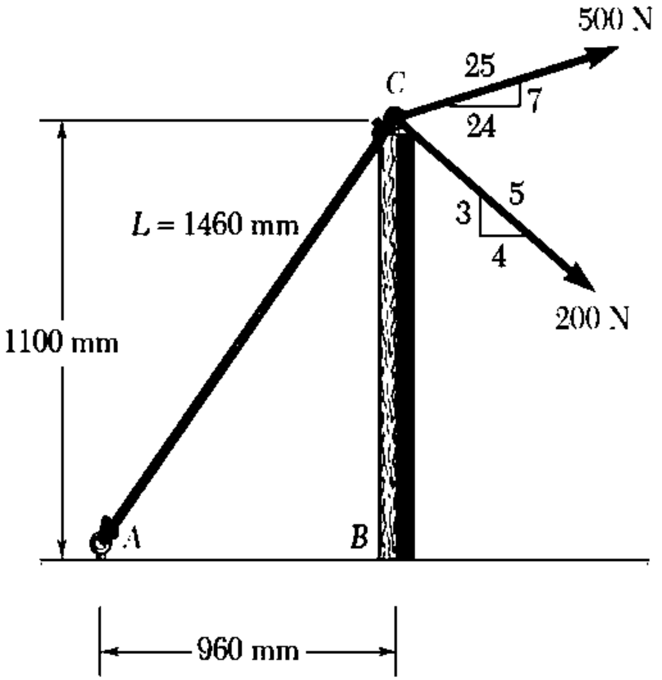
$$\& \quad \alpha = \tan^{-1}\frac{R_y}{R_x} = -9.068°$$
$$= 80.93°$$



Problems

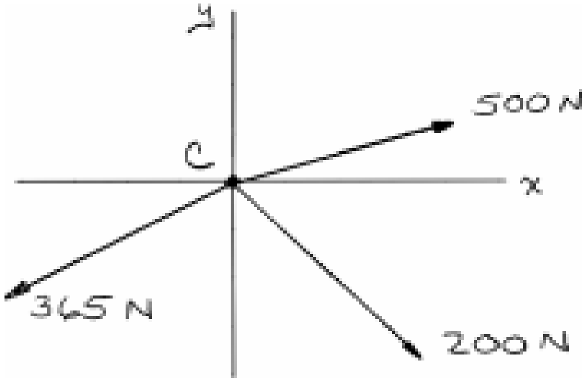
Prob 2.36: Knowing that the tension in rope AC is 365 N, determine the resultant of the three forces exerted at point C of post BC.

Prob 2.40: For the post of Prob. 2.36, determine
(a) the required tension in rope AC if the resultant of the three forces exerted at point C is to be horizontal,
(b) the corresponding magnitude of the resultant.



SOLUTION **Problem 2.36**

Determine force components:



Cable force AC: $F_x = -(365 \text{ N})\dfrac{960}{1460} = -240 \text{ N}$

$F_y = -(365 \text{ N})\dfrac{1100}{1460} = -275 \text{ N}$

500-N Force: $F_x = (500 \text{ N})\dfrac{24}{25} = 480 \text{ N}$

$F_y = (500 \text{ N})\dfrac{7}{25} = 140 \text{ N}$

200-N Force: $F_x = (200 \text{ N})\dfrac{4}{5} = 160 \text{ N}$

$F_y = -(200 \text{ N})\dfrac{3}{5} = -120 \text{ N}$

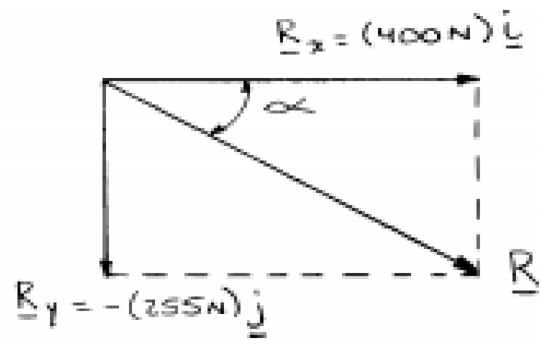
and $R_x = \Sigma F_x = -240 \text{ N} + 480 \text{ N} + 160 \text{ N} = 400 \text{ N}$

$R_y = \Sigma F_y = -275 \text{ N} + 140 \text{ N} - 120 \text{ N} = -255 \text{ N}$

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

$$= \sqrt{(400 \text{ N})^2 + (-255 \text{ N})^2}$$

$$= 474.37 \text{ N}$$

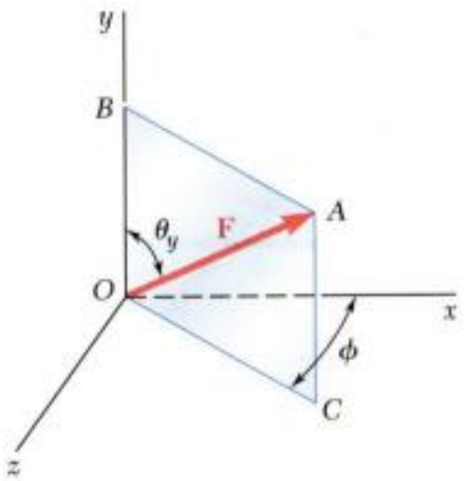


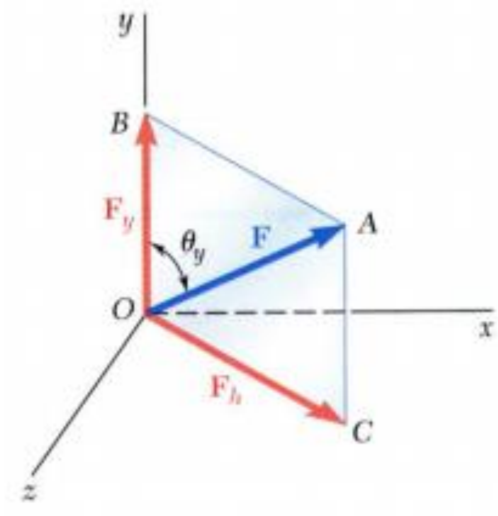
Further: $\tan\alpha = \dfrac{255}{400}$

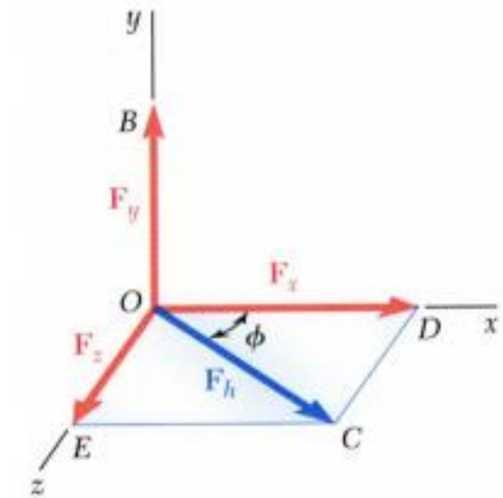
$\alpha = 32.5°$

$\mathbf{R} = 474 \text{ N} \measuredangle 32.5° \blacktriangleleft$

Rectangular Components in Space







- The vector $\vec{F}$ is contained in the plane *OBAC*.

- Resolve $\vec{F}$ into horizontal and vertical components.

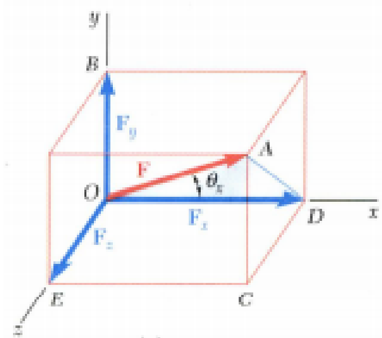
$$F_y = F\cos\theta_y$$

$$F_h = F\sin\theta_y$$

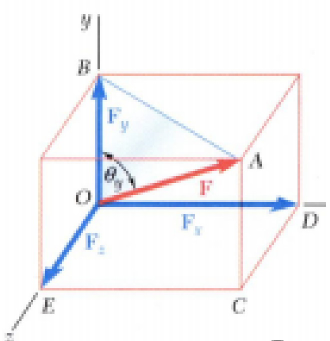
- Resolve F_h into rectangular components

$$F_x = F_h\cos\phi$$
$$= F\sin\theta_y\cos\phi$$
$$F_z = F_h\sin\phi$$
$$= F\sin\theta_y\sin\phi$$

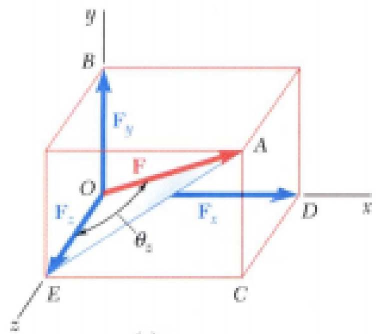
Rectangular Components in Space



$F_x = F\cos\theta_x$



$F_y = F\cos\theta_y$



$F_z = F\cos\theta_z$

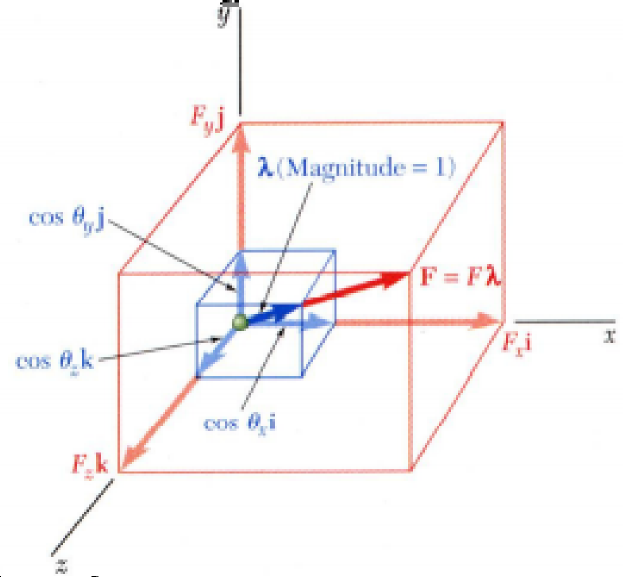
$$\boldsymbol{F} = F_x\boldsymbol{i} + F_y\boldsymbol{j} + F_z\boldsymbol{k}$$

$$\boldsymbol{F} = F\cos\theta_x\boldsymbol{i} + F\cos\theta_y\boldsymbol{j} + F\cos\theta_z\boldsymbol{k}$$

$$\boldsymbol{F} = F(\cos\theta_x\boldsymbol{i} + \cos\theta_y\boldsymbol{j} + \cos\theta_z\boldsymbol{k})$$

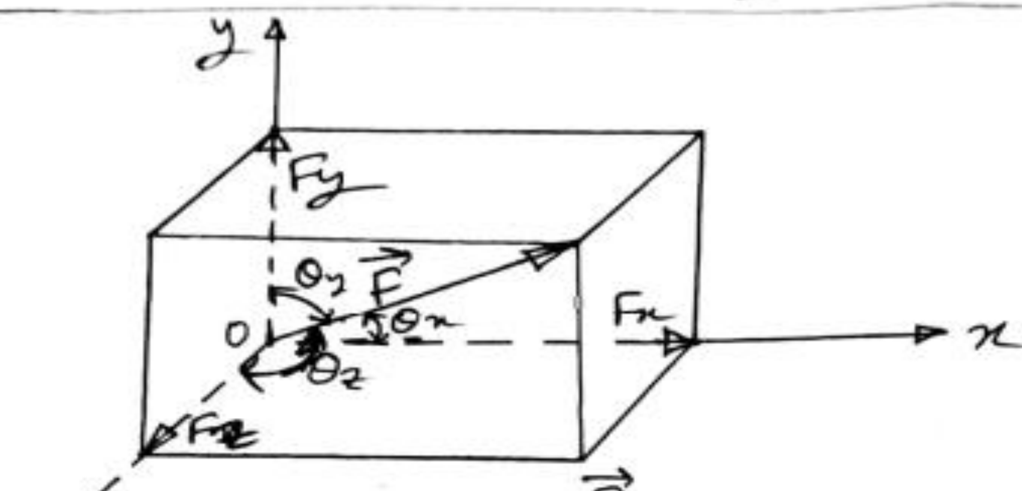
$$\boldsymbol{F} = F\boldsymbol{\lambda}$$

Where $\boldsymbol{\lambda} = \cos\theta_x\boldsymbol{i} + \cos\theta_y\boldsymbol{j} + \cos\theta_z\boldsymbol{k}$



$\boldsymbol{\lambda}$ is a unit vector along the line of action of $\boldsymbol{F}$ and $\cos\theta_x$, $\cos\theta_y$ and $\cos\theta_z$ are the direction cosine for $\boldsymbol{F}$

Three Dimensional Force system :



z

The force $\vec{F}$ acting at a point O has rectangular components F_x, F_y & F_z

where, $F_x = F\cos\theta_x$, $F_y = F\cos\theta_y$

$F_z = F\cos\theta_z$

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

& $\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$

$$= F\underbrace{(\cos\theta_x\hat{i} + \cos\theta_y\hat{j} + \cos\theta_z\hat{k})}_{\vec{\lambda}}$$

The unit vector $\hat{i}, \hat{j}, \hat{k}$ are in the x, y & z directions respectively.

$\therefore \vec{F} = F . \vec{\lambda}$ where $\vec{\lambda}$ is a unit vector along the line of action ~~direction~~ of $\vec{F}$ & has a magnitude of 1

& $\cos\theta_x = \frac{F_x}{F}$, $\cos\theta_y = \frac{F_y}{F}$ & $\cos\theta_z = \frac{F_z}{F}$

$$\vec{F} = F\vec{\lambda} \quad \therefore \vec{\lambda} = \frac{\vec{F}}{F}$$

$$\therefore \vec{\lambda} = \frac{\hat{i}F_x + \hat{j}F_y + \hat{k}F_z}{\sqrt{F_x^2 + F_y^2 + F_z^2}}$$

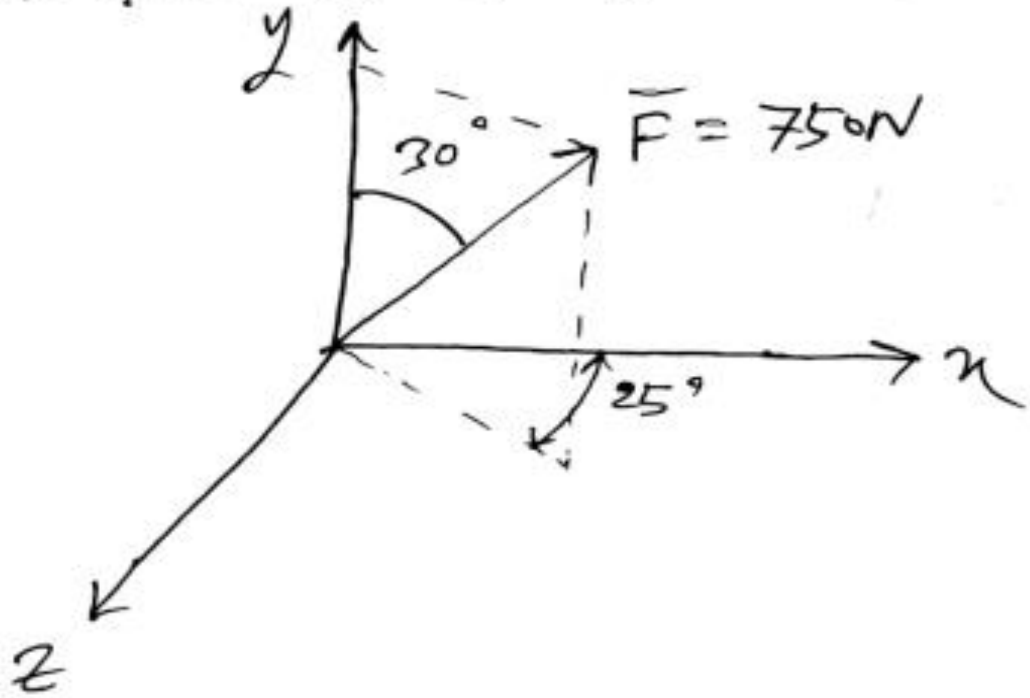
or we can write

$$\vec{\lambda} = \frac{F_x}{F}\hat{i} + \frac{F_y}{F}\hat{j} + \frac{F_z}{F}\hat{k}$$

$$\text{or } \vec{\lambda} = \hat{i}\cos\theta_x + \hat{j}\cos\theta_y + \hat{k}\cos\theta_z$$

$\cos\theta_x$, $\cos\theta_y$ & $\cos\theta_z$ are the direction of cosine for F.

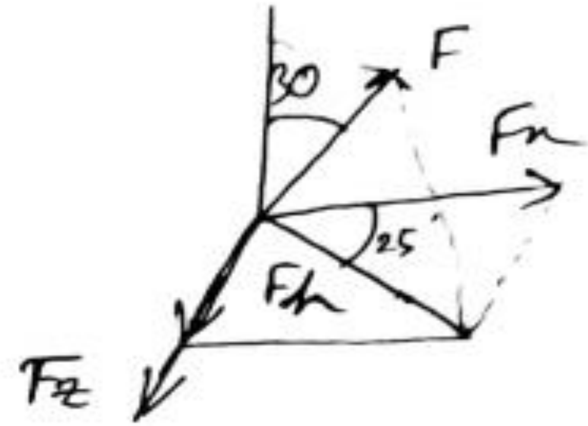
Problem : Determine (a) x, y, z components of the 750 N force & (b) the angles θ_x, θ_y & θ_z that the force forms with the co-ordinate axis.



$$F_h = F \sin\theta_y$$

$$= 750 \sin 30^\circ$$

$$F_h = 430.2 \text{ N}$$



Now,

$$F_x = F_h \cos 25^\circ = \boxed{390 \text{ N}}$$

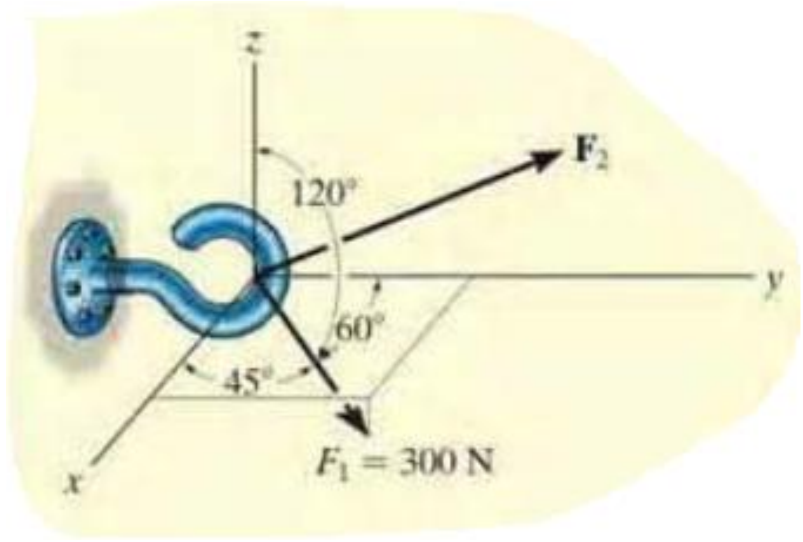
$$F_y = F \cos 30^\circ = \boxed{614 \text{ N}}$$

$$F_z = F_h \sin 25^\circ = \boxed{181.8 \text{ N}}$$

& $\cos\theta_x = \dfrac{F_x}{F}$; $\cos\theta_y = \dfrac{F_y}{F}$ & $\cos\theta_z = \dfrac{F_z}{F}$

$\theta_x = \boxed{}$; $\theta_y = \boxed{}$; $\theta_z = \boxed{}$ (Ans)

Problem: Two forces act on the hook shown in Fig. Specify the magnitude of F_2 and its coordinate direction angles of F_2 that the resultant force F_R acts along the positive y axis and has a magnitude of 8OO N.

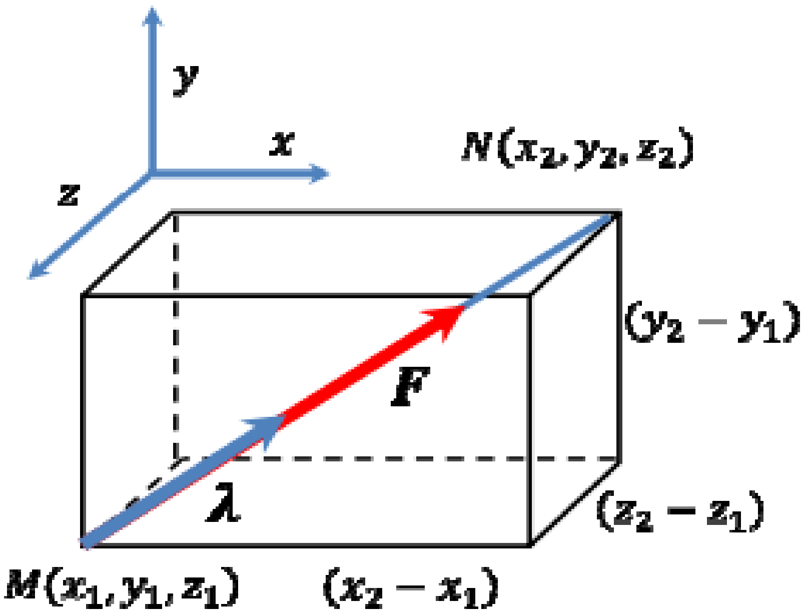


Self Study

Rectangular Components in Space

Direction of the force is defined by the location of two points

$M(x_1, y_1, z_1)$ and $N(x_2, y_2, z_2)$



$\boldsymbol{d}$ is the vector joining M and N

$$\boldsymbol{d} = d_x\boldsymbol{i} + d_y\boldsymbol{j} + d_z\boldsymbol{k}$$

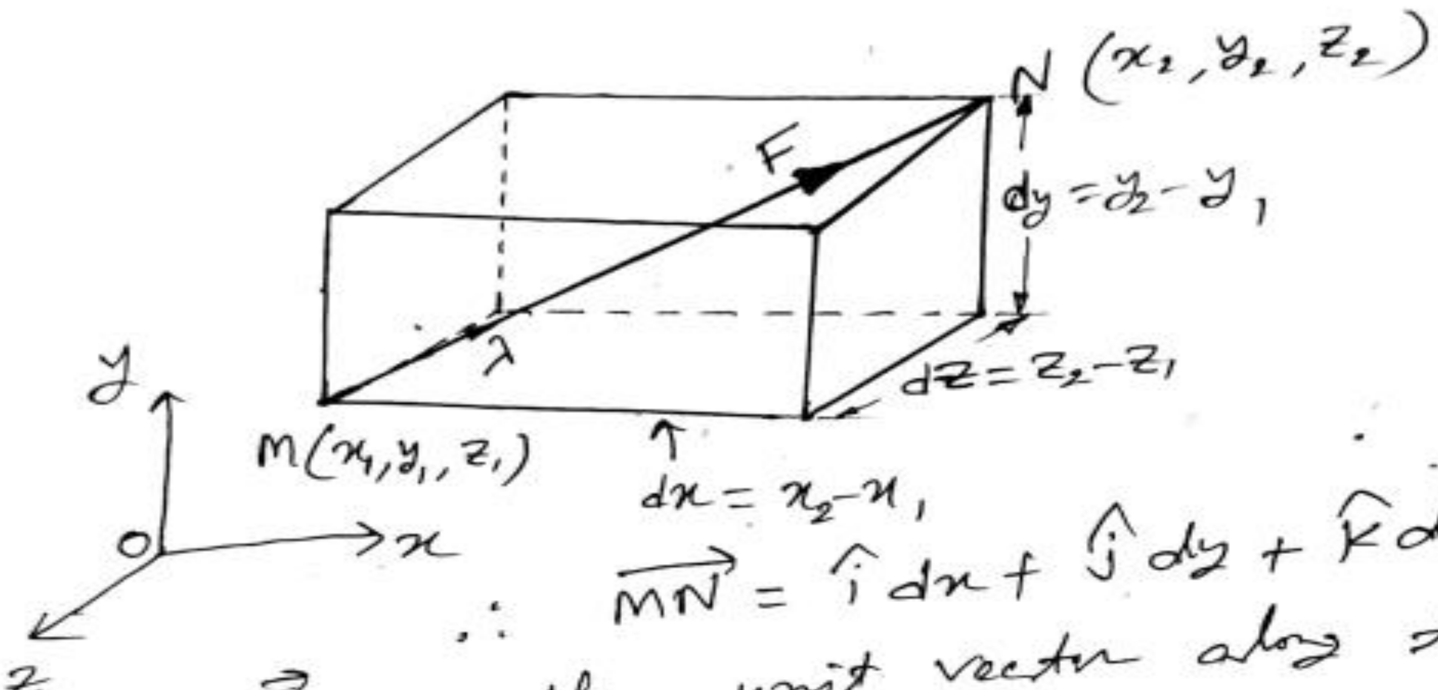
$$d_x = (x_2 - x_1) \qquad d_y = (y_2 - y_1)$$

$$d_z = (z_2 - z_1)$$

$$\boldsymbol{F} = F\boldsymbol{\lambda}$$

$$= F\left(\frac{d_x\boldsymbol{i} + d_y\boldsymbol{j} + d_z\boldsymbol{k}}{d}\right)$$

$$F_x = F\frac{d_x}{d} \qquad F_y = F\frac{d_y}{d} \qquad F_z = F\frac{d_z}{d}$$



$$\therefore \ \overrightarrow{MN} = \hat{i}\,dx + \hat{j}\,dy + \hat{k}\,dz$$

Let $\vec{\lambda}$ be the unit vector along the line of action of $\vec{F}$.

$$\therefore \ \vec{\lambda} = \frac{\overrightarrow{MN}}{MN} = \frac{\hat{i}\,dx + \hat{j}\,dy + \hat{k}\,dz}{\sqrt{dx^2 + dy^2 + dz^2}}$$

$$\therefore \ \hat{\lambda} = \frac{1}{d}\left(\hat{i}\,dx + \hat{j}\,dy + \hat{k}\,dz\right) \quad \left[\text{Here } |\overrightarrow{MN}| = MN = d\right]$$

where, $d = \sqrt{dx^2 + dy^2 + dz^2}$

But, $\vec{F} = \vec{\lambda} F$

$$\therefore \vec{F} = \frac{F}{d}\left(\hat{i}\,dx + \hat{j}\,dy + \hat{k}\,dz\right)$$

$$\vec{F} = \hat{i}\left(F\cdot\frac{dx}{d}\right) + \hat{j}\left(F\cdot\frac{dy}{d}\right) + \hat{k}\left(F\cdot\frac{dz}{d}\right)$$

Again $\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$

So comparing we find,

$$F_x = F\frac{dx}{d};\quad F_y = F\frac{dy}{d};\quad F_z = F\frac{dz}{d}$$

also, $F_x = F\cos\theta_x$, $F_y = F\cos\theta_y$, $F_z = F\cos\theta_z$

So, $\cos\theta_x = \dfrac{dx}{d}$; $\cos\theta_y = \dfrac{dy}{d}$ & $\cos\theta_z = \dfrac{dz}{d}$

Now, $\vec{F} = \vec{\lambda} F$

$$\Rightarrow \vec{F} = F \left[\frac{\hat{i}\, dx + \hat{j}\, dy + \hat{k}\, dz}{\sqrt{dx^2 + dy^2 + dz^2}} \right]$$

$$\therefore \vec{F} = F \cdot \frac{\hat{i}(x_2 - x_1) + \hat{j}(y_2 - y_1) + \hat{k}(z_2 - z_1)}{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}}$$

Addition of Concurrent forces in space:

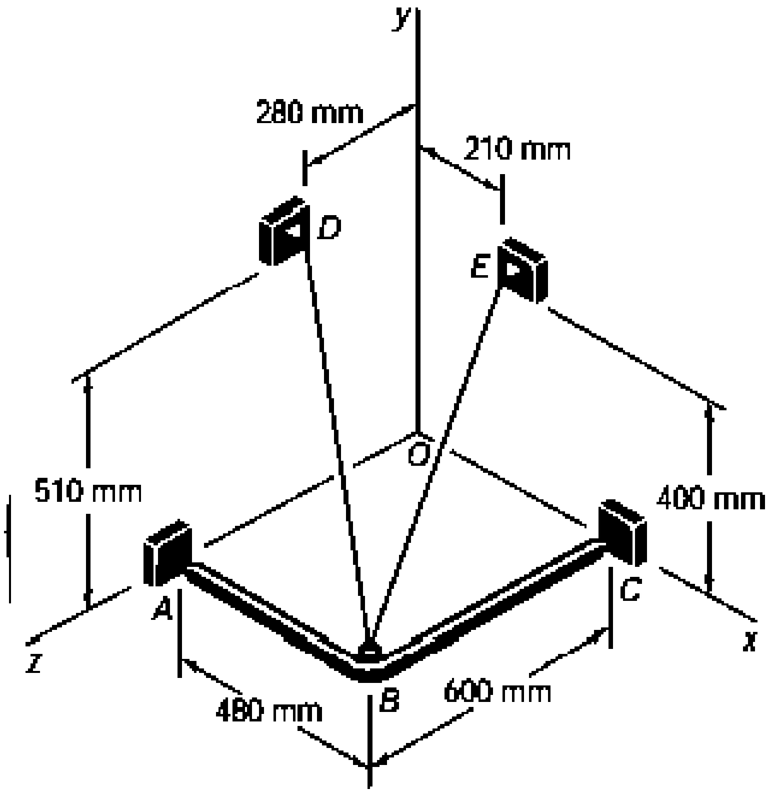
$$\vec{R} = \vec{F}$$

$$\therefore R_x = \Sigma F_x$$

$$R_y = \Sigma F_y$$

$$R_z = \Sigma F_z$$

Problem: A frame ABC is supported in part by cable DBE that passes through a frictionless ring at B. Knowing that the tension in the cable is 385 N, determine the components of the force exerted by the cable on the support at D



SOLUTION

$$\overrightarrow{DB} = (480 \text{ mm})\mathbf{i} - (510 \text{ mm})\mathbf{j} + (320 \text{ mm})\mathbf{k}$$

$$DB = \sqrt{(480 \text{ mm})^2 + (510 \text{ mm}^2) + (320 \text{ mm})^2}$$

$$= 770 \text{ mm}$$

$$\mathbf{F} = F\boldsymbol{\lambda}_{DB}$$

$$= F\frac{\overrightarrow{DB}}{DB}$$

$$= \frac{385 \text{ N}}{770 \text{ mm}}[(480 \text{ mm})\mathbf{i} - (510 \text{ mm})\mathbf{j} + (320 \text{ mm})\mathbf{k}]$$

$$= (240 \text{ N})\mathbf{i} - (255 \text{ N})\mathbf{j} + (160 \text{ N})\mathbf{k}$$

$$F_x = +240 \text{ N}, \quad F_y = -255 \text{ N}, \quad F_z = +160.0 \text{ N} \blacktriangleleft$$

Self Study

Beer and Johnston (10th Edition)

2.31, 2.32, 2.33, 2.35, 2.36, 2.38, 2.40, 2.90, 2.95, 2.97

Hibbeler R.C. (12th Edition)

2.97

+

All the problems solved in class lectures