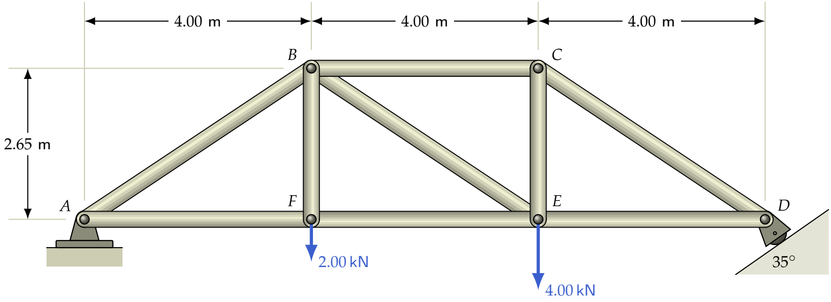
Method of Joints — Step by Step Examples

Engineering Statics

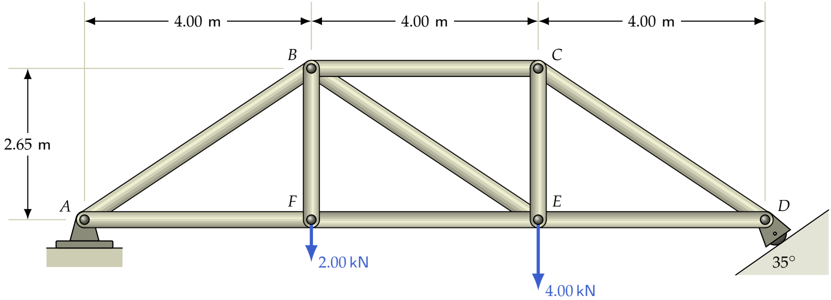
Last revision on October 19, 2025



Method of Joints: Example 1

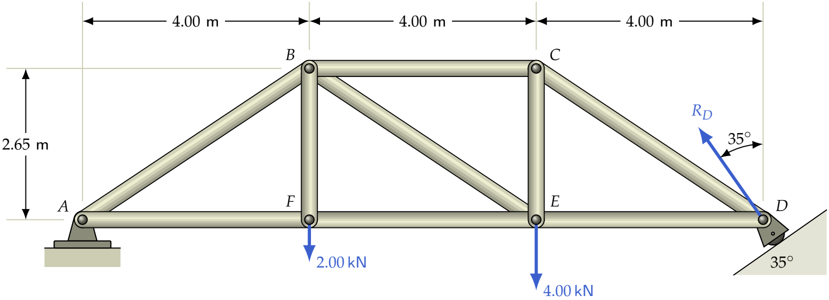
The truss is supported by a pinned connection at A and a roller, inclined at 35° to the horizontal, at D.

Determine the internal force in each truss member due to the applied loads at E and F.



Find the reaction at D

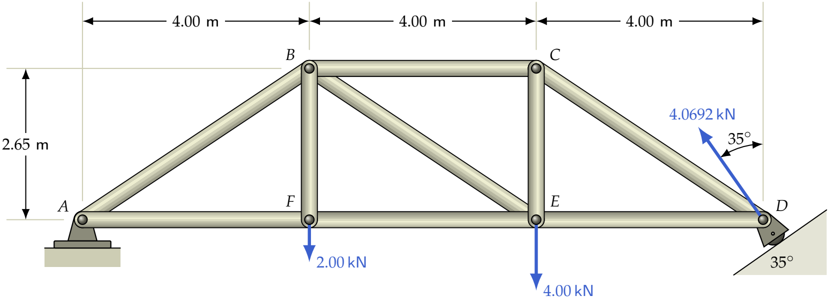
Take moments of the external forces acting on the truss, about A:



Find the reaction at D

Take moments of the external forces acting on the truss, about A:

$$\sum M_A = R_D \cos 35^\circ \times 12.0\,\text{m} - 2.00\,\text{kN} \times 4.00\,\text{m} - 4.00\,\text{kN} \times 8.00\,\text{m} = 0$$



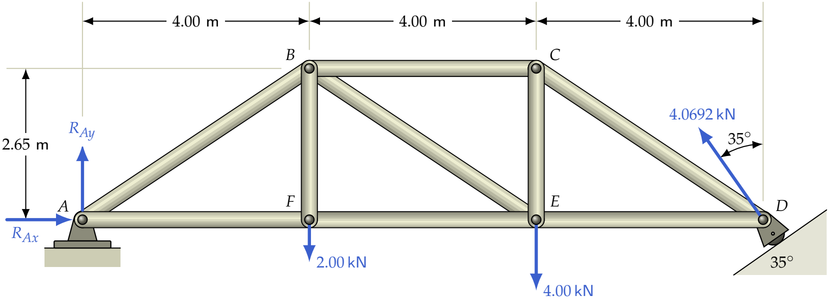
Find the reaction at D

Take moments of the external forces acting on the truss, about A:

$$\sum M_A = R_D \cos 35^\circ \times 12.0\,\text{m} - 2.00\,\text{kN} \times 4.00\,\text{m} - 4.00\,\text{kN} \times 8.00\,\text{m} = 0$$

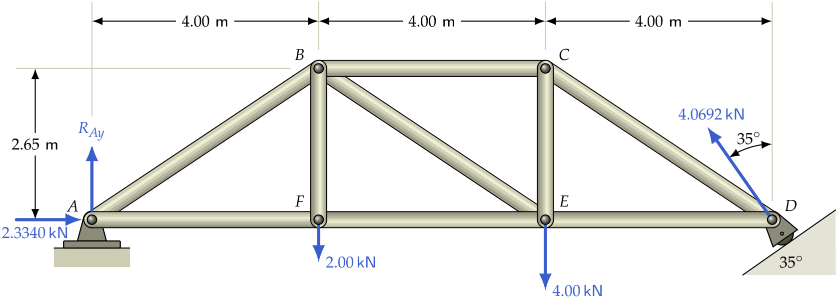
$$\Rightarrow R_D = \frac{40.0\,\text{kN}\cdot\text{m}}{12.0\,\text{m} \times \cos 35^\circ}$$

$$= 4.0692\,\text{kN}$$



Find the reaction at A

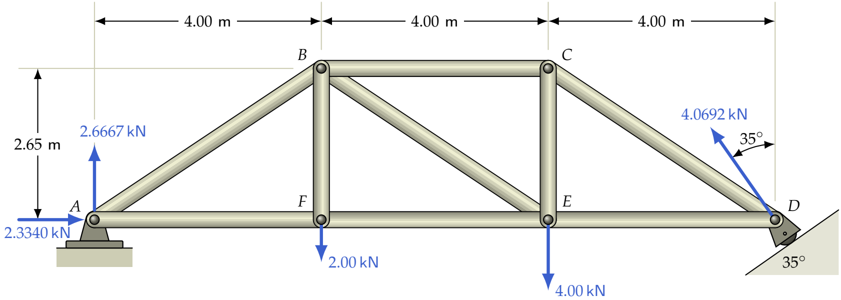
Note: We could proceed to find all the forces in the truss members, working from D back to A, **without** finding the reaction at A. But the reaction at A is useful for a check – at the end of the problem – to make sure that we haven't made any errors along the way.



Find the reaction at A

$$\sum F_x = R_{Ax} - 4.0692 \sin 35^\circ \text{ kN} = 0$$

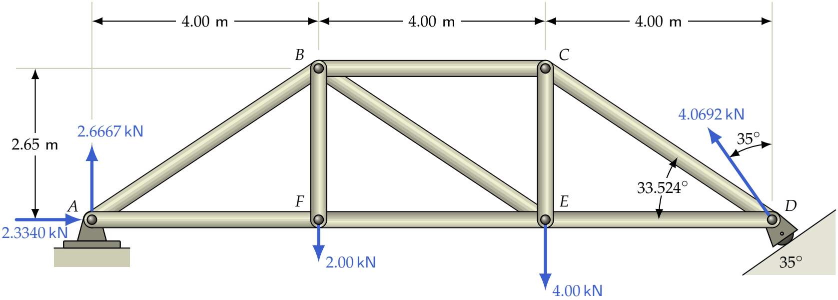
$$\Rightarrow R_{Ax} = 2.3340 \text{ kN}$$



Find the reaction at A

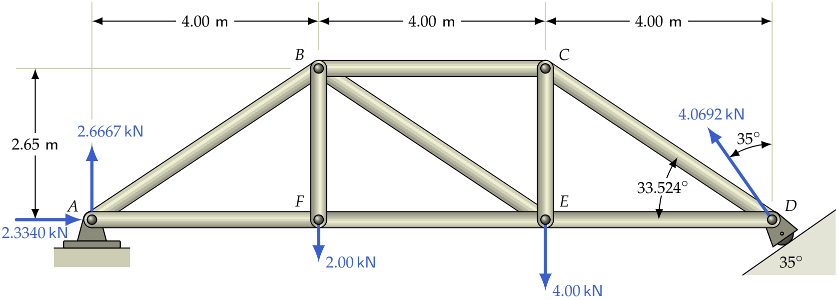
$$\sum F_x = R_{Ax} - 4.0692 \sin 35^\circ \text{ kN} = 0$$
$$\Rightarrow R_{Ax} = 2.3340 \text{ kN}$$

$$\sum F_y = R_{Ay} + 4.0692 \cos 35^\circ \text{ kN} - 2.00 \text{ kN} - 4.00 \text{ kN} = 0$$
$$\Rightarrow R_{Ay} = 2.6667 \text{ kN}$$



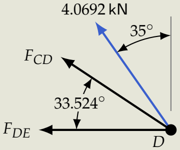
Find the truss angle

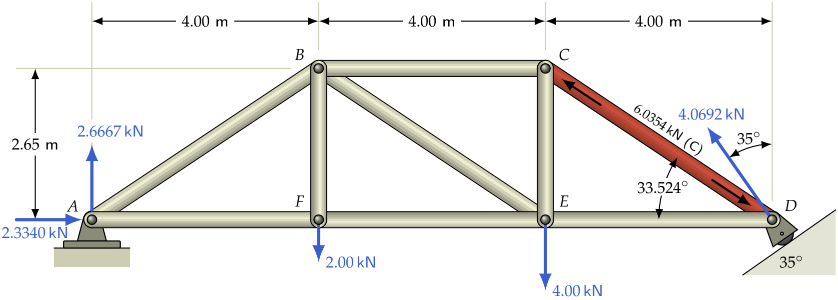
$$
\begin{aligned}
\angle CDE &= \tan^{-1}\left[\frac{CE}{DE}\right] \\
&= \tan^{-1}\left[\frac{2.65\,\mathrm{m}}{4.00\,\mathrm{m}}\right] \\
&= 33.524^\circ
\end{aligned}
$$



Joint D

First, the free body diagram:





Joint D

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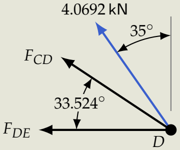
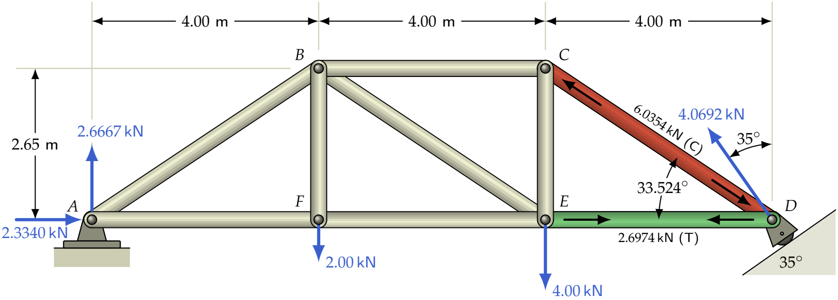


$$\sum F_y = 4.0692 \cos 35^\circ \text{ kN} + F_{CD} \sin 33.524^\circ = 0$$

$$\Rightarrow \boldsymbol{F_{CD} = -6.0354\,\text{kN}}$$



Joint D

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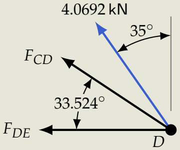


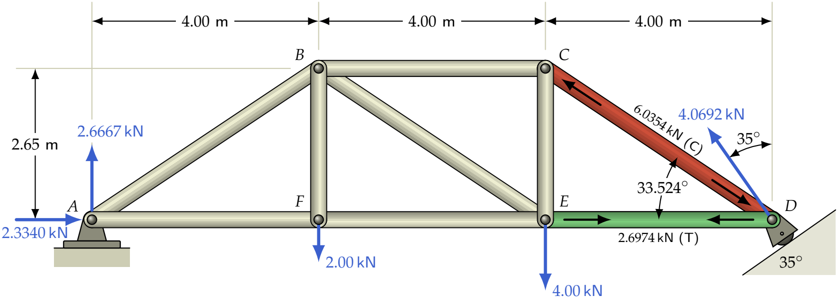
$$\sum F_y = 4.0692 \cos 35^\circ \text{ kN} + F_{CD} \sin 33.524^\circ = 0$$

$$\Rightarrow \boldsymbol{F_{CD} = -6.0354\,\text{kN}}$$

$$\sum F_x = -4.0692 \sin 35^\circ \text{ kN} - F_{CD} \cos 33.524^\circ - F_{DE} = 0$$

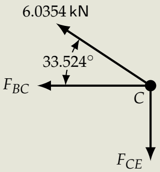
$$= -2.3340 \text{ kN} - (-6.0354 \text{ kN}) \cos 33.524^\circ - F_{DE} = 0$$

$$\Rightarrow \boldsymbol{F_{DE} = 2.6974\,\text{kN}}$$

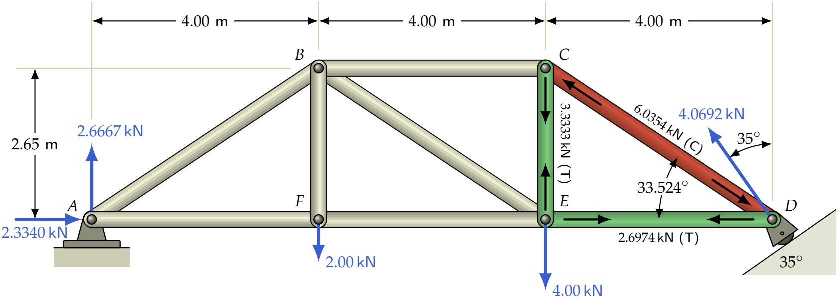


4.00 m
4.00 m
4.00 m
B
C
2.65 m
2.6667 kN
6.0354 kN (C)
4.0692 kN
35°
33.524°
A
F
E
D
2.3340 kN
2.6974 kN (T)
2.00 kN
35°
4.00 kN

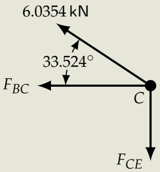
Joint C



6.0354 kN
33.524°
F_{BC}
C
F_{CE}

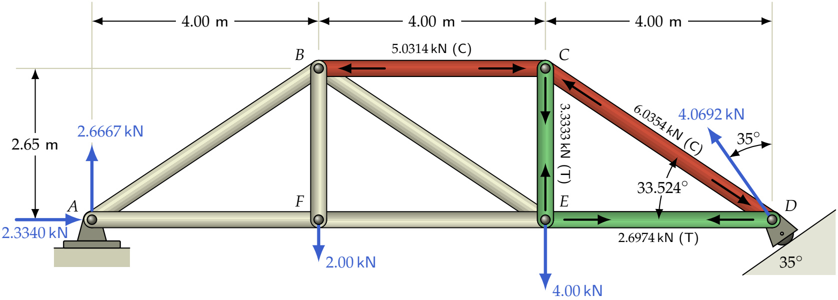


Joint C

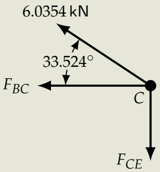


$$\sum F_y = 6.0354 \sin 33.524^\circ \text{ kN} - F_{CE} = 0$$

$$\Rightarrow \boldsymbol{F_{CE} = 3.3333\,\text{kN}}$$



Joint C

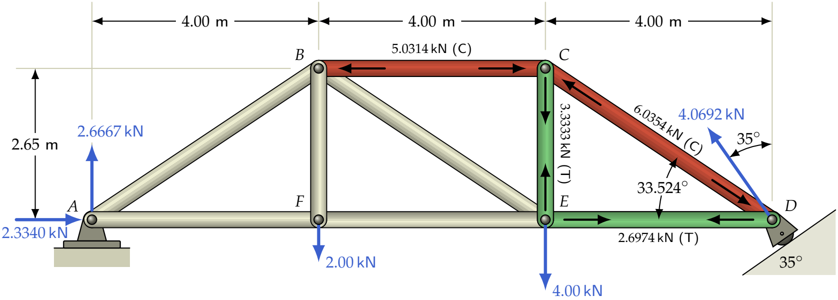


$$\sum F_y = 6.0354 \sin 33.524^\circ \text{ kN} - F_{CE} = 0$$

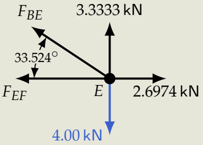
$$\Rightarrow \boldsymbol{F_{CE} = 3.3333\,\text{kN}}$$

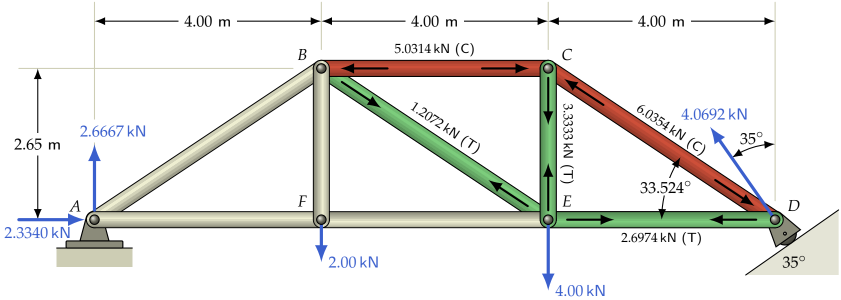
$$\sum F_x = -6.0354 \cos 33.524^\circ \text{ kN} - F_{BC} = 0$$

$$\Rightarrow \boldsymbol{F_{BC} = -5.0314}\,\text{kN}$$

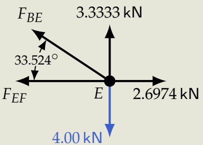

4.00 m
4.00 m
4.00 m
B
C
5.0314 kN (C)
2.65 m
2.6667 kN
A
2.3340 kN
F
2.00 kN
3.3333 kN (T)
E
4.00 kN
6.0354 kN (C)
4.0692 kN
35°
33.524°
D
2.6974 kN (T)
35°

Joint E


F_{BE}
3.3333 kN
33.524°
F_{EF}
E
2.6974 kN
4.00 kN

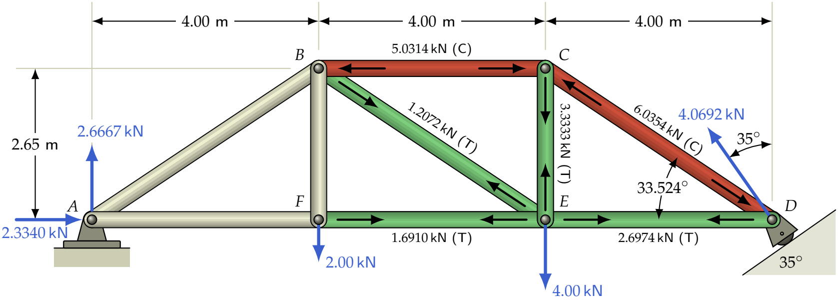


Joint E

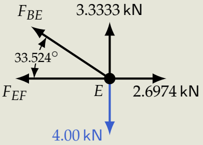


$$\sum F_y = 3.3333\,\text{kN} + F_{BE}\sin 33.524^\circ\ \text{kN} - 4.00\,\text{kN} = 0$$

$$\Rightarrow \boldsymbol{F_{BE} = 1.2072\,\text{kN}}$$



Joint E

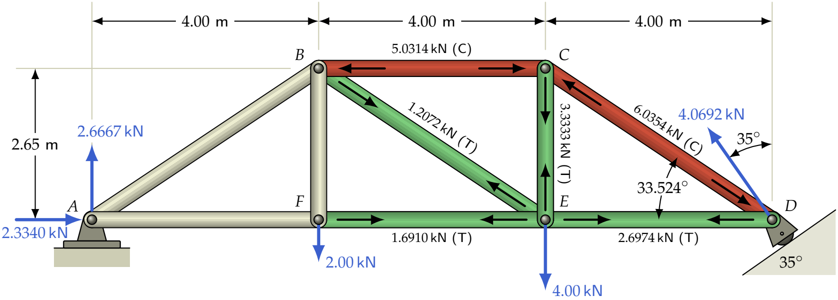


$$\sum F_y = 3.3333\,\text{kN} + F_{BE}\sin 33.524^\circ\,\text{kN} - 4.00\,\text{kN} = 0$$

$$\Rightarrow \boldsymbol{F_{BE} = 1.2072\,\text{kN}}$$

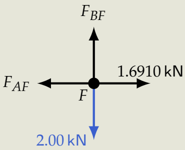
$$\sum F_x = 2.6974\,\text{kN} - 1.2072\cos 33.524^\circ\,\text{kN} - F_{EF} = 0$$

$$\Rightarrow \boldsymbol{F_{EF} = 1.6910\,\text{kN}}$$

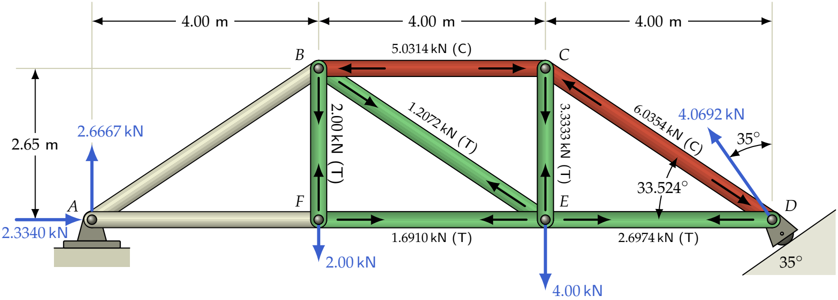


4.00 m
4.00 m
4.00 m
B
C
5.0314 kN (C)
2.65 m
2.6667 kN
1.2072 kN (T)
3.3333 kN (T)
6.0354 kN (C)
4.0692 kN
35°
33.524°
A
F
E
D
2.3340 kN
1.6910 kN (T)
2.6974 kN (T)
2.00 kN
4.00 kN
35°

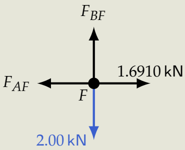
Joint F



F_{BF}
1.6910 kN
F_{AF}
F
2.00 kN

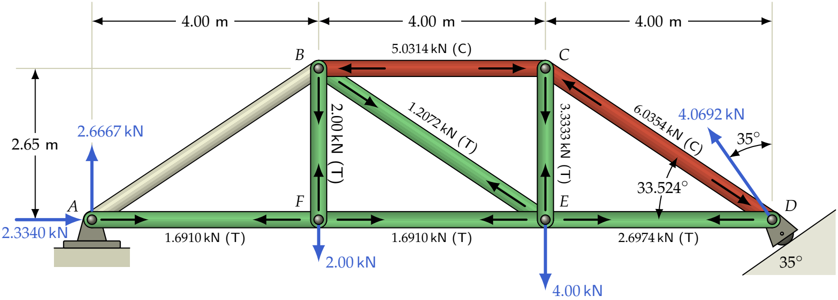


Joint F

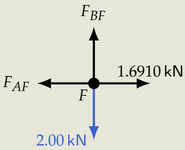


$$\sum F_y = F_{BF} - 2.00\,\text{kN}$$

$$\Rightarrow \boldsymbol{F_{BF} = 2.00\,\text{kN}}$$



Joint F

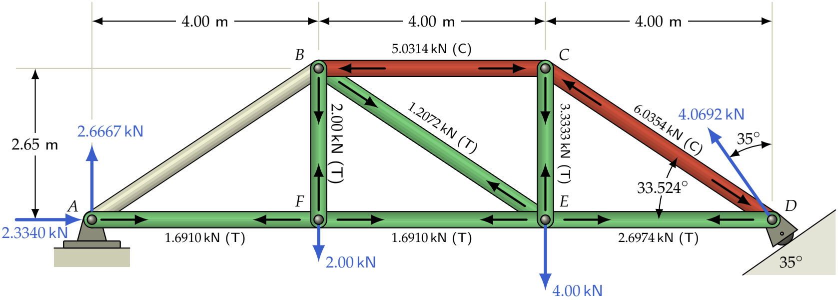


$$\sum F_y = F_{BF} - 2.00\,\text{kN}$$

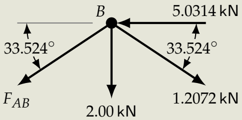
$$\Rightarrow \boldsymbol{F_{BF} = 2.00\,\text{kN}}$$

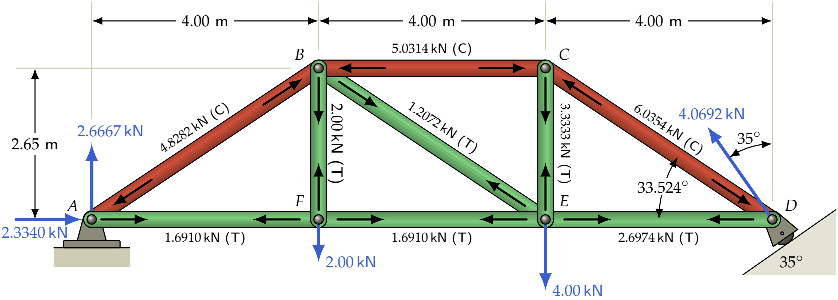
$$\sum F_x = 1.6910\,\text{kN} - F_{AF} = 0$$

$$\Rightarrow \boldsymbol{F_{AF} = 1.6910\,\text{kN}}$$

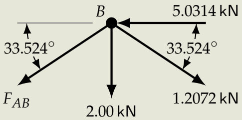

4.00 m
4.00 m
4.00 m
B
C
5.0314 kN (C)
2.65 m
2.6667 kN
1.2072 kN (T)
2.00 kN (T)
3.3333 kN (T)
6.0354 kN (C)
4.0692 kN
35°
33.524°
A
F
E
D
2.3340 kN
1.6910 kN (T)
1.6910 kN (T)
2.6974 kN (T)
2.00 kN
4.00 kN
35°

Joint B


B
5.0314 kN
33.524°
33.524°
F_AB
2.00 kN
1.2072 kN

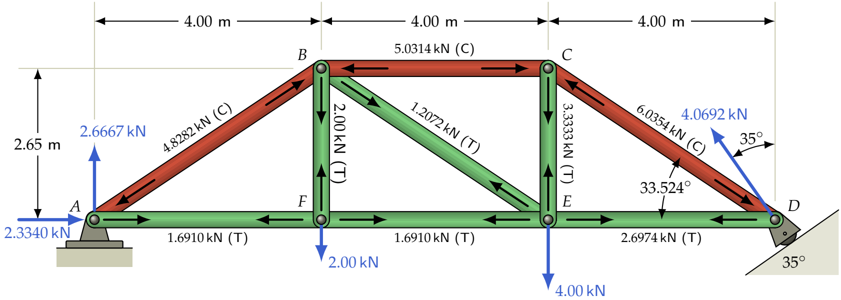


Joint B

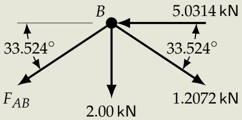


$$\sum F_x = -5.0314\,\text{kN} + 1.2072\cos 33.524^\circ\,\text{kN} - F_{AB}\cos 33.524^\circ = 0$$

$$\Rightarrow \boldsymbol{F_{AB} = -4.8282}\,\text{kN}$$



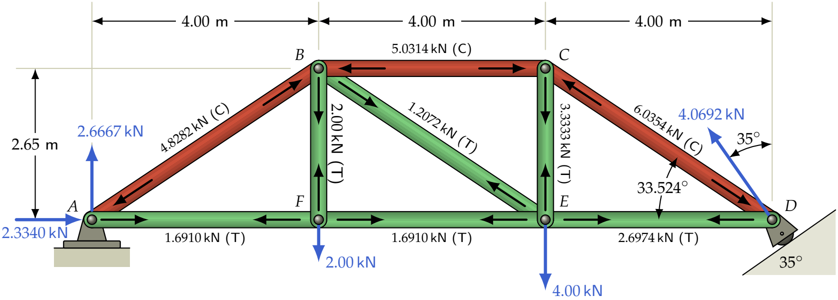
Joint B



$$\sum F_x = -5.0314\,\text{kN} + 1.2072\cos 33.524^\circ\,\text{kN} - F_{AB}\cos 33.524^\circ = 0$$

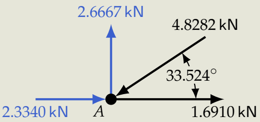
$$\Rightarrow \boldsymbol{F_{AB}} = \mathbf{-4.8282}\,\text{kN}$$

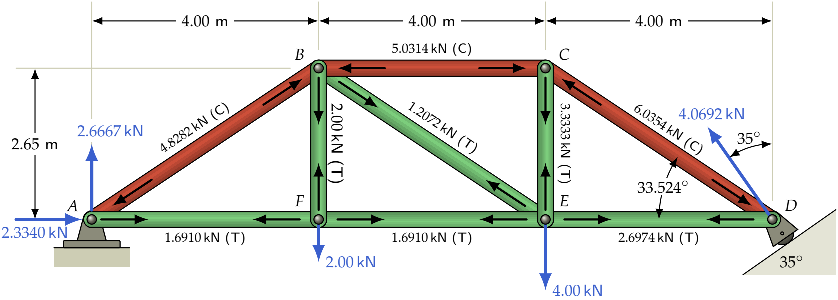
All the truss member forces are now found.



Check for equilibrium at A

This is to verify that we haven't made an error in our member force calculations.





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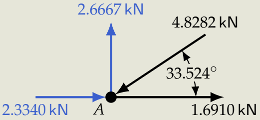
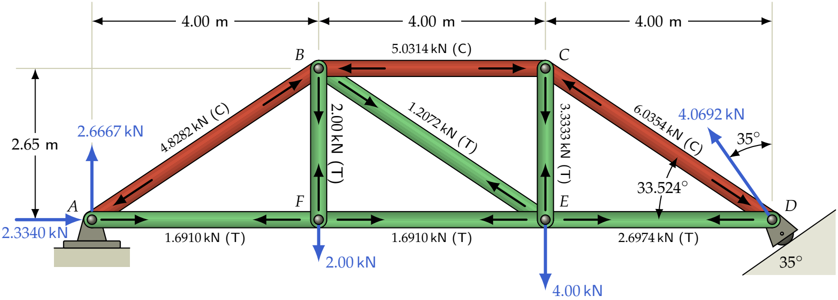


$$\sum F_x = 2.3340\,\text{kN} + 1.6910\,\text{kN} - 4.8282\cos 33.524^\circ\,\text{kN}$$
$$= -0.000050918\,\text{kN} \approx 0 \quad \checkmark$$



Check for equilibrium at A

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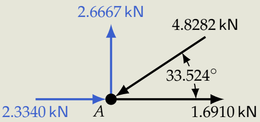
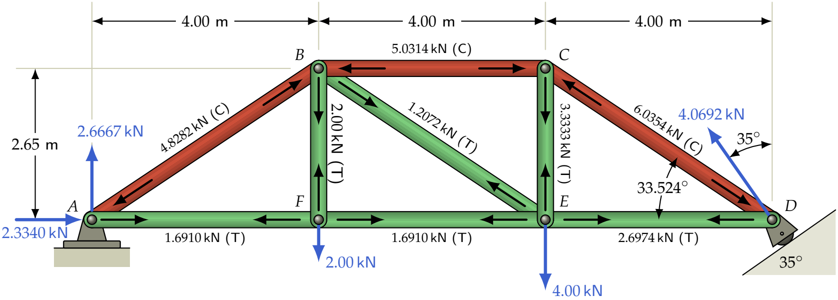


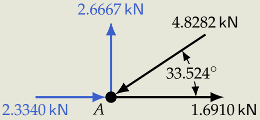
$$\sum F_x = 2.3340\,\text{kN} + 1.6910\,\text{kN} - 4.8282\cos 33.524^\circ\,\text{kN}$$
$$= -0.000050918\,\text{kN} \approx 0 \quad \checkmark$$

$$\sum F_y = 2.6667\,\text{kN} - 4.8282\sin 33.524^\circ\,\text{kN}$$
$$= 0.00015160\,\text{kN} \approx 0 \quad \checkmark$$



Check for equilibrium at A

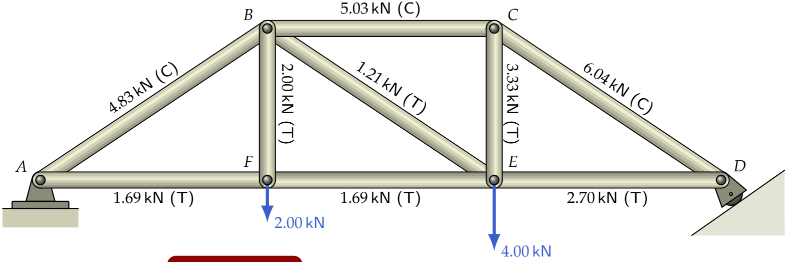
This is to verify that we haven't made an error in our member force calculations.



$$\sum F_x = 2.3340\,\text{kN} + 1.6910\,\text{kN} - 4.8282\cos 33.524^\circ\,\text{kN}$$
$$= -0.000050918\,\text{kN} \approx 0 \quad \checkmark$$

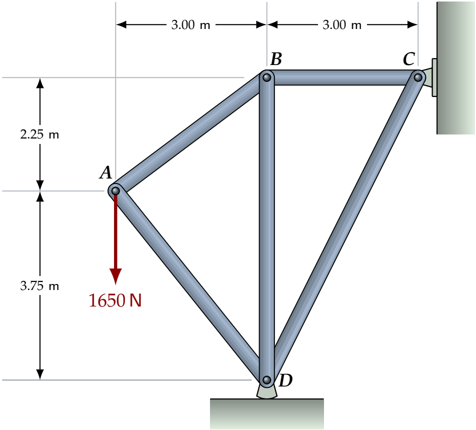
$$\sum F_y = 2.6667\,\text{kN} - 4.8282\sin 33.524^\circ\,\text{kN}$$
$$= 0.00015160\,\text{kN} \approx 0 \quad \checkmark$$

It only remains to convert the results back to the precision given by the input values.



The Results

$AB = 4.83\,\text{kN}$	(Compression)
$AF = 1.69\,\text{kN}$	(Tension)
$BC = 5.03\,\text{kN}$	(Compression)
$BE = 1.21\,\text{kN}$	(Tension)
$BF = 2.00\,\text{kN}$	(Tension)
$CD = 6.04\,\text{kN}$	(Compression)
$CE = 3.33\,\text{kN}$	(Tension)
$DE = 2.70\,\text{kN}$	(Tension)
$EF = 1.69\,\text{kN}$	(Tension)

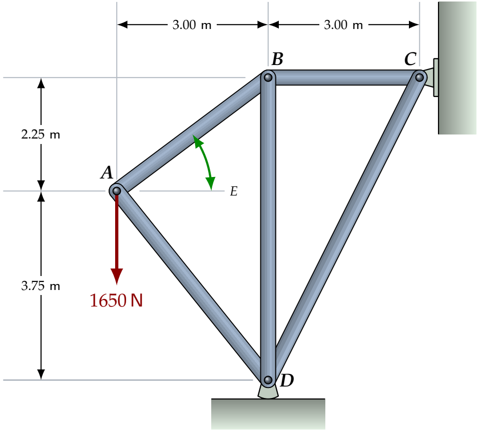


Method of Joints: Example 2

Solve for the internal forces in each of the truss members. Specify whether they are in tension or in compression. Then use the reactions at C and D to verify your results.

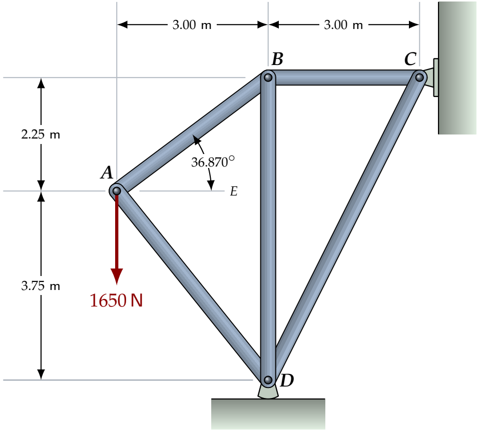
Find the angles

$$\angle BAE = \tan^{-1}\left[\frac{2.25}{3.00}\right]$$



Find the angles

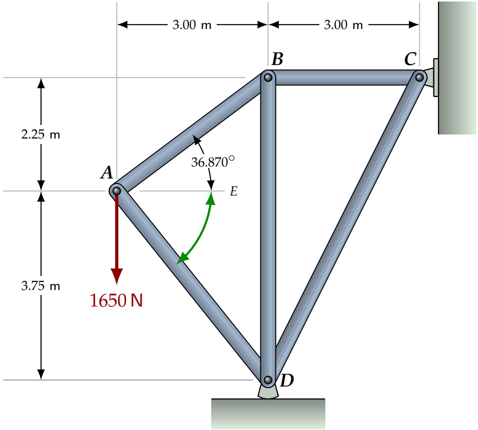
$$\angle BAE = \tan^{-1}\left[\frac{2.25}{3.00}\right]$$
$$= 36.870^\circ$$



Find the angles

$$\angle BAE = \tan^{-1}\left[\frac{2.25}{3.00}\right]$$
$$= 36.870^\circ$$

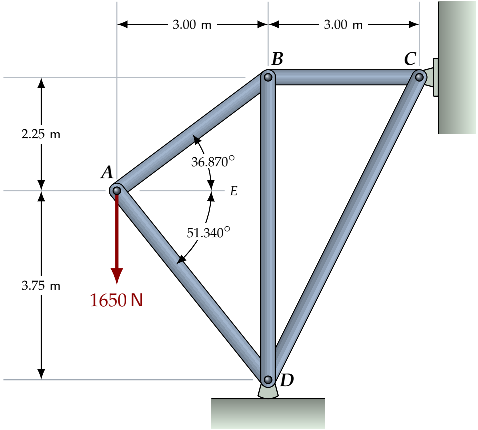
$$\angle DAE = \tan^{-1}\left[\frac{3.75}{3.00}\right]$$



Find the angles

$$\angle BAE = \tan^{-1}\left[\frac{2.25}{3.00}\right]$$
$$= 36.870^\circ$$

$$\angle DAE = \tan^{-1}\left[\frac{3.75}{3.00}\right]$$
$$= 51.340^\circ$$



Find the angles

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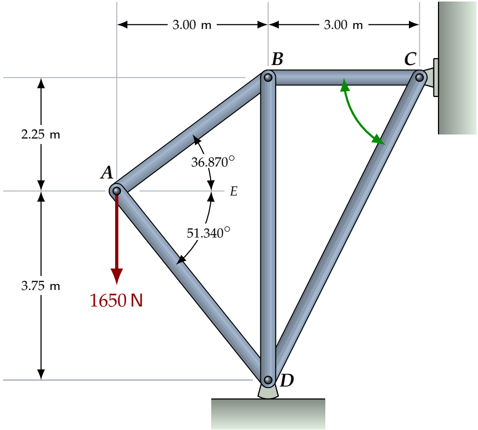
$$= 51.340^\circ$$

$$\angle BCD = \tan^{-1}\left[\frac{6.00}{3.00}\right]$$

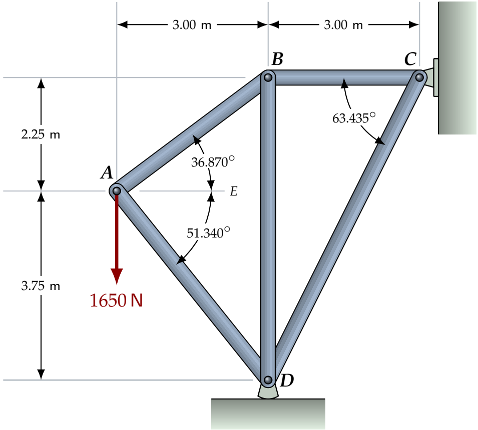


Find the angles

$$\angle BAE = \tan^{-1}\left[\frac{2.25}{3.00}\right]$$
$$= 36.870^\circ$$

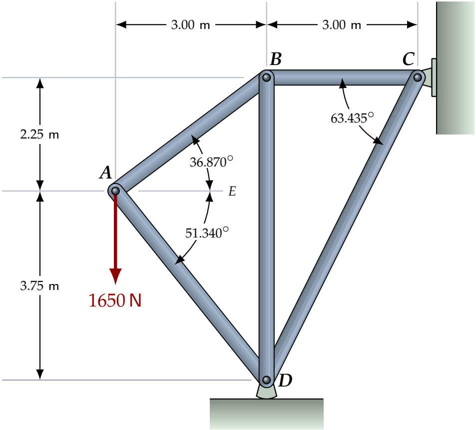
$$\angle DAE = \tan^{-1}\left[\frac{3.75}{3.00}\right]$$
$$= 51.340^\circ$$

$$\angle BCD = \tan^{-1}\left[\frac{6.00}{3.00}\right]$$
$$= 63.435^\circ$$



Joint A

Draw the unknown forces in tension, pointing away from the joint they are acting upon. Then a positive result means the member is in tension and a ndegative result implies compression.



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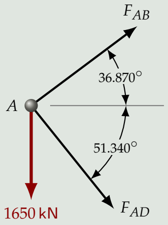

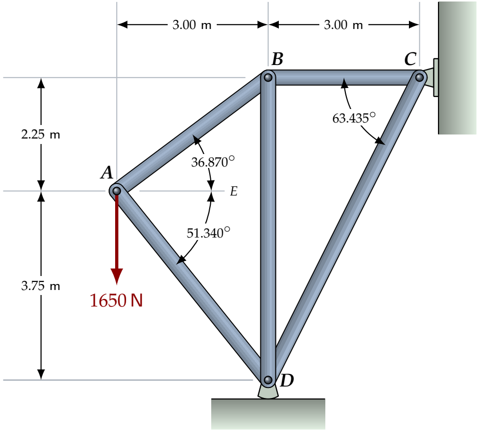

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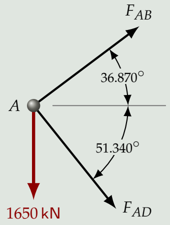
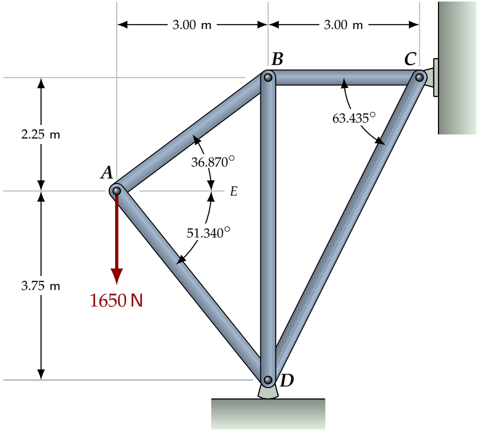


$$\sum F_x = F_{AB} \cos 36.870^\circ + F_{AD} \cos 51.430^\circ = 0$$



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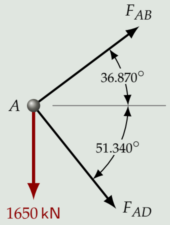
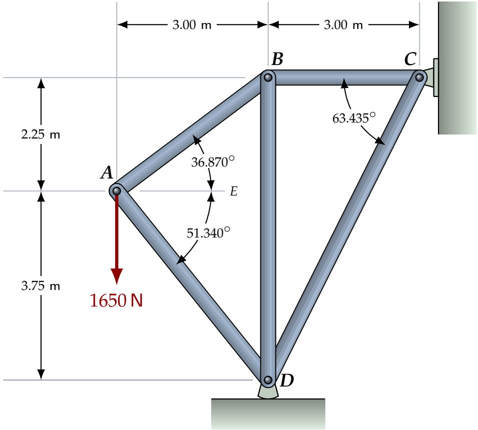


$$\sum F_x = F_{AB}\cos 36.870^\circ + F_{AD}\cos 51.430^\circ = 0$$

$$\sum F_y = F_{AB}\sin 36.870^\circ - F_{AD}\sin 51.340^\circ - 1650\ \mathrm{N} = 0$$



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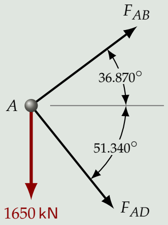

$$\sum F_x = F_{AB}\cos 36.870^\circ + F_{AD}\cos 51.430^\circ = 0$$
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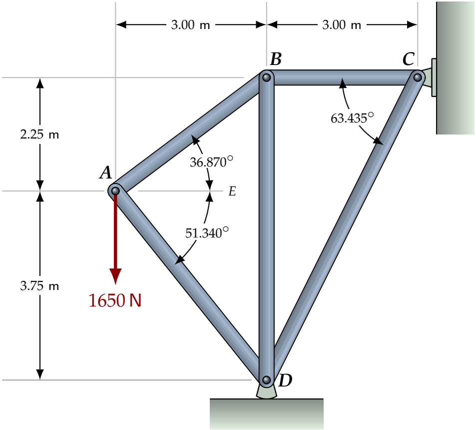
Now, use the **system-solver** on your calculator to solve these two equations for F_{AB} and F_{AD}.



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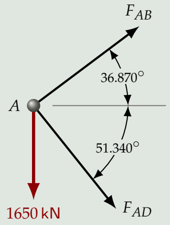

$$\sum F_x = F_{AB}\cos 36.870^\circ + F_{AD}\cos 51.430^\circ = 0$$

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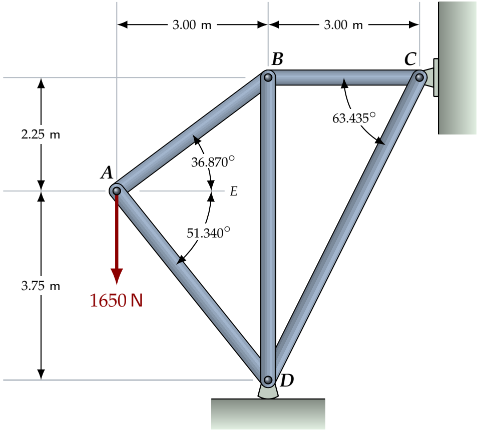
Now, use the **system-solver** on your calculator to solve these two equations for F_{AB} and F_{AD}.

$\boldsymbol{F_{AB} = 1031.3\text{ N}}$ and $\boldsymbol{F_{AD} = -1320.6\text{ N}}$.



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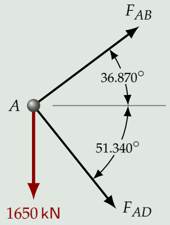

$$\sum F_x = F_{AB}\cos 36.870^\circ + F_{AD}\cos 51.430^\circ = 0$$

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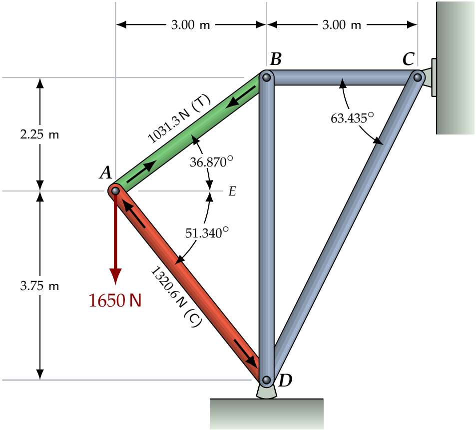
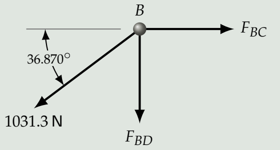
Now, use the **system-solver** on your calculator to solve these two equations for F_{AB} and F_{AD}.

$$\boldsymbol{F_{AB} = 1031.3\ \text{N}} \text{ and } \boldsymbol{F_{AD} = -1320.6\ \text{N}}.$$

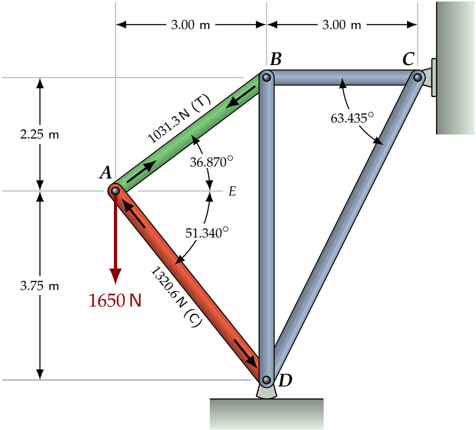
F_{AB} is positive, so member AB is in tension. F_{AD} is negative, so AD is in compression.



Joint B

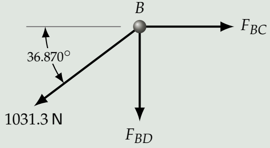


B
F_{BC}
36.870°
1031.3 N
F_{BD}



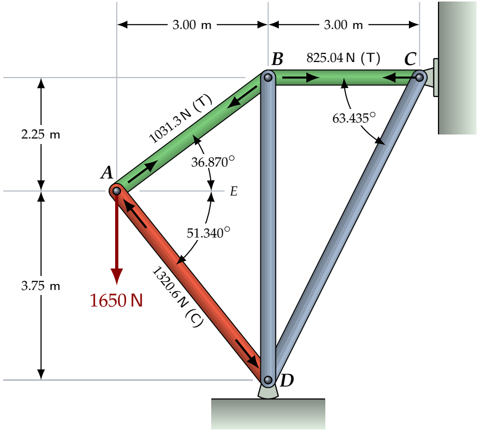
3.00 m
3.00 m
B
C
2.25 m
1031.3 N (T)
63.435°
36.870°
A
E
51.340°
3.75 m
1650 N
1320.6 N (C)
D

Joint B

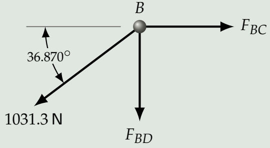


$$\sum F_x = F_{BC} - 1031.3 \cos 36.870^\circ \text{ N} = 0$$

$$\Rightarrow \boldsymbol{F_{BC} = 825.04\,\mathrm{N}}$$



Joint B

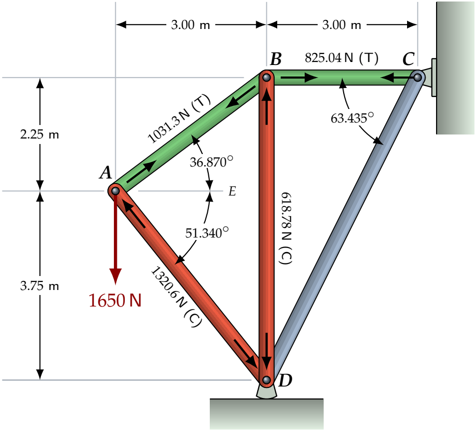


$$\sum F_x = F_{BC} - 1031.3 \cos 36.870^\circ \text{ N} = 0$$

$$\Rightarrow \boldsymbol{F_{BC} = 825.04\ \text{N}}$$

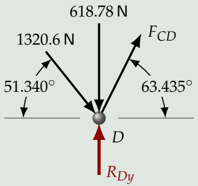
$$\sum F_y = -F_{BD} - 1031.3 \sin 36.870^\circ \text{ N} = 0$$

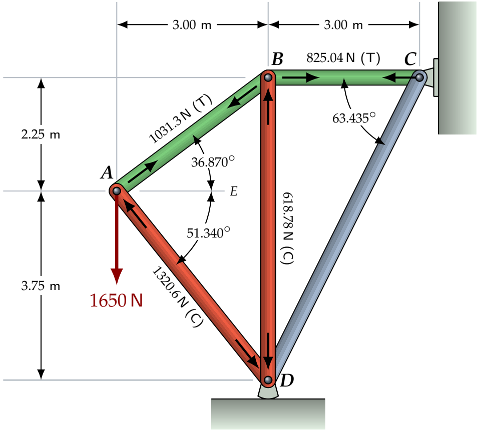
$$\Rightarrow \boldsymbol{F_{BD} = -618.78\ \text{N}}$$



Joint D

Note that we have to include the reaction from the rocker at D in the free body diagram since it also acts on the joint.





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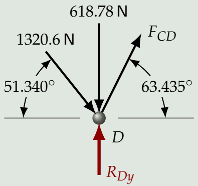
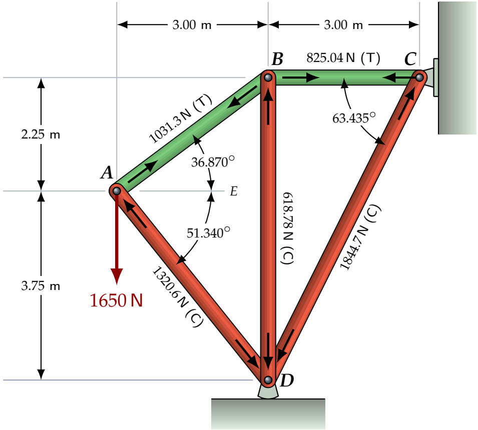


$$\sum F_x = F_{CD}\cos 63.435^\circ + 1320.6\cos 51.340^\circ \ \text{N} = 0$$

$$\Rightarrow F_{CD} = -\frac{1320.6\cos 51.340^\circ \ \text{N}}{\cos 63.435^\circ}$$

$$\Rightarrow \boldsymbol{F_{CD} = -1844.7\,\mathrm{N}}$$



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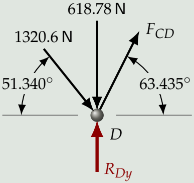
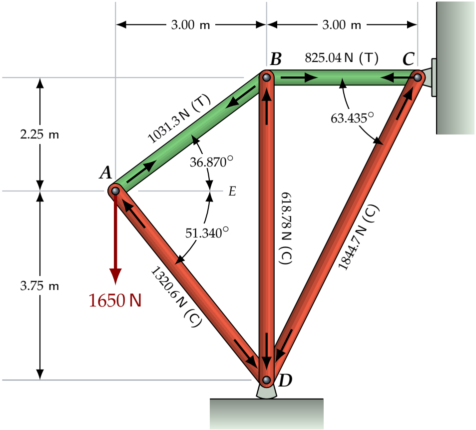


$$\sum F_x = F_{CD}\cos 63.435^\circ + 1320.6\cos 51.340^\circ \ \mathrm{N} = 0$$

$$\Rightarrow F_{CD} = -\frac{1320.6\cos 51.340^\circ \ \mathrm{N}}{\cos 63.435^\circ}$$

$$\Rightarrow \boldsymbol{F_{CD} = -1844.7\,\mathrm{N}}$$

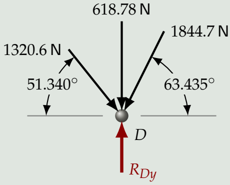
All the internal forces in the truss have now been found.

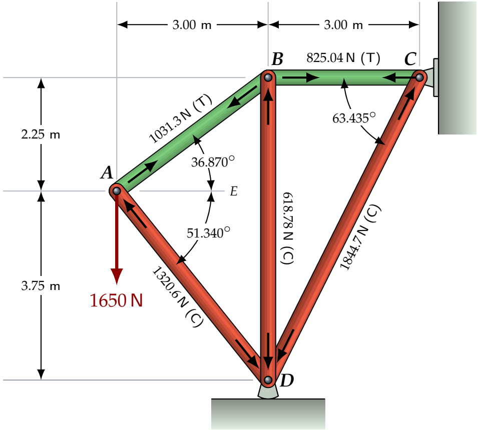


Do a calculation check!

There are some checks we can make to ensure there are no errors in our calculations. We use moments and the summing of the reactions.

First, determine R_{Dy}, the y-component of the reaction at D (D is supported by a rocker and has no x-component):





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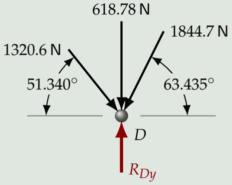
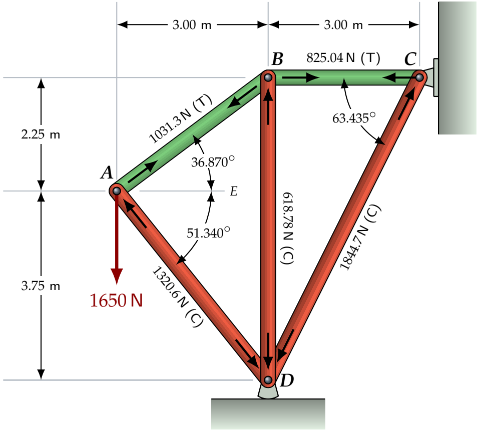


$$\sum F_y = R_{Dy} - 1320.6 \sin 51.340^\circ \text{ N} - 618.78 \text{ N}$$
$$- 1844.7 \sin 63.435^\circ \text{ N} = 0$$
$$\Rightarrow R_{Dy} = 3299.9 \text{ N}$$



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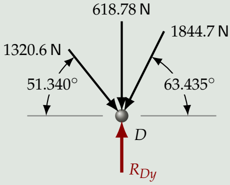
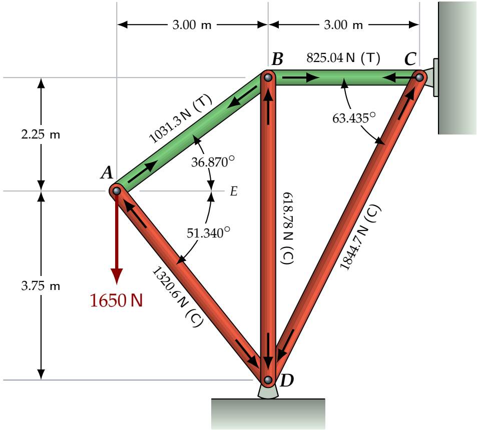


$$\sum F_y = R_{Dy} - 1320.6 \sin 51.340^\circ \text{ N} - 618.78 \text{ N}$$
$$- 1844.7 \sin 63.435^\circ \text{ N} = 0$$
$$\Rightarrow R_{Dy} = 3299.9 \text{ N}$$

If we calculate R_{Dy} by taking moments about C of the external forces acting the truss, we get:

$$\sum M_C = (1650 \text{ N}) \cdot (6.00 \text{ m}) - R_{Dy} \cdot (3.00 \text{ m}) = 0$$
$$\Rightarrow R_{Dy} = 3300 \text{ N} \quad \checkmark$$



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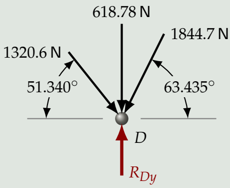

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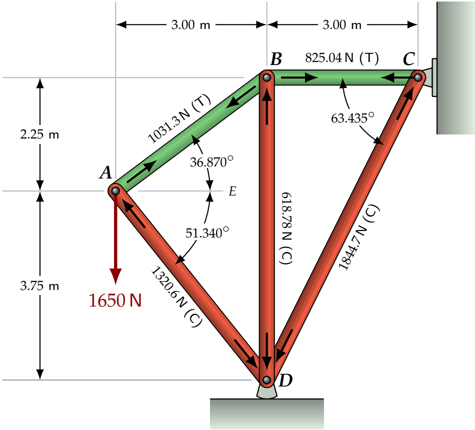
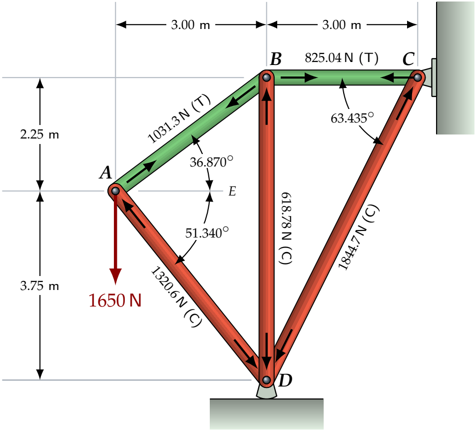
Note: This is as expected from our previous calculation — apart from some rounding error in the fifth digit.



Check cont'd

Notice that results from members AC, AB, BD and CD were incorporated into this check (since AB was used in the calculation of BD) so it is safe to assume that these results are correct.

But we have not checked member BC.
We do that by summing all the external forces, and then investigating joint C.



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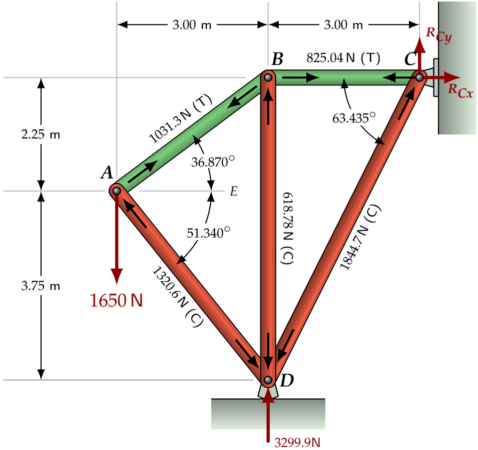
$$\sum F_x = R_{Cx} = 0$$

$$\sum F_y = R_{Cy} + 3299.9\,\text{N} - 1650\,\text{N}$$

$$\Rightarrow R_{Cy} = -1649.9\,\text{N}$$



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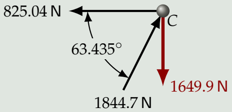
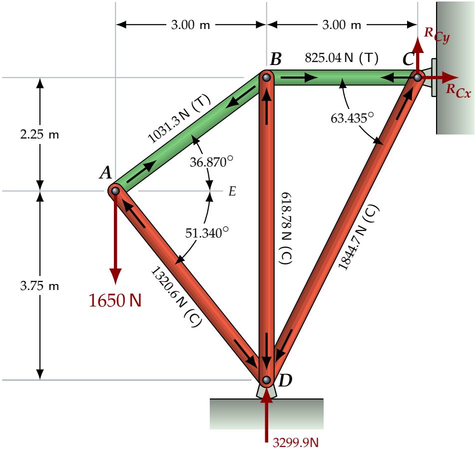
Now, examine joint C for equilibrium:





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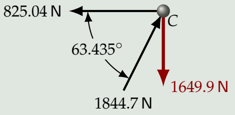
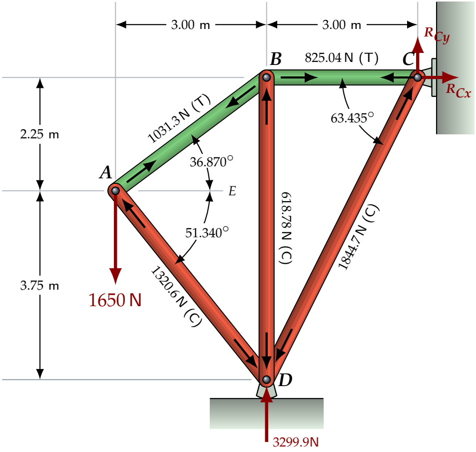


$$\sum F_x = 1844.7 \cos 63.435^\circ\ \text{N} - 825.04\,\text{N}$$

$$= -0.066554\ \text{N} \approx 0 \quad \checkmark$$



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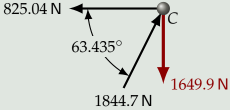
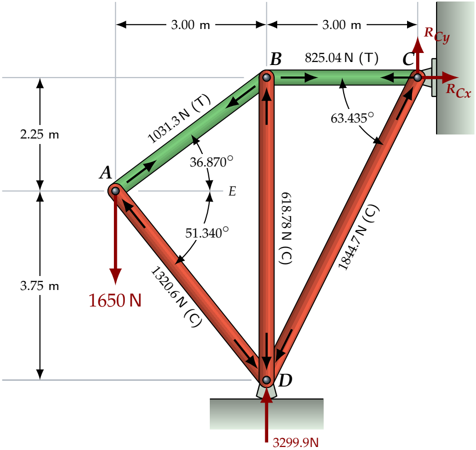
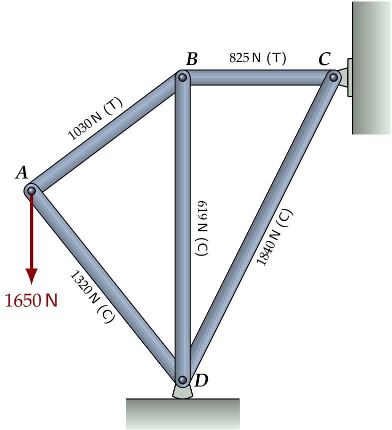


$$\sum F_x = 1844.7\cos 63.435^\circ\text{ N} - 825.04\text{ N}$$
$$= -0.066554\text{ N} \approx 0 \quad \checkmark$$

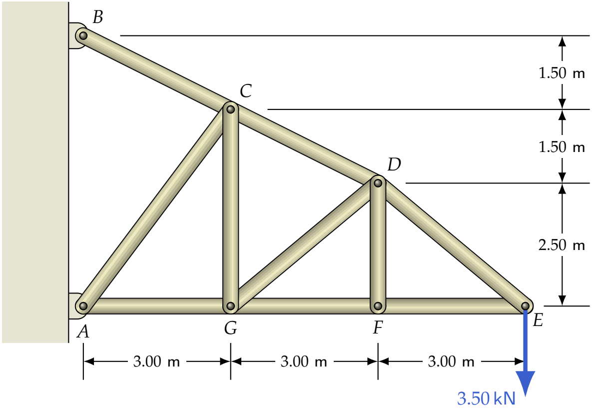
$$\sum F_y = 1844.7\sin 63.435^\circ - 1649.9\text{ N}$$
$$= 0.05057\text{ N} \approx 0 \quad \checkmark$$





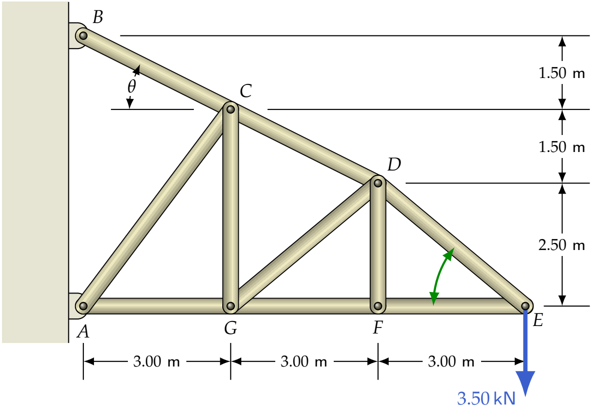
The Results

$$AB = 1030 \text{ N} \quad \text{(Tension)}$$
$$AC = 1320 \text{ N} \quad \text{(Compression)}$$
$$BC = 825 \text{ N} \quad \text{(Tension)}$$
$$BD = 619 \text{ N} \quad \text{(Compression)}$$
$$CD = 1840 \text{ N} \quad \text{(Compression)}$$



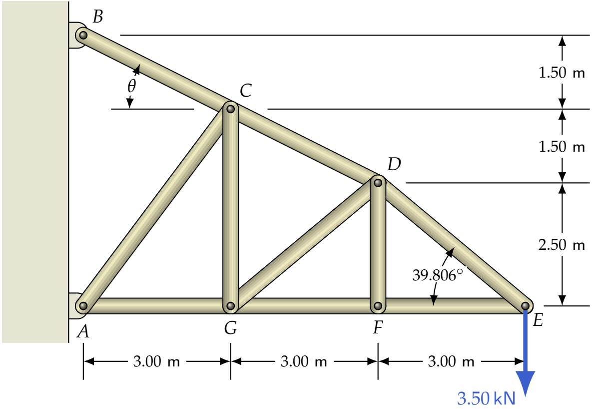
Method of Joints: Example 3

Analyze the truss above to determine the internal forces in each truss member. All connections are pinned.



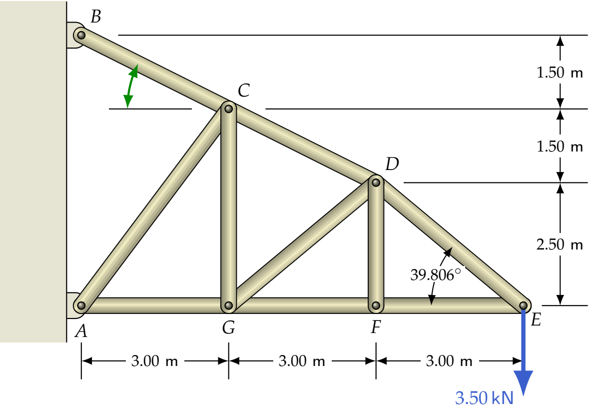
Find the angles

$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right]$$



Find the angles

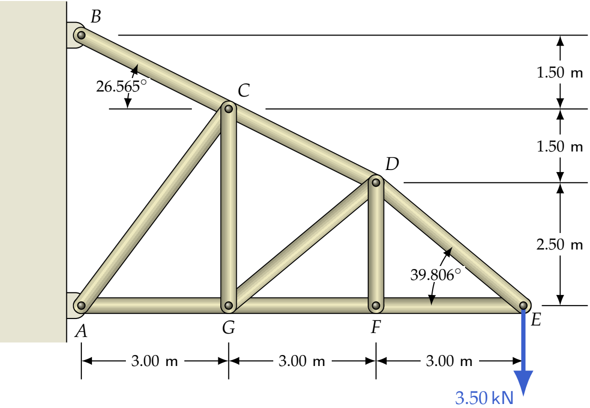
$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right]$$
$$= 39.806^\circ$$



Find the angles

$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right]$$
$$= 39.806^\circ$$

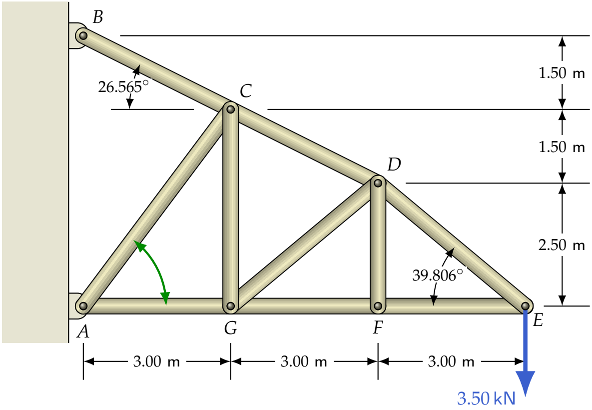
$$\theta = \tan^{-1}\left[\frac{1.50}{3.00}\right]$$



Find the angles

$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right] = 39.806^\circ$$

$$\theta = \tan^{-1}\left[\frac{1.50}{3.00}\right] = 26.565^\circ$$

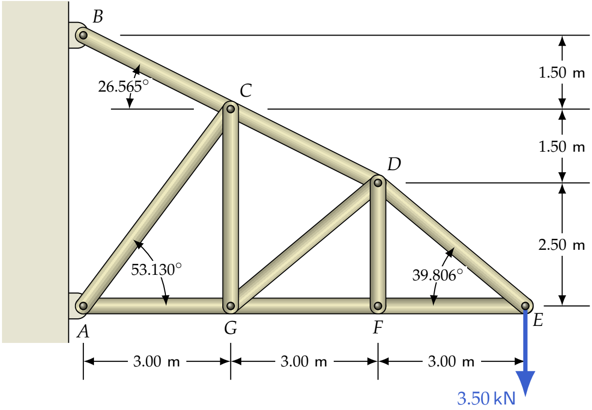


Find the angles

$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right]$$
$$= 39.806^\circ$$

$$\theta = \tan^{-1}\left[\frac{1.50}{3.00}\right]$$
$$= 26.565^\circ$$

$$\angle CAG = \tan^{-1}\left[\frac{4.00}{3.00}\right]$$

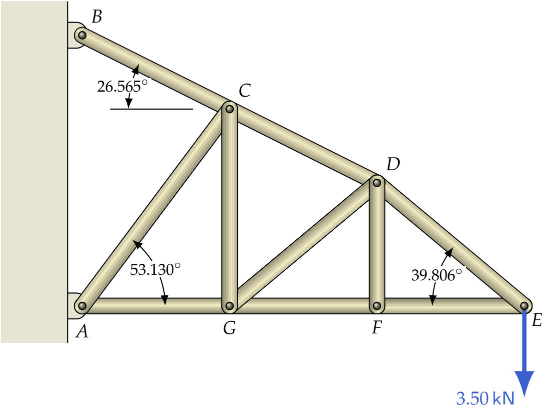


Find the angles

$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right]$$
$$= 39.806^\circ$$

$$\theta = \tan^{-1}\left[\frac{1.50}{3.00}\right]$$
$$= 26.565^\circ$$

$$\angle CAG = \tan^{-1}\left[\frac{4.00}{3.00}\right]$$
$$= 53.130^\circ$$



Find the angles

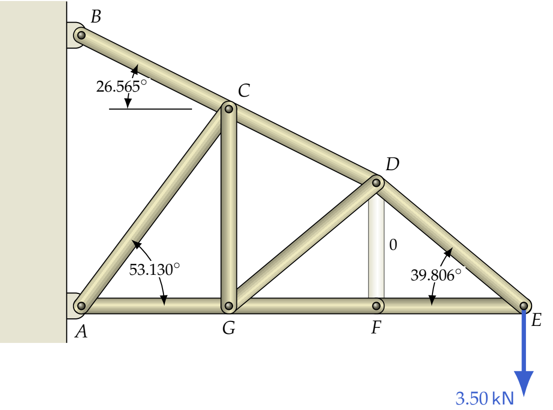
$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right] = 39.806^\circ$$

$$\theta = \tan^{-1}\left[\frac{1.50}{3.00}\right] = 26.565^\circ$$

$$\angle CAG = \tan^{-1}\left[\frac{4.00}{3.00}\right] = 53.130^\circ$$

Notice:

1. By inspection, truss member DF is a **zero-force** member. (Consider the y-components acting at F.)



Find the angles

$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right]$$
$$= 39.806^\circ$$

$$\theta = \tan^{-1}\left[\frac{1.50}{3.00}\right]$$
$$= 26.565^\circ$$

$$\angle CAG = \tan^{-1}\left[\frac{4.00}{3.00}\right]$$
$$= 53.130^\circ$$

Notice:

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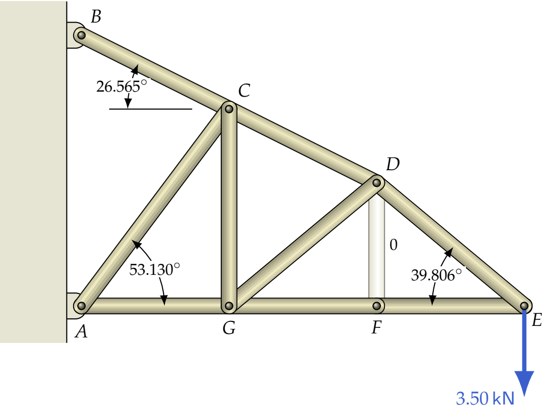


Find the angles

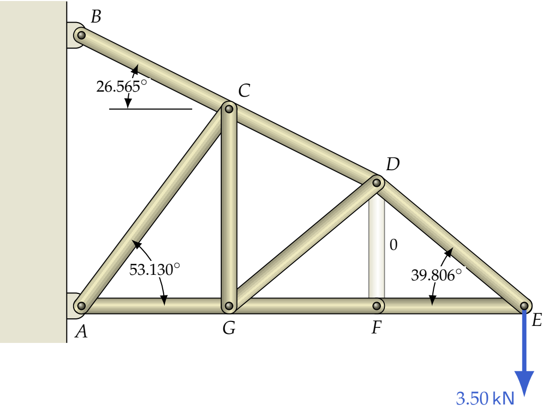
$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right]$$
$$= 39.806°$$

$$\theta = \tan^{-1}\left[\frac{1.50}{3.00}\right]$$
$$= 26.565°$$

$$\angle CAG = \tan^{-1}\left[\frac{4.00}{3.00}\right]$$
$$= 53.130°$$

Notice:

1. By inspection, truss member DF is a **zero-force** member. (Consider the y-components acting at F.)
2. We can start at joint E and analyze the truss joints $E \to F \to D \to G \to C$, without calculating the reactions at A and B.



Find the angles

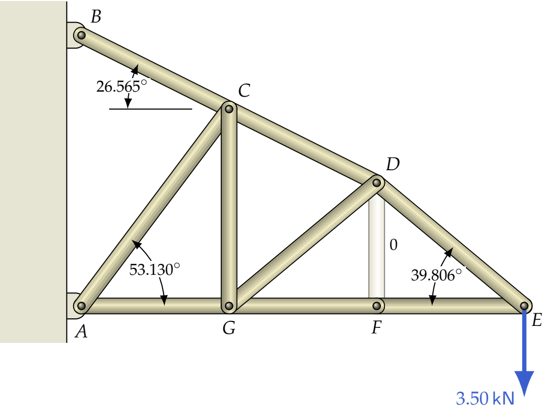
$$\angle DEF = \tan^{-1}\left[\frac{2.50}{3.00}\right] = 39.806^\circ$$

$$\theta = \tan^{-1}\left[\frac{1.50}{3.00}\right] = 26.565^\circ$$

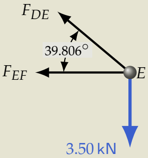
$$\angle CAG = \tan^{-1}\left[\frac{4.00}{3.00}\right] = 53.130^\circ$$

Notice:

1. By inspection, truss member DF is a **zero-force** member. (Consider the y-components acting at F.)
2. We can start at joint E and analyze the truss joints $E \to F \to D \to G \to C$, without calculating the reactions at A and B.
3. Finding the reactions at A and B **is** useful, however, to verify our results; if we have not made mistakes, then the sum of all forces acting at A (including the reaction) will equal 0. Similarly, the sum of all forces acting at B will equal 0.

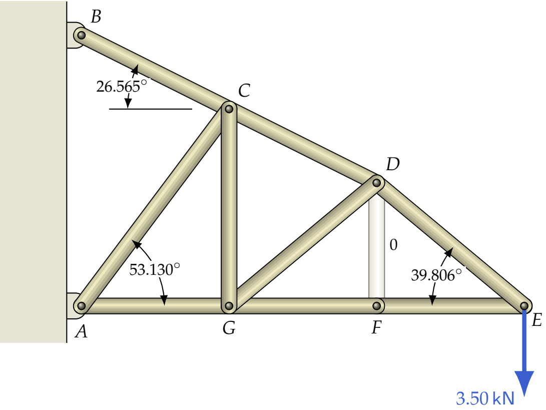


Joint E

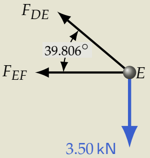


Considerations:

1. Draw a free body diagram (FBD) — for each joint!
2. Draw all unknown FBD forces (F_{DE} and F_{DE} in this case) in tension, pointing away from the joint. Then, a positive result indicates tension and a negative result indicates compression.



Joint E

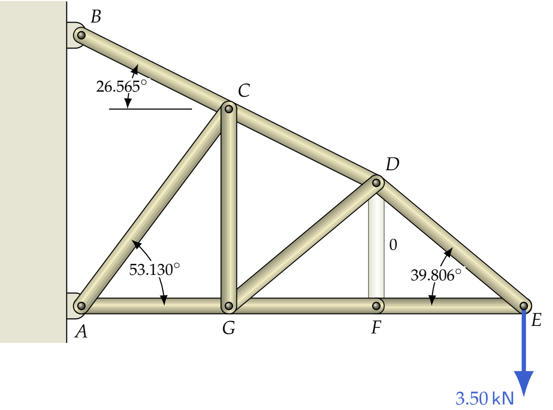


$$\sum F_y = F_{DE} \sin 39.806^\circ - 3.50\,\text{kN} = 0$$

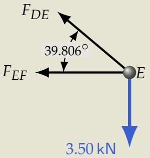
$$\Rightarrow F_{DE} = 5.4671\,\text{kN}$$

Considerations:

1. Draw a free body diagram (FBD) — for each joint!
2. Draw all unknown FBD forces (F_{DE} and F_{DE} in this case) in tension, pointing away from the joint. Then, a positive result indicates tension and a negative result indicates compression.
3. Sum the y-components first, so that we have only one variable (F_{DE}) and can find it directly.



Joint E



$$\sum F_y = F_{DE} \sin 39.806^\circ - 3.50\,\text{kN} = 0$$

$$\Rightarrow F_{DE} = 5.4671\,\text{kN}$$

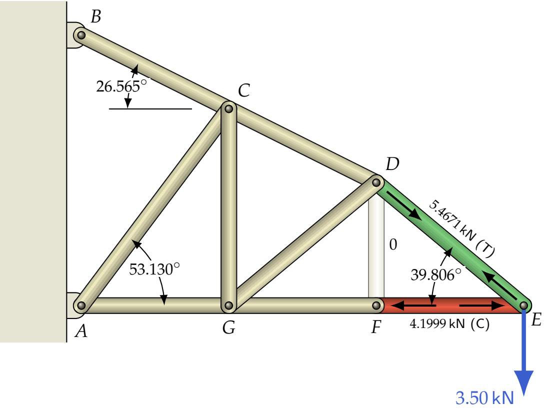
$$\sum F_x = -F_{DE} \cos 39.806^\circ - F_{EF} = 0$$

$$\Rightarrow F_{EF} = -5.4671 \cos 39.806^\circ\,\text{kN}$$

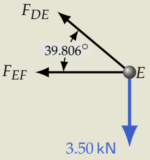
$$= -4.1999\,\text{kN}$$

Considerations:

1. Draw a free body diagram (FBD) — for each joint!
2. Draw all unknown FBD forces (F_{DE} and F_{DE} in this case) in tension, pointing away from the joint. Then, a positive result indicates tension and a negative result indicates compression.
3. Sum the y-components first, so that we have only one variable (F_{DE}) and can find it directly.



Joint E

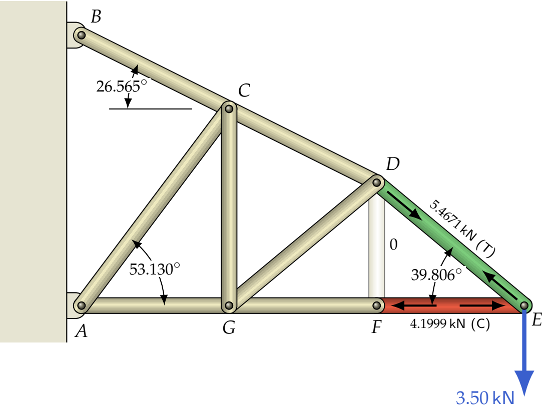


$$\sum F_y = F_{DE} \sin 39.806^\circ - 3.50\,\text{kN} = 0$$
$$\Rightarrow F_{DE} = 5.4671\,\text{kN}$$

$$\sum F_x = -F_{DE} \cos 39.806^\circ - F_{EF} = 0$$
$$\Rightarrow F_{EF} = -5.4671 \cos 39.806^\circ\,\text{kN}$$
$$= -4.1999\,\text{kN}$$

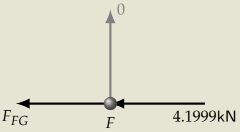
Considerations:

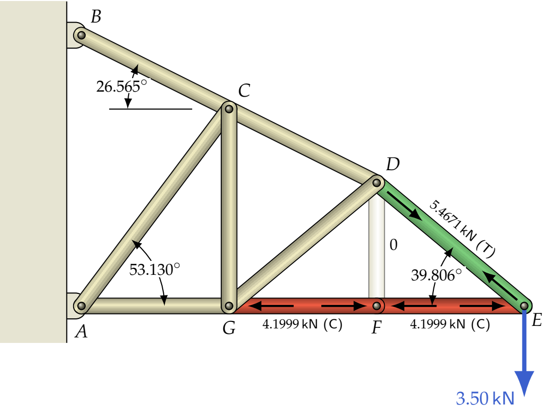
1. Draw a free body diagram (FBD) — for each joint!
2. Draw all unknown FBD forces (F_{DE} and F_{DE} in this case) in tension, pointing away from the joint. Then, a positive result indicates tension and a negative result indicates compression.
3. Sum the y-components first, so that we have only one variable (F_{DE}) and can find it directly.
4. Maintain all 5 working significant digits (or more) for now to reduce the accumulation of rounding errors.



Joint F

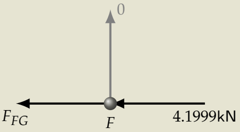
This one is easy!





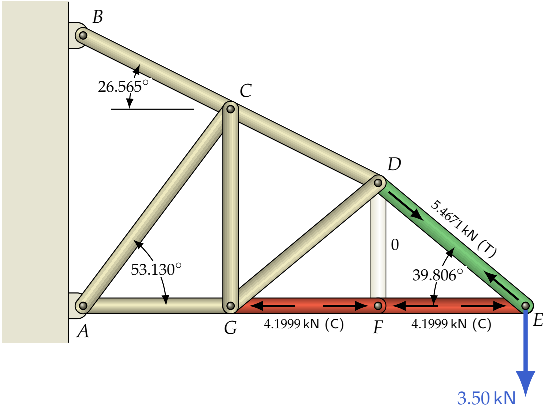
Joint F

This one is easy!

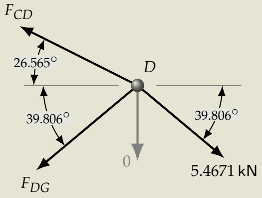


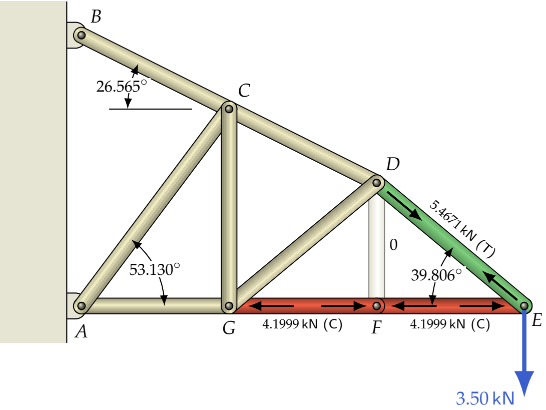
$$\sum F_x = -F_{FG} - 4.1999\,\text{kN} = 0$$

$$\Rightarrow F_{FG} = -4.1999\,\text{kN}$$

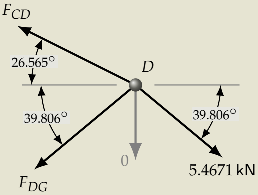

B
26.565°
C
D
53.130°
0
5.4671 kN (T)
39.806°
A
G
4.1999 kN (C)
F
4.1999 kN (C)
E
3.50 kN

Joint D

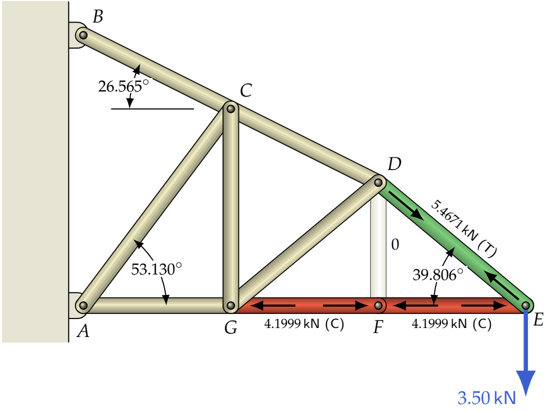

F_{CD}
26.565°
D
39.806°
39.806°
0
5.4671 kN
F_{DG}



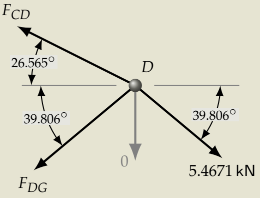
Joint D



$$
\begin{aligned}
\sum F_x &= 5.4671 \cos 39.806^\circ \text{ kN} \\
&\quad - F_{CD} \cos 26.565^\circ \\
&\quad - F_{DG} \cos 39.806^\circ \\
&= 0
\end{aligned}
$$

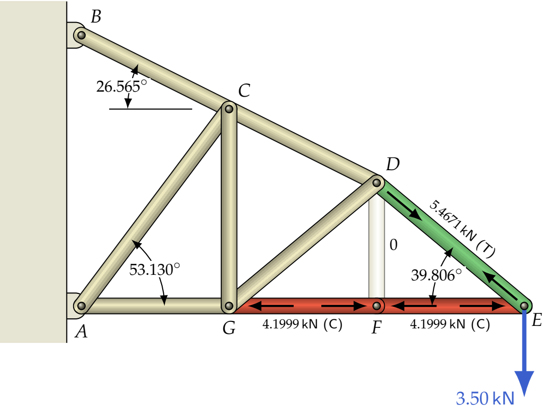


Joint D

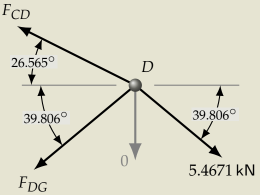


$$\sum F_x = 5.4671 \cos 39.806^\circ \text{ kN} - F_{CD} \cos 26.565^\circ - F_{DG} \cos 39.806^\circ = 0$$

$$\sum F_y = F_{CD} \sin 26.565^\circ - F_{DG} \sin 39.806^\circ - 5.4671 \sin 39.806^\circ \text{ kN} = 0$$



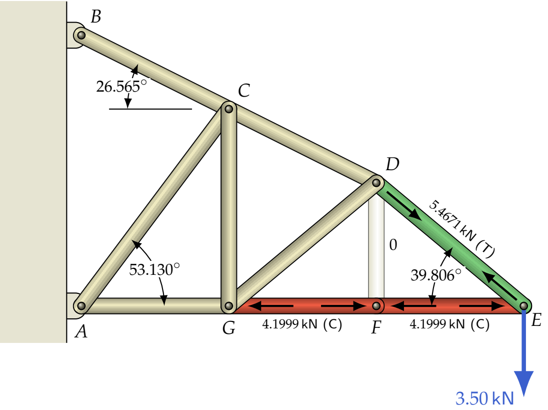
Joint D



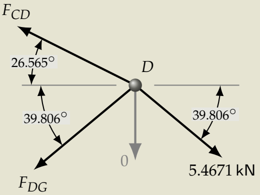
$$\sum F_x = 5.4671 \cos 39.806^\circ \text{ kN} - F_{CD} \cos 26.565^\circ - F_{DG} \cos 39.806^\circ = 0$$

$$\sum F_y = F_{CD} \sin 26.565^\circ - F_{DG} \sin 39.806^\circ - 5.4671 \sin 39.806^\circ \text{ kN} = 0$$

Now, use the **system-solver** on your calculator to solve these two equations for F_{CD} and F_{DG}.



Joint D

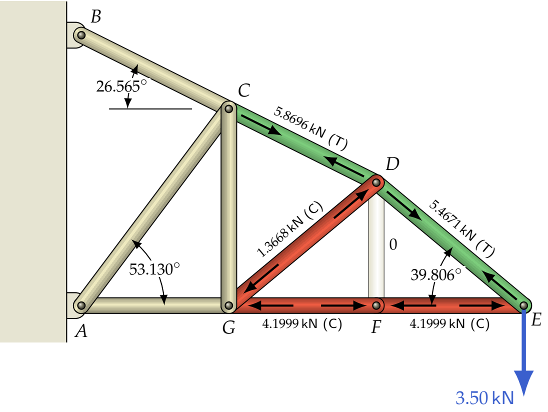


$$\sum F_x = 5.4671 \cos 39.806^\circ \text{ kN} - F_{CD} \cos 26.565^\circ - F_{DG} \cos 39.806^\circ = 0$$

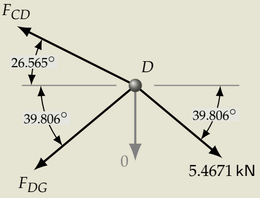
$$\sum F_y = F_{CD} \sin 26.565^\circ - F_{DG} \sin 39.806^\circ - 5.4671 \sin 39.806^\circ \text{ kN} = 0$$

Now, use the **system-solver** on your calculator to solve these two equations for F_{CD} and F_{DG}.

$$F_{CD} = 5.8696 \text{ kN}, \; F_{DG} = -1.3668 \text{ kN}$$



Joint D

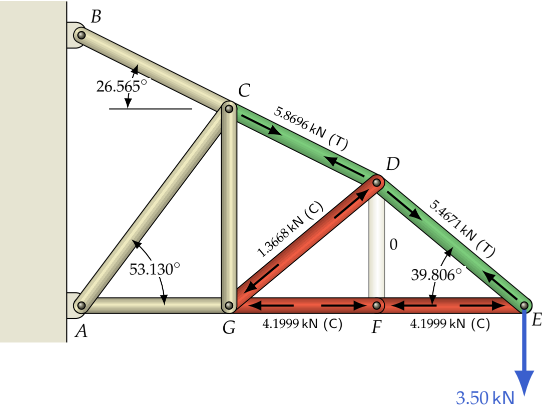


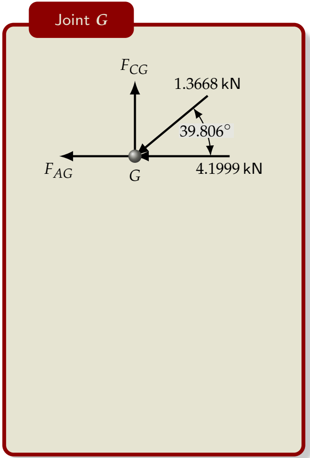
$$\begin{aligned}\sum F_x &= 5.4671 \cos 39.806^\circ \text{ kN} \\ &\quad - F_{CD} \cos 26.565^\circ \\ &\quad - F_{DG} \cos 39.806^\circ \\ &= 0\end{aligned}$$

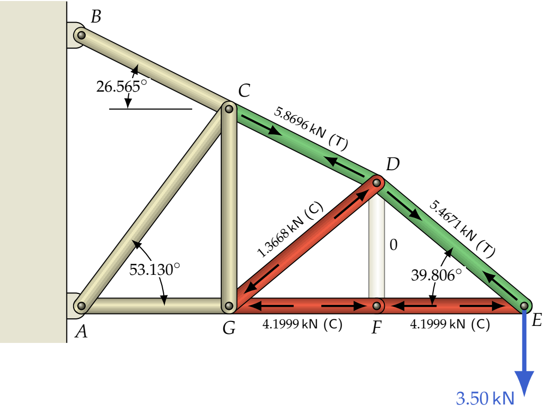
$$\begin{aligned}\sum F_y &= F_{CD} \sin 26.565^\circ \\ &\quad - F_{DG} \sin 39.806^\circ \\ &\quad - 5.4671 \sin 39.806^\circ \text{ kN} \\ &= 0\end{aligned}$$

Now, use the **system-solver** on your calculator to solve these two equations for F_{CD} and F_{DG}.

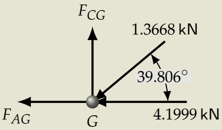
$F_{CD} = 5.8696\,\text{kN},\ F_{DG} = -1.3668\,\text{kN}$


B
26.565°
C
5.8696 kN (T)
D
1.3668 kN (C)
0
5.4671 kN (T)
53.130°
39.806°
A
G
4.1999 kN (C)
F
4.1999 kN (C)
E
3.50 kN

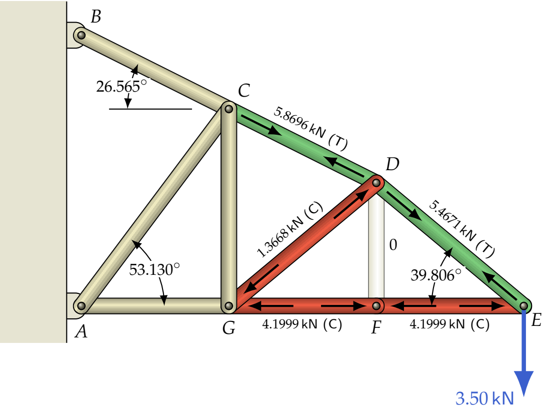

Joint G
F_{CG}
1.3668 kN
39.806°
F_{AG}
G
4.1999 kN



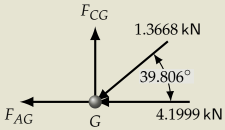
Joint G



$$\begin{aligned} \sum F_y &= F_{CG} - 1.3668 \sin 39.806^\circ \text{ kN} \\ &= 0 \\ \Rightarrow F_{CG} &= 0.87501 \text{ kN} \end{aligned}$$

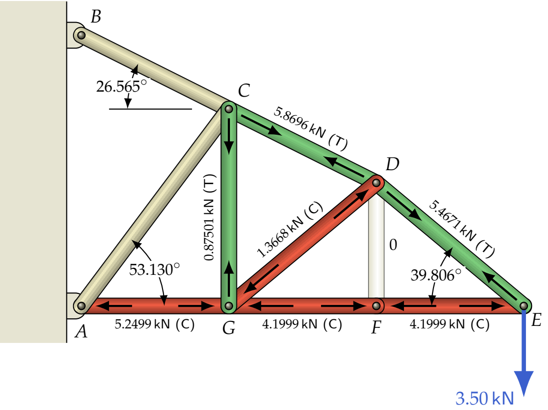


Joint G

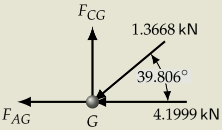


$$\sum F_y = F_{CG} - 1.3668 \sin 39.806^\circ \text{ kN}$$
$$= 0$$
$$\Rightarrow F_{CG} = 0.87501 \text{ kN}$$

$$\sum F_x = -4.1999 \text{ kN}$$
$$- 1.3668 \cos 39.806^\circ \text{ kN} - F_{AG}$$
$$= 0$$
$$\Rightarrow F_{AG} = -5.2499 \text{ kN}$$



Joint G

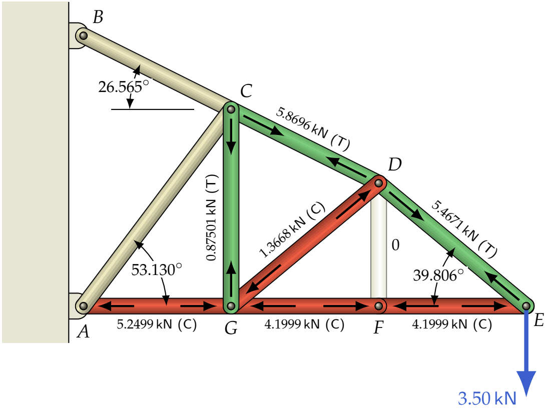


$$\sum F_y = F_{CG} - 1.3668 \sin 39.806^\circ \text{ kN} = 0$$

$$\Rightarrow F_{CG} = 0.87501 \text{ kN}$$

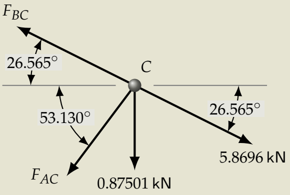
$$\sum F_x = -4.1999 \text{ kN} - 1.3668 \cos 39.806^\circ \text{ kN} - F_{AG} = 0$$

$$\Rightarrow F_{AG} = -5.2499 \text{ kN}$$

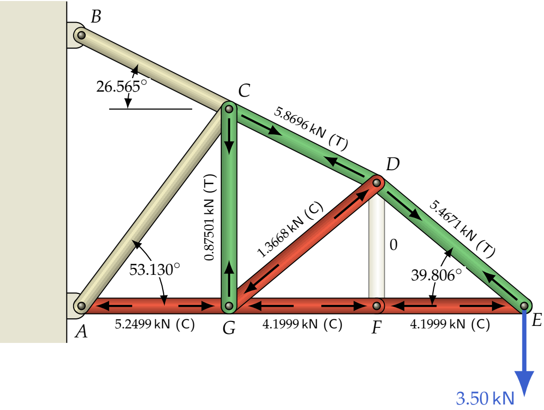


B
26.565°
C
5.8696 kN (T)
D
0.87501 kN (T)
1.3668 kN (C)
5.4671 kN (T)
0
53.130°
39.806°
A
5.2499 kN (C)
G
4.1999 kN (C)
F
4.1999 kN (C)
E
3.50 kN

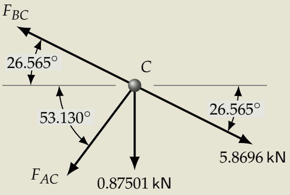
Joint C



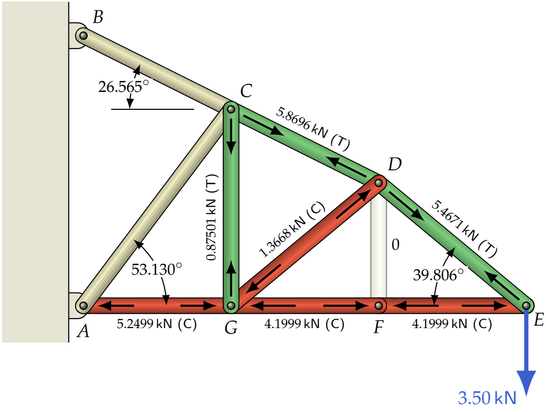
F_{BC}
26.565°
C
53.130°
26.565°
5.8696 kN
F_{AC}
0.87501 kN



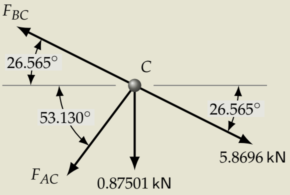
Joint C



$$\begin{aligned}\sum F_x &= 5.8696 \cos 26.565^\circ \text{ kN} \\ &\quad - F_{BC} \cos 26.565^\circ \\ &\quad - F_{AC} \cos 53.130^\circ \\ &= 0\end{aligned}$$

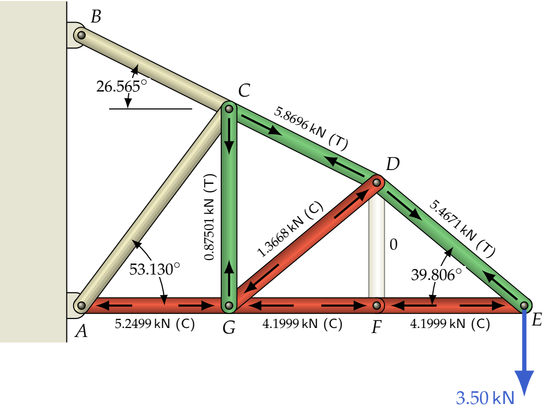


Joint C

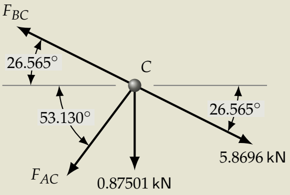


$$
\begin{aligned}
\sum F_x &= 5.8696 \cos 26.565^\circ \text{ kN} \\
&\quad - F_{BC} \cos 26.565^\circ \\
&\quad - F_{AC} \cos 53.130^\circ \\
&= 0
\end{aligned}
$$

$$
\begin{aligned}
\sum F_y &= F_{BC} \sin 26.565^\circ \\
&\quad - F_{AC} \sin 53.130^\circ \\
&\quad - 5.8696 \sin 26.565^\circ \text{ kN} \\
&\quad - 0.87501 \text{ kN} \\
&= 0
\end{aligned}
$$



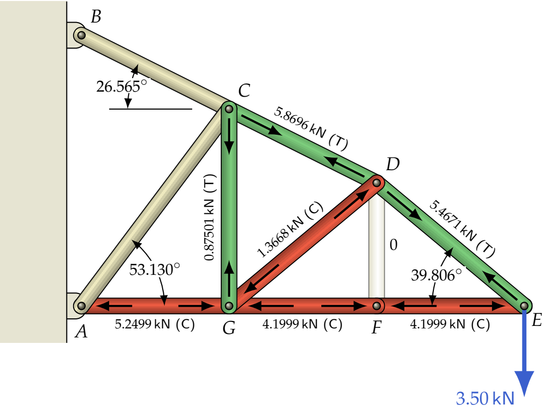
Joint C



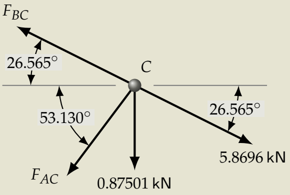
$$\sum F_x = 5.8696 \cos 26.565^\circ \text{ kN} - F_{BC} \cos 26.565^\circ - F_{AC} \cos 53.130^\circ = 0$$

$$\sum F_y = F_{BC} \sin 26.565^\circ - F_{AC} \sin 53.130^\circ - 5.8696 \sin 26.565^\circ \text{ kN} - 0.87501 \text{ kN} = 0$$

Now, use the **system-solver** on your calculator to solve these two equations for F_{AC} and F_{BC}.



Joint C

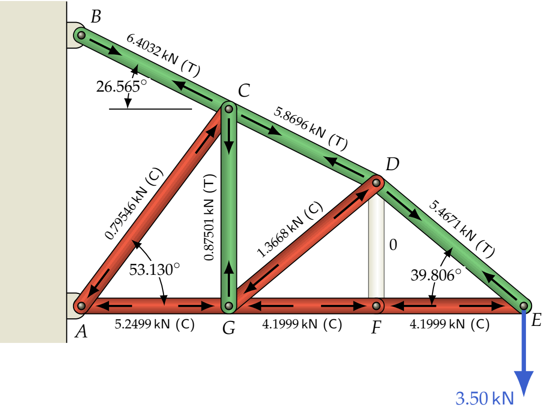


$$\sum F_x = 5.8696 \cos 26.565^\circ \text{ kN} - F_{BC} \cos 26.565^\circ - F_{AC} \cos 53.130^\circ = 0$$

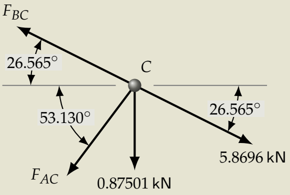
$$\sum F_y = F_{BC} \sin 26.565^\circ - F_{AC} \sin 53.130^\circ - 5.8696 \sin 26.565^\circ \text{ kN} - 0.87501 \text{ kN} = 0$$

Now, use the **system-solver** on your calculator to solve these two equations for F_{AC} and F_{BC}.

$F_{AC} = -0.79546$ kN, $F_{BC} = 6.4032$ kN



Joint C

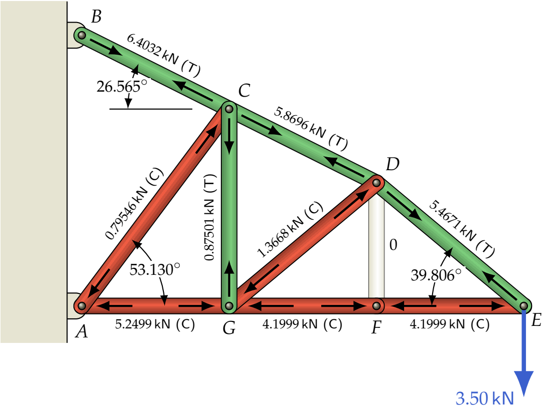


$$
\begin{aligned}
\sum F_x &= 5.8696 \cos 26.565^\circ \text{ kN} \\
&\quad - F_{BC} \cos 26.565^\circ \\
&\quad - F_{AC} \cos 53.130^\circ \\
&= 0
\end{aligned}
$$

$$
\begin{aligned}
\sum F_y &= F_{BC} \sin 26.565^\circ \\
&\quad - F_{AC} \sin 53.130^\circ \\
&\quad - 5.8696 \sin 26.565^\circ \text{ kN} \\
&\quad - 0.87501 \text{ kN} \\
&= 0
\end{aligned}
$$

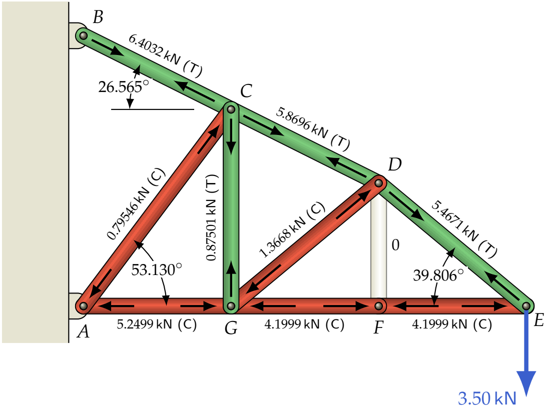
Now, use the **system-solver** on your calculator to solve these two equations for F_{AC} and F_{BC}.

$F_{AC} = -0.79546$ kN, $F_{BC} = 6.4032$ kN



Finished . . . almost

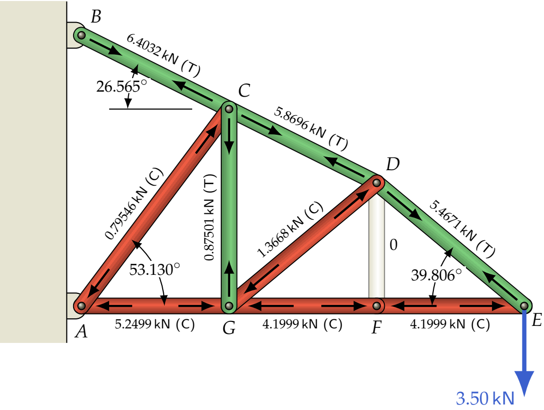
Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:



Finished . . . almost

Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

$$AB = 0.795 \text{ kN (Compression)}$$
$$AG = 5.25 \text{ kN (Compression)}$$
$$BC = 6.40 \text{ kN (Tension)}$$
$$CD = 5.87 \text{ kN (Tension)}$$
$$CG = 0.875 \text{ kN (Tension)}$$
$$DE = 5.47 \text{ kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37 \text{ kN (Compression)}$$
$$EF = 4.20 \text{ kN (Compression)}$$
$$FG = 4.20 \text{ kN (Compression)}$$



Finished . . . almost

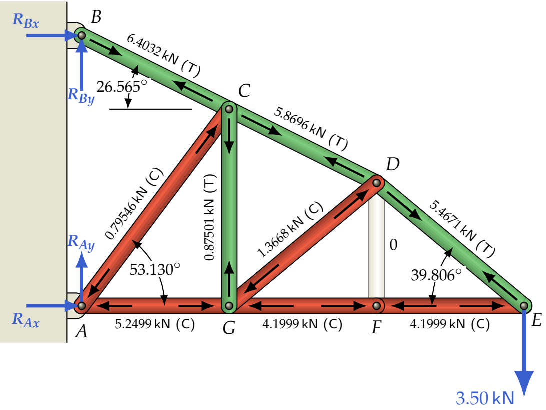
Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

$$AB = 0.795 \text{ kN (Compression)}$$
$$AG = 5.25 \text{ kN (Compression)}$$
$$BC = 6.40 \text{ kN (Tension)}$$
$$CD = 5.87 \text{ kN (Tension)}$$
$$CG = 0.875 \text{ kN (Tension)}$$
$$DE = 5.47 \text{ kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37 \text{ kN (Compression)}$$
$$EF = 4.20 \text{ kN (Compression)}$$
$$FG = 4.20 \text{ kN (Compression)}$$

But are these correct?

We could easily have made an error in a truss member calculation, causing most or all subsequent results to be incorrect.

Let's do a check. We can calculate the reactions at A and B, then check that all external forces acting on the truss do actually sum to zero in the x and y directions.



Finished . . . almost

Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

$$AB = 0.795 \text{ kN (Compression)}$$
$$AG = 5.25 \text{ kN (Compression)}$$
$$BC = 6.40 \text{ kN (Tension)}$$
$$CD = 5.87 \text{ kN (Tension)}$$
$$CG = 0.875 \text{ kN (Tension)}$$
$$DE = 5.47 \text{ kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37 \text{ kN (Compression)}$$
$$EF = 4.20 \text{ kN (Compression)}$$
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But are these correct?

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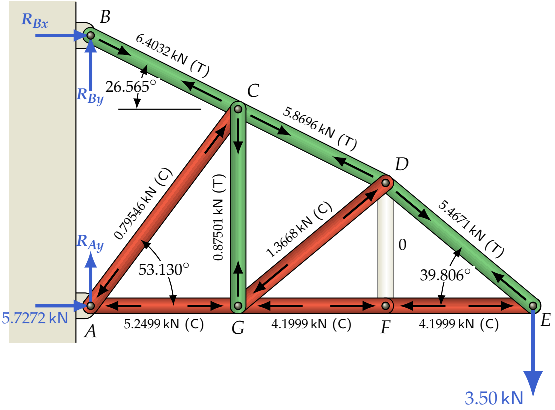
Let's do a check. We can calculate the reactions at A and B, then check that all external forces acting on the truss do actually sum to zero in the x and y directions.



Finished . . . almost

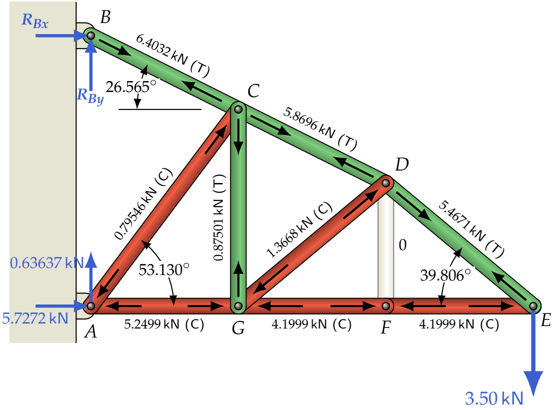
Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

$$AB = 0.795 \text{ kN (Compression)}$$
$$AG = 5.25 \text{ kN (Compression)}$$
$$BC = 6.40 \text{ kN (Tension)}$$
$$CD = 5.87 \text{ kN (Tension)}$$
$$CG = 0.875 \text{ kN (Tension)}$$
$$DE = 5.47 \text{ kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37 \text{ kN (Compression)}$$
$$EF = 4.20 \text{ kN (Compression)}$$
$$FG = 4.20 \text{ kN (Compression)}$$

Reaction at A

$$\sum F_x = R_{Ax} - 0.79546 \cos 53.130^\circ \text{ kN} - 5.2499 \text{ kN} = 0$$

$$\Rightarrow R_{Ax} = 5.7272 \text{ kN}$$



Finished . . . almost

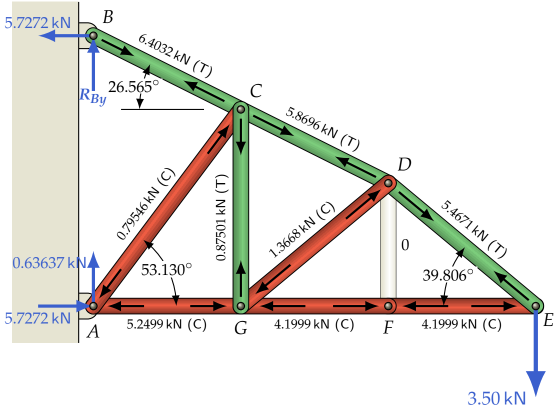
Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

$$AB = 0.795 \text{ kN (Compression)}$$
$$AG = 5.25 \text{ kN (Compression)}$$
$$BC = 6.40 \text{ kN (Tension)}$$
$$CD = 5.87 \text{ kN (Tension)}$$
$$CG = 0.875 \text{ kN (Tension)}$$
$$DE = 5.47 \text{ kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37 \text{ kN (Compression)}$$
$$EF = 4.20 \text{ kN (Compression)}$$
$$FG = 4.20 \text{ kN (Compression)}$$

Reaction at A

$$\sum F_x = R_{Ax} - 0.79546 \cos 53.130^\circ \text{ kN} - 5.2499 \text{ kN} = 0$$
$$\Rightarrow R_{Ax} = 5.7272 \text{ kN}$$

$$\sum F_y = R_{Ay} - 0.79546 \sin 53.130^\circ \text{ kN} = 0$$
$$\Rightarrow R_{Ay} = 0.63637 \text{ kN}$$



Finished . . . almost

Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

$$AB = 0.795 \text{ kN (Compression)}$$
$$AG = 5.25 \text{ kN (Compression)}$$
$$BC = 6.40 \text{ kN (Tension)}$$
$$CD = 5.87 \text{ kN (Tension)}$$
$$CG = 0.875 \text{ kN (Tension)}$$
$$DE = 5.47 \text{ kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37 \text{ kN (Compression)}$$
$$EF = 4.20 \text{ kN (Compression)}$$
$$FG = 4.20 \text{ kN (Compression)}$$

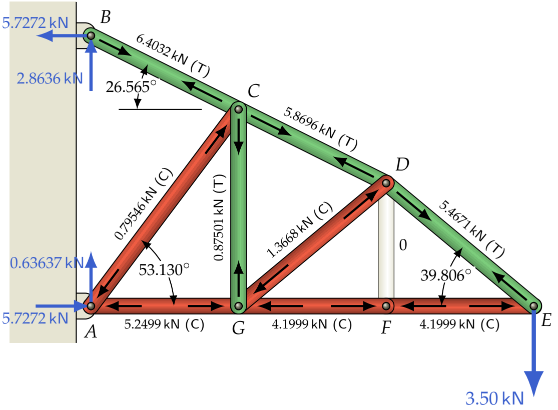
Reaction at *A*

$$\sum F_x = R_{Ax} - 0.79546 \cos 53.130° \text{ kN} - 5.2499 \text{ kN} = 0$$
$$\Rightarrow R_{Ax} = 5.7272 \text{ kN}$$

$$\sum F_y = R_{Ay} - 0.79546 \sin 53.130° \text{ kN} = 0$$
$$\Rightarrow R_{Ay} = 0.63637 \text{ kN}$$

Reaction at *B*

$$\sum F_x = R_{Bx} + 6.4032 \cos 26.565° \text{ kN} = 0$$
$$\Rightarrow R_{Bx} = -5.7272 \text{ kN}$$



Finished . . . almost

Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

$$
\begin{aligned}
AB &= 0.795 \text{ kN (Compression)}\\
AG &= 5.25 \text{ kN (Compression)}\\
BC &= 6.40 \text{ kN (Tension)}\\
CD &= 5.87 \text{ kN (Tension)}\\
CG &= 0.875 \text{ kN (Tension)}\\
DE &= 5.47 \text{ kN (Tension)}\\
DF &= 0\\
DG &= 1.37 \text{ kN (Compression)}\\
EF &= 4.20 \text{ kN (Compression)}\\
FG &= 4.20 \text{ kN (Compression)}
\end{aligned}
$$

Reaction at *A*

$$\sum F_x = R_{Ax} - 0.79546 \cos 53.130^\circ \text{ kN} - 5.2499 \text{ kN} = 0$$

$$\Rightarrow R_{Ax} = 5.7272 \text{ kN}$$

$$\sum F_y = R_{Ay} - 0.79546 \sin 53.130^\circ \text{ kN} = 0$$

$$\Rightarrow R_{Ay} = 0.63637 \text{ kN}$$

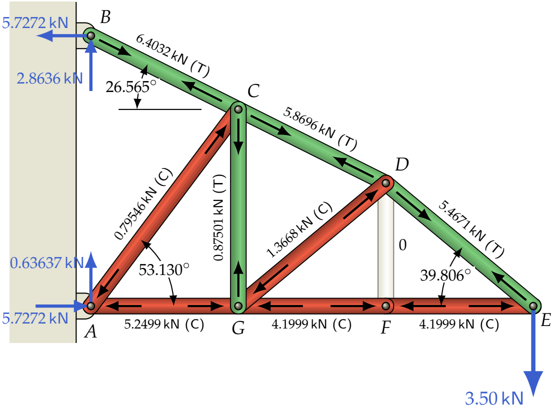
Reaction at *B*

$$\sum F_x = R_{Bx} + 6.4032 \cos 26.565^\circ \text{ kN} = 0$$

$$\Rightarrow R_{Bx} = -5.7272 \text{ kN}$$

$$\sum F_y = R_{By} - 6.4032 \sin 26.565 \text{ kN} = 0$$

$$\Rightarrow R_{By} = 2.8636 \text{ kN}$$



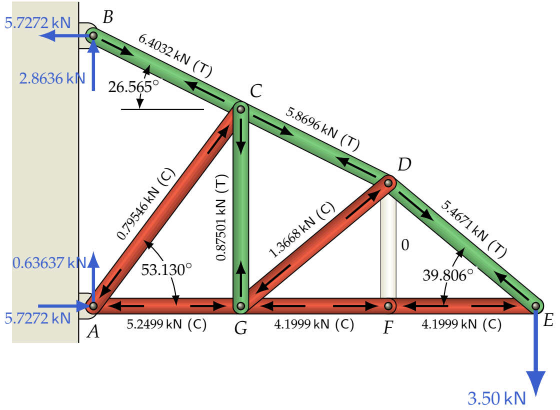
Finished . . . almost

Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

$$AB = 0.795 \text{ kN (Compression)}$$
$$AG = 5.25 \text{ kN (Compression)}$$
$$BC = 6.40 \text{ kN (Tension)}$$
$$CD = 5.87 \text{ kN (Tension)}$$
$$CG = 0.875 \text{ kN (Tension)}$$
$$DE = 5.47 \text{ kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37 \text{ kN (Compression)}$$
$$EF = 4.20 \text{ kN (Compression)}$$
$$FG = 4.20 \text{ kN (Compression)}$$

The final check!

$$\sum F_x = R_{Ax} + R_{Bx} = 5.7272\text{ kN} - 5.7272\text{ kN} = 0 \quad \checkmark$$



Finished . . . almost

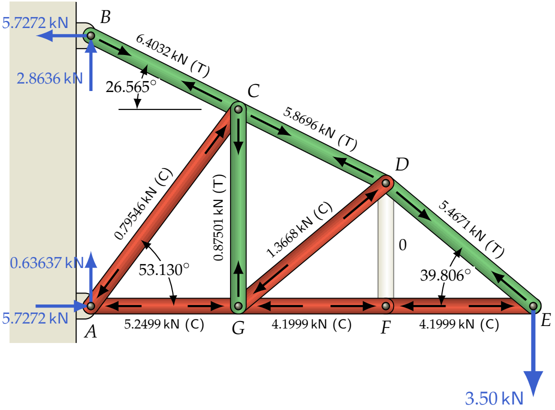
Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

$$AB = 0.795\ \text{kN (Compression)}$$
$$AG = 5.25\ \text{kN (Compression)}$$
$$BC = 6.40\ \text{kN (Tension)}$$
$$CD = 5.87\ \text{kN (Tension)}$$
$$CG = 0.875\ \text{kN (Tension)}$$
$$DE = 5.47\ \text{kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37\ \text{kN (Compression)}$$
$$EF = 4.20\ \text{kN (Compression)}$$
$$FG = 4.20\ \text{kN (Compression)}$$

The final check!

$$\sum F_x = R_{Ax} + R_{Bx} = 5.7272\ \text{kN} - 5.7272\ \text{kN} = 0 \quad \checkmark$$

$$\sum F_y = R_{Ay} + R_{By} - 3.50\ \text{kN} = 0.63637\ \text{kN} - 2.8636\ \text{kN} - 3.50\ \text{kN} = -0.00003\ \text{kN} \quad \checkmark$$



Finished . . . almost

Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

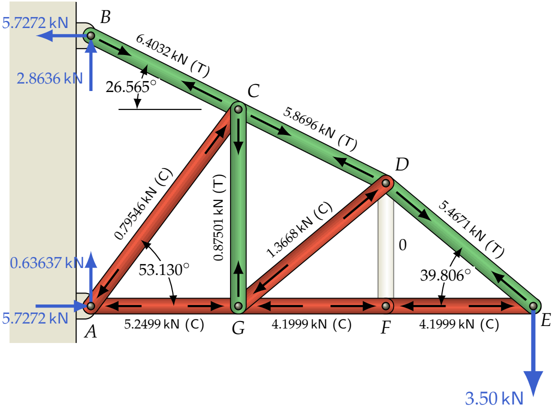
$$AB = 0.795 \text{ kN (Compression)}$$
$$AG = 5.25 \text{ kN (Compression)}$$
$$BC = 6.40 \text{ kN (Tension)}$$
$$CD = 5.87 \text{ kN (Tension)}$$
$$CG = 0.875 \text{ kN (Tension)}$$
$$DE = 5.47 \text{ kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37 \text{ kN (Compression)}$$
$$EF = 4.20 \text{ kN (Compression)}$$
$$FG = 4.20 \text{ kN (Compression)}$$

The final check!

$$\sum F_x = R_{Ax} + R_{Bx} = 5.7272 \text{ kN} - 5.7272 \text{ kN} = 0 \quad \checkmark$$

$$\sum F_y = R_{Ay} + R_{By} - 3.50 \text{ kN} = 0.63637 \text{ kN} - 2.8636 \text{ kN} - 3.50 \text{ kN} = -0.00003 \text{ kN} \quad \checkmark$$

Note: We could also check by taking moments about C or D. (Taking moments about E, F, G or A would not pick up any errors in R_{Ax}. Moments about A or B would not pick up errors in R_{By} or R_{Ay}.)



Finished . . . almost

Inputs (lengths and the load at E) were accurate to 3 significant digits so our results can be no more accurate than this:

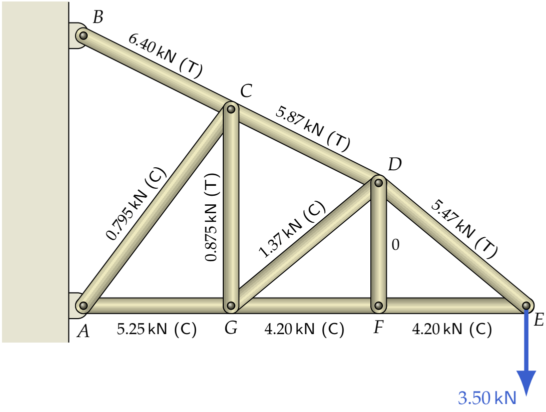
$$AB = 0.795 \text{ kN (Compression)}$$
$$AG = 5.25 \text{ kN (Compression)}$$
$$BC = 6.40 \text{ kN (Tension)}$$
$$CD = 5.87 \text{ kN (Tension)}$$
$$CG = 0.875 \text{ kN (Tension)}$$
$$DE = 5.47 \text{ kN (Tension)}$$
$$DF = 0$$
$$DG = 1.37 \text{ kN (Compression)}$$
$$EF = 4.20 \text{ kN (Compression)}$$
$$FG = 4.20 \text{ kN (Compression)}$$

The final check!

$$\sum F_x = R_{Ax} + R_{Bx} = 5.7272 \text{ kN} - 5.7272 \text{ kN} = 0 \quad \checkmark$$

$$\sum F_y = R_{Ay} + R_{By} - 3.50 \text{ kN} = 0.63637 \text{ kN} - 2.8636 \text{ kN} - 3.50 \text{ kN} = -0.00003 \text{ kN} \quad \checkmark$$

Note: We could also check by taking moments about C or D. (Taking moments about E, F, G or A would not pick up any errors in R_{Ax}. Moments about A or B would not pick up errors in R_{By} or R_{Ay}.)



The Results

$AB = 0.795$ kN (Compression)

$AG = 5.25$ kN (Compression)

$BC = 6.40$ kN (Tension)

$CD = 5.87$ kN (Tension)

$CG = 0.875$ kN (Tension)

$DE = 5.47$ kN (Tension)

$DF = 0$

$DG = 1.37$ kN (Compression)

$EF = 4.20$ kN (Compression)

$FG = 4.20$ kN (Compression)