

Equilibrium of Structures

By the end of this lesson, you should be able to:

- Calculate the reaction forces of internal members of any structure



Outline

- Method
- Examples

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Frames and Machines

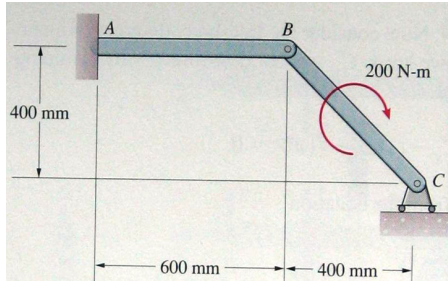
Isolate individual members (cut through joints)

- 1) Analyze entire structure
- 2) Analyze members
 - Reaction forces of different members must be equal and opposite

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Example

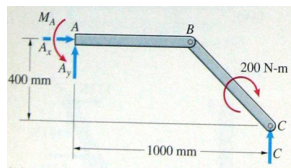
The frame is subjected to a 200 N-m couple. Determine the forces and couples on its members



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Solution

- 1) Determine Reactions for entire structure:



$$\sum F_x = A_x = 0$$

$$\sum F_y = A_y + C = 0$$

$$\sum M_{(point A)} = M_A - 200 + (1m)C = 0$$

Can't find A_y , M_A , or C – too many unknown variables

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Solution (continued)

- 2) Analyze members

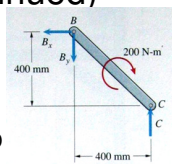
- a) Member BC:

$$\sum F_x = -B_x = 0$$

$$\sum F_y = -B_y + C = 0$$

$$\sum M_{(point B)} = -200 + (.4m)C = 0$$

$$B_x = 0, B_y = 500 \text{ N}, C = 500 \text{ N}$$



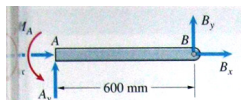
- b) Member AB:

$$\sum F_x = A_x + B_x = 0$$

$$\sum F_y = A_y + B_y = 0$$

$$\sum M_{(point A)} = M_A + (.6m)B_y = 0$$

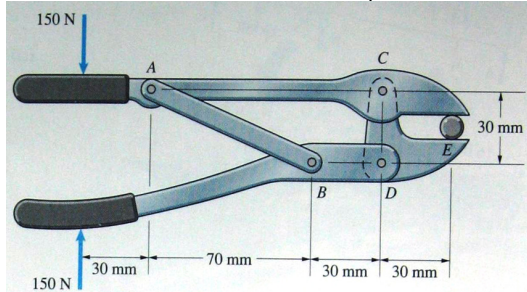
$$A_y = -500 \text{ N}, M_A = -300 \text{ Nm}$$



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Example

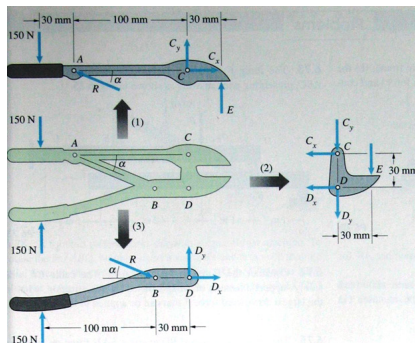
What forces are exerted on the bolt at E as a result of the 150 N forces on the pliers?



Solution

- 1) There is no unknown information to be gained by looking at the entire structure
- 2) Members

We want to find E



Solution (continued)

2) Members

a) Bottom (easier):

$$\sum F_x = R \cos \alpha + D_x = 0$$

$$\sum F_y = 150 - R \sin \alpha + D_y = 0$$

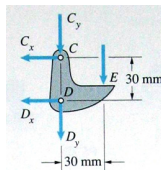
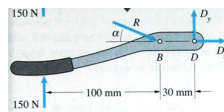
$$\sum M_{(\text{point } B)} = 30D_y - (100)(150) = 0$$

$$D_x = -1517 \text{ N}, D_y = 500 \text{ N}, R = 1650 \text{ N}$$

b) Sum moments of middle to find E

$$\sum M_{(\text{point } C)} = -30E - 30D_x = 0$$

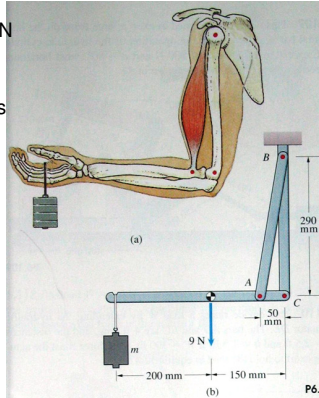
$$E = 1517 \text{ N}$$



Example

The weight of the forearm is 9N
The mass is 2 kg

- A) Determine tension in biceps
- B) Determine magnitude of force exerted on upper arm by forearm at elbow



Tip

If an external load is applied at a joint, you may attach it to any **one** of the members.

Not a common situation

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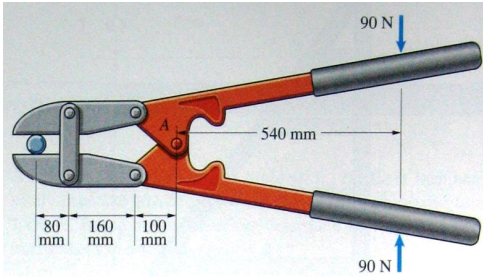
Important Points?

- What are the 2 most important things you learned?
- What is the 1 thing you understand the least?
 - Difficulty with Concept or English?
 - (If English, pronunciation or speed?)

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Typical Exam question

Determine the force exerted on the bolt by the bolt cutters, and the magnitude of the force the members exert on each other at the pin connection A.



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