ENGINEERING MECHANICS BAA1113

Chapter 2: Force Vectors (Static)

by

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Chapter Description

- Aims
  - To review the Parallelogram Law and Trigonometry
  - To explain the Force Vectors
  - To explain the Vectors Operations (Parlaw & Cartesian)
  - To express force and position in Cartesian Vectors

- Expected Outcomes
  - Able to solve the problems of force and position vectors in the mechanics applications by using Cartesian Coordinate System

- References
  - Russel C. Hibbeler. Engineering Mechanics: Statics & Dynamics, 14^{th} Edition

Chapter Outline

2.1 Scalars and Vectors – part I

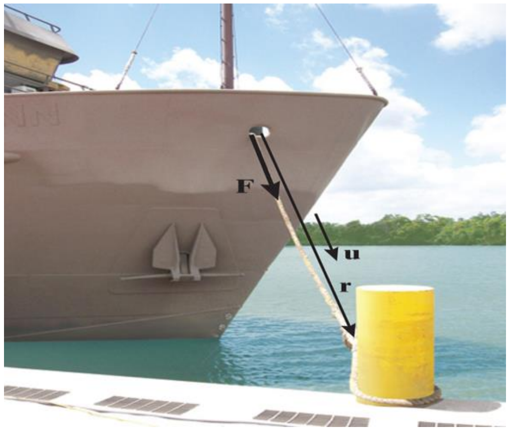
2.2 Vectors Operations – part I

2.3 Vectors Addition of Forces – part I

2.4 Cartesian Vectors – part II

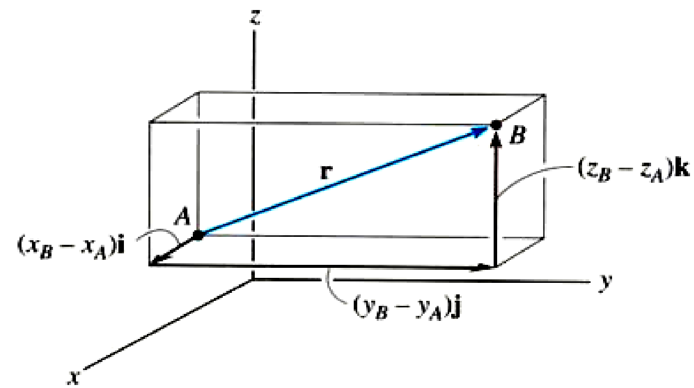
2.5 **Force and Position Vectors – part III**

2.5 Position Vector



- **B** is the **ending point** and **A** is the **starting point**
- Must **subtract** the **tail** coordinates **from** the **tip**

What is Position Vector?



- It is a **fixed vector** that locates a **point in space** relative to another **point**
- A Position can be defined by its **coordinate** in **3-D space**
- A **Position vector** directed from A to B is denoted as $\boldsymbol{r}_{AB}$
- Let point A (X_A, Y_A, Z_A) and B (X_B, Y_B, Z_B)

$$\boldsymbol{r}_{AB} = \{(X_B - X_A)\,\boldsymbol{i} + (Y_B - Y_A)\,\boldsymbol{j} + (Z_B - Z_A)\,\boldsymbol{k}\}\text{m}$$

Application of Position Vector

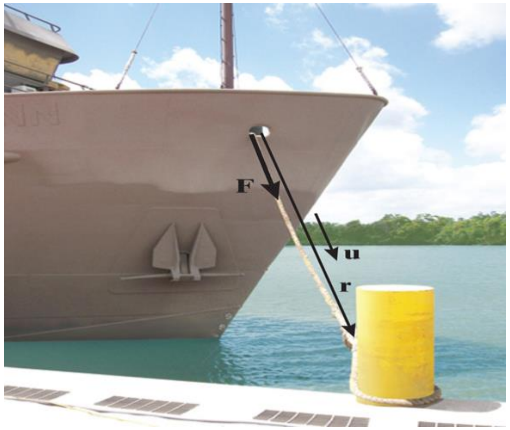
Measure the **length** of cable AB

Position vector **r** can be established

r = *x***i** + *y***j** + *z***k**

Magnitude **r** represent the **length** of cable

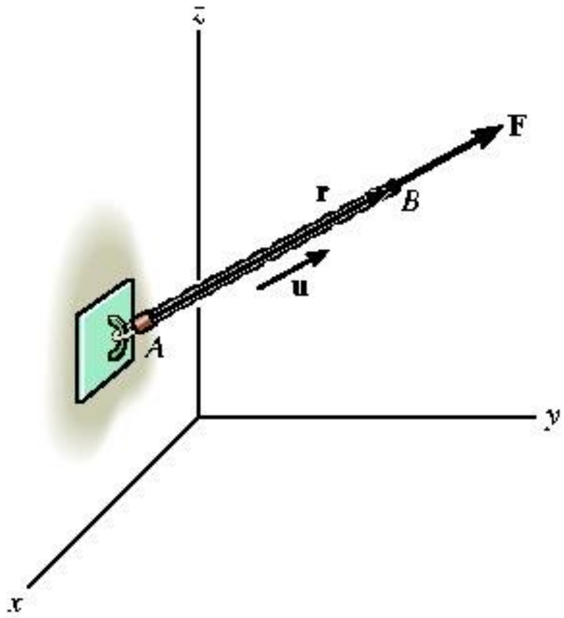
Measure the **direction** of cable AB



Unit vector **u** = **r**/r

Angles α, β, γ represent the **direction** of cable AB

Force Vector Directed Along a Line



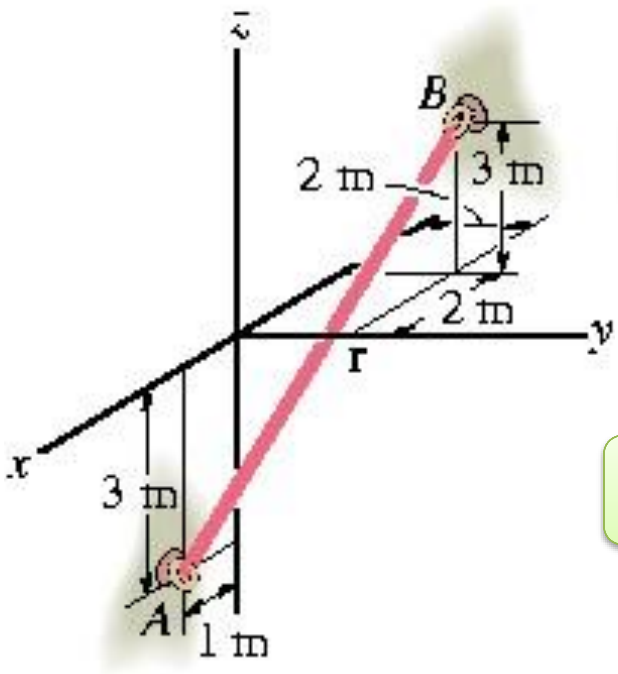
If a **force** is directed along a **line**

- It can represent the force vector in **Cartesian coordinates** by using a **unit vector and the force's magnitude**

- Step 1: Established position vector $\boldsymbol{r_{AB}}$
- Step 2: Established unit vector $\boldsymbol{u_{AB}} = (\boldsymbol{r_{AB}}/ r_{AB})$
- Step 3: Magnitude of force $\mathbf{F} = F\, \boldsymbol{u_{AB}}$

Example 2.12

The elastic rubber band is attached to points A and B. Determine the length and direction measured from A to B



(a)

Step 1

- Established position vector $\boldsymbol{r}_{AB}$

Step 2

- Established unit vector $\boldsymbol{u}_{AB} = (\boldsymbol{r}_{AB} / r_{AB})$

Magnitude r_{AB} = length of the rubber band

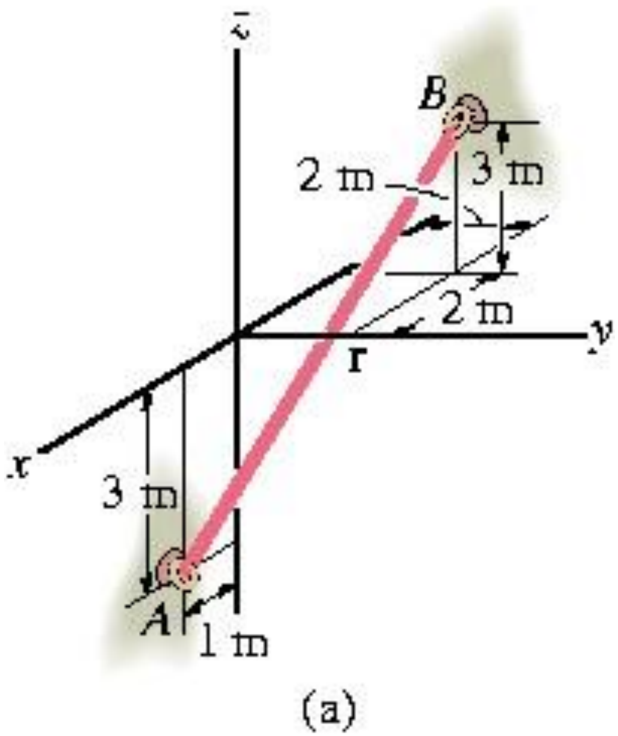
Step 3

Direction = coordinate angles of $\boldsymbol{r}_{AB}$

$$\boldsymbol{u}_{AB} = \cos\alpha\, \boldsymbol{i} + \cos\beta\, \boldsymbol{j} + \cos\gamma\, \boldsymbol{k}$$

Solution Example 2.12

The elastic rubber band is attached to points A and B. Determine the length and direction measured from A to B



Step 1

- Established position vector $\boldsymbol{r}_{AB}$

- From A to B, it's need to go -3 m in the x-direction, 2 m in the y-direction, and 6 m in the z-direction

$\boldsymbol{r}_{AB} = \{ -3\,\boldsymbol{i} + 2\,\boldsymbol{j} + 6\,\boldsymbol{k} \}$m

or

-point A (X_A, Y_A, Z_A) and B (X_B, Y_B, Z_B)

-point A (1, 0, -3) and B (-2, 2, 3)

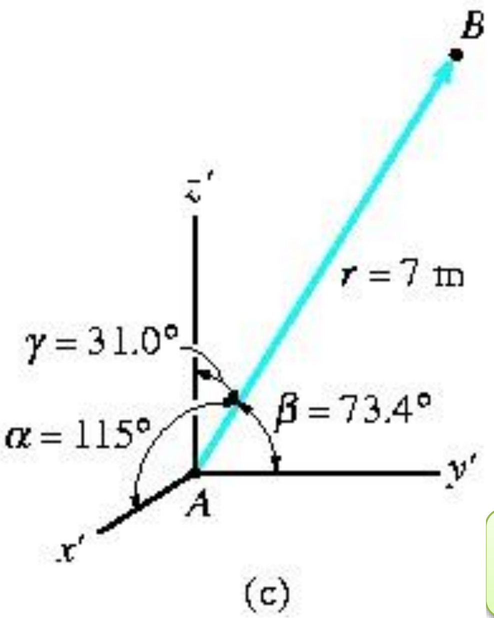
$\boldsymbol{r}_{AB} = \{(X_B - X_A)\,\boldsymbol{i} + (Y_B - Y_A)\,\boldsymbol{j} + (Z_B - Z_A)\,\boldsymbol{k}\}$m

$\boldsymbol{r}_{AB} = \{(-2 - 1)\,\boldsymbol{i} + (2 - 0)\,\boldsymbol{j} + (3 - (-3))\,\boldsymbol{k}\}$m

$\boldsymbol{r}_{AB} = \{(-3)\,\boldsymbol{i} + (2)\,\boldsymbol{j} + (6)\,\boldsymbol{k}\}$m

Solution Example 2.12

The elastic rubber band is attached to points A and B. Determine the length and direction measured from A to B



Step 2

- Established unit vector $u_{AB} = (r_{AB} / r_{AB})$

$$r_{AB} = \sqrt{(-3)^2 + (2)^2 + (6)^2} = 7m$$

Magnitude = length of the rubber band =7m

u_{AC} = (-3/7) ***i*** + (2/7) ***j*** + (6/7) ***k***) } N

u_{AC} = -0.428 ***i*** + 0.285 ***j*** + 0.857 ***k***) } N

Step 3

- Direction A to B

u_{AB} = cos α ***i*** + cos β ***j*** + cos γ ***k***

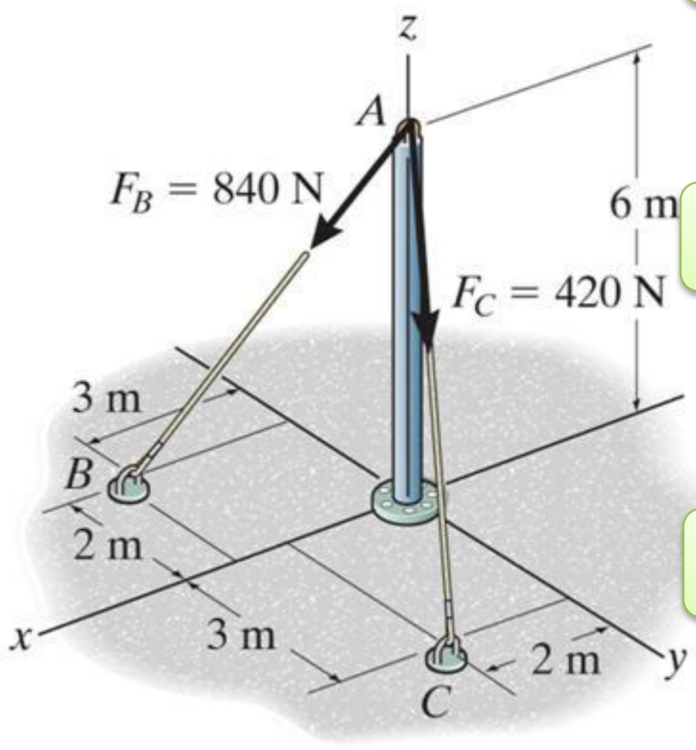
α = $\cos^{-1}(-3/7)$ = 115°

β = $\cos^{-1}(2/7)$ = 73.4°

γ = $\cos^{-1}(6/7)$ = 31°

Example 2.13

Determine the force $\mathbf{F}_{AC}$ in the Cartesian vectors. Given , the 420 N Force along the cable **AC**



Step 1

- Established position vector $\boldsymbol{r}_{AC}$

Step 2

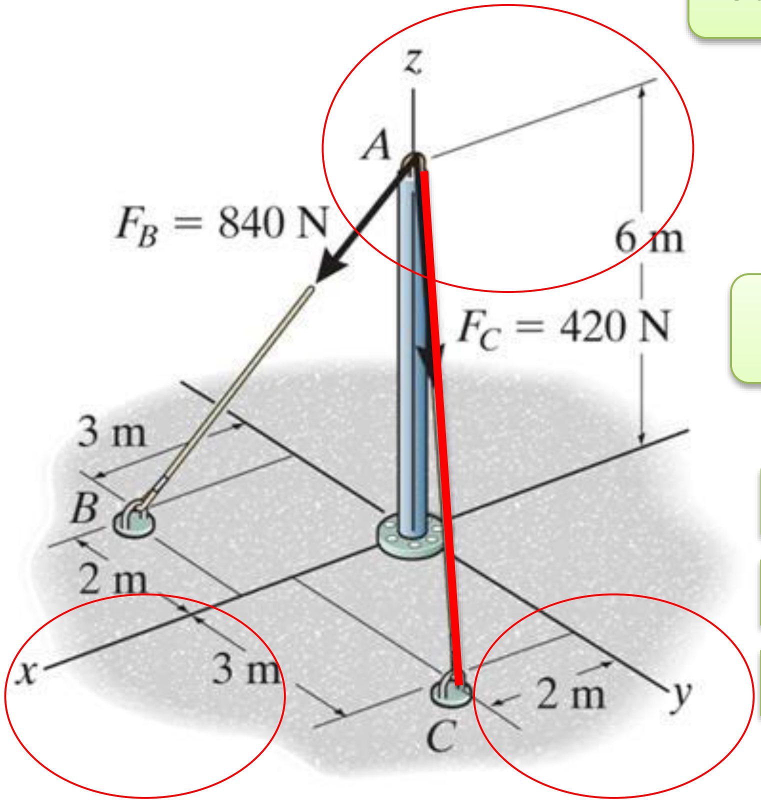
- Established unit vector $\boldsymbol{u}_{AC} = (\boldsymbol{r}_{AC} / r_{AC})$

Step 3

- Magnitude of force $\mathbf{F} = F\ \boldsymbol{u}_{AC}$

Solution Example 2.13

Determine the force $\mathbf{F}_{AC}$ in the Cartesian vectors. Given , the 420 N Force along the cable **AC**



Step 1

- Established position vector r_{AC}

- From A to C, it's need to go 2 m in the x-direction, 3 m in the y-direction, and -6 m in the z-direction

$$r_{AC} = \{2\,i + 3\,j - 6\,k\}\text{m}$$

or

-point A (X_A, Y_A, Z_A) and C (X_C, Y_C, Z_C)

-point A (0, 0, 6) and C (2, 3, 0)

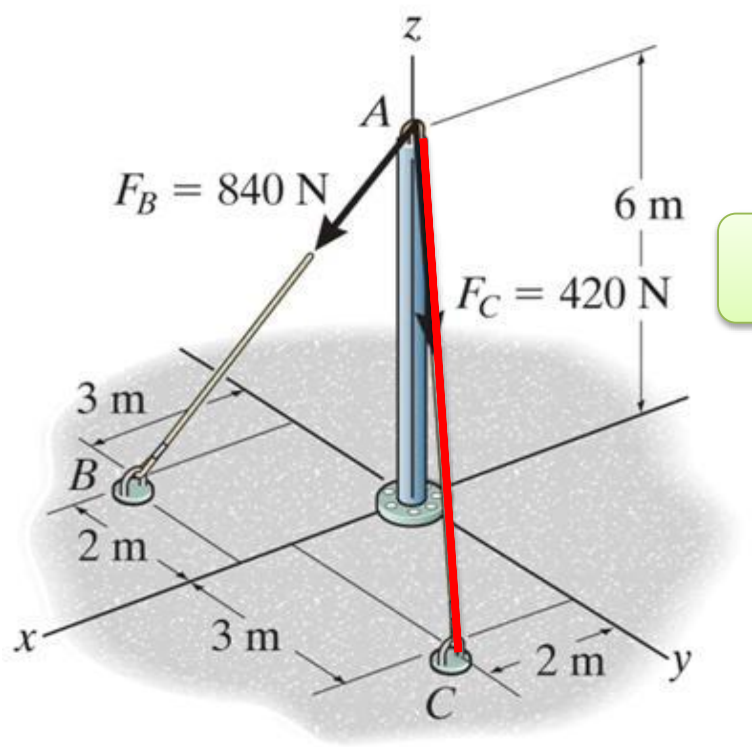
$$r_{AC} = \{(X_C - X_A)\,i + (Y_C - Y_A)\,j + (Z_C - Z_A)\,k\}\text{m}$$

$$r_{AC} = \{(2 - 0)\,i + (3 - 0)\,j + (0 - 6)\,k\}\text{m}$$

$$r_{AC} = \{(2)\,i + (3)\,j + (-6)\,k\}\text{m}$$

Solution Example 2.13

Determine the force $\mathbf{F}_{AC}$ in the Cartesian vectors. Given , the 420 N Force along the cable **AC**



Step 2

- Established unit vector $u_{AC} = (r_{AC} / r_{AC})$

$$r_{AC} = \sqrt{(2)^2 + (3)^2 + (-6)^2} = 7m$$

Step 3

- Magnitude of force **F** = F u_{AC}

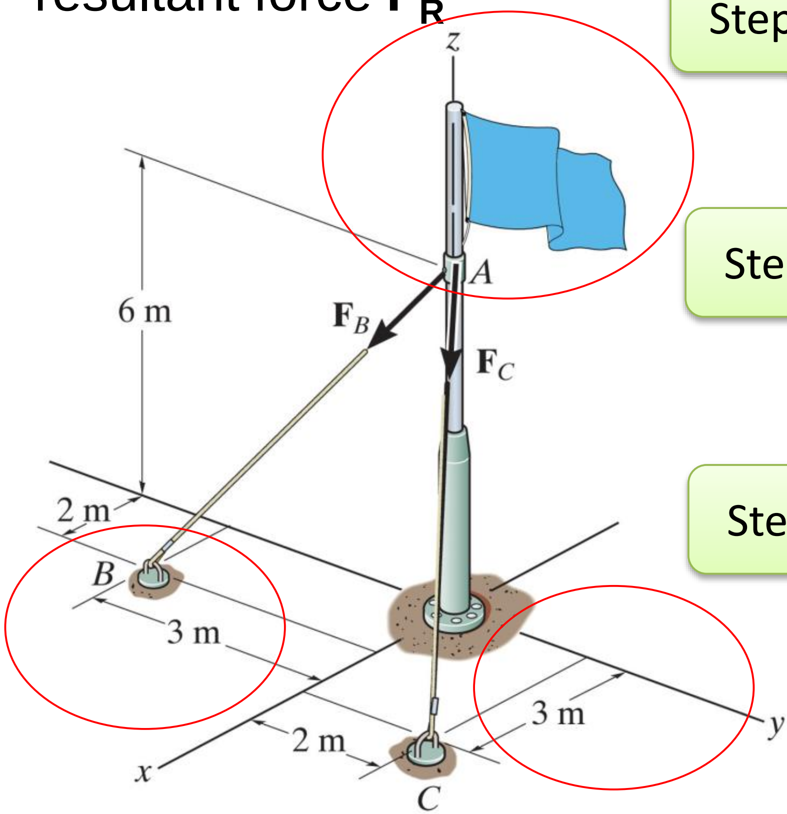
F = 420N u_{AC}

$\mathbf{F}_{AC}$ = 420{ (2 ***i*** + 3 ***j*** – 6 ***k***) / 7 } N

$\mathbf{F}_{AC}$ = {120 ***i*** + 180 ***j*** – 360 ***k*** } N

Example 2.14

Two forces are acting on the flag pole which F_B = 560N and F_C = 700N. Determine the magnitude and coordinate direction angles of the resultant force $\mathbf{F_R}$



Step 1

- Established position vector

  $\boldsymbol{r_{AB}}$

  $\boldsymbol{r_{AC}}$

Step 2

- Established unit vector

  $\boldsymbol{u_{AB}} = (\boldsymbol{r_{AB}} / r_{AB})$

  $\boldsymbol{u_{AC}} = (\boldsymbol{r_{AC}} / r_{AC})$

Step 3

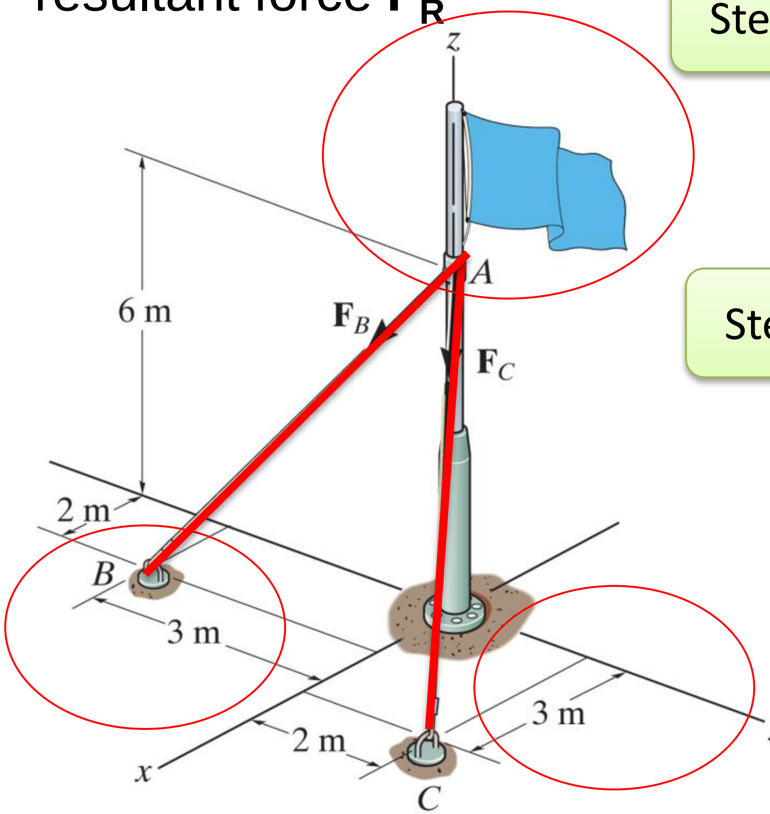
- Magnitude of force $\mathbf{F_{AB}} = F_{AB} / \boldsymbol{u_{AB}}$

  $\mathbf{F_{AC}} = F_{AC} / \boldsymbol{u_{AC}}$

- Add the two forces to get $\mathbf{F_R}$
- Calculate the magnitude and direction of $\mathbf{F_R}$

Example 2.14

Two forces are acting on the flag pole which F_B = 560N and F_C = 700N. Determine the magnitude and coordinate direction angles of the resultant force $\mathbf{F_R}$



Step 1

- Established position vector

$\boldsymbol{r_{AB}} = \{2\,\boldsymbol{i} - 3\,\boldsymbol{j} - 6\,\boldsymbol{k}\}$ m

$\boldsymbol{r_{AC}} = \{3\,\boldsymbol{i} + 2\,\boldsymbol{j} - 6\,\boldsymbol{k}\}$ m

Step 2

- Established unit vector

$\boldsymbol{u_{AB}} = (\boldsymbol{r_{AB}}/\, r_{AB}$

$$r_{AB} = \sqrt{(2)^2 + (-3)^2 + (-6)^2} = 7m$$

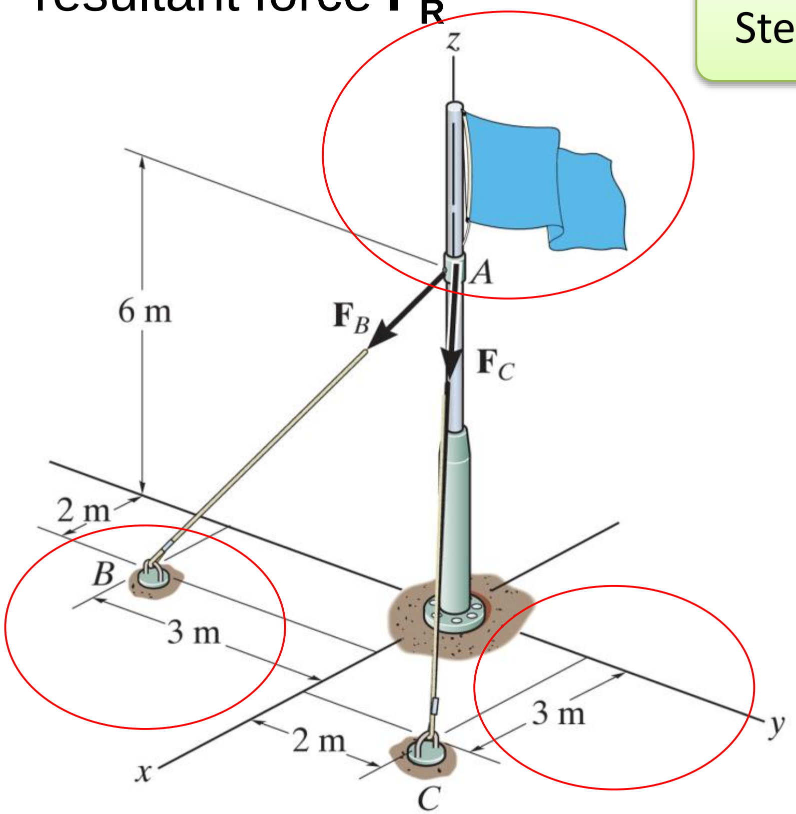
$\boldsymbol{u_{AC}} = (\boldsymbol{r_{AC}}/\, r_{AC}$

$$r_{AC} = \sqrt{(3)^2 + (2)^2 + (-6)^2} = 7m$$

Example 2.14

Two forces are acting on the flag pole which F_B = 560N and F_C = 700N. Determine the magnitude and coordinate direction angles of the resultant force $\mathbf{F_R}$

Step 3



- Magnitude of force

$\mathbf{F_{AB}} = F_{AB} / \boldsymbol{u_{AB}}$

$\boldsymbol{F_{AB}} = 560\ (\boldsymbol{r_{AB}} / r_{AB})\ \text{N}$

$\boldsymbol{F_{AB}} = 560\ (2\,\boldsymbol{i} - 3\,\boldsymbol{j} - 6\,\boldsymbol{k}) / 7\ \text{N}$

$\boldsymbol{F_{AB}} = (160\,\boldsymbol{i} - 240\,\boldsymbol{j} - 480\,\boldsymbol{k})\ \text{N}$

$\mathbf{F_{AC}} = F_{AC} / \boldsymbol{u_{AC}}$

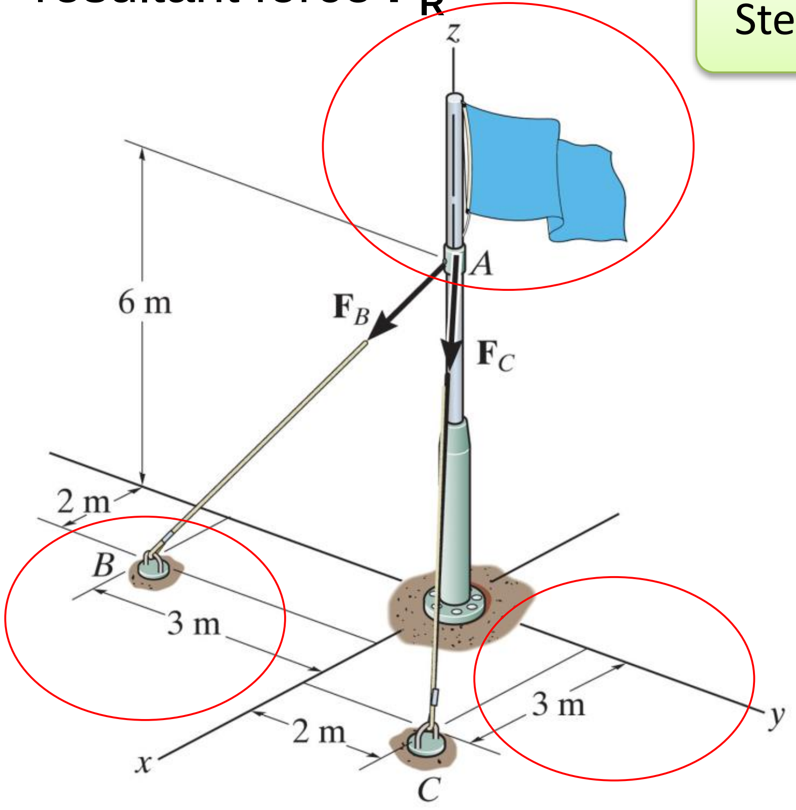
$\boldsymbol{F_{AC}} = 700\ (\boldsymbol{r_{AC}} / r_{AC})\ \text{N}$

$\boldsymbol{F_{AC}} = 700\ (3\,\boldsymbol{i} + 2\,\boldsymbol{j} - 6\,\boldsymbol{k}) / 7\ \text{N}$

$\boldsymbol{F_{AC}} = \{300\,\boldsymbol{i} + 200\,\boldsymbol{j} - 600\,\boldsymbol{k}\}\ \text{N}$

Example 2.14

Two forces are acting on the flag pole which F_B = 560N and F_C = 700N. Determine the magnitude and coordinate direction angles of the resultant force $\mathbf{F_R}$



Step 3

- Magnitude of $\mathbf{F_R}$

F_{AB} = (160 ***i*** – 240 ***j*** – 480 ***k***) N

F_{AC} = {300 ***i*** + 200 ***j*** – 600 ***k***} N

$F_R = F_{AB} + F_{AC}$
= {460 ***i*** – 40 ***j*** – 1080 ***k***} N

$$F_R = \sqrt{(460)^2 + (-40)^2 + (-1080)^2} = 1174.5N$$

F_R = 1175 N

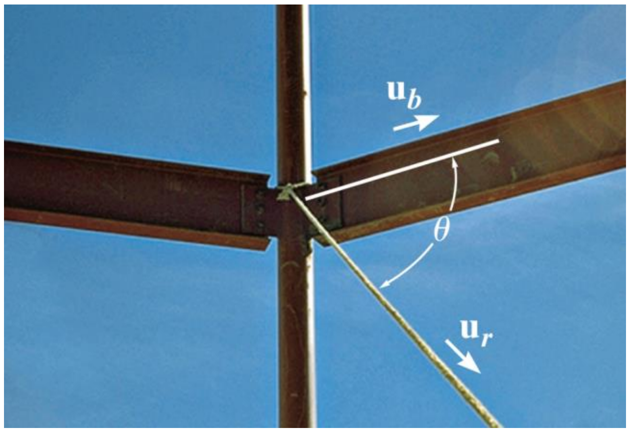
- Direction angles of $\mathbf{F_R}$

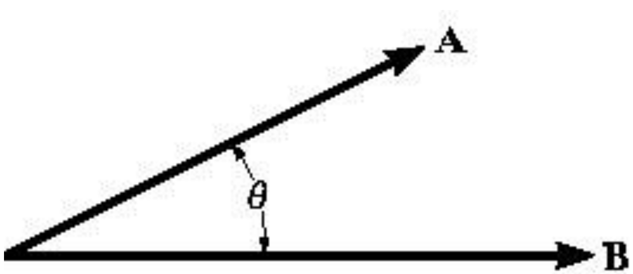
$\alpha = \cos^{-1}(460/1175)$ = 66.9°

$\beta = \cos^{-1}(-40/1175)$ = 92.0°

$\gamma = \cos^{-1}(-1080/1175)$ = 157°

Dot Product





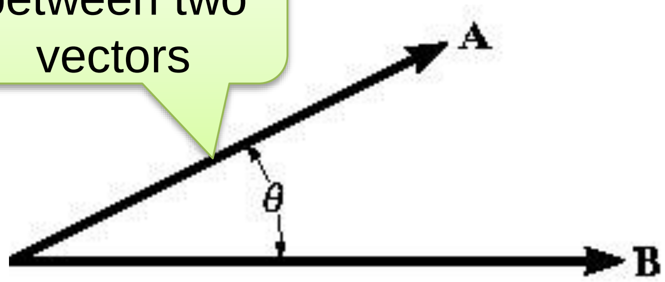
$\boldsymbol{i} \bullet \boldsymbol{j} = 0$ & $\boldsymbol{i} \bullet \boldsymbol{i} = 1$

- A **dot product** of vectors **A** and **B** can be defined by **A**· **B** = AB cos θ
- Use to determine the **angle between two vectors** and its magnitude
- Its angle θ is the smallest angle between the two vectors and is always in a range of **0° to 180°**
- The result of **dot product** is a **scalar** ($\pm$Number)
- Units of the dot product will be the product of the **units** of the ***A*** and ***B*** vectors

$$\boldsymbol{A} \bullet \boldsymbol{B} = (A_x \boldsymbol{i} + A_y \boldsymbol{j} + A_z \boldsymbol{k}) \bullet (B_x \boldsymbol{i} + B_y \boldsymbol{j} + B_z \boldsymbol{k})$$
$$= A_x B_x + A_y B_y + A_z B_z$$

Application of Dot Product

Angle between two vectors



- The angle formed between two vectors or intersecting lines

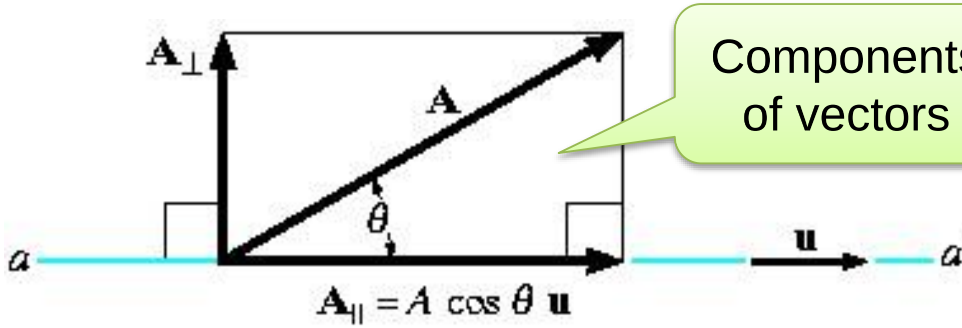
  $\theta = \cos^{-1} [(\mathbf{A}\cdot\mathbf{B})/(AB)]$

  $0^\circ \leq \theta \leq 180^\circ$

Note: if $\mathbf{A}\cdot\mathbf{B} = 0$, $\cos^{-1} 0 = 90^\circ$,

A is perpendicular to **B**

Components of vectors



- The components of a vector parallel and perpendicular to a line
- Component of **A** parallel or collinear with line aa’ is defined by $\mathbf{A}_\parallel$ (projection of **A** onto the line)

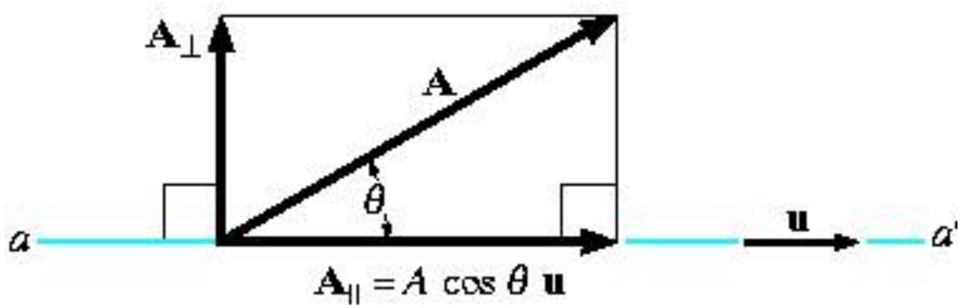
  $A_\parallel = A \cos \theta$
- If direction of line is specified by unit vector **u** ($u = 1$),

  $A_\parallel = A \cos \theta = \mathbf{A}\cdot\mathbf{u}$

Application of Dot Product

- If $A_{\parallel}$ is positive, $\mathbf{A}_{\parallel}$ has a directional sense same as **u**
- If $A_{\parallel}$ is negative, $\mathbf{A}_{\parallel}$ has a directional sense opposite to **u**
- $\mathbf{A}_{\parallel}$ expressed as a vector

$$\mathbf{A}_{\parallel} = A \cos\theta \, \mathbf{u}$$
$$= (\mathbf{A}\cdot\mathbf{u})\mathbf{u}$$



Application of Dot Product

For component of A perpendicular to line aa'

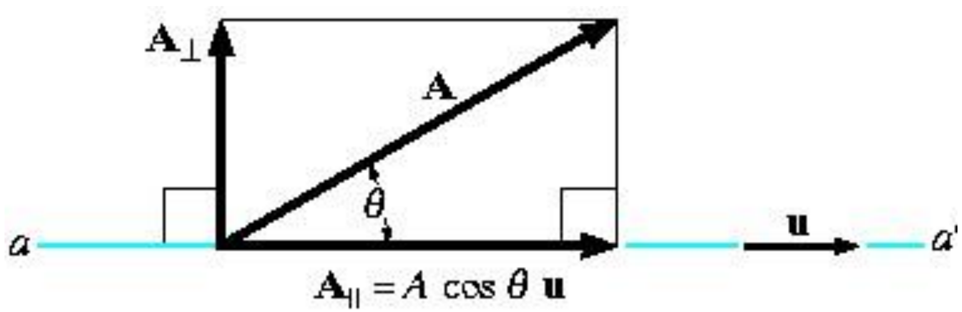
1. Since $\mathbf{A} = \mathbf{A}_{\parallel} + \mathbf{A}_{\perp}$,

   then $\mathbf{A}_{\perp} = \mathbf{A} - \mathbf{A}_{\parallel}$

2. $\theta = \cos^{-1} [(\mathbf{A} \cdot \mathbf{u})/(A)]$

   then $\mathbf{A}_{\perp} = A\sin\theta$

3. If $\mathbf{A}_{\parallel}$ is known, by Pythagorean Theorem



Law of Operation of Dot Product

1. Commutative law

$$\mathbf{A}\cdot\mathbf{B} = \mathbf{B}\cdot\mathbf{A}$$

2. Multiplication by a scalar

$$a(\mathbf{A}\cdot\mathbf{B}) = (a\mathbf{A})\cdot\mathbf{B} = \mathbf{A}\cdot(a\mathbf{B}) = (\mathbf{A}\cdot\mathbf{B})a$$

3. Distribution law

$$\mathbf{A}\cdot(\mathbf{B} + \mathbf{D}) = (\mathbf{A}\cdot\mathbf{B}) + (\mathbf{A}\cdot\mathbf{D})$$

Law of Operation of Dot Product

- Cartesian Vector Formulation

  - Dot product of Cartesian unit vectors

  Eg: **i**·**i** = (1)(1)cos0° = 1 and

  i·**j** = (1)(1)cos90° = 0

  - Similarly

  i·**i** = 1 **j**·**j** = 1 **k**·**k** = 1

  i·**j** = 0 **i**·**k** = 1 **j**·**k** = 1

Law of Operation of Dot Product

- Cartesian Vector Formulation

  - Dot product of 2 vectors **A** and **B**

$$\mathbf{A}\cdot\mathbf{B} = (A_x\mathbf{i} + A_y\mathbf{j} + A_z\mathbf{k})\cdot(B_x\mathbf{i} + B_y\mathbf{j} + B_z\mathbf{k})$$

$$= A_xB_x(\mathbf{i}\cdot\mathbf{i}) + A_xB_y(\mathbf{i}\cdot\mathbf{j}) + A_xB_z(\mathbf{i}\cdot\mathbf{k})$$

$$+ A_yB_x(\mathbf{j}\cdot\mathbf{i}) + A_yB_y(\mathbf{j}\cdot\mathbf{j}) + A_yB_z(\mathbf{j}\cdot\mathbf{k})$$

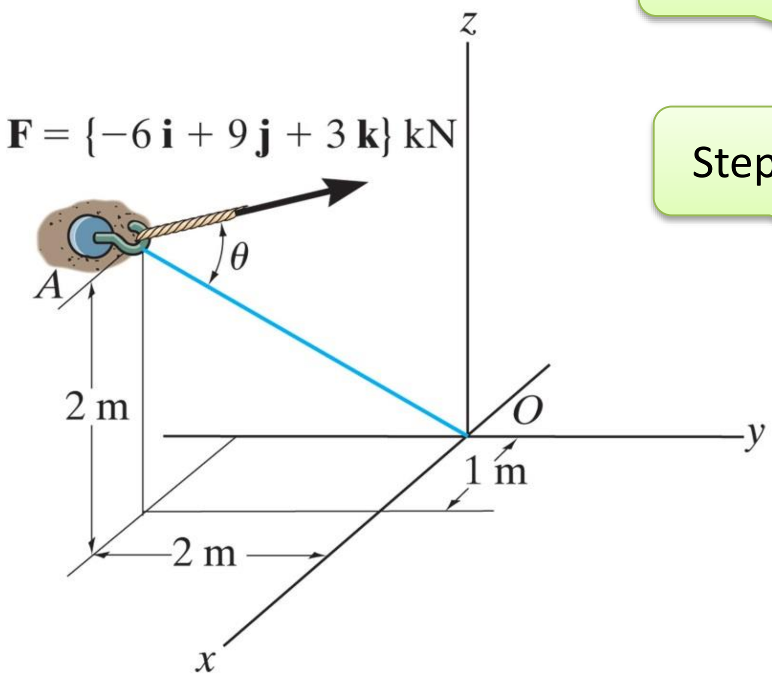
$$+ A_zB_x(\mathbf{k}\cdot\mathbf{i}) + A_zB_y(\mathbf{k}\cdot\mathbf{j}) + A_zB_z(\mathbf{k}\cdot\mathbf{k})$$

$$= A_xB_x + A_yB_y + A_zB_z$$

Note: since result is a scalar, be careful of including any unit vectors in the result

Example 2.15

The force are acting on the hook at point A. Determine the angle between the force and the line AO, and the magnitude of the projection of force along the line AO



Step 1

- Established position vector

$\boldsymbol{r_{AO}}$

Step 2

- Established dot product

$\boldsymbol{F} \bullet \boldsymbol{r_{AO}}$

$\theta = \cos^{-1}\{(\boldsymbol{F} \bullet \boldsymbol{r_{AO}})/(F \; r_{AO})\}$

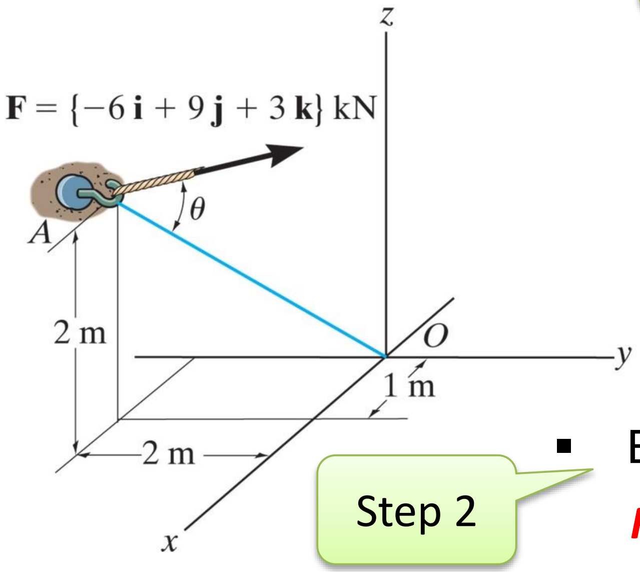
Step 3

- Magnitude of the projection of force, $\mathbf{F_{AO}}$

$F_{AO} = \boldsymbol{F} \bullet \boldsymbol{u_{AO}}$ or $F \cos \theta$

Solution Example 2.15

The force are acting on the hook at point A. Determine the angle between the force and the line AO, and the magnitude of the projection of force along the line AO



Step 1

- Established position vector

$\boldsymbol{r}_{AO} = \{-1\,\boldsymbol{i} + 2\,\boldsymbol{j} - 2\,\boldsymbol{k}\}$ m

$$r_{AO} = \sqrt{(-1)^2 + (2)^2 + (-2)^2} = 3m$$

$\boldsymbol{F} = \{-6\,\boldsymbol{i} + 9\,\boldsymbol{j} + 3\,\boldsymbol{k}\}$ kN

$$F = \sqrt{(-6)^2 + (9)^2 + (3)^2} = 11.22m$$

Step 2

- Established dot product

$\boldsymbol{i} \bullet \boldsymbol{j} = 0$ & $\boldsymbol{i} \bullet \boldsymbol{i} = 1$

$\boldsymbol{F} \bullet \boldsymbol{r}_{AO} = A_x B_x + A_y B_y + A_z B_z$

$\boldsymbol{F} \bullet \boldsymbol{r}_{AO} = (-6)(-1) + (9)(2) + (3)(-2) = 18$ kN·m

$\theta = \cos^{-1}\{(\boldsymbol{F} \bullet \boldsymbol{r}_{AO})/(F\ \ r_{AO})\}$

$\theta = \cos^{-1}\{18 / (11.22 \times 3)\} = \underline{57.67^\circ}$

Solution Example 2.15

Step 3

- Magnitude of the projection of force, F_{AO}

$$F_{AO} = \mathbf{F} \bullet \mathbf{u}_{AO} \quad \text{or} \quad F \cos\theta$$

$$\mathbf{u}_{AO} = \mathbf{r}_{AO} / r_{AO} = (-1/3)\,\mathbf{i} + (2/3)\,\mathbf{j} + (-2/3)\,\mathbf{k}$$

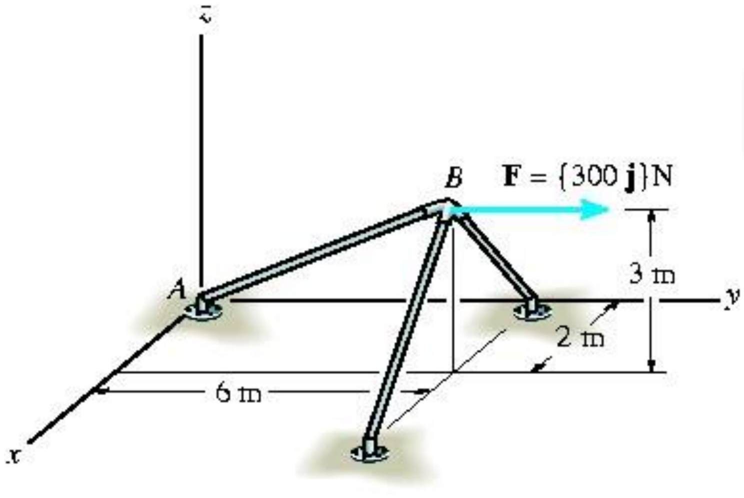
$$F_{AO} = \mathbf{F} \bullet \mathbf{u}_{AO} = (-6)(-1/3) + (9)(2/3) + (3)(-2/3) = \underline{6.00\text{ kN}}$$

or

$$F_{AO} = F \cos\theta = 11.22 \cos(57.67^\circ) = \underline{6.00\text{ kN}}$$

Example 2.16

The frame is subjected to a horizontal force, **F = {300j}** at point B. Determine the components of this force parallel and perpendicular to the member AB



(a)

Step 1

- Established position vector

$\boldsymbol{u}_B$

Step 2

- Established dot product

$F_{AB} = F \cos\theta = F \bullet \boldsymbol{u}_B$

Step 3

Express in Cartesian form:

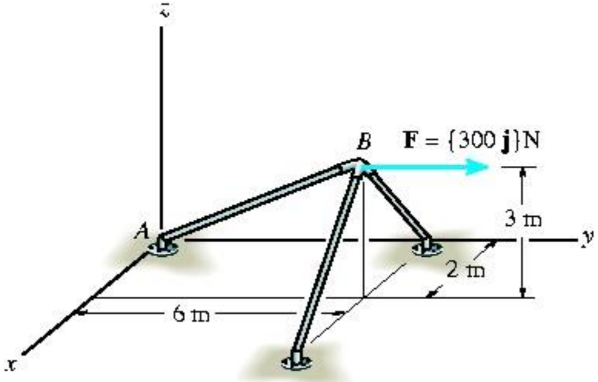
- Parallel component
- Perpendicular componet

Step 4

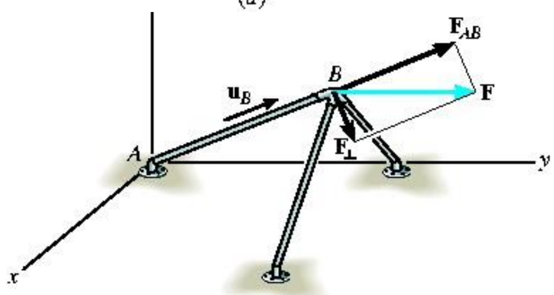
$\mathbf{A} = \mathbf{A}_{\parallel} + \mathbf{A}_{\perp}$, then $\mathbf{A}_{\perp} = \mathbf{A} - \mathbf{A}_{\parallel}$

Solution Example 2.16

The frame is subjected to a horizontal force, **F = {300j}** at point B. Determine the components of this force parallel and perpendicular to the member AB



(a)



(b)

Step 1

- Established position & unit vector

$$\vec{u}_B = \frac{\vec{r}_B}{|\vec{r}_B|} = \frac{2\vec{i} + 6\vec{j} + 3\vec{k}}{\sqrt{(2)^2 + (6)^2 + (3)^2}}$$

$$= 0.286\vec{i} + 0.857\vec{j} + 0.429\vec{k}$$

Step 2 , dot product

$$|\vec{F}_{AB}| = |\vec{F}| \cos\theta$$

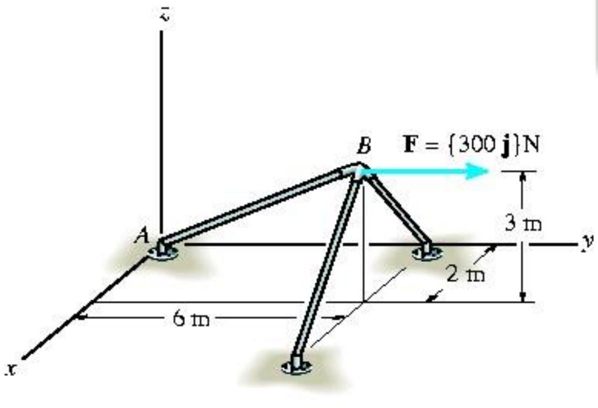
$$= \vec{F}.\vec{u}_B = (300\vec{j}) \cdot (0.286\vec{i} + 0.857\vec{j} + 0.429\vec{k})$$

$$= (0)(0.286) + (300)(0.857) + (0)(0.429)$$

$$= 257.1N$$

Solution Example 2.16

The frame is subjected to a horizontal force, **F = {300j}** at point B. Determine the components of this force parallel and perpendicular to the member AB



(a)

Step 3

Since result is a positive scalar, $\mathbf{F}_{AB}$ has the same sense of direction as $\mathbf{u}_B$. Express in Cartesian form:

$$\vec{F}_{AB} = \left|\vec{F}_{AB}\right| \vec{u}_{AB}$$

$$= (257.1N)(0.286\vec{i} + 0.857\vec{j} + 0.429\vec{k})$$

$$= \{73.5\vec{i} + 220\vec{j} + 110\vec{k}\}N$$

Step 4

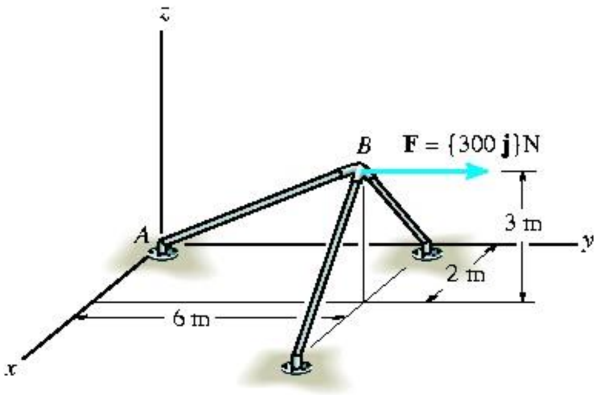
Perpendicular component

$$\vec{F}_{\perp} = \vec{F} - \vec{F}_{AB} = 300\vec{j} - (73.5\vec{i} + 220\vec{j} + 110\vec{k})$$

$$= \{-73.5\vec{i} + 80\vec{j} - 110\vec{k}\}N$$

Solution Example 2.16

The frame is subjected to a horizontal force, **F = {300j}** at point B. Determine the components of this force parallel and perpendicular to the member AB



(a)

Step 5

Magnitude can be determined From $\mathbf{F}_\perp$ or from Pythagorean Theorem

A = $\mathbf{A}_\parallel$ + $\mathbf{A}_\perp$,
then $\mathbf{A}_\perp$ = **A** - $\mathbf{A}_\parallel$

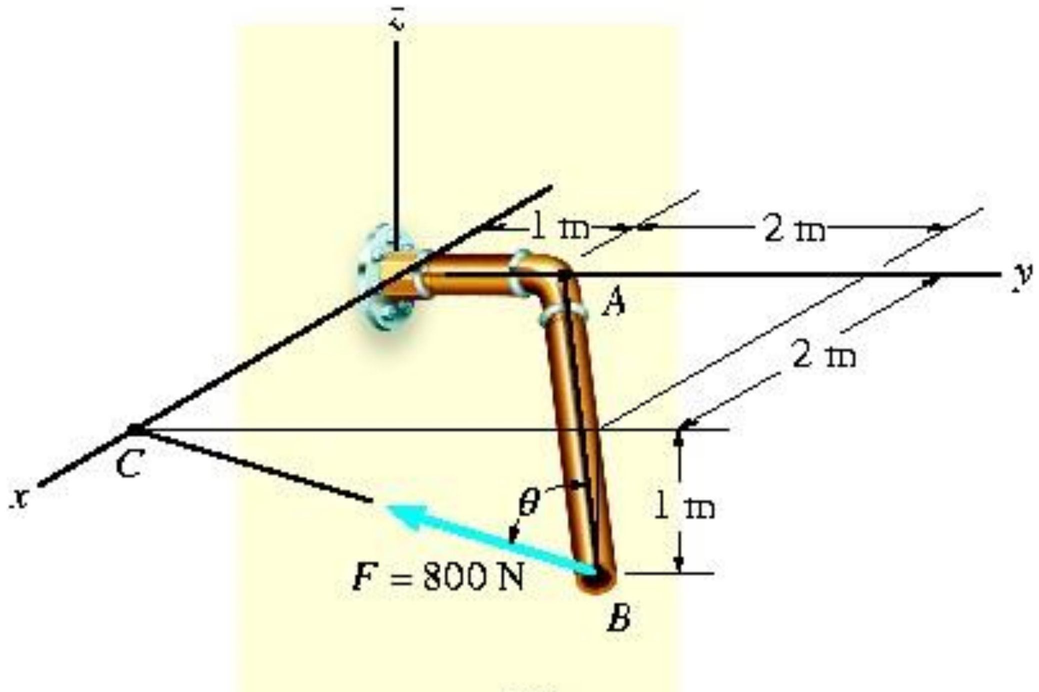
$$\left|\vec{F}_\perp\right| = \sqrt{\left|\vec{F}\right|^2 - \left|\vec{F}_{AB}\right|^2}$$

$$= \sqrt{(300N)^2 - (257.1N)^2}$$

$$= 155N$$

Example 2.17

The pipe is subjected to force, **F = 800 N** at point B. Determine the angle θ between **F** and pipe segment BA, and the magnitude of the components of force **F**, which are parallel and perpendicular to the member BA



(a)

Solution Example 2.17

For angle θ

r$_{BA}$ = {-2**i** - 2**j** + 1**k**}m

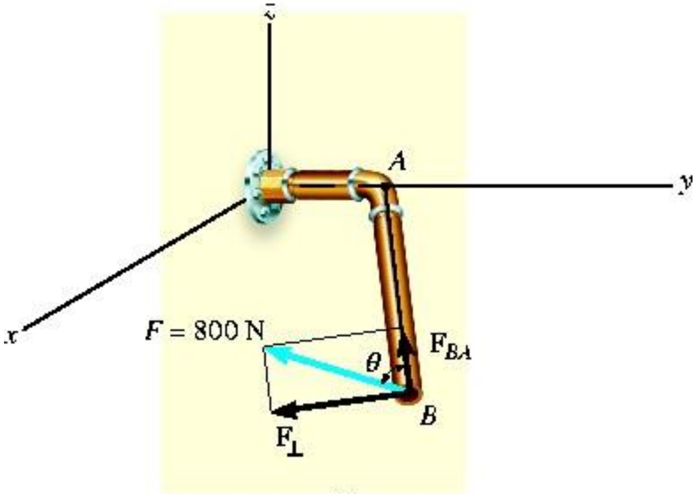
r$_{BC}$ = {- 3**j** + 1**k**}m

Thus,

$$\cos\theta = \frac{\vec{r}_{BA}\cdot\vec{r}_{BC}}{|\vec{r}_{BA}||\vec{r}_{BC}|} = \frac{(-2)(0)+(-2)(-3)+(1)(1)}{3\sqrt{10}}$$

$$= 0.7379$$

$$\theta = 42.5^{\circ}$$



(b)

$$\vec{u}_{AB} = \frac{\vec{r}_{AB}}{|\vec{r}_{AB}|} = \frac{(-2\vec{i} - 2\vec{j} + 1\vec{k})}{3}$$

$$= \left(-\frac{2}{3}\right)\vec{i} + \left(-\frac{2}{3}\right)\vec{j} + \left(\frac{1}{3}\right)\vec{k}$$

$$|\vec{F}_{AB}| = \vec{F}.\vec{u}_B$$

$$= (-758.9\vec{j} + 253.0\vec{k})\cdot\left(-\frac{2}{3}\right)\vec{i} + \left(-\frac{2}{3}\right)\vec{j} + \left(\frac{1}{3}\right)\vec{k}$$

$$= 0 + 506.0 + 84.3$$

$$= 590N$$

Express in Cartesian form:

- Parallel component
- Perpendicular componet

Solution Example 2.17

Checking from trigonometry,

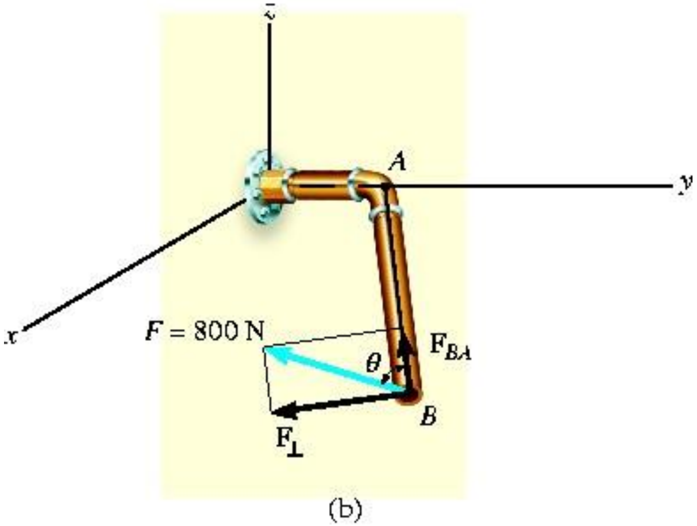
$$\left|\vec{F}_{AB}\right| = \left|\vec{F}\right| \cos\theta$$

$$= 800 \cos 42.5^\circ\, N$$

$$= 540\, N$$

Magnitude can be determined

From **F**⊥



(b)

$$\left|\vec{F}_{\perp}\right| = \left|\vec{F}\right| \sin\theta = 800 \sin 42.5^\circ = 540 N$$

Magnitude can be determined from **F**⊥
or from Pythagorean Theorem

$$\left|\vec{F}_{\perp}\right| = \sqrt{\left|\vec{F}\right|^2 - \left|\vec{F}_{AB}\right|^2}$$

$$= \sqrt{(800)^2 - (590)^2}$$

$$= 540 N$$

Conclusion of The Chapter 2 part III

- Conclusions

  - The Force and Position vector have been identified and determined in the mechanics
  - The Dot Product has been implemented in determine an angle between two vectors

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