Burj Dubai (2008)

$h = 705\ m$

$A = 8000\ m^2$

Convert to US units (3 significant fig)

$$h = 705\ m \ \frac{1\ ft}{0.3048\ m} = 2.31 \times 10^3\ ft$$

I could have also used $1\ m = 3.281\ ft$

$$A = 8000\ m^2 \ \frac{1\ ft^2}{(0.3048\ m)^2} = 8.61 \times 10^4\ ft^2$$

$$\boxed{\begin{aligned} h &= 2.31 \times 10^3\ ft \\ A &= 8.61 \times 10^4\ ft^2 \end{aligned}}$$

FUN FACTS

To give you some scale the tallest building in Madrid is 250 m (Torre Repsol) ~ 820 ft. This is the project I worked on for 5 years.

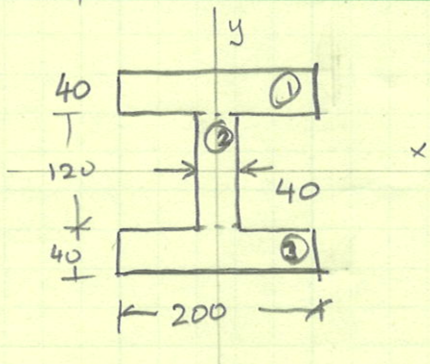
Bill Baker, the structural engineer in charge of Burj Khalifa works for SOM (Skidmore, Owings & Merril) and he is an adjunct @ NU @ the Architectural certificate.

Check www.som.com/projects/burj-Khalifa

AA

1.14

A. ALARCÓN



$A = ?$ m^2

in^2

I'll show you how to do it so you are ready for centroids!

This typical constuction beam can be seen as a composite area ≡ sum of rectangles. Later we will study centroids and we will use a table with key #'s.

	Area (mm^2)
1	$200 \times 40 = 8000$
2	$120 \times 40 = 4800$
3	$= 1$ $\quad 8000$

$$\Sigma = 20800 \text{ mm}^2 = 20800 \times 10^{-6} = 0.0208 \text{ m}^2$$

$$A = 20800 \text{ mm}^2 \ \frac{1 \text{ in}^2}{(25.4 \text{ mm})^2} = 32.2 \text{ in}^2$$

$$\boxed{\begin{aligned} A &= 0.0208 \text{ m}^2 \\ A &= 32.2 \text{ in}^2 \end{aligned}}$$

* We will study these beams in CEE216!

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1.25

A. ALARCÓN

$g = 9.81 \ m/s^2$

$R_{earth} = 6370 \ km$

$G = 6.67 \times 10^{-11} \ N m^2/kg^2$

mass of earth = ?

Acceleration due to gravity a

$$a = \frac{G m_E}{r^2}$$

G ≡ gravitational constant

m_E ≡ mass of eath

r = radius of earth

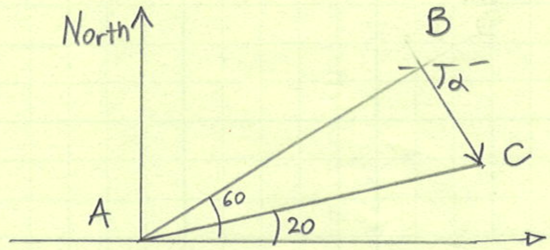
$$m_E = \frac{g r^2}{G} = \frac{(9.8)(6370 \times 10^3)^2}{6.67 \times 10^{-11}} = 5.97 \times 10^{24} \ kg$$

$$\frac{\frac{m}{s^2} \cancel{m^2}}{\frac{N \cancel{m^2}}{kg^2}} = \frac{kg^2}{kg} = kg$$

$$\boxed{m_E = 5.97 \times 10^{24} \ kg}$$

AA

2.14 A. ALARCÓN

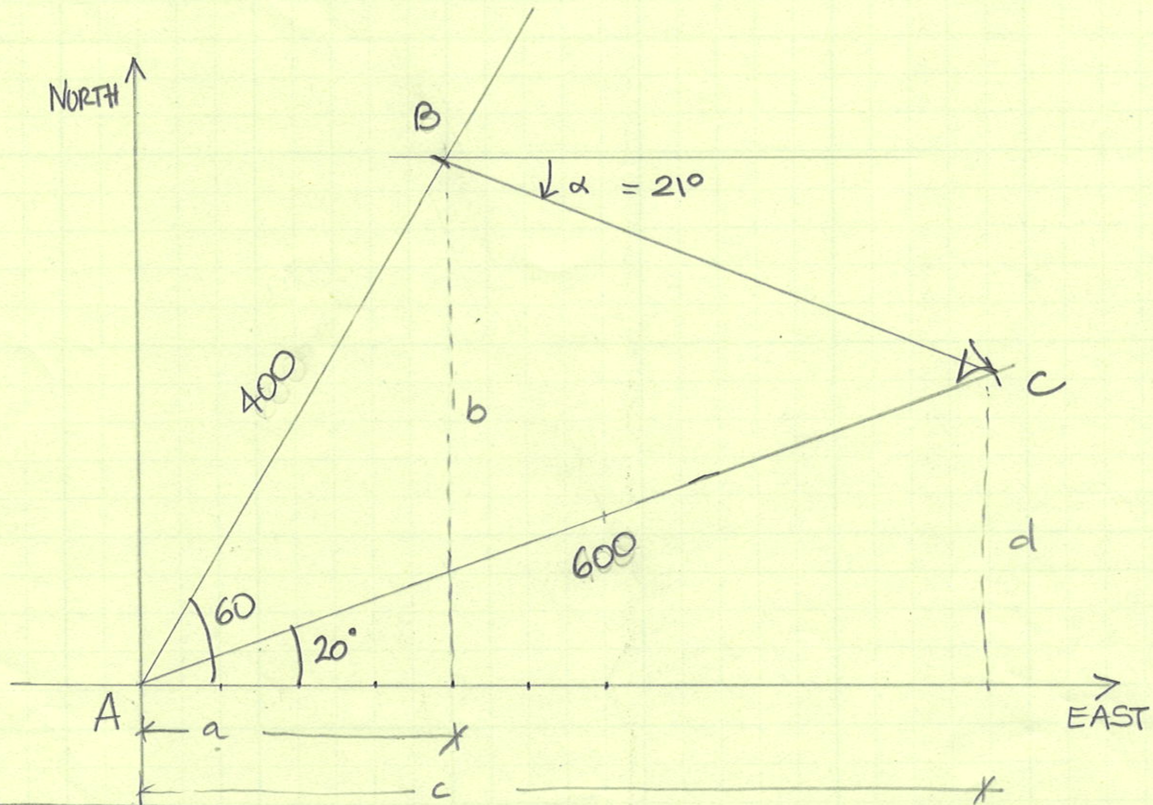


$|\vec{r}_{BC}| = ?$

$\alpha = ?$

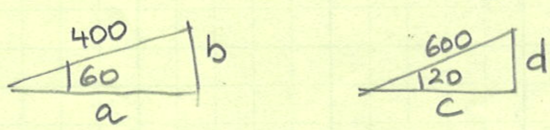
$|AB| = 400\ m$

$|AC| = 600\ m$



$\boxed{\overline{BC} \text{ measured on figure} \rightarrow 390\ m}$ $\boxed{\alpha = 21° \text{ measured}}$

We can also check w/ trigonometry



$a = 400 \cos 60 = 200$ $c = 600 \cos 20 = 563.8$

$b = 400 \sin 60 = 346.41$ $d = 600 \sin 20 = 205.21$

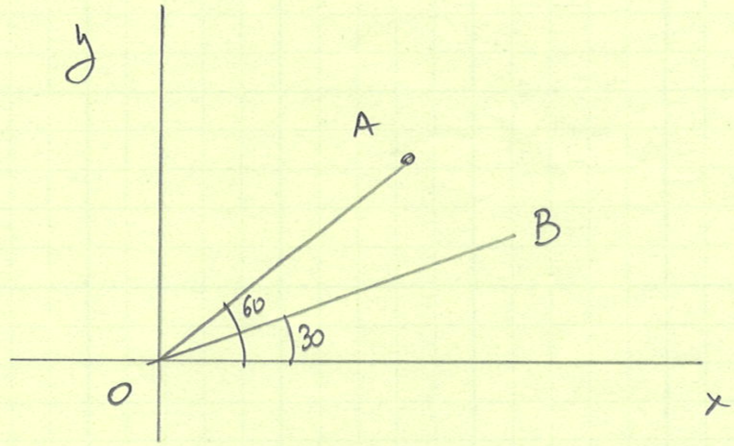
$\vec{r}_{AB} + \vec{r}_{BC} = \vec{r}_{AC} \Rightarrow \vec{r}_{BC} = \vec{r}_{AC} - \vec{r}_{AB} = (563.8 - 200)\vec{i} + (205.21 - 346)\vec{j}$

$= 363.8\vec{i} - 141.2\vec{j} \Rightarrow |\vec{r}_{BC}| = 390\ m$

AA

2.41

A. ALARCÓN

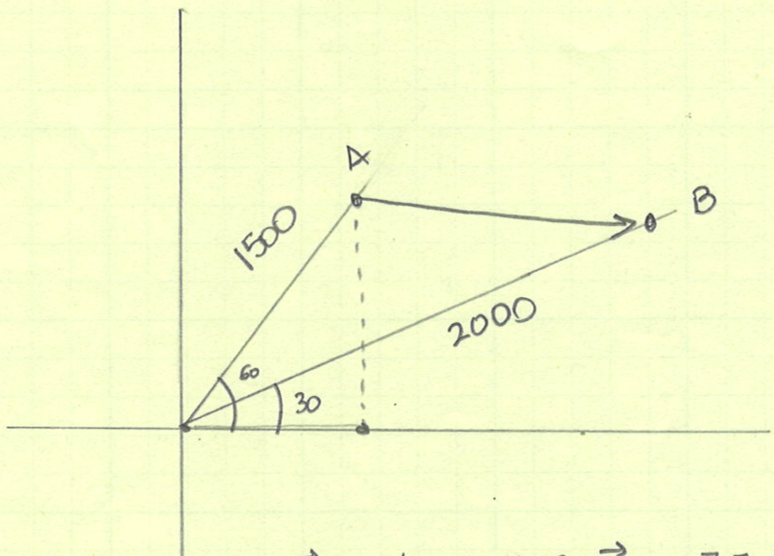


$OA = 1500 \text{ m}$

$OB = 2000 \text{ m}$

a) $\vec{r}_{AB}$

b) = unitvector $A \to B$



$\vec{r}_{OA} = 1500 \cos 60 \, \vec{i} + 1500 \sin 60 \, \vec{j} = 750 \vec{i} + 1299 \vec{j} \quad (m)$

$\vec{r}_{OB} = 2000 \cos 30 \, \vec{i} + 2000 \sin 30 \, \vec{j} = 1732 \vec{i} + 1000 \vec{j} \quad (m)$

$\vec{r}_{OA} + \vec{r}_{AB} = \vec{r}_{OB} \quad \to \vec{r}_{AB} = \vec{r}_{OB} - \vec{r}_{OA} = 982 \vec{i} - 299 \vec{j} \quad (m)$

b) $\vec{e} = \dfrac{\vec{r}_{AB}}{|r_{AB}|} = \dfrac{982 \vec{i} - 299 \vec{j}}{\sqrt{982^2 + 299^2}} = 0.957 \vec{i} - 0.29 \vec{j}$

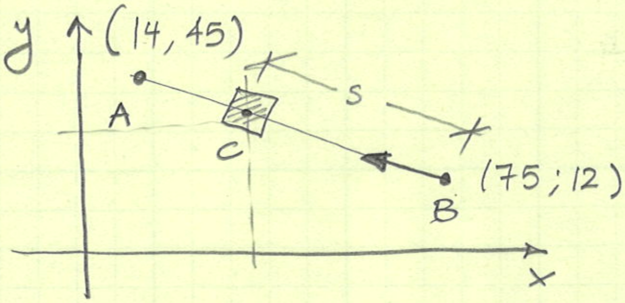
$\sqrt{982^2+299^2} \to 1026.51$

$$\boxed{\begin{aligned} \vec{r}_{AB} &= 982 \vec{i} - 299 \vec{j} \\ \vec{e} &= 0.957 \vec{i} - 0.29 \vec{j} \end{aligned}}$$

AA

2.57

A. ALARCÓN



$s = 45$ inches $= 45''$

a) $\vec{e}_{BA}$

(b) use e_{BA} to calculate coordinates of C

$$\left.\begin{array}{l} A(14;45) \\ B(75;12) \end{array}\right\} \; \underbrace{\vec{r}_{BA}}_{A-B} = ((75-14);(12-45)) = -61\vec{i} + 33\vec{j}$$

$$|\vec{r}_{BA}| = \sqrt{61^2 + 33^2} = 69.35$$

$$\vec{e}_{BA} = \frac{1}{69.35}\left(-61\vec{i} + 33\vec{j}\right) = -0.879\vec{i} + 0.476\vec{j}$$

$$\boxed{\vec{e}_{BA} = -0.879\vec{i} + 0.476\vec{j}}$$

(b) $\underbrace{\vec{r}_{BC}}_{C-B} = (x_C - 75)\vec{i} + (y_C - 12)\vec{j}$

$$|\vec{r}_{BC}| = \sqrt{(x_C - 75)^2 + (y_C - 12)^2} = 45$$ given! :)

$$\bar{e}_{BC} = \bar{e}_{BA} = -0.879\vec{i} + 0.476\vec{j}$$

$$-0.879\vec{i} + 0.476\vec{j} = \frac{1}{45}\left(x - 75\right)\vec{i} + (y_C - 12)\vec{j}$$

$$-0.879 = \frac{1}{45}(x_C - 75) \rightarrow x_C = 35.445$$

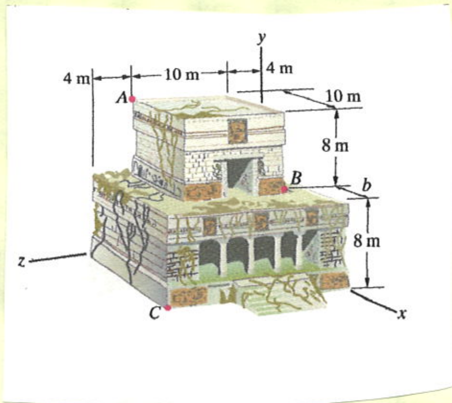
$$0.476 = \frac{1}{45}(y_C - 12) \rightarrow y_C = 33.42$$

$$\boxed{C = 35.4 \; ; 33.4} \text{ in}$$

AA

2.78

A. ALARCÓN



a) $|\vec{r}_{AB}| = ?$

b) direction cosines = ?

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a)

$A(0, 16, 14)$

$B(10, 8, 4)$

$$\underbrace{\vec{r}_{AB}}_{B-A} = (10-0;\ 8-16;\ 4-14) = (10;\ -8;\ -10)\ m$$

$$= 10\vec{i} - 8\bar{j} - 10\vec{k}\ (m)$$

$$|\bar{r}_{AB}| = \sqrt{10^2 + (-8)^2 + (-10)^2} = \sqrt{264} = 16.2\ m$$

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b)

$$\cos\theta_x = \frac{(r_{AB})_x}{|\bar{r}_{AB}|} = \frac{10}{\sqrt{264}} = 0.615$$

$$\cos\theta_y = \frac{(r_{AB})_y}{|\bar{r}_{AB}|} = \frac{-8}{\sqrt{264}} = -0.492$$

$$\cos\theta_z = \frac{(r_{AB})_z}{|\bar{r}_{AB}|} = \frac{-10}{\sqrt{264}} = -0.615$$

$$\boxed{\begin{aligned} |\bar{r}_{AB}| &= 16.2\ m \\ \cos\theta_x &= 0.615 \\ \cos\theta_y &= -0.492 \\ \cos\theta_z &= -0.615 \end{aligned}}$$

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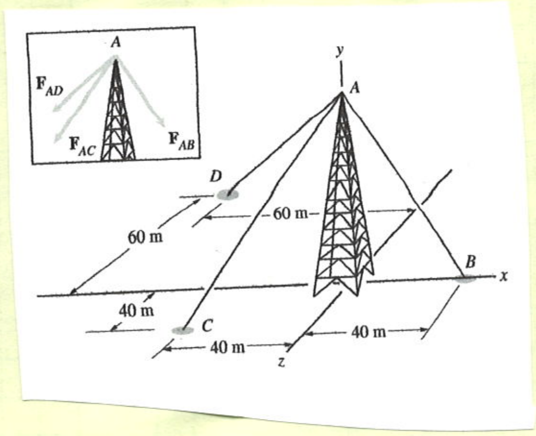

$|\vec{F}_{AB}| = 2\ kN$

x, z components of $\Sigma = 0$

$|F_{AC}| = ?$ $|F_{AD}| = ?$

$$\left.\begin{array}{l} A\ (0;70;0) \\ B\ (40;0;0 \end{array}\right\} \quad \vec{r}_{AB} \overset{B-A}{=} (40;\ -70;\ 0) \qquad |r_{AB}| = 80.6$$

C $(-40;\ 0;\ 40)$

D $(-60;\ 0;\ -60)$

$$\vec{r}_{AC} = \underset{C-A}{(}-40;\ -70;\ 40) \qquad |r_{AC}| = \sqrt{40^2+70^2+40^2} = 90$$

$$\vec{r}_{AD} = \underset{D-A}{(}-60,\ -70,\ -60) \qquad |r_{AD}| = \sqrt{60^2+70^2+60^2} = 110$$

$$\vec{e}_{AB} = \frac{\vec{r}_{AB}}{|\vec{r}_{AB}|} = \frac{40}{80.6}\vec{i} - \frac{70}{80.6}\vec{j} = 0.4963\,\vec{i} - 0.8684\,\vec{j}$$

$$\vec{e}_{AC} = \frac{\vec{r}_{AC}}{|\vec{r}_{AC}|} = \frac{-40}{90}\vec{i} - \frac{70}{90}\vec{j} + \frac{40}{90}\vec{k} = -0.444\,\vec{i} - 0.777\,\vec{j} + 0.444\,\vec{k}$$

$$\vec{e}_{AD} = \frac{\vec{r}_{AD}}{|\vec{r}_{AD}|} = \frac{-60}{110}\vec{i} - \frac{70}{110}\vec{j} + \frac{60}{110}\vec{k} = -0.545\,\vec{i} - 0.636\,\vec{j} - 0.545\,\vec{k}$$

$$\vec{F}_{AB} = |F|\,\vec{e}_{AB} = 2\,\vec{e}_{AB} = 0.9926\,\vec{i} - 1.737\,\vec{j}$$

$$\vec{F}_{AC} = F_{AC}\,(-0.444\,\vec{i} - 0.777\,\vec{j} + 0.444\,\vec{k})$$

$$\vec{F}_{AD} = F_{AD}\,(-0.545\,\vec{i} - 0.636\,\vec{j} - 0.545\,\vec{k})$$

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Sum of forces

$\vec{F_R} = \vec{F_{AB}} + \vec{F_{AC}} + \vec{F_{AD}}$

component on x : $[0.9926 - F_{AC}(0.444) - F_{AD}(0.545)]\vec{i}$ ①

component y : $[-1.737 - F_{AC}(0.777) - F_{AD}(0.636)]\vec{j}$ ②

comp. z : $[0 + F_{AC}(0.444) - F_{AD}(0.545)]\vec{k}$ ③

Since the problem gives us Σx component = 0

Σz " = 0

① $0.9926 = F_{AC}(0.444) + \cancel{F_{AD}(0.545)}$

③ $0 = F_{AC}(0.444) - \cancel{F_{AD}(0.545)}$

$0.9926 = 0.888\, F_{AC}$

$\boxed{F_{AC} = 1.12 \text{ kN}}$

From 3 $\quad F_{AD} = \dfrac{0.444}{0.545} F_{AC} = 0.91 \text{ kN}$

$\boxed{\begin{array}{l} F_{AC} = 1.12 \text{ kN} \\ F_{AD} = 0.91 \text{ kN} \end{array}}$

AA