Balance of Forces in Equilibrium

Compute the forces in pulleys, ropes, beam, and frame members that require multiple free-body diagrams.

Compute the reactions for compound beams, frames, or similar devices.

Show why it is advantageous to: Separate elements at pins and draw multiple FBDs & identify 2-force members.
QUICK PROBLEM SOLVING

Given: A frame and loads as shown.
Find: The reactions that the pins exert on the frame at A, B, and C.

Plan:
a) Draw a FBD of members AB and BC.
b) Apply the equations of equilibrium to each FBD to solve for the six unknowns.

QUICK PROBLEM SOLVING (continued)

FBDs of members AB and BC:

Summing moments about A and C on each member, we get:
\[ \sum M_A = B_x (0.4) + B_y (0.4) - 1000 (0.2) = 0 \]
\[ \sum M_C = -B_x (0.4) + B_y (0.6) + 500 (0.4) = 0 \]
\[ B_y = 0 \quad \text{and} \quad B_x = 500 \text{ N} \]

WORKING EXAMPLE

Given: The wall crane supports an external load of 700 lb.
Find: The force in the cable at the winch motor W and the horizontal and vertical components of the pin reactions at A, B, C, and D.

Plan:
a) Draw FBDs of the frame's members and pulleys.
b) Apply the equations of equilibrium and solve for the unknowns.
EXAMPLE (continued)

FBD of the Pulley E:

\[ + \sum F_y = 2T - 700\ lb = 0 \]

\[ T = 350\ lb \]

Equations of Equilibrium:

\[ \sum F_x = C_x - 350 = 0 \]

\[ C_x = 350\ lb \]

\[ \sum F_y = C_y - 350 = 0 \]

\[ C_y = 350\ lb \]

\[ \sum F_x = -B_x + 350 - 350\sin 30\degree = 0 \]

\[ B_x = 175\ lb \]

\[ \sum F_y = B_y - 350\cos 30\degree = 0 \]

\[ B_y = 303.1\ lb \]

Note that member BD is a two-force member.

\[ \sum M_A = TBD\sin 45\degree (4\ ft) - 303.1\ (4\ ft) - 700\ (8\ ft) = 0 \]

\[ TBD = 2409\ lb \]

\[ + \sum F_y = A_y + 2409\sin 45\degree - 303.1 - 700 = 0 \]

\[ A_y = -700\ lb \]

\[ + \sum F_x = A_x - 2409\cos 45\degree + 175 - 350 = 0 \]

\[ A_x = 1880\ lb \]

Why are trusses like donuts?

Donuts are not good in compression either.

After the 5th one you feel kinda sick.

Both = fun!

You can’t drive to school without them.

If they fall to the ground they are not any good anymore.

Analysis of Machines
Pliers, Cutters, and Grips

Find vertical clamping force at E

APPLICATIONS

Frames are commonly used to support external loads.

How is a frame different than a truss?

How can you determine the forces at the joints and supports of a frame?

Find all reaction forces and forces at pinned connections in press
Animation of Bridge Deflection

(Graph of Maximum Deflection)

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