ME13A: ENGINEERING STATICS



COURSE INTRODUCTION

Details of Lecturer

- **Course Lecturer**: Dr. E.I. Ekwue
- **Room Number**: 216 Main Block, Faculty of Engineering

- **Email:** ekwue@eng.uwi.tt ,
- Tel. No. : 662 2002 Extension 3171
- Office Hours: 9 a.m. to 12 Noon. (Tue, Wed and Friday)

COURSE GOALS

- This course has two specific goals:
- (i) To introduce students to basic concepts of force, couples and moments in two and three dimensions.
- (ii) To develop analytical skills relevant to the areas mentioned in (i) above.

COURSE OBJECTIVES

- Upon successful completion of this course, students should be able to:

i) Determine the resultant of coplanar and space force systems.

- (ii) Determine the centroid and center of mass of plane areas and volumes.

- (iii) Distinguish between concurrent, coplanar and space force systems

- (iv) Draw free body diagrams.

COURSE OBJECTIVES CONTD.

- (v) Analyze the reactions and pin forces induces in coplanar and space systems using equilibrium equations and free body diagrams.
- (vi) Determine friction forces and their influence upon the equilibrium of a system.
- (vii) Apply sound analytical techniques and logical procedures in the solution of engineering problems.

Course Content

- (i) Introduction, Forces in a plane, Forces in space
- (ii) Statics of Rigid bodies
- (iii) Equilibrium of Rigid bodies (2 and 3 dimensions)
- (iv) Centroids and Centres of gravity
- (v) Moments of inertia of areas and masses
- (vi) Analysis of structures (Trusses, Frames and Machines)
- (vii) Forces in Beams
- (viii)Friction

Teaching Strategies

- The course will be taught via Lectures and Tutorial Sessions, the tutorial being designed to complement and enhance both the lectures and the students appreciation of the subject.
- Course work assignments will be reviewed with the students.

Course Textbook and Lecture Times

- Vector Mechanics For Engineers By F.P. Beer and E.R. Johnston (Third Metric Edition), McGraw-Hill.

- Lectures: Wednesday, 1.00 to 1.50 p.m.
  Thursday , 10.10 to 11.00 a.m.
  Tutorials: Monday, 1.00 to 4.00 p.m. [Once in Two Weeks]

Attendance at Lectures and Tutorials is Compulsory

Tutorial Outline

Chapter 2 – STATICS OF PARTICLES

2.39*, 41, 42*, 55, 85*, 86, 93*, 95, 99*, 104, 107*, 113

Chapter 3 – RIGID BODIES: EQUIVALENT SYSTEM OF FORCES

3.1*, 4, 7*, 21, 24*, 38, 37*, 47, 48*, 49, 70*, 71, 94*, 96, 148*, 155

Chapter 4 – EQUILIBRIUM OF RIGID BODIES

4.4*, 5, 9*, 12, 15*, 20, 21*, 31, 61*, 65, 67*, 93, 115*

Chapters 5 and 9 – CENTROIDS AND CENTRES OF GRAVITY, MOMENTS OF INERTIA

5.1*, 5, 7*, 21, 41*, 42, 43*, 45, 75*, 77 9.1*, 2, 10*, 13, 31*, 43, 44*

Chapter 6 – ANALYSIS OF STRUCTURES

6.1*, 2, 6*, 9, 43*, 45, 75*, 87, 88*, 95, 122*, 152, 166*, 169

Chapters 7 and 8 – FORCES IN BEAMS AND FRICTION

7.30 , 35, 36, 81, 85 8.25, 21, 65

* For Chapters 1 to 6 and 9, two groups will do the problems in asterisks; the other two groups will do the other ones. All the groups will solve all the questions in Chapters 7 and 8.

Time-Table For Tutorials/Labs

	MONDAY 1:00 - 4:00 P.M.			
Week Group	**1,5,9**	**2,6,10**	**3,7,11,**	**4,8,12**
K	-	**ME13A**	**ME16A (3,7)**	**ME13A**
L	**ME13A**	-	**ME13A**	**ME16A (4,8)**
M	**ME16A (5,9)**	**ME13A**	-	**ME13A**
N	**ME13A**	**ME16A (6,10)**	**ME13A**	-

Course Assessment

- (i) One (1) mid-semester test, 1-hour duration counting for 20% of the total course.

- (ii) One (1) End-of-semester examination, 2 hours duration counting for 80% of the total course marks.

ME13A: ENGINEERING STATICS

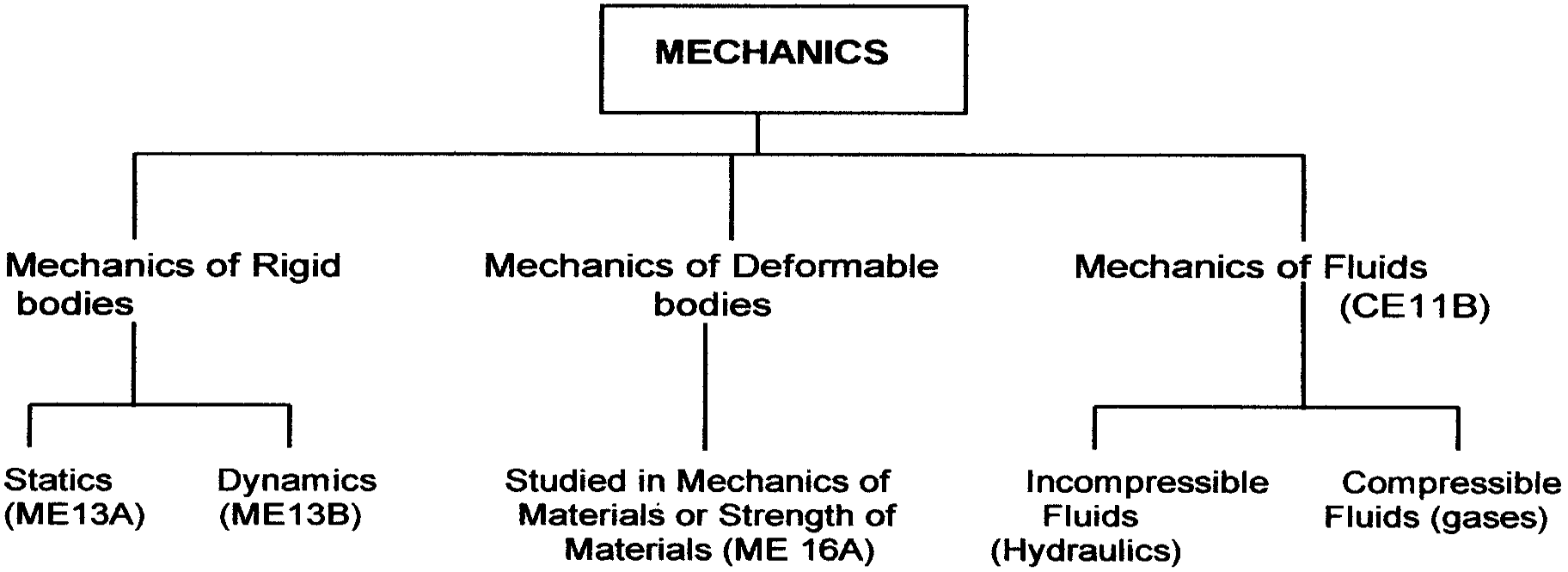


CHAPTER ONE: INTRODUCTION

1.1 MECHANICS

- Body of Knowledge which Deals with the Study and Prediction of the State of Rest or Motion of Particles and Bodies under the action of Forces

PARTS OF MECHANICS



Further Courses

1. Strength of Materials 1 (ME21A)
2. Strength of Materials 2 (ME21B)
3. Advanced Mechanics of Solids (Optional) (ME33A)

1.2 STATICS

- Statics Deals With the Equilibrium of Bodies, That Is Those That Are Either at Rest or Move With a Constant Velocity.
- Dynamics Is Concerned With the Accelerated Motion of Bodies and Will Be Dealt in the Next Semester.

ME13A: ENGINEERING STATICS



CHAPTER TWO: STATICS OF PARTICLES

2.1 PARTICLE

A particle has a mass but a size that can be neglected.

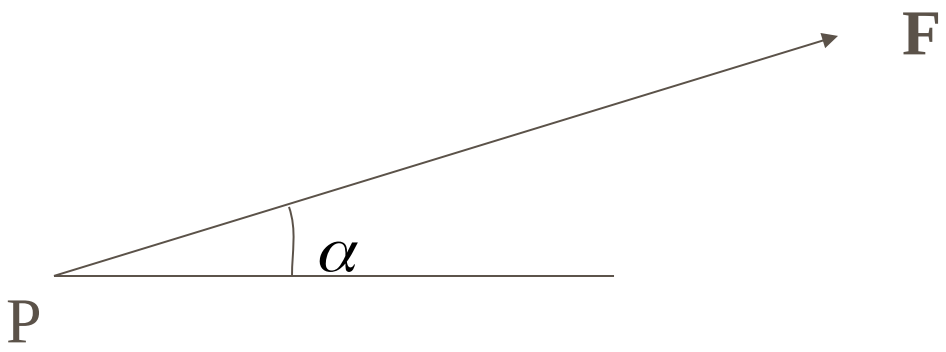
When a body is idealised as a particle, the principles of mechanics reduce to a simplified form, since the geometry of the body will not be concerned in the analysis of the problem.

PARTICLE CONTINUED

- All the forces acting on a body will be assumed to be applied at the same point, that is the forces are assumed concurrent.

2.2 FORCE ON A PARTICLE

- A Force is a Vector quantity and must have Magnitude, Direction and Point of action.



Force on a Particle Contd.

- **Note:** Point P is the point of action of force and α and $\rightarrow$ are directions. To notify that **F** is a vector, it is printed in bold as in the text book.
- Its magnitude is denoted as |F| or simply F.

Force on a Particle Contd.

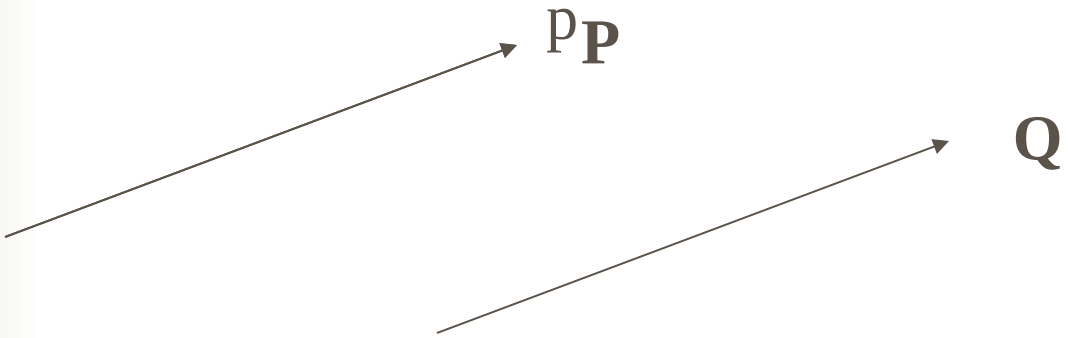
- There can be many forces acting on a particle.

- The *resultant* of a system of forces on a particle is the *single force* which has the *same effect* as the *system* of forces. The resultant of two forces can be found using the *paralleolegram* law.

2.2.VECTOR OPERATIONS

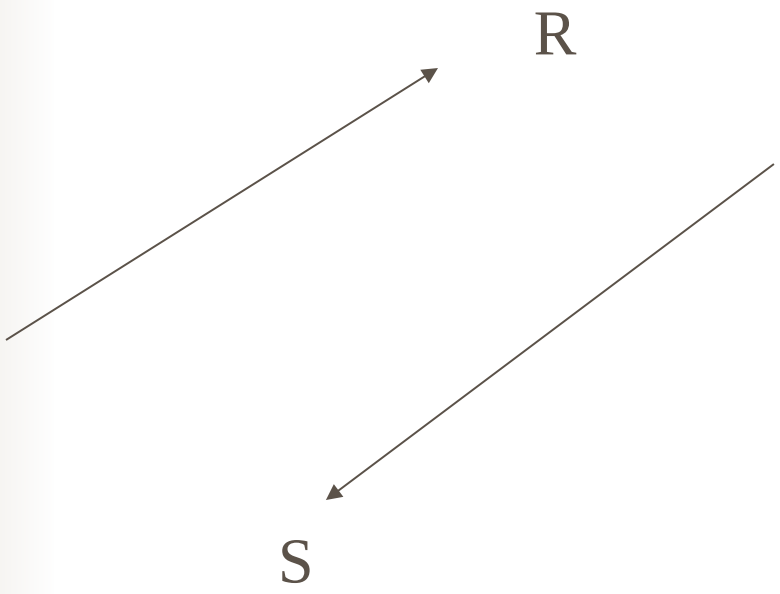
- **2.3.1 EQUAL VECTORS**

  Two *vectors* are *equal* if they are equal in *magnitude* and act in the *same* direction.



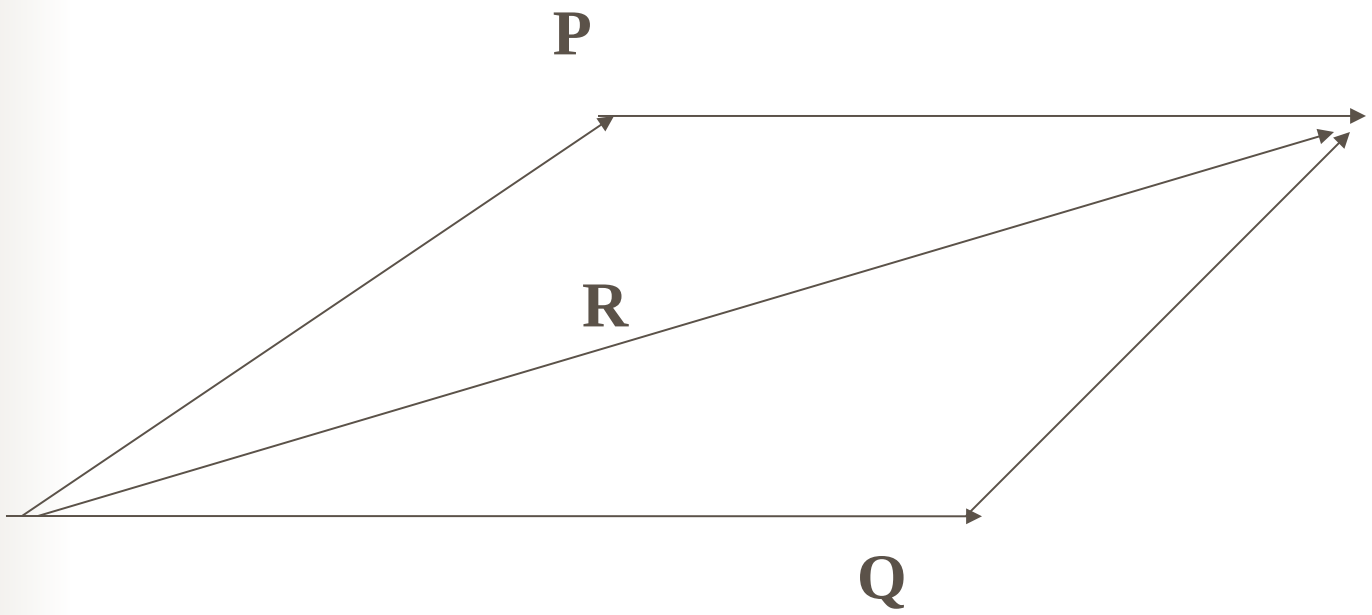
Equal Vectors Contd.

- Forces equal in Magnitude can act in opposite Directions



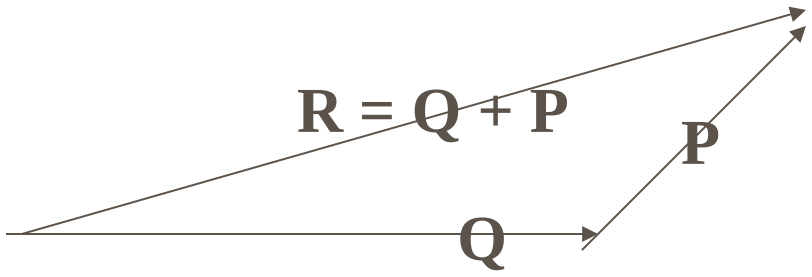
2.3.2 Vector Addition

- Using the Paralleogram Law, Construct a Parm. with two Forces as Parts. The resultant of the forces is the diagonal.



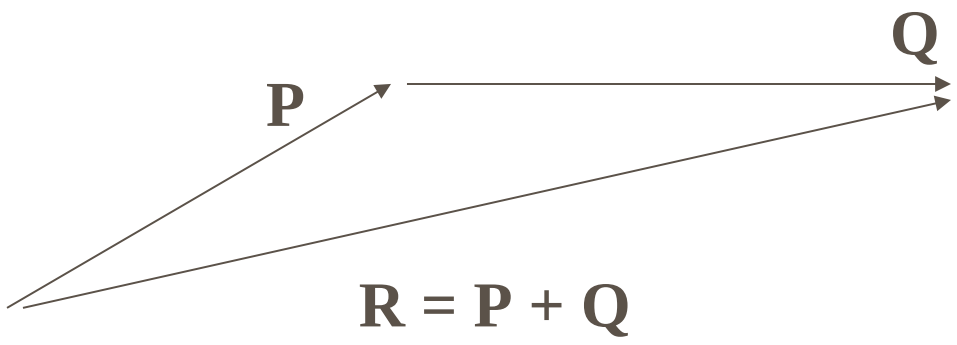
Vector Addition Contd.

- Triangle Rule: Draw the first Vector. Join the tail of the Second to the head of the First and then join the head of the third to the tail of the first force to get the resultant force, R



Triangle Rule Contd.

- Also:

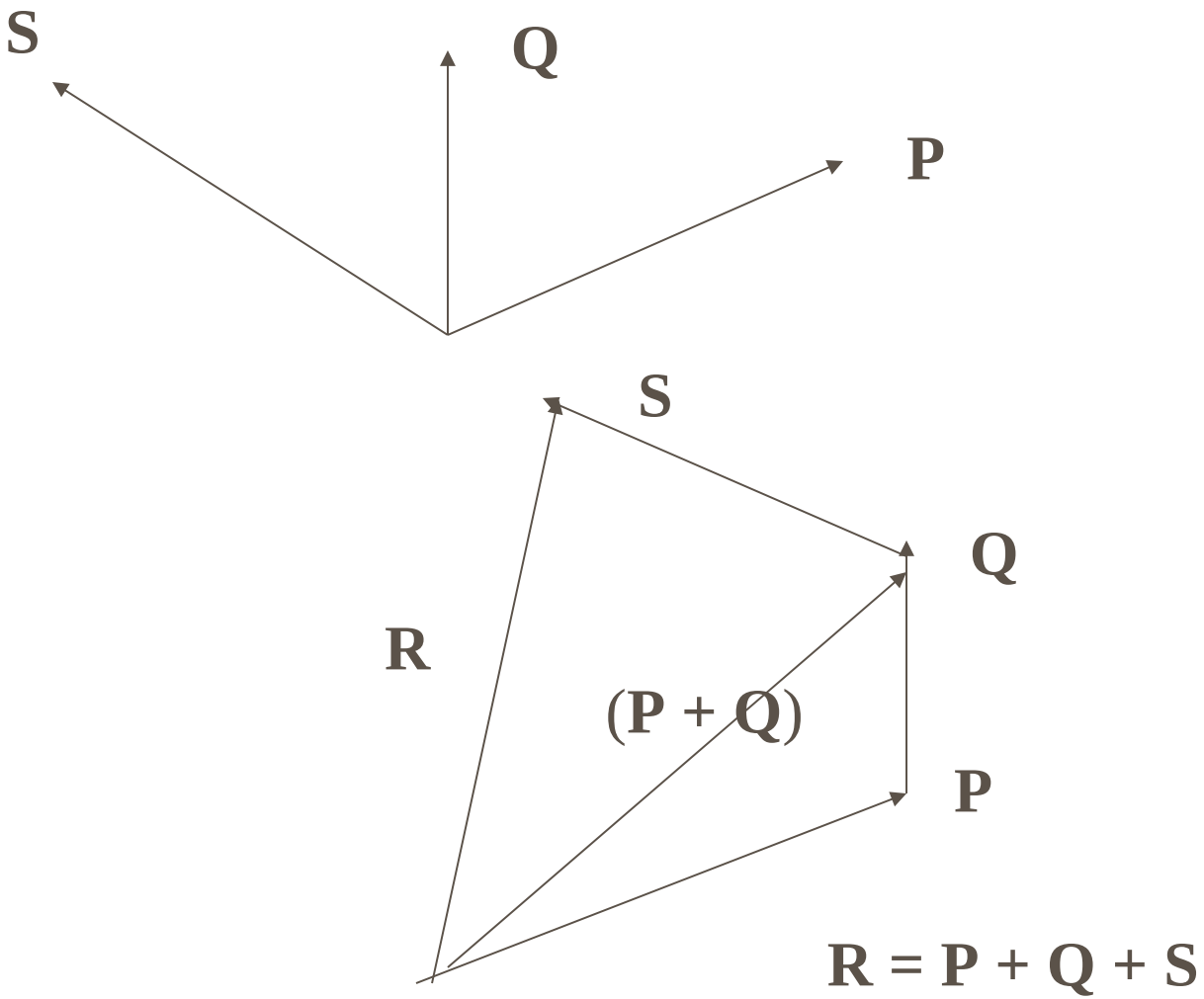


Q + P = P + Q. This is the cummutative law of vector addition

Polygon Rule

- Can be used for the addition of more than two vectors. Two vectors are actually summed and added to the third.

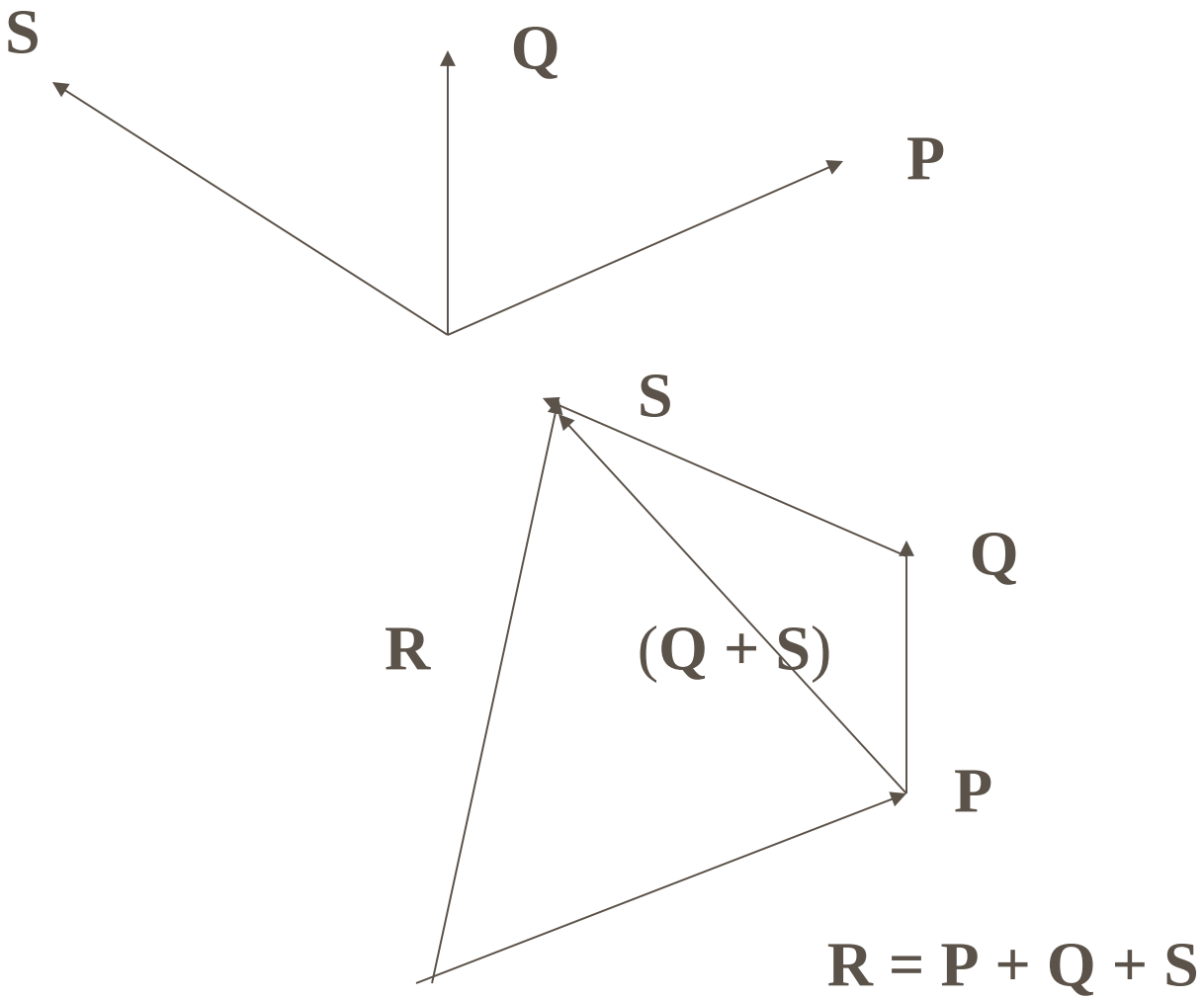
Polygon Rule contd.



Polygon Rule Contd.

- P + Q = (P + Q) ……. Triangle Rule
- i.e. **P + Q + S = (P + Q) + S = R**
- **The method of drawing the vectors is immaterial . The following method can be used.**

Polygon Rule contd.

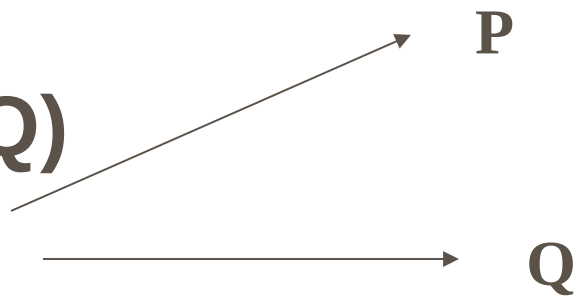


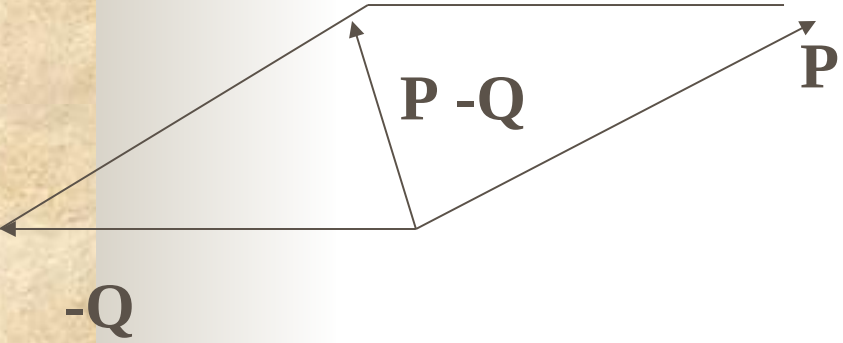
Polygon Rule Concluded

- Q + S = (Q + S) ……. Triangle Rule
- P + Q + S = P + (Q + S) = R
- i.e. P + Q + S = (P + Q) + S = P + (Q + S)
- This is the associative Law of Vector Addition

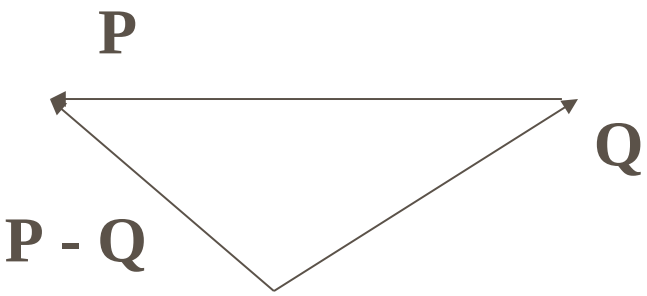
2.3.3. Vector Subtraction

- P - Q = P + (- Q)





Parm. Rule



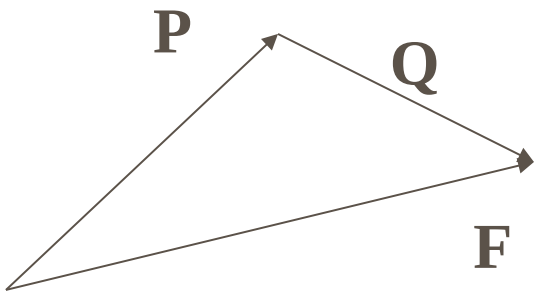
Triangle Rule

2.4 Resolution of Forces

- It has been shown that the resultant of forces acting at the same point (concurrent forces) can be found.
- In the same way, a given force, F can be resolved into components.
- There are two major cases.

Resolution of Forces: Case 1

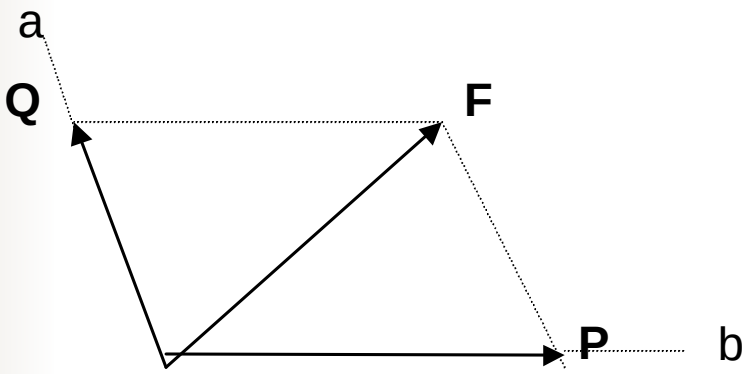
- **(a) When one of the two components, P is known:** The second component **Q** is obtained using the triangle rule. Join the tip of **P** to the tip of **F**. The magnitude and direction of **Q** are determined graphically or by trignometry.



i.e. **F = P + Q**

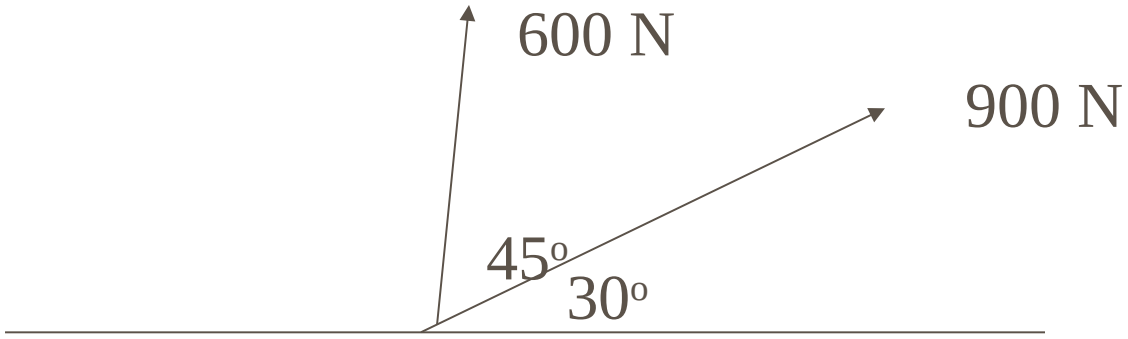
Resolution of Forces: Case 2

(b) When the line of action of each component is known: The force, **F** can be resolved into two components having lines of action along lines ‘a’ and ‘b’ using the paralleogram law. From the head of **F**, extend a line parallel to ‘a’ until it intersects ‘b’. Likewise, a line parallel to ‘b’ is drawn from the head of **F** to the point of intersection with ‘a’. The two components **P** and **Q** are then drawn such that they extend from the tail of **F** to points of intersection.



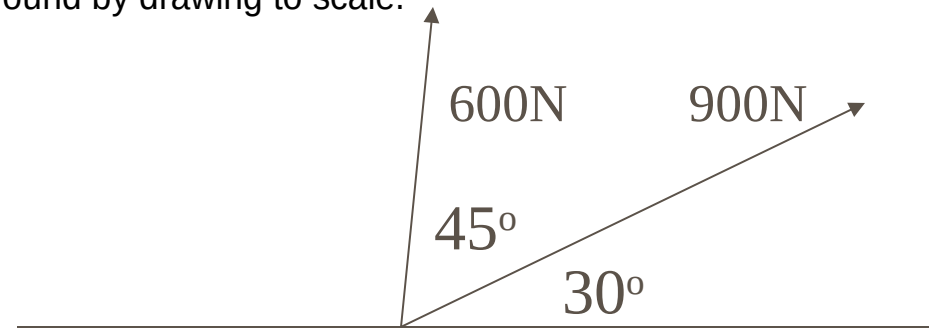
Example

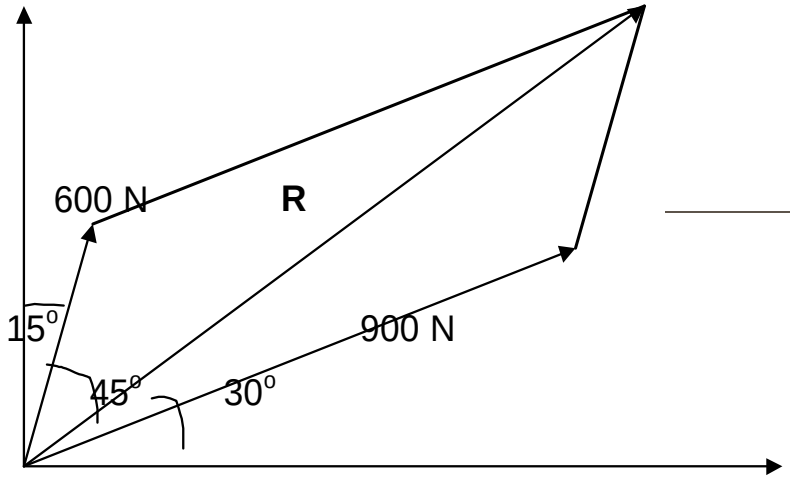
- Determine graphically, the magnitude and direction of the resultant of the two forces using (a) Paralleolegram law and (b) the triangle rule.



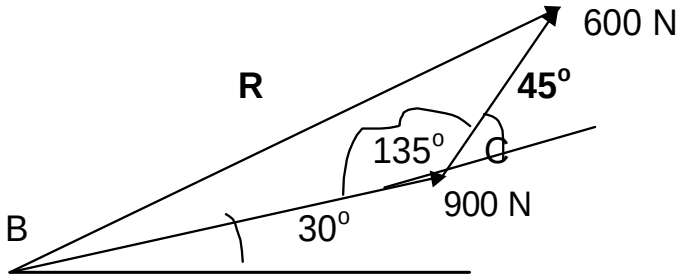
Solution

Solution: A parm. with sides equal to 900 N and 600 N is drawn to scale as shown. The magnitude and direction of the resultant can be found by drawing to scale.





The triangle rule may also be used. Join the forces in a tip to tail fashion and measure the magnitude and direction of the resultant.

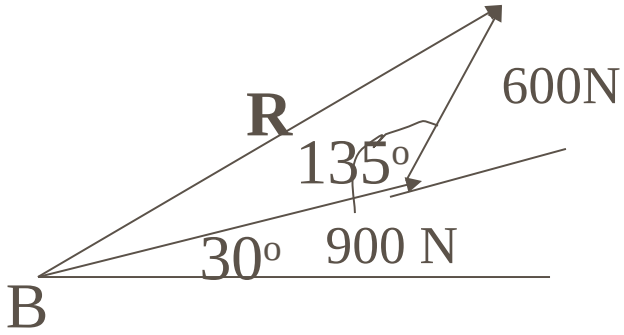


Trignometric Solution

Using the cosine law:

$$R^2 = 900^2 + 600^2 - 2 \times 900 \times 600 \cos 135^0$$

$$R = 1390.6 = 1391 \text{ N}$$



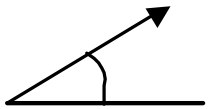
Using the sine law:

$$\frac{R}{\sin 135^o} = \frac{600}{\sin B} \quad i.e. \quad B = \sin^{-1} \frac{600 \sin 135^o}{1391}$$

$$= 17.8^o$$

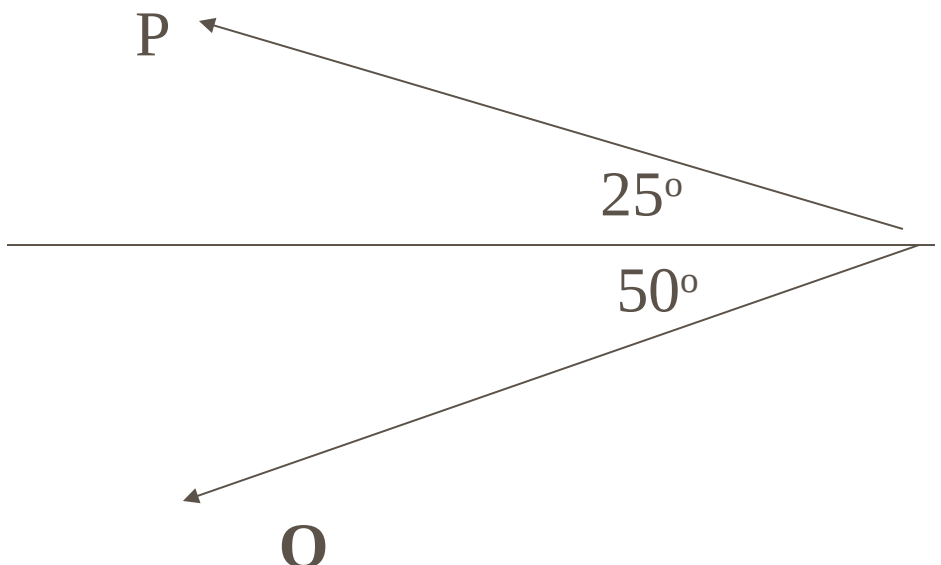
$$The\ angle\ of\ the\ resultant = 30 + 17.8 = 47.8^o$$

ie. R = 139N



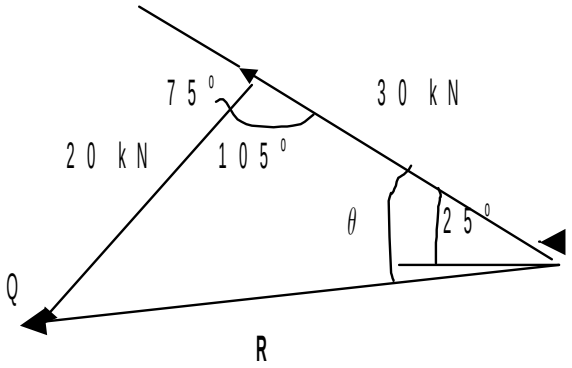
Example

- Two structural members B and C are bolted to bracket A. Knowing that both members are in tension and that **P** = 30 kN and **Q** = 20 kN, determine the magnitude and direction of the resultant force exerted on the bracket.



Solution

Solution: Using Triangle rule:



$R^2 = 30^2 + 20^2 - 2 \times 30 \times 20 \cos 105^0$ - cosine law

$R = 40.13\ N$

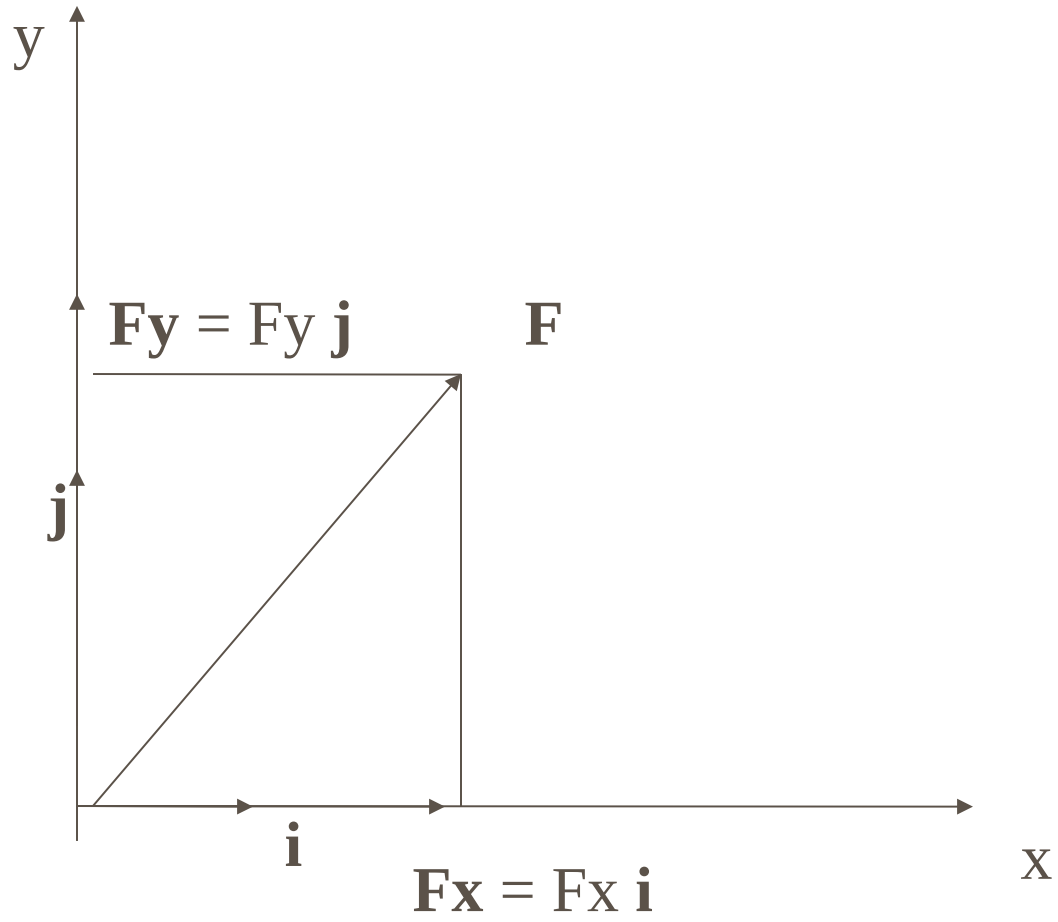
Using sine rule:

$$\frac{40.13\ N}{Sin\ 105^0} = \frac{20}{Sin\ \theta} \quad and \quad Sin^{-1} = \frac{20 \sin 105^0}{40.13} = 28.8^0$$

$Angle\ R = 28.8^0 - 25^0 = 3.8^0$

$i.e \quad R = 40.1\ N, \qquad 3.8^0$

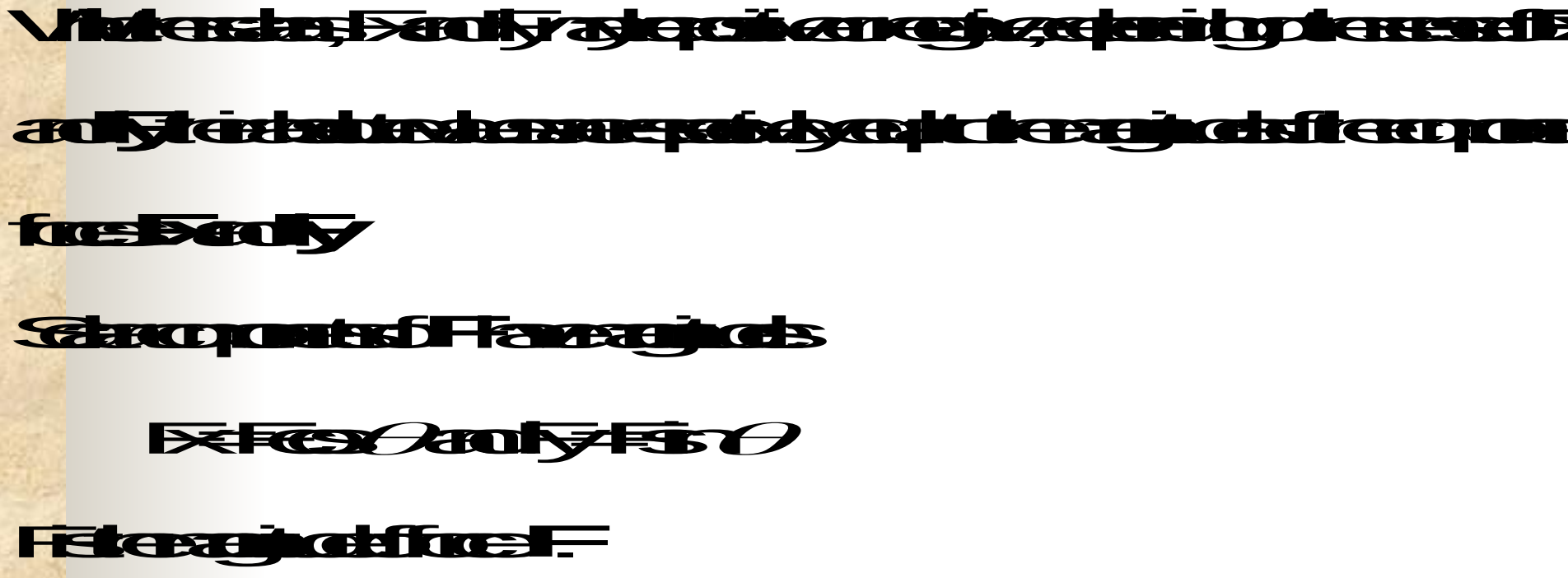
2.5 RECTANGULAR COMPONENTS OF FORCE



RECTANGULAR COMPONENTS OF FORCE CONTD.

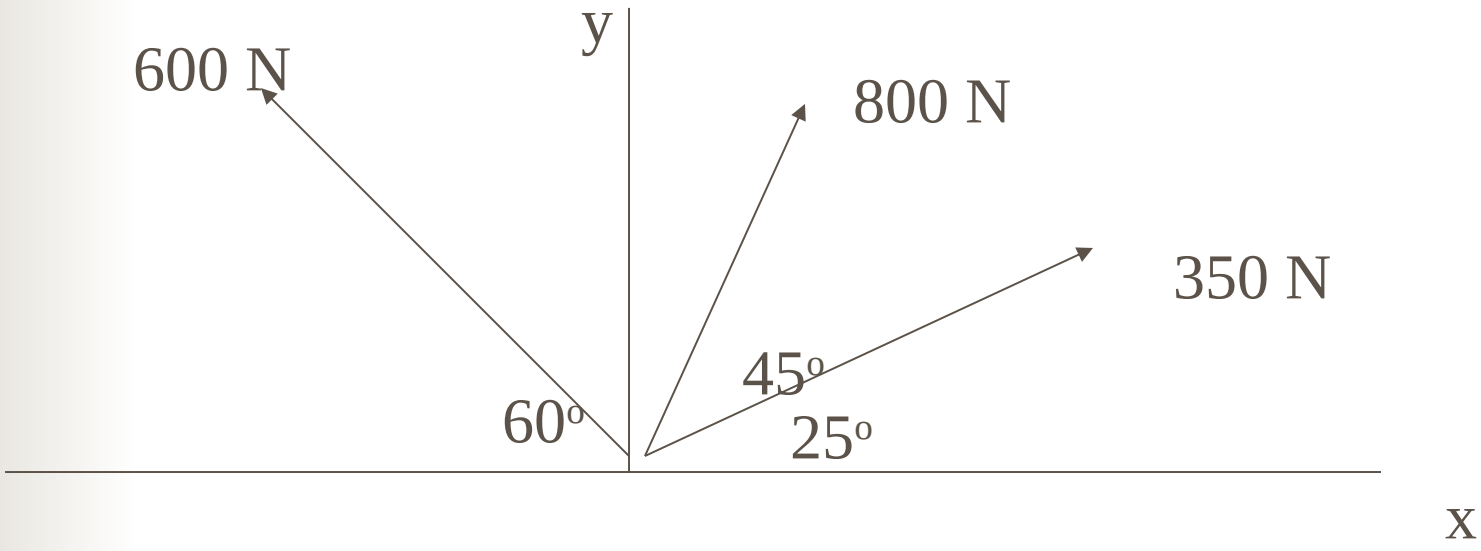
- In many problems, it is desirable to resolve force **F** into two perpendicular components in the x and y directions.
- **Fx** and **Fy** are called rectangular vector components.
- In two-dimensions, the cartesian unit vectors **i** and **j** are used to designate the directions of x and y axes.
- **Fx** = Fx **i** and **Fy** = Fy **j**
- i.e. **F** = Fx **i** + Fy **j**
- Fx and Fy are scalar components of **F**

RECTANGULAR COMPONENTS OF FORCE CONTD.



Example

- Determine the resultant of the three forces below.



Solution

$\sum F_x = 350 \cos 25^\circ + 800 \cos 70^\circ - 600 \cos 60^\circ$

$= 317.2 + 273.6 - 300 = 290.8 \text{ N}$

$\sum F_y = 350 \sin 25^\circ + 800 \sin 70^\circ + 600 \sin 60^\circ$

$= 147.9 + 751 + 519.6 = 1419.3 \text{ N}$

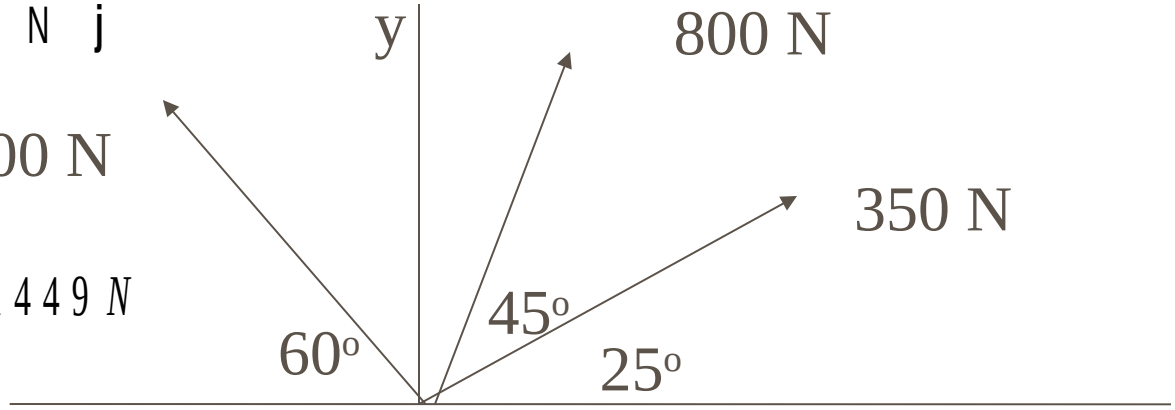
i.e. $\mathbf{F} = 290.8 \text{ N } \mathbf{i} + 1419.3 \text{ N } \mathbf{j}$

Resultant, F

$$F = \sqrt{290.8^2 + 1419.3^2} = 1449 N$$

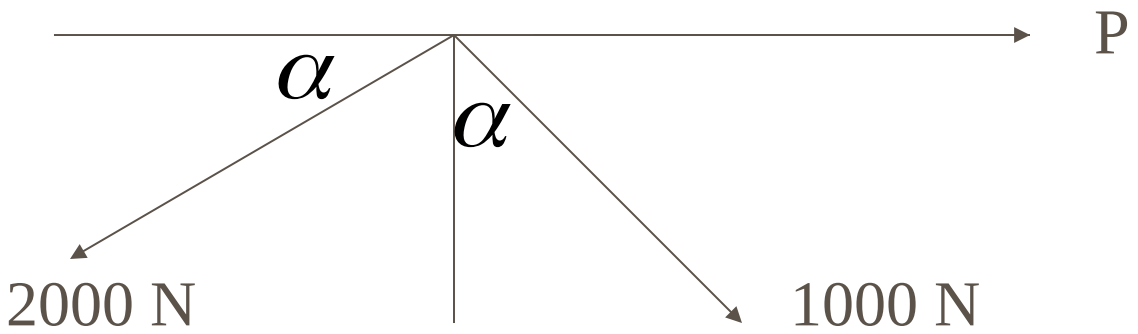
$$\theta = \tan^{-1} \frac{1419.3}{290.8} = 78.4^0$$

$\mathbf{F} = 1449 \text{ N} \quad 78.4^\circ$



Example

- A hoist trolley is subjected to the three forces shown. Knowing that $\alpha = 40^{o}$, determine (a) the magnitude of force, P for which the resultant of the three forces is vertical (b) the corresponding magnitude of the resultant.



Solution

(a) The resultant being vertical means that the horizontal component is zero.

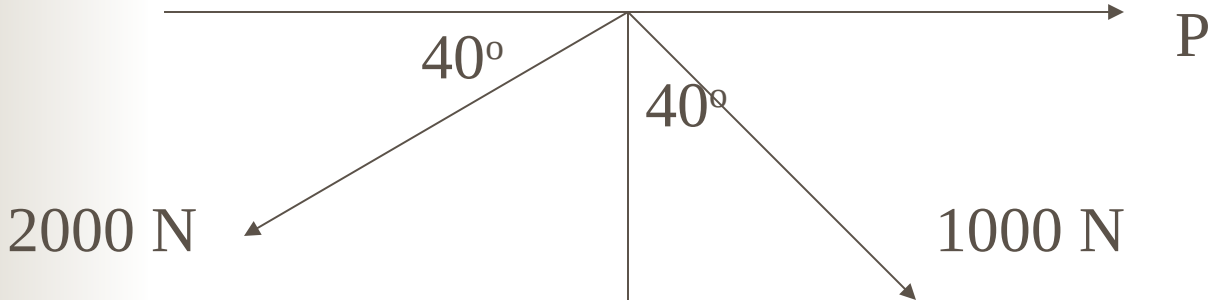
Σ F x = 1000 sin 40^o + P - 2000 cos 40^o = 0

P = 2000 cos 40^o - 1000 sin 40^o =

1532.1 - 642.8 = 889.3 = **889 kN**

(b) Σ Fy = - 2000 sin 40^o - 1000 cos 40^o =

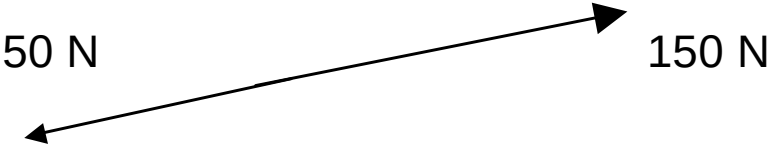
- 1285.6 - 766 = **- 2052 N** = **2052 N** ↓



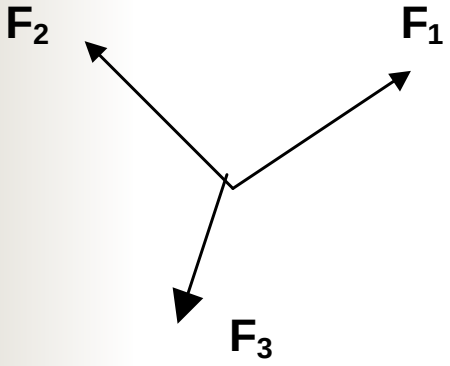
2.6. EQUILIBRIUM OF A PARTICLE

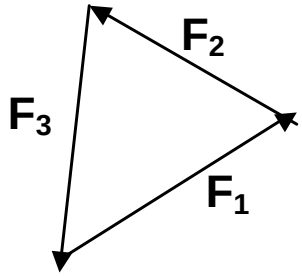
A particle is said to be at equilibrium when the resultant of all the forces acting on it is zero. It two forces are involved on a body in equilibrium, then the forces are equal and opposite.

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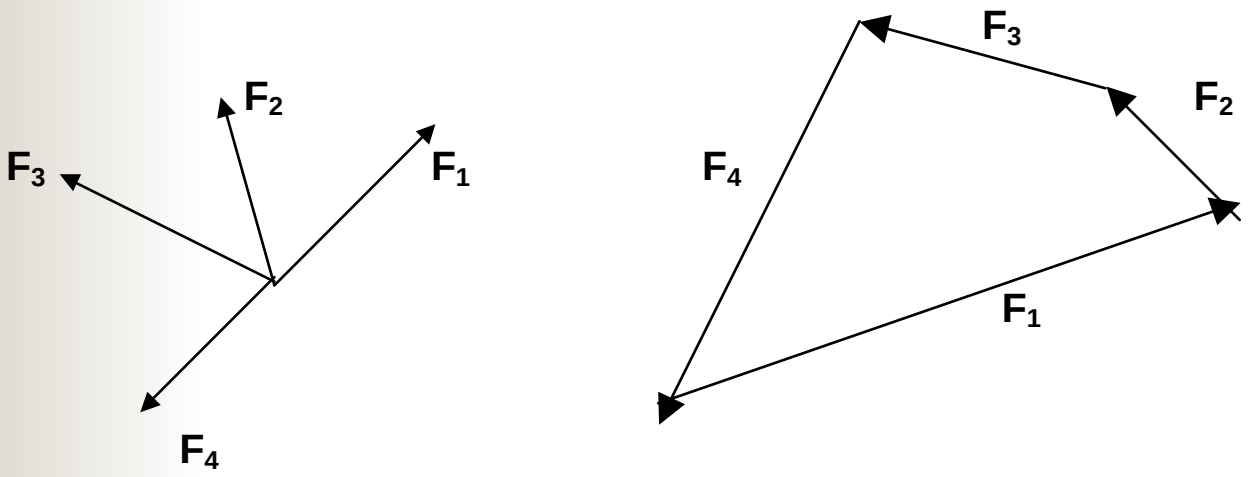
If there are three forces, when resolving, the triangle of forces will close, if they are in equilibrium.





EQUILIBRIUM OF A PARTICLE CONTD.

If there are more than three forces, the polygon of forces will be closed if the particle is in equilibrium.



The closed polygon provides a graphical expression of the equilibrium of forces. Mathematically: For equilibrium:

$$\mathbf{R} = \Sigma \mathbf{F} = 0$$

i.e. Σ (Fx **i** + Fy j) = 0 or Σ (Fx) **i** + Σ (Fy) **j**

EQUILIBRIUM OF A PARTICLE CONCLUDED

- **For equilibrium:**
- $\sum Fx = 0$ and
- $\sum F y = 0.$
- **Note:** Considering Newton's first law of motion, equilibrium can mean that the particle is either at rest or moving in a straight line at constant speed.

FREE BODY DIAGRAMS:

- Space diagram represents the sketch of the physical problem. The free body diagram selects the significant particle or points and draws the force system on that particle or point.
- **Steps:**
- **1.** Imagine the particle to be isolated or cut free from its surroundings. Draw or sketch its outlined shape.

Free Body Diagrams Contd.

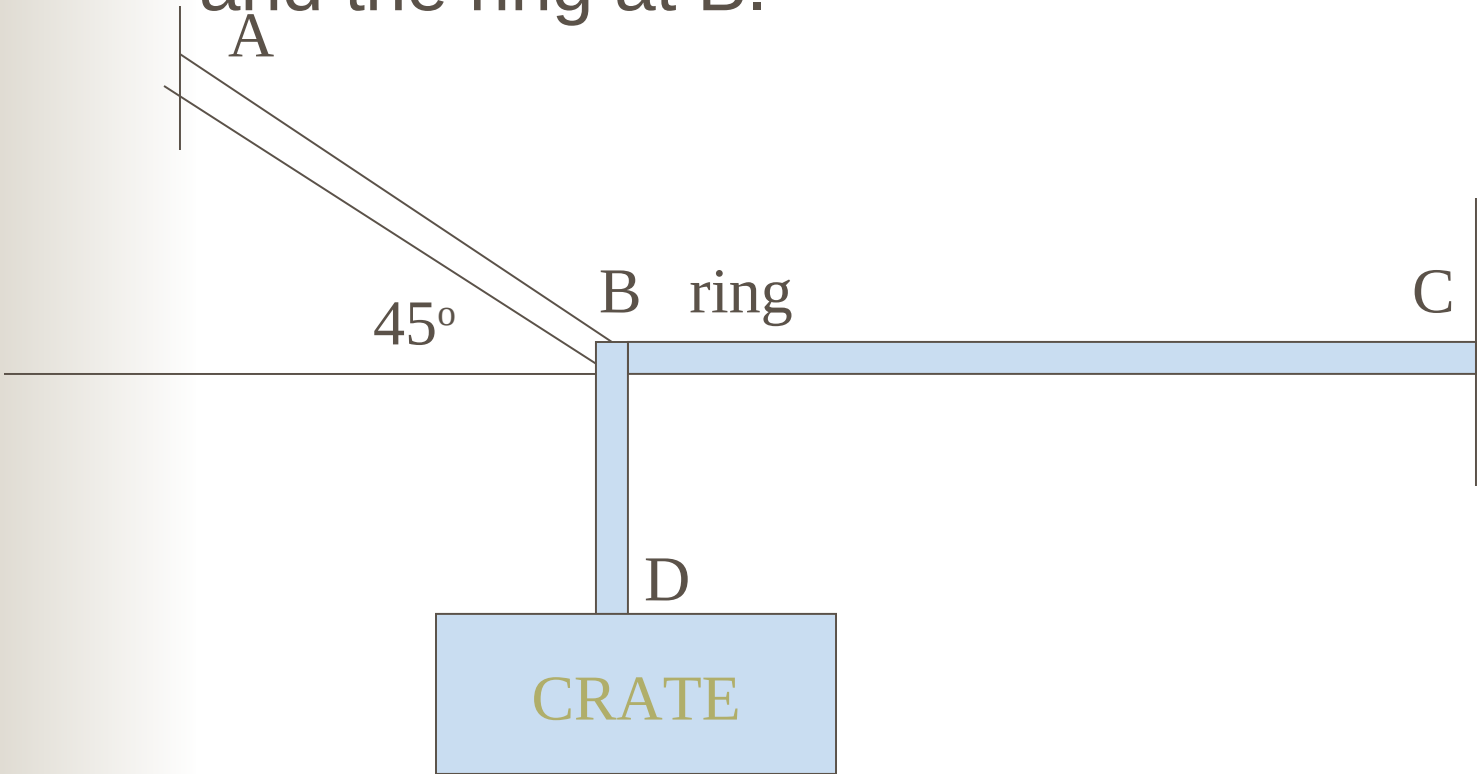
- 2. Indicate on this sketch all the forces that act on the particle.
- These include active forces - tend to set the particle in motion e.g. from cables and weights and reactive forces caused by constraints or supports that prevent motion.

Free Body Diagrams Contd.

- 3. Label known forces with their magnitudes and directions. use letters to represent magnitudes and directions of unknown forces.
- Assume direction of force which may be corrected later.

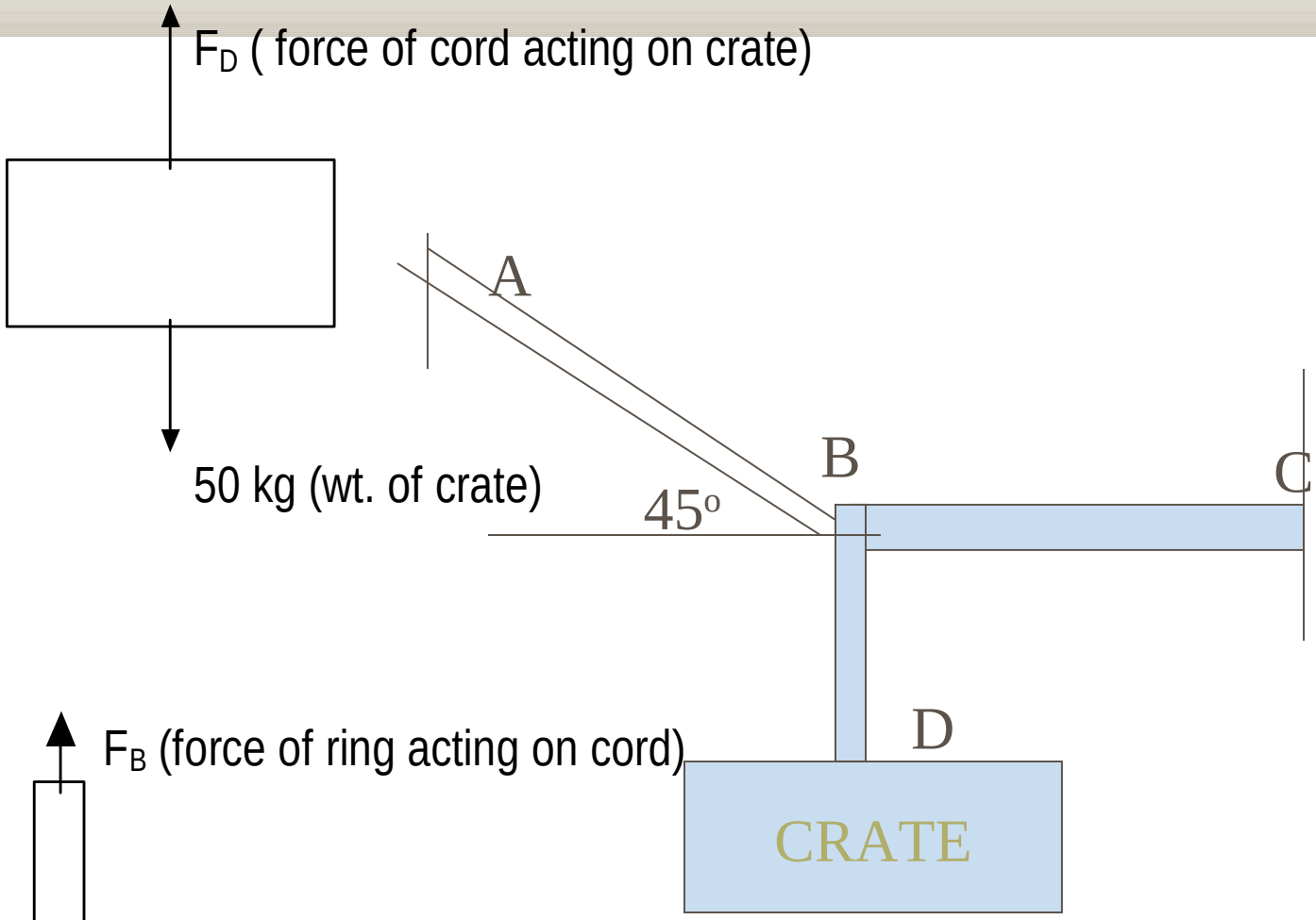
Example

- The crate below has a weight of 50 kg. Draw a free body diagram of the crate, the cord BD and the ring at B.



Solution

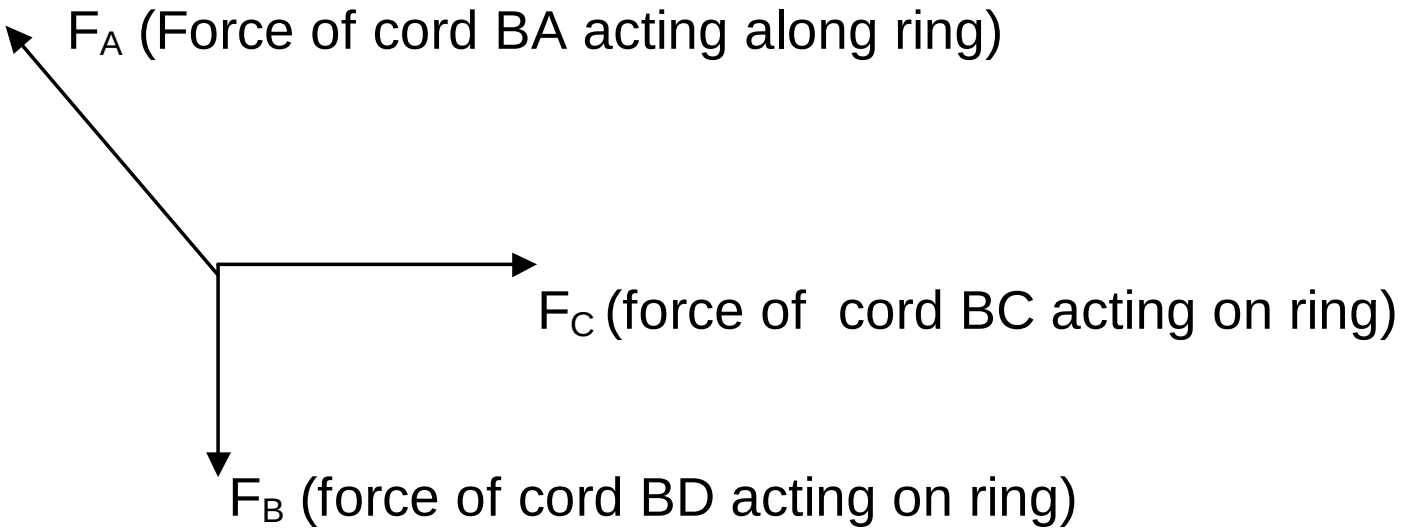
(a) Crate



(b) Cord BD

Solution Contd.

(c) Ring



Example

Example: Problem 2.36: Two cables are tied at C and loaded as shown. Determine the tension in AC and BC.

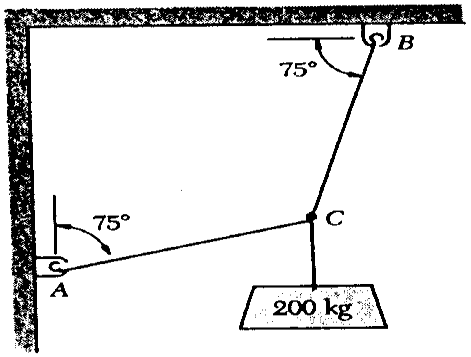
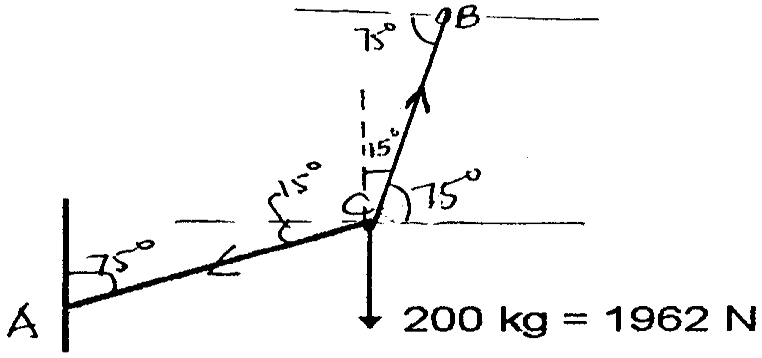


Fig. P2.36

Solution: Free body diagram



200 kg = 200 x 9.81 N = 1962 N

For equilibrium: $\Sigma F_x = 0$ i.e $F_{BC} \cos 75° - F_{AC} \sin 75° = 0$

Cos 15° or

Solution Contd.

$$F_{BC} = \frac{F_{AC} \sin 75^{0}}{\cos 75^{0}} = 3.73 F_{AC} \ldots\ldots\ldots\ldots (1)$$

$$\Sigma Fy = 0 \quad \text{i.e.} \quad F_{BC} \sin 75^{0} - F_{AC} \cos 75^{0} - 1962 = 0$$

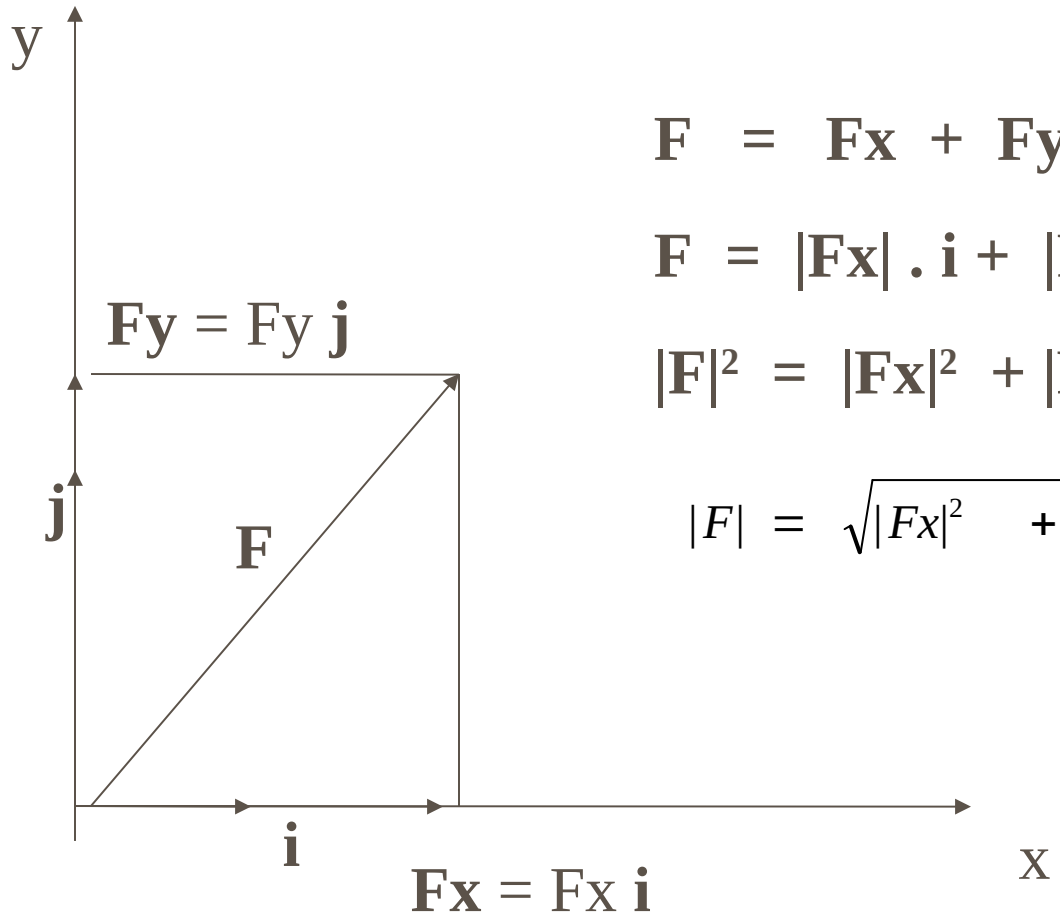
$$F_{BC} = \frac{1962 + 0.26 F_{AC}}{0.966} = 2031.2 + 0.27 F_{AC} \ldots\ldots (2)$$

From Equations (1) and (2), $3.73 F_{AC} = 2031.2 + 0.27 F_{AC}$

$$F_{AC} = 587 \text{ N}$$

From (1), $F_{BC} = 3.73 \times 587 = \underline{\mathbf{2190 \text{ N}}}$

RECTANGULAR COMPONENTS OF FORCE (REVISITED)



$$\mathbf{F} = \mathbf{Fx} + \mathbf{Fy}$$

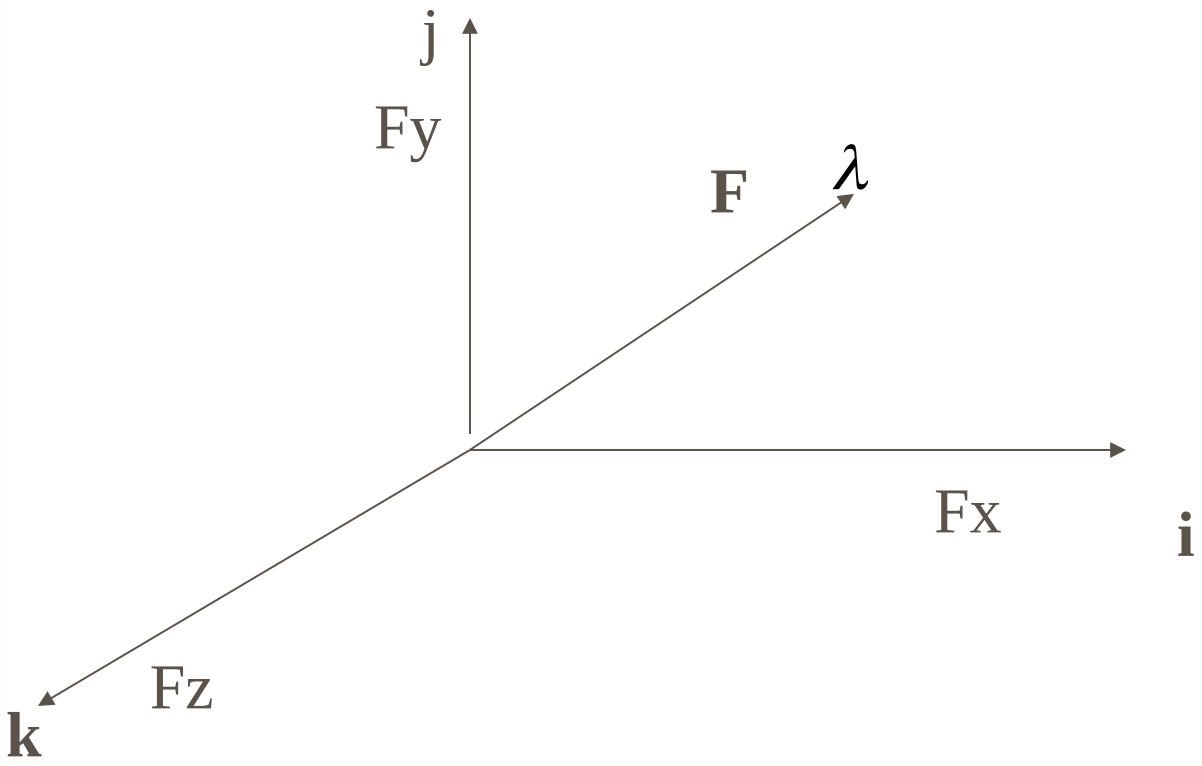
$$\mathbf{F} = |\mathbf{Fx}| \cdot \mathbf{i} + |\mathbf{Fy}| \cdot \mathbf{j}$$

$$|\mathbf{F}|^2 = |\mathbf{Fx}|^2 + |\mathbf{Fy}|^2$$

$$|F| = \sqrt{|Fx|^2 + |Fy|^2}$$

2.8 Forces in Space

- Rectangular Components



Rectangular Components of a Force in Space

$$\mathbf{F} = \mathbf{Fx} + \mathbf{Fy} + \mathbf{Fz}$$

$$\mathbf{F} = |\mathbf{Fx}|\,.\,\mathbf{i} + |\mathbf{Fy}|\,.\,\mathbf{j} + |\mathbf{Fz}|\,.\,\mathbf{k}$$

$$|\mathbf{F}|^2 = |\mathbf{Fx}|^2 + |\mathbf{Fy}|^2 + |\mathbf{Fz}|^2$$

$$|F| = \sqrt{|Fx|^2 + |Fy|^2 + |Fz|^2}$$

$$|Fx| = |F|\cos\theta_x \qquad |Fy| = |F|\cos\theta_y \qquad |Fz| = |F|\cos\theta_z$$

$Cos\theta_x, Cos\theta_y$ and $Cos\theta_z$ are called direction cosines of angles θ_x, θ_y and θ_z

Forces in Space Contd.

i.e. $\mathbf{F} = F(\cos\theta_x\, i + \cos\theta_y\, j + \cos\theta_z\, k) = F\lambda$

F can therefore be expressed as the product of scalar, F

and the unit vector λ where: $\lambda = \cos\theta_x\, i + \cos\theta_y\, j + \cos\theta_z\, k.$

λ is a unit vector of magnitude 1 and of the same direction as **F**.

λ is a unit vector along the line of action of **F.**

Forces in Space Contd.

Also:

$\lambda_x = \cos\theta_x$, $\lambda_y = \cos\theta_y$ and $\lambda_z = \cos\theta_z$ - Scalar vectors

i.e. magnitudes.

$\lambda_x^2 + \lambda_y^2 + \lambda_z^2 = 1 = \lambda^2$

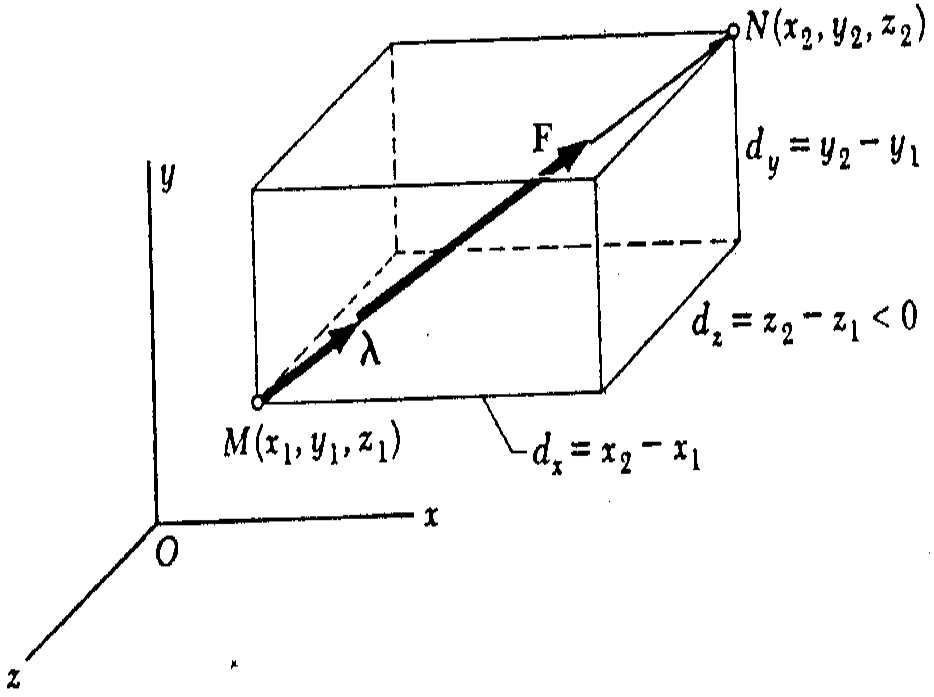
i.e. $\boxed{\cos^2\theta_x + \cos^2\theta_y + \cos^2\theta_z = 1}$

Note: If components, Fx, Fy, and Fz of a Force, **F** are known,

the magnitude of **F**, $F = F_x^2 + F_y^2 + F_z^2$

Direction cosines are: $\cos\theta_x = F_x/F$, $\cos\theta_y = F_y/F$ and $\cos^2\theta_z = F_z/F$

2.8.2 Force Defined by Magnitude and Two Points on its Line of Action



Consider two points along the direction of force, **F** with co-ordinates M (x_1, y_1 ,z_1) and N (x_2, y_2 ,z_2). Consider the vector **MN** which is of same sense as **F**. The position vector: $\mathbf{MN} = d_x\,\mathbf{i} + d_y\,\mathbf{j} + d_z\,\mathbf{k}$

Where: d_x, d_y and d_z are scalar components of **MN.**

Force Defined by Magnitude and two Points on its Line of Action Contd.

Unit vector, λ along the line of action of **F = MN/**MN

MN is the distance, d from M to N.

$$\lambda = \mathbf{MN}/\mathrm{MN} = 1/d\,(d_x\,\mathbf{i} + d_y\,\mathbf{j} + d_z\,\mathbf{k})$$

Recall that: $\mathbf{F} = F\,\lambda$

$$\mathbf{F} = F\lambda = F/d\,(d_x\,\mathbf{i} + d_y\,\mathbf{j} + d_z\,\mathbf{k})$$

$$F_x = \frac{Fd_x}{d}, \quad F_y = \frac{Fd_y}{d}, \quad F_z = \frac{Fd_z}{d}$$

$$d_x = x_2 - x_1, \quad d_y = y_2 - y_1, \quad d_z = z_2 - z_1$$

$$d = \sqrt{d_x^{\,2} + d_y^{\,2} + d_z^{\,2}}$$

$$\cos\theta_x = \frac{d_x}{d}, \quad \cos\theta_y = \frac{d_y}{d}, \quad \cos\theta_z = \frac{d_z}{d}$$

2.8.3 Addition of Concurrent Forces in Space

The resultant, **R** of two or more forces in space is obtained by summing their rectangular components i.e.

$$\mathbf{R} = \Sigma \mathbf{F}$$

$$\text{i.e. } R_x \mathbf{i} + R_y \mathbf{j} + R_z \mathbf{k} = \Sigma (F_x \mathbf{i} + F_y \mathbf{j} + F_z \mathbf{k})$$

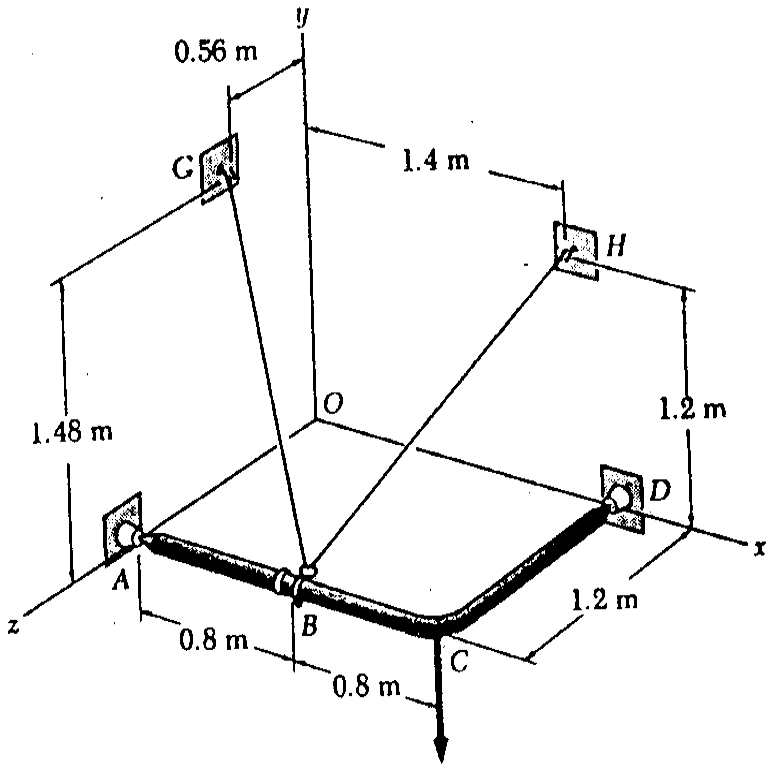
$$= (\Sigma F_x)\ \mathbf{i} + (\Sigma F_y)\mathbf{j} + (\Sigma F_z)\mathbf{k}$$

$$R_x = \Sigma \mathbf{Fx}, \qquad R_y = \Sigma \mathbf{Fy}, \qquad R_z = \Sigma \mathbf{Fz}$$

$$R = R_x^2 + R_y^2 + R_z^2$$

$$\cos \theta_x = R_x/R \qquad \cos \theta_y = R_y/R \qquad \cos \theta_z = R_z/R$$

Example: Problem 2.66: Two cables BG and BH are attached to the frame ACD as shown. Knowing that the tension in cable BH is 750 N, determine the components of the force exerted by cable BH on the frame at B.



Solution: Position vector of **BH** = 0.6 m **i** + 1.2 m **j** - 1.2 m **k**

Solution

Solution:

Position vector of **BH** = 0.6 m **i** + 1.2 m **j** - 1.2 m **k**

Magnitude, BH = $\sqrt{0.6^2 + 1.2^2 + 1.2^2} = 1.8\ m$

$$\lambda_{BH} = \frac{\vec{BH}}{|BH|} = \frac{1}{1.8}\left[(0.6\ m\ i + 1.2\ m\ j - 1.2\ m\ k)\right]$$

$$\vec{T_{BH}} = |T_{BH}|.\quad \lambda_{BH} = |T_{BH}|\ \frac{\vec{BH}}{|BH|} = \frac{750\ N}{1.8\ m}\left[0.6\ m\ i + 1.2\ m\ j - 1.2\ m\ k\right]$$

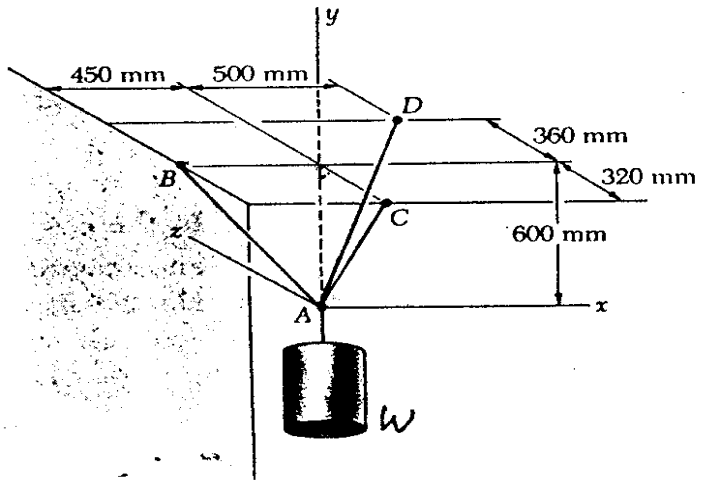
$$\vec{T_{BH}} = (250\ N)\ \vec{i} + (500\ N)\ \vec{j} - (500\ N)\ \vec{k}$$

$$F_x = 250\ N,\quad F_y = 500\ N,\quad F_z = -\ 500\ N$$

2.9 EQUILIBRIUM OF A PARTICLE IN SPACE

- For equilibrium:
- $\sum F_x = 0$, $\sum F_y = 0$ and $\sum F_z = 0$.
- The equations may be used to solve problems dealing with the equilibrium of a particle involving no more than three unknowns.

Example: Problem 2.78: A container is supported by three cables which are attached to a ceiling as shown. Determine the weight, W of the container, knowing that the tension in Cable AD is 4.3 kN.



Solution: Position vector, **AC** = 0 **i** + 600 mm **j** - 320 mm **k**

$AC = \sqrt{600^2 + 320^2} = 680$ mm

$\mathbf{T_{AC}} = T_{AC} \cdot \lambda_{AC} = T_{AC} \times \mathbf{AC}/AC = T_{AC}/680\ (600\ \text{mm}\ \mathbf{j} - 320\ \text{mm}\ \mathbf{k})$

$\mathbf{T_{AC}} = T_{AC}\ (0.88\ \mathbf{j} - 0.47\ \mathbf{k})$ ..... (1)

Position vector **AB** = - 450 mm **i** + 600 mm **j**

$AB = \sqrt{450^2 + 600^2} = 750$ mm

$\mathbf{T_{AB}} = T_{AB} \times \mathbf{AB}/AB = T_{AB}/750\ (\mathbf{AB}) = T_{AB}\ (-0.6\ \mathbf{i} + 0.8\ \mathbf{j})$ ..... (2)

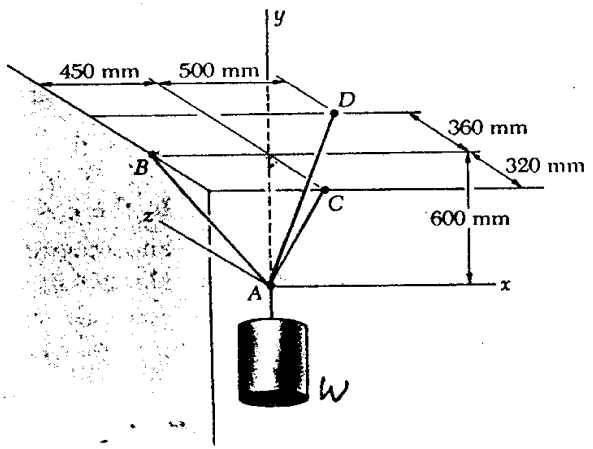
Position vector of **AD**, = 500 mm **i** + 600 mm **j** + 360 mm **k**

$AD = \sqrt{500^2 + 600^2 + 360^2} = 860$ mm.

$\mathbf{T_{AD}} = T_{AD} \times \mathbf{AD}/AD = (4300\ N/860\ mm) \times AD$

$= 2500\ N\,\mathbf{i} + 3000\ N\,\mathbf{j} + 1800\ N\,\mathbf{k}$ ..... (3)

Load, $\mathbf{W} = -W\,\mathbf{j}$ .....(4)



Summary

Tensions	x dir	y dir	z dir
AC	0	$0.88\,T_{AC}$	$-0.47\,T_{AC}$
AB	$-0.6\,T_{AB}$	$0.8\,T_{AB}$	0
AD	2500 N	3000 N	1800 N
W	0	$-W$	0

Using equations 1 to 4:

$\Sigma F_x = 0$ i.e. $-0.6\,T_{AB} + 2500 = 0$

$\mathbf{T_{AB}} = 2500/0.6 = 4167$ N

$\Sigma F_z = 0$ i.e. $-0.47\,T_{AC} + 1800 = 0$

$T_{AC} = 3829.78$ N

$\Sigma F_y = 0$ i.e. $0.88\,T_{AC} + 0.8\,T_{AB} - W + 3000 = 0$

$W = 0.88\,T_{AC} + 3333.6 + 3000$ i.e. $W = (0.88 \times 3829.78) + 6333.6$ N

$W = 9703.8$ N = **9.70kN**