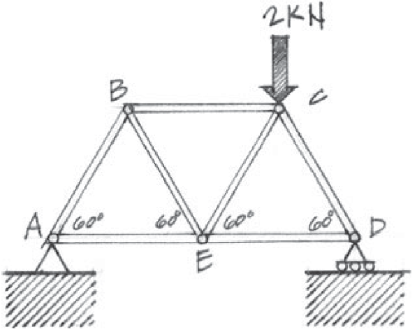
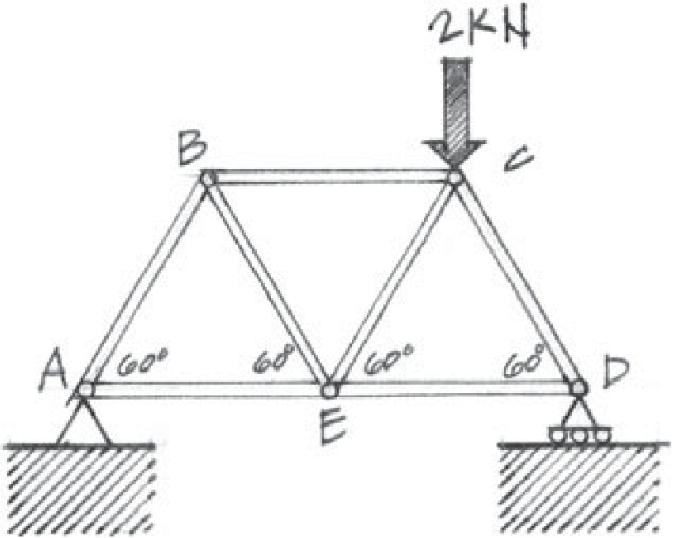
Physics 8 — Monday, November 11, 2019

- Last week, you skimmed Ch4 (load tracing) and read Ch5 (strength of materials) of Onouye/Kane. This week, you're reading Ch6 (cross-sectional properties) and Ch7 (simple beams).

How many "reaction forces" (or components thereof) are exerted by the supports (i.e. exerted on the truss by the supports)?

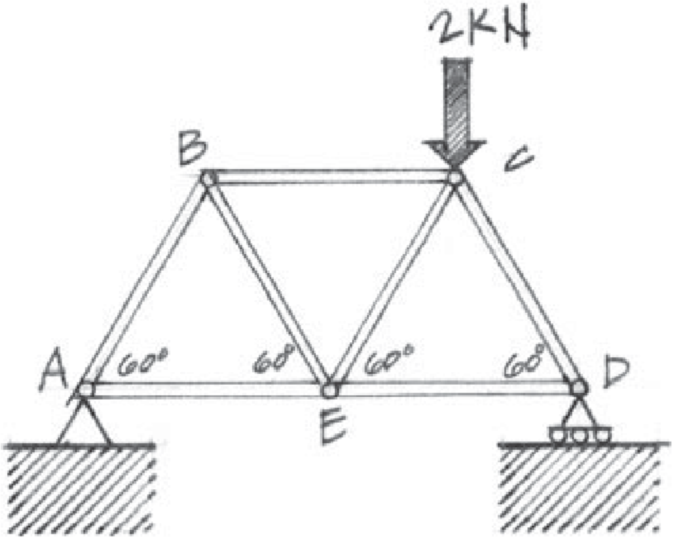


(A) 1 (B) 2 (C) 3 (D) 4 (E) 5 (F) 6 (G) 7 (H) 8



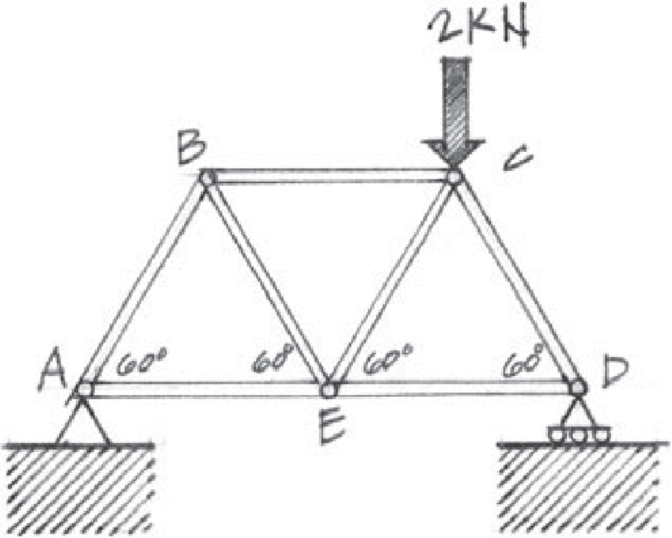
How many "reaction forces" are exerted by the supports (i.e. exerted on the truss by the supports)?

(A) 1 (B) 2 (C) 3 (D) 4 (E) 5 (F) 6 (G) 7 (H) 8

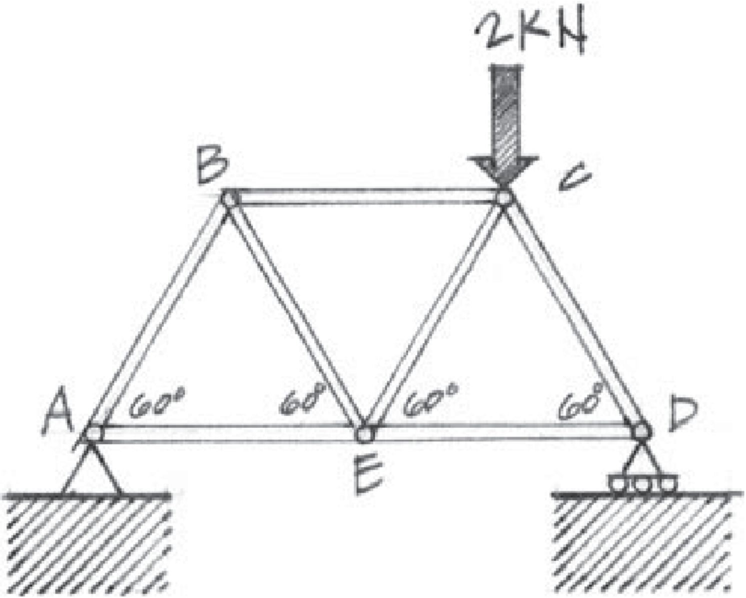


How many internal forces (tensions or compressions in the members) do we need to solve for to “solve” this truss?

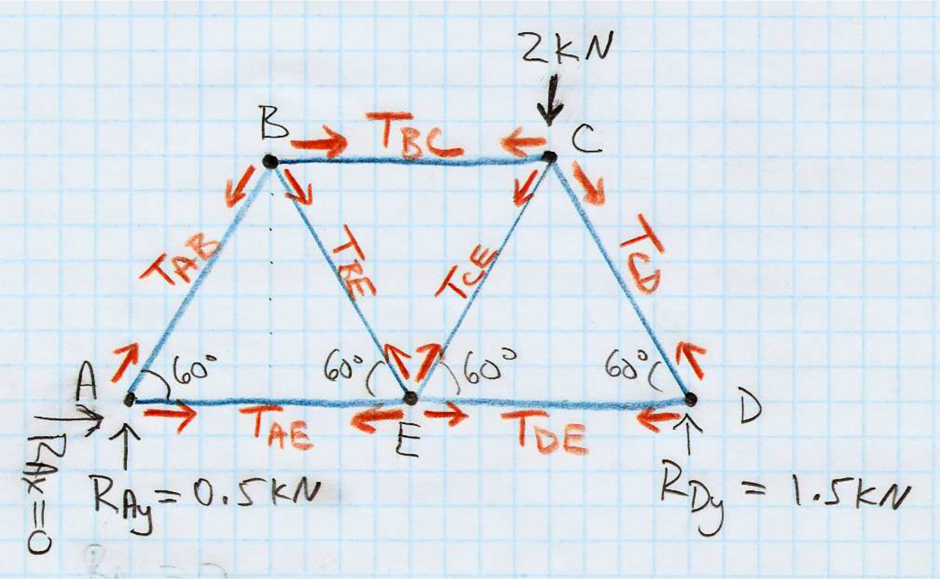
(A) 1 (B) 2 (C) 3 (D) 4 (E) 5 (F) 6 (G) 7 (H) 8



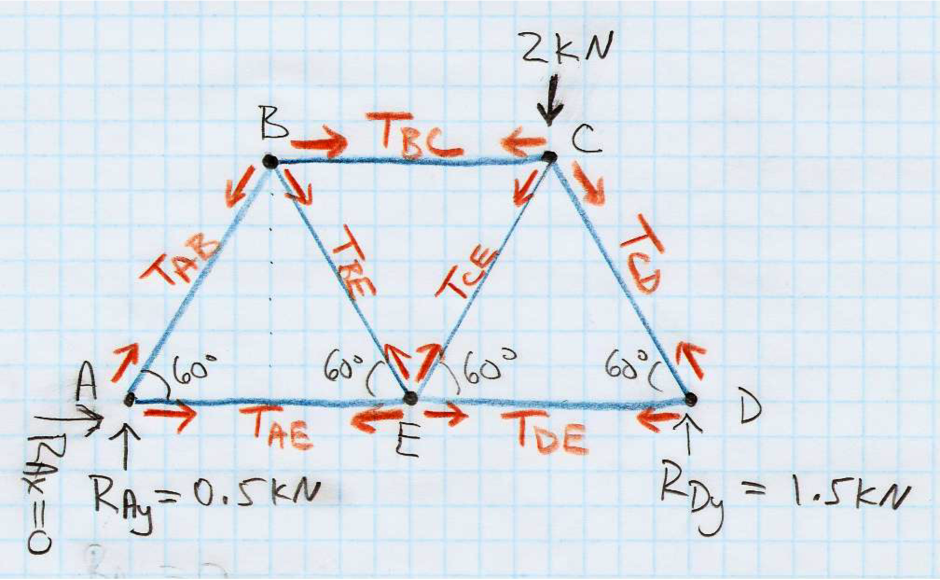
Do you see any joint at which there are ≤ 2 unknown forces (in this context, total, internal+external)? If so, we can start there. If not, we need to start with an EFBD for the truss as a whole.



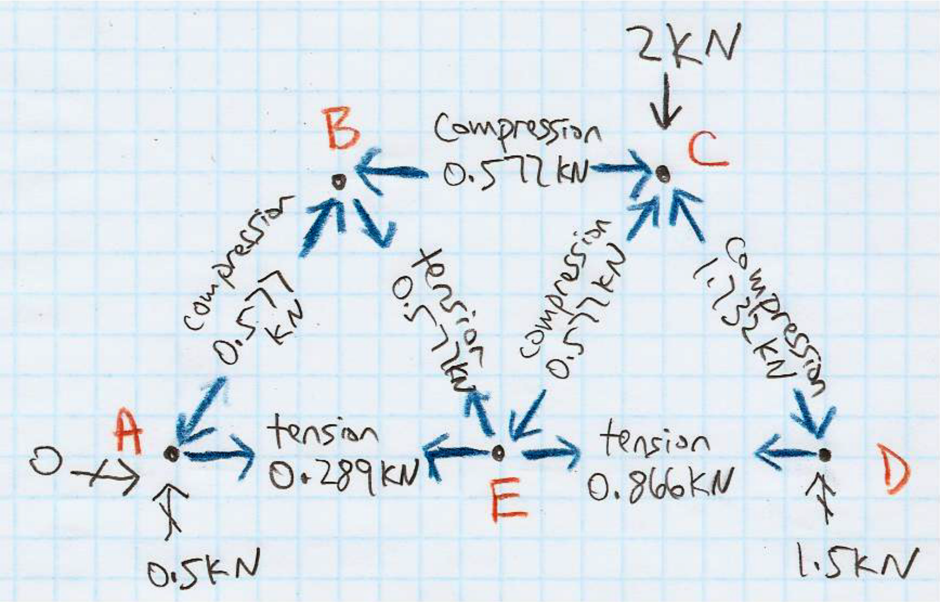
Try to guess $R_{A,x}$, $R_{A,y}$, and $R_{D,y}$ by inspection. Then let's check with the usual equations.



Now start from a joint having ≤ 2 unknown forces. In this case, I just went through the joints alphabetically. You can make your life easier by seeking out equations having just 1 unknown.



$T_{AB} = -0.577$ kN, $T_{AE} = +0.289$ kN, $T_{BE} = +0.577$ kN,
$T_{BC} = -0.577$ kN, $T_{CE} = -0.577$ kN, $T_{CD} = -1.732$ kN,
$T_{DE} = +0.866$ kN. My notation: tension > 0, compression < 0.


2KN
B
C
A
E
D
Compression
0.577 kN
compression
0.577 kN
tension
0.577 kN
compression
0.577 kN
compression
1.732 kN
tension
0.289 kN
tension
0.866 kN
0
0.5 kN
1.5 kN

$\cos 60^\circ = 0.5, \quad \sin 60^\circ = 0.866$

Joint A: $0 + T_{AE} + T_{AB}\cos 60^\circ = 0$

$0.5\,\text{kN} + T_{AB}\sin 60^\circ = 0 \Rightarrow \boxed{T_{AB} = -0.577\,\text{kN}}$

$\boxed{T_{AE} = +0.289\,\text{kN}}$

Joint B: $-T_{AB}\cos 60^\circ + T_{BE}\cos 60^\circ + T_{BC} = 0$

$-T_{AB}\sin 60^\circ - T_{BE}\sin 60^\circ = 0 \Rightarrow \boxed{T_{BE} = +0.577\,\text{kN}}$

$\boxed{T_{BC} = -0.577\,\text{kN}}$

Joint C: $-T_{BC} - T_{CE}\cos 60^\circ + T_{CD}\cos 60^\circ = 0 \Rightarrow T_{CD} = T_{CE} - 1.155\,\text{kN}$

(could do C, D, or E at this point)

$-2\,\text{kN} - T_{CE}\sin 60^\circ - T_{CD}\sin 60^\circ = 0$

$-2\,\text{kN} - T_{CE}\sin 60^\circ - (T_{CE} - 1.155\,\text{kN})\sin 60^\circ = 0$

$2T_{CE}\sin 60^\circ = -2\,\text{kN} + 1.0\,\text{kN} = -1\,\text{kN}$

$\boxed{T_{CE} = -0.577\,\text{kN}}$

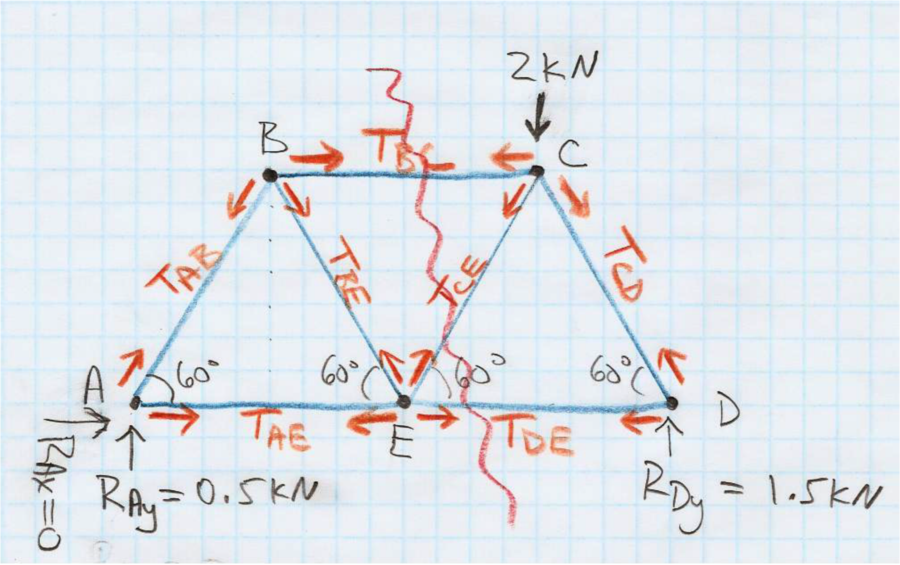
$T_{CD} = T_{CE} - 1.155\,\text{kN} = \boxed{-1.732\,\text{kN} = T_{CD}}$

Joint D: $-T_{DE} - T_{CD}\cos 60^\circ = 0 \Rightarrow \boxed{T_{DE} = +0.866\,\text{kN}}$

(check): $1.5\,\text{kN} + T_{CD}\sin 60^\circ = 0$ ✓

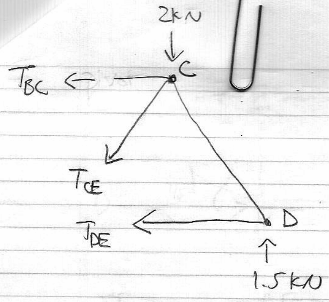
(check Joint E): $-T_{AE} + T_{DE} - T_{BE}\cos 60^\circ + T_{CE}\cos 60^\circ = 0$ ✓

$+T_{BE}\sin 60^\circ + T_{CE}\sin 60^\circ = 0$ ✓



Let's try drawing an EFBD for the **right** side of the cut ("section").

(We'll start next time with the Method of Sections for this truss.)



$$\sum F_x = 0 \Rightarrow -T_{BC} - T_{CE}\cos 60^\circ - T_{DE} = 0$$

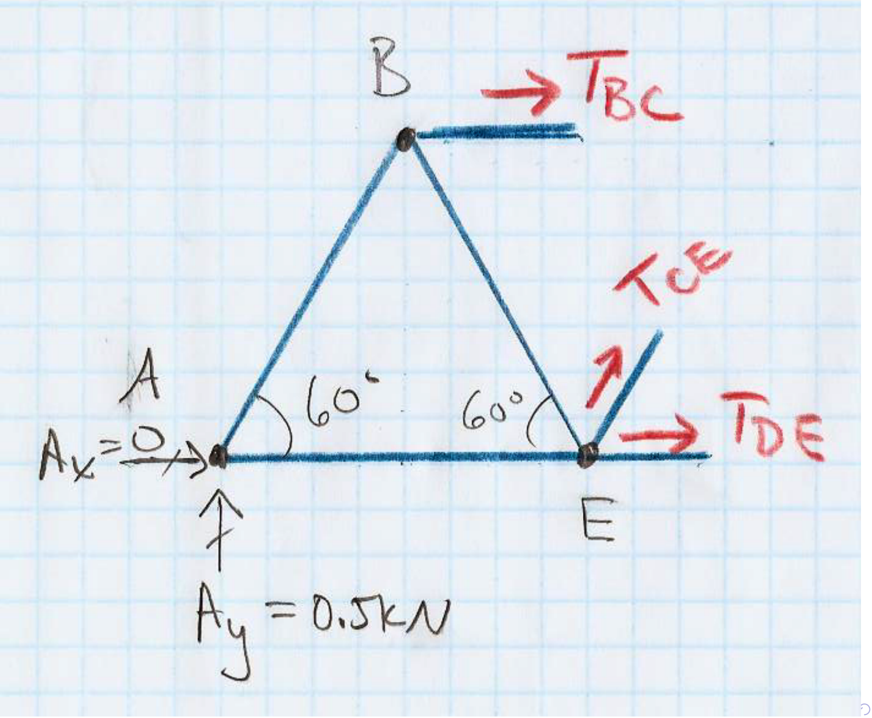
$$\sum F_y = 0 \Rightarrow -2kN + 1.5kN - T_{CE}\sin 60^\circ = 0$$

$$\sum M_c = 0 \Rightarrow +(1.5kN)\left(\frac{L}{2}\right) - T_{DE}\, L\sin 60^\circ = 0$$

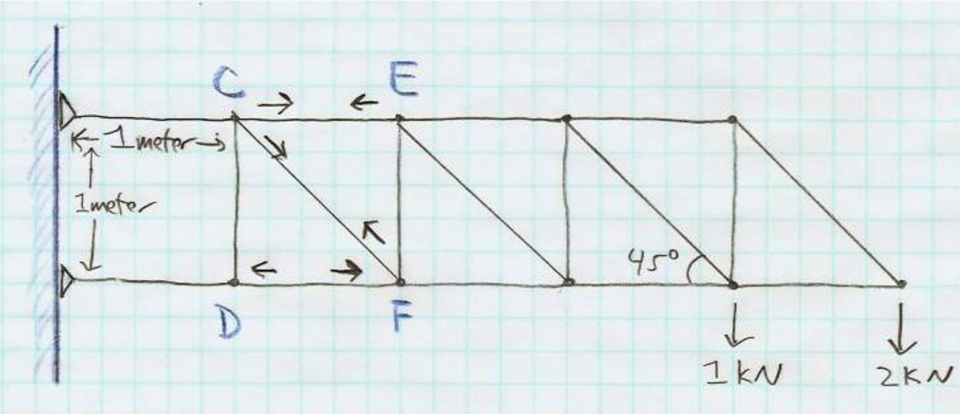
$$T_{DE} = \frac{1.5kN}{2\sin 60^\circ} = +0.866kN$$

$$T_{CE} = \frac{-0.5kN}{\sin 60^\circ} = -0.577kN$$

$$T_{BC} = -(T_{CE}\cos 60^\circ + T_{DE}) = -0.577$$

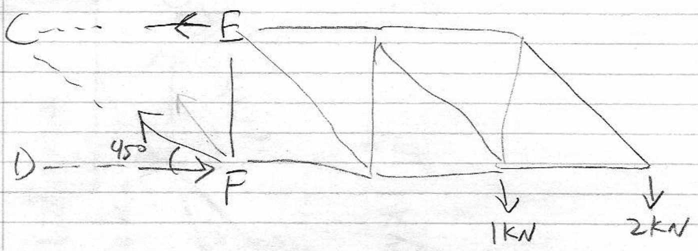


B
T_{BC}
T_{CE}
A
60°
60°
T_{DE}
$A_x = 0$
E
$A_y = 0.5kN$



Here's another truss problem that you can solve using the Method of Sections. Find forces in members **CE**, **CF**, and **DF**, with assumed force directions as shown.

- What happens if an assumed force direction is backwards?
- Where should we "section" the truss?
- Then what do we do next?



$\sum F_x = 0 = -CE - CF\cos 45^\circ + DF = 0$

$\sum F_y = 0 = CF\sin 45^\circ = 3kN \Rightarrow \boxed{CF = 3kN\sqrt{2}}$

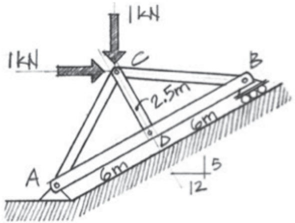
$\sum M_{DF} = 0 = CE(1) - (1kN)(2) - (2kN)(3)$

$\Rightarrow \boxed{CE = 8kN}$

$DF = CE + CF\cos 45^\circ = 8kN + 3kN$

$\boxed{DF = 11kN}$

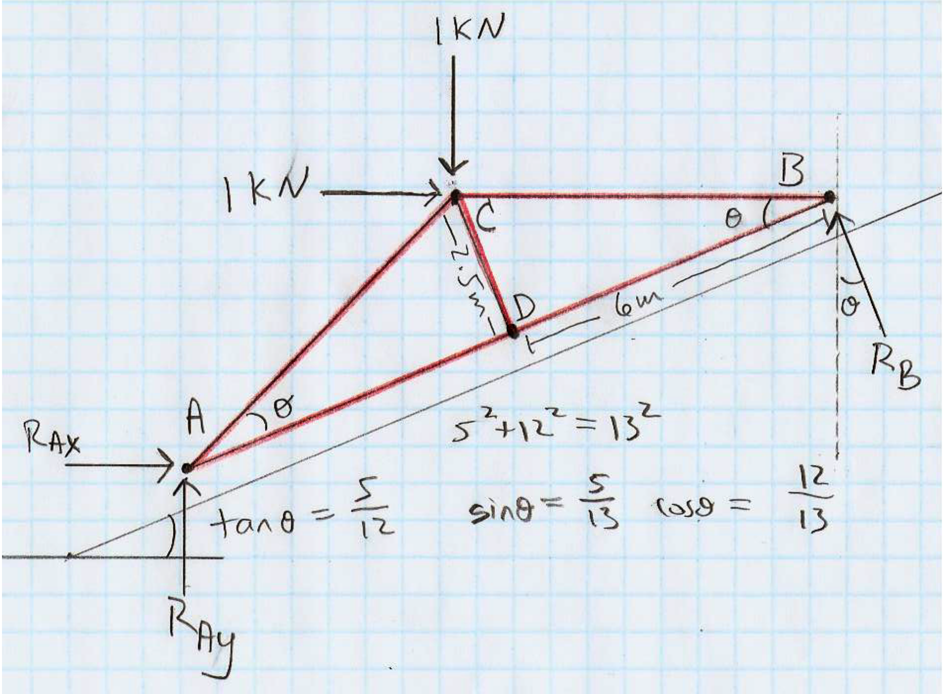
2.38 An inclined king-post truss supports a vertical and horizontal force at *C*. Determine the support reactions developed at *A* and *B*.



This is not really a "truss problem," since we're not asked to solve for the internal forces in the truss, but it is an example of a pretty tricky equilibrium problem.

Let's try working through this together in class. (I think it's deviously tricky!)

Notice, from the given dimensions: the angle of the incline is the same as the interior angle at joints A and B of the truss. Also notice pin/hinge support at A and roller support at B.


1KN
1KN
B
C
θ
2.5m
D
6m
θ
R_B
A
θ
R_Ax
$5^2+12^2=13^2$
$\tan\theta = \frac{5}{12}$
$\sin\theta = \frac{5}{13}$
$\cos\theta = \frac{12}{13}$
R_Ay

① $0 = \sum_{\text{on truss}} F_x = R_{Ax} + 1\,kN - R_B \sin\theta$

$$\Rightarrow R_{Ax} = R_B \sin\theta - 1\,kN$$

② $0 = \sum_{\text{on truss}} F_y = R_{Ay} - 1\,kN + R_B \cos\theta$

$$\Rightarrow R_{Ay} = 1\,kN - R_B \cos\theta$$

③ $0 = \sum_{\circlearrowleft} M_A = R_B (12m) - 1\,kN (12m \sin\theta) - 1\,kN (6.5m \cos 2\theta)$

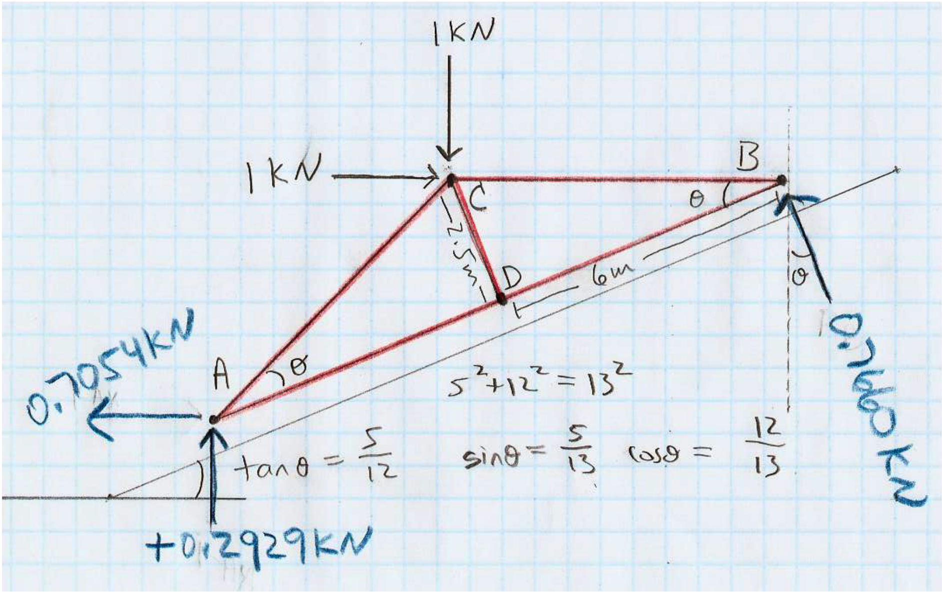
$$\Rightarrow R_B = 1\,kN (\sin\theta) + \frac{6.5}{12}\,kN (\cos 2\theta) = 0.7660\,kN$$

$$(R_B)_x = -R_B \sin\theta = -0.2946\,kN$$

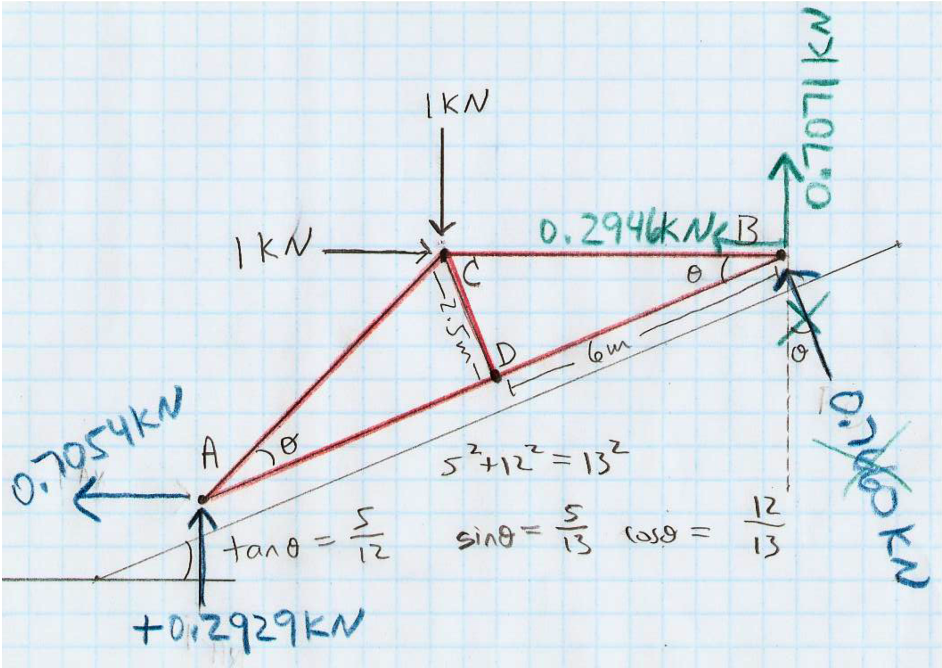
$$(R_B)_y = R_B \cos\theta = 0.7071\,kN$$

$$R_{Ax} = (0.2946 - 1)\,kN = -0.7054\,kN$$

$$R_{Ay} = (1 - 0.7071)\,kN = 0.2929\,kN$$

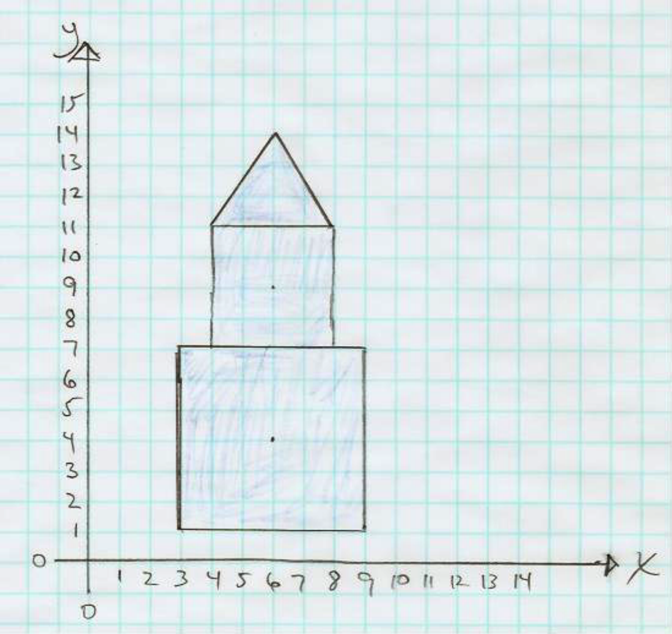


1KN
1KN
B
C
θ
2.5m
D
6m
θ
0.7054KN
A
θ
$5^2+12^2=13^2$
0.7660KN
$\tan\theta = \frac{5}{12}$
$\sin\theta = \frac{5}{13}$
$\cos\theta = \frac{12}{13}$
+0.2929KN


1KN
1KN
0.2946kN
B
0.7071kN
C
θ
2.5m
D
6m
θ
0.7054kN
A
θ
$5^2+12^2=13^2$
$\tan\theta = \frac{5}{12}$
$\sin\theta = \frac{5}{13}$
$\cos\theta = \frac{12}{13}$
+0.2929kN
0.7660 kN

- The idea of computing centroids of simple and composite shapes is very, very briefly introduced in O/K ch3 (in the context of "distributed loads"), and is discussed in much more detail in O/K ch6 (you read this week, for Monday).
- Let's go through one example using rectangles and triangles. It will help you in cases when you need to solve for the "reaction forces" on a beam that carries distributed loads. (Example coming up next.)

What is X_{centroid} for the shaded area?



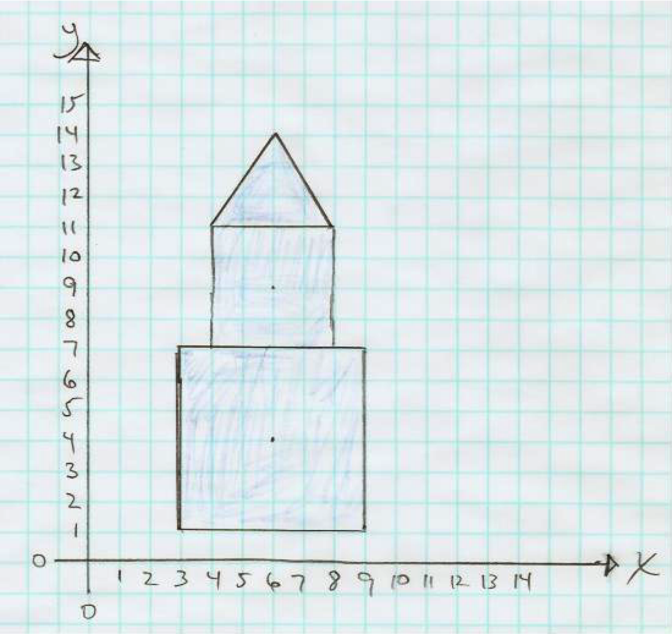
(A) 0

(B) 3

(C) 6

(D) 9

What are the areas of the three individual polygons?



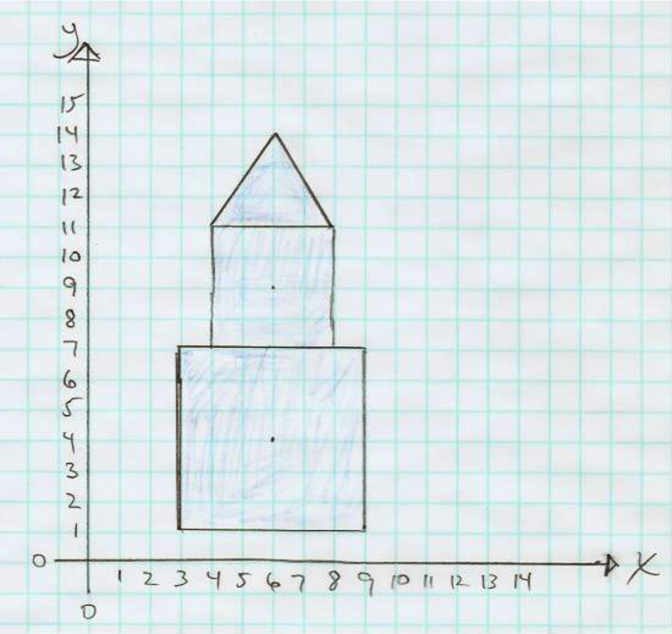
(A) 36, 16, 16

(B) 36, 16, 12

(C) 36, 16, 8

(D) 36, 16, 6

What are the Y_{centroid} values of the three individual polygons?



(A) 4, 9, 11

(B) 4, 9, 11.667

(C) 4, 9, 12

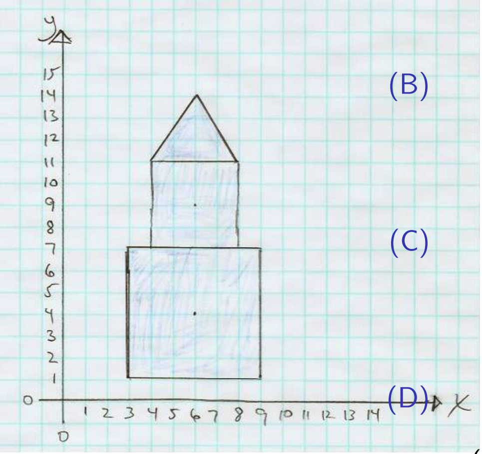
(D) 4, 9, 12.333

(E) 4, 9, 12.5

(F) 4, 9, 13

(G) 4, 9, 14

What is Y_{centroid} for the whole shaded area?



(A)

$$\frac{4+9+12}{3} = 8.33$$

(B)

$$\frac{(4)(36)+(9)(16)+(12)(6)}{36+16+6} = 6.21$$

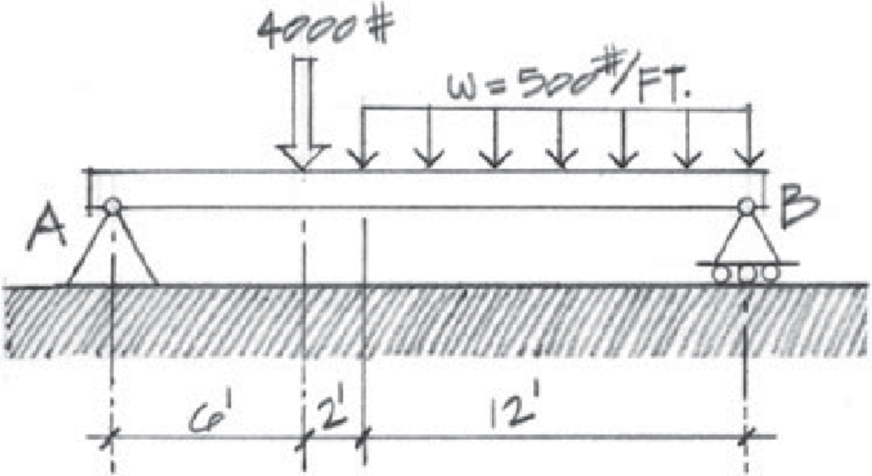
(C)

$$\frac{(4)(36)+(9)(16)+(12)(6)}{4+9+12} = 14.4$$

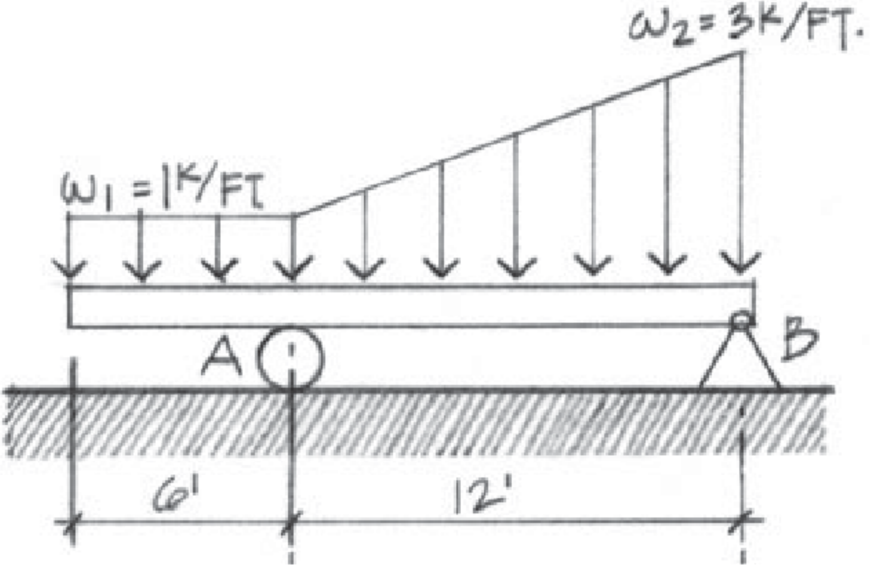
(D)

$$\frac{(4^2)(36)+(9^2)(16)+(12^2)(6)}{36+16+6} = 47.2$$

There's one problem similar to this (but using metric units) on HW(?): Determine the support reactions at A and B.



This one is harder than your homework, because the distributed load is non-uniform: Determine the support reactions at A and B.



Physics 8 — Monday, November 11, 2019

- Last week, you skimmed Ch4 (load tracing) and read Ch5 (strength of materials) of Onouye/Kane. This week, you're reading Ch6 (cross-sectional properties) and Ch7 (simple beams).