

Chapter IV b

Simple Machines and Frames



Lecture Overview

- introduction, definition of machines and frames
- external forces vs. internal forces
 - isolation of members
- examples



Definition of frames and machines

Interconnected rigid bodies. Structure consisting of at least one multi-force member.

Internal forces not necessarily in the direction of the member.

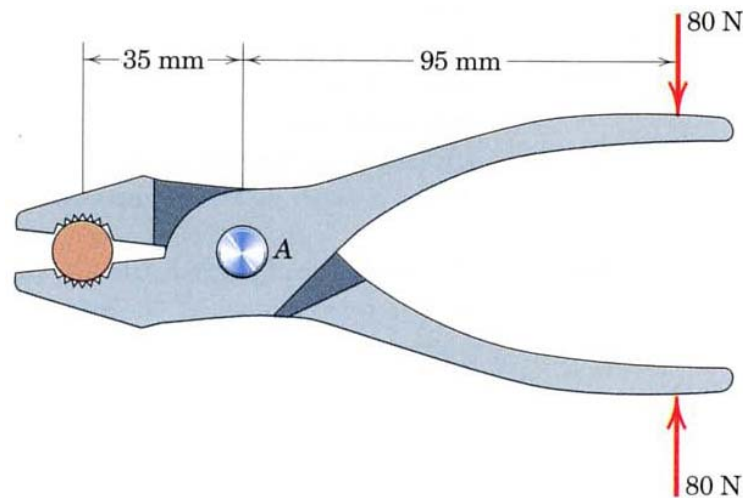


fig by J.L. Meriam, L.G. Kraige, Engineering Mechanics I



Definition of frames and machines

Isolation of members – principle of action and reaction considering rectangular components.

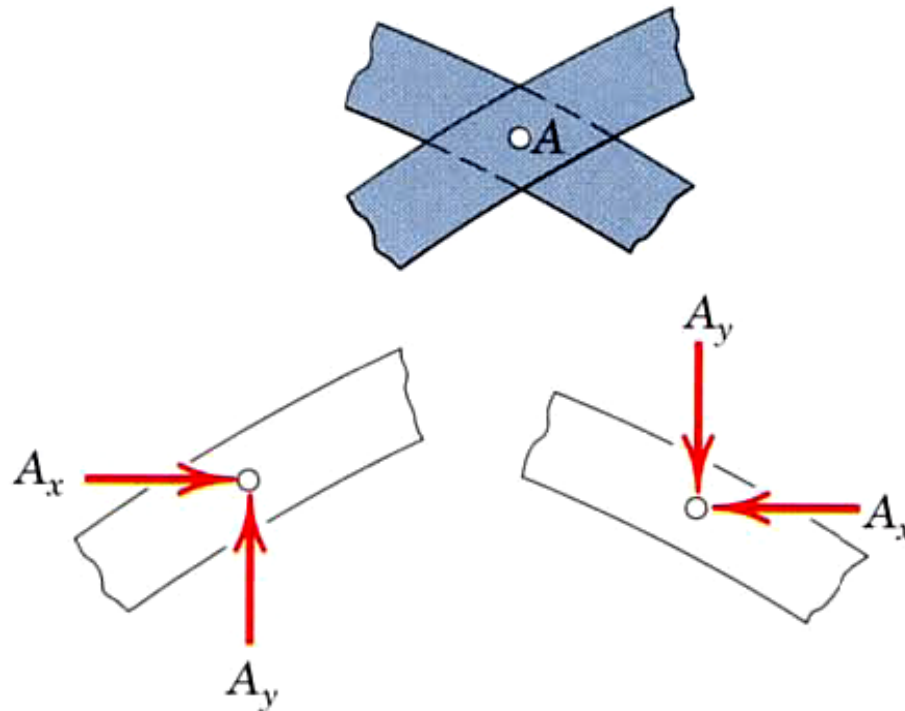


fig by J.L. Meriam, L.G. Kraige, Engineering Mechanics I



1. Structure constitutes a rigid unit by itself.

First determine all possible external forces (treat structure like a single rigid body)

Secondly dismember the structure and consider equilibrium on each part.

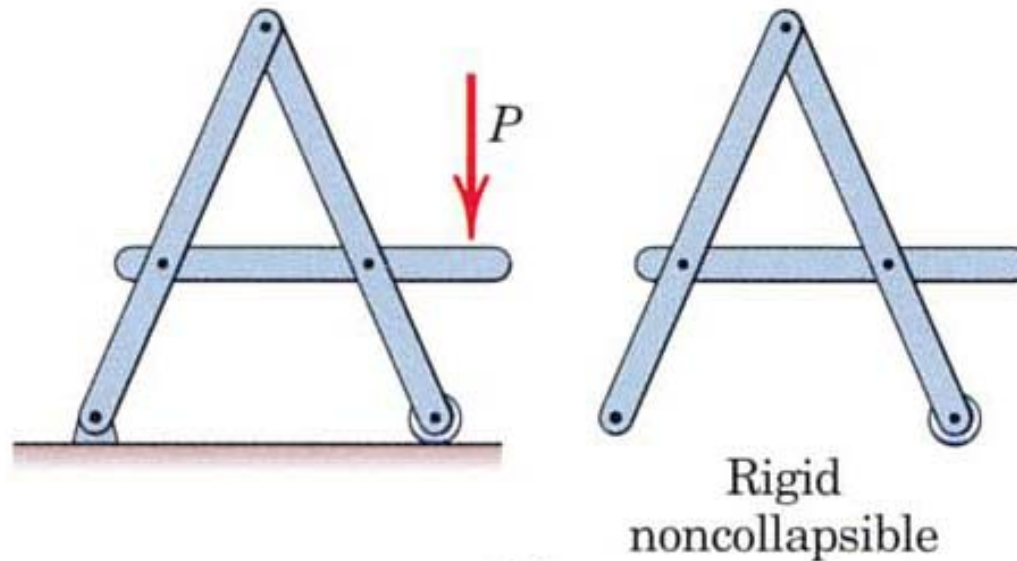


fig by J.L. Meriam, L.G. Kraige, Engineering Mechanics I



2. Structure is not a rigid unit by itself, rigidity depending on its support conditions.

Equilibrium equations (3) not sufficient to determine the support reaction forces (e.g. 4).

Structure to be dismembered and equilibrium to be considered on each part to determine all external forces.

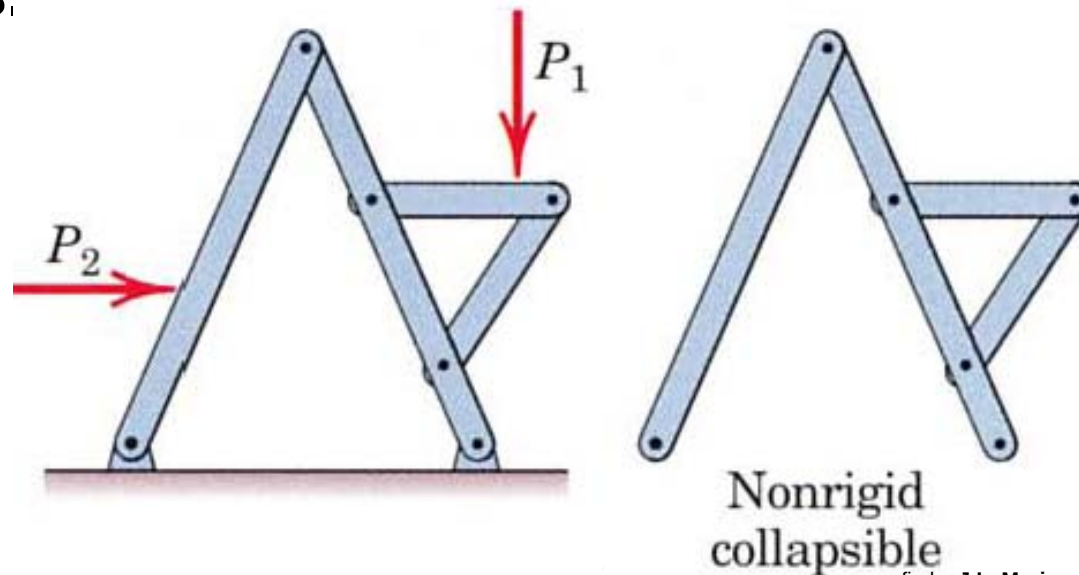


fig by J.L. Meriam, L.G. Kraige, Engineering Mechanics I





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Faculty of Technology

Engineering Mechanics
material by Karsten Schlesier

Department of
Civil Engineering

example 4.2

For the given situation determine the force F applied to the rod by each chaw of the pliers and the support force at A.

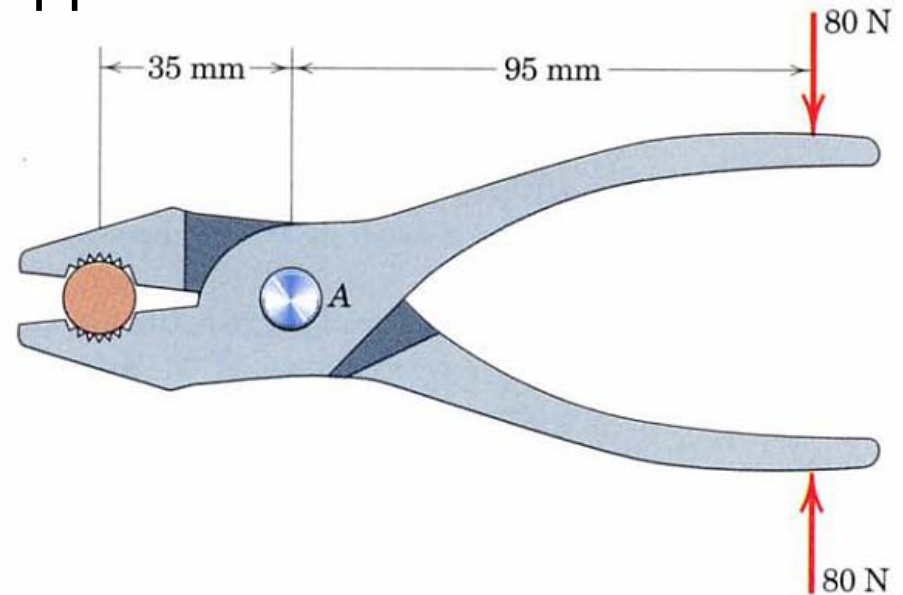


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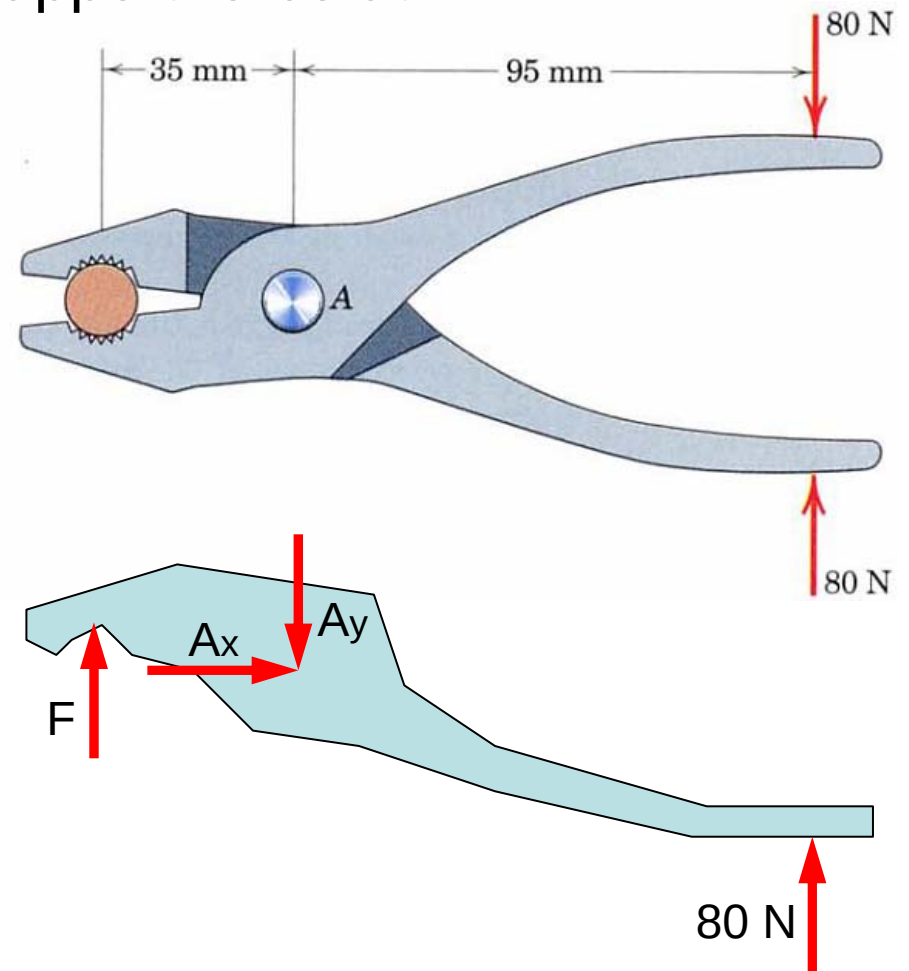
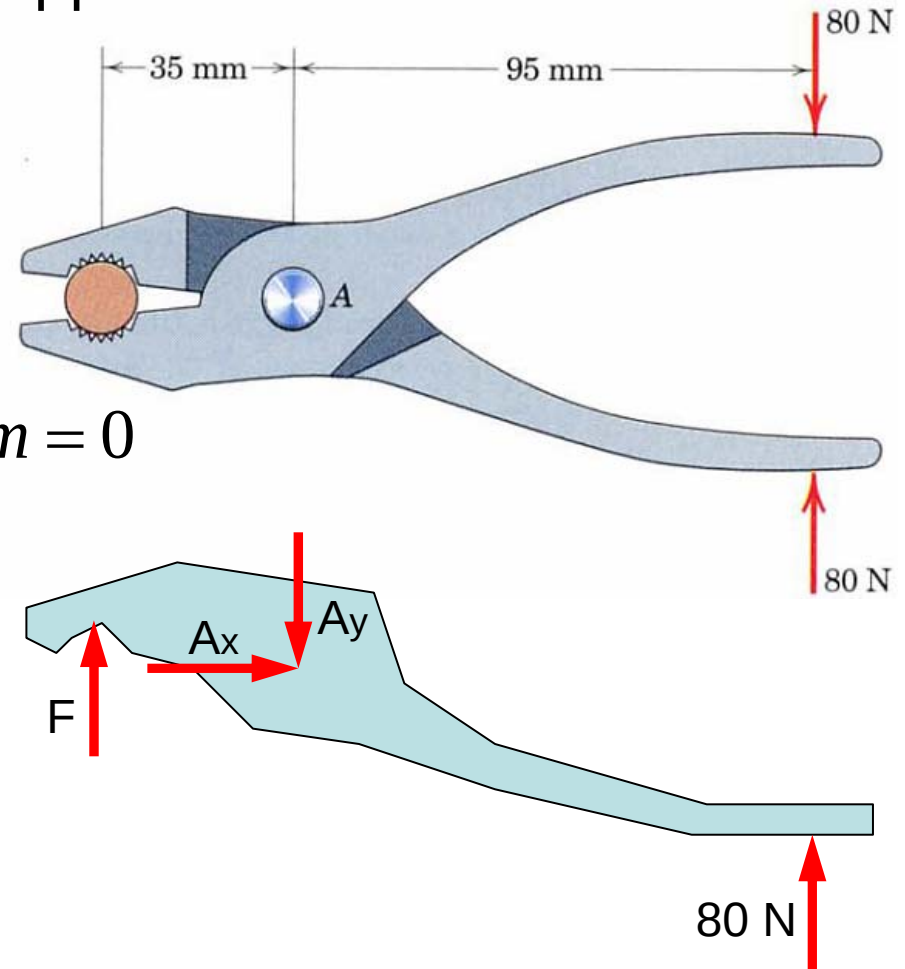


fig by J.L. Meriam, L.G. Kraige, Engineering Mechanics I



example 4.2

For the given situation determine the force F applied to the rod by each chaw of the pliers and the support force at A.



$$\sum M_A = 0: 80N \cdot 95mm - F \cdot 35mm = 0$$

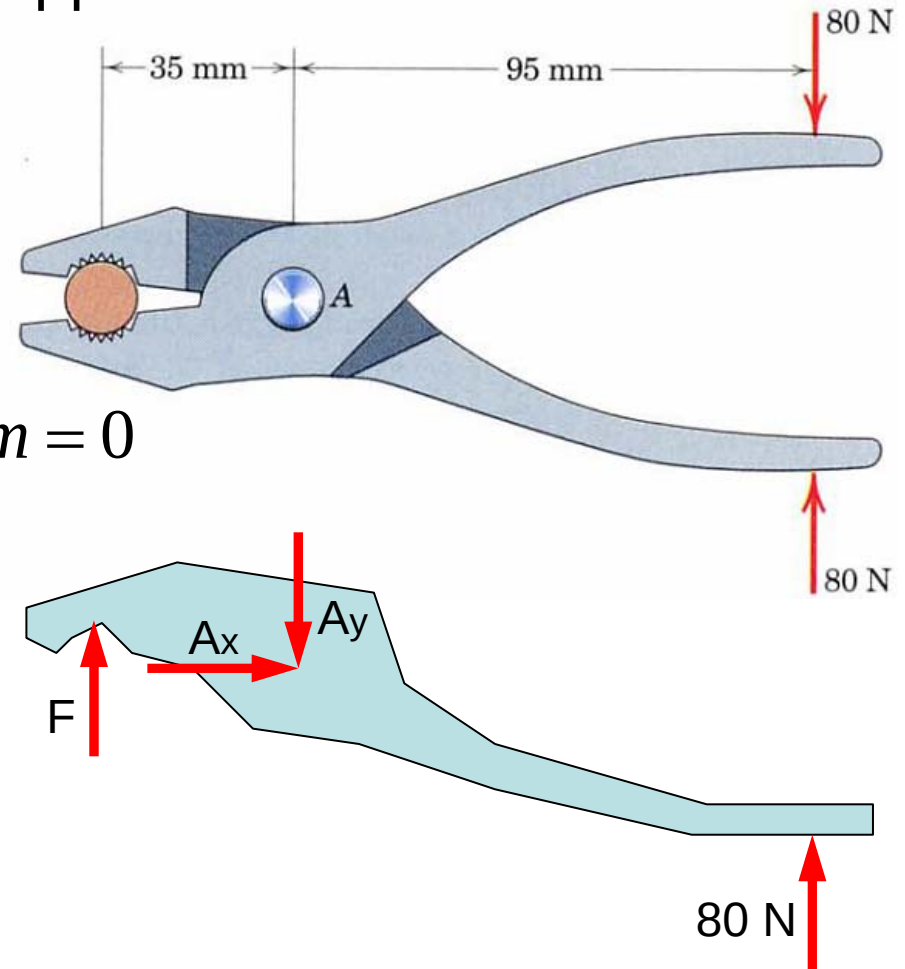
$$F = 217.14N$$

fig by J.L. Meriam, L.G. Kraige, Engineering Mechanics I



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For the given situation determine the force F applied to the rod by each chaw of the pliers and the support force at A.



$$\sum M_A = 0: 80\text{ N } 95\text{ mm} - F 35\text{ mm} = 0$$

$$F = 217.14\text{ N}$$

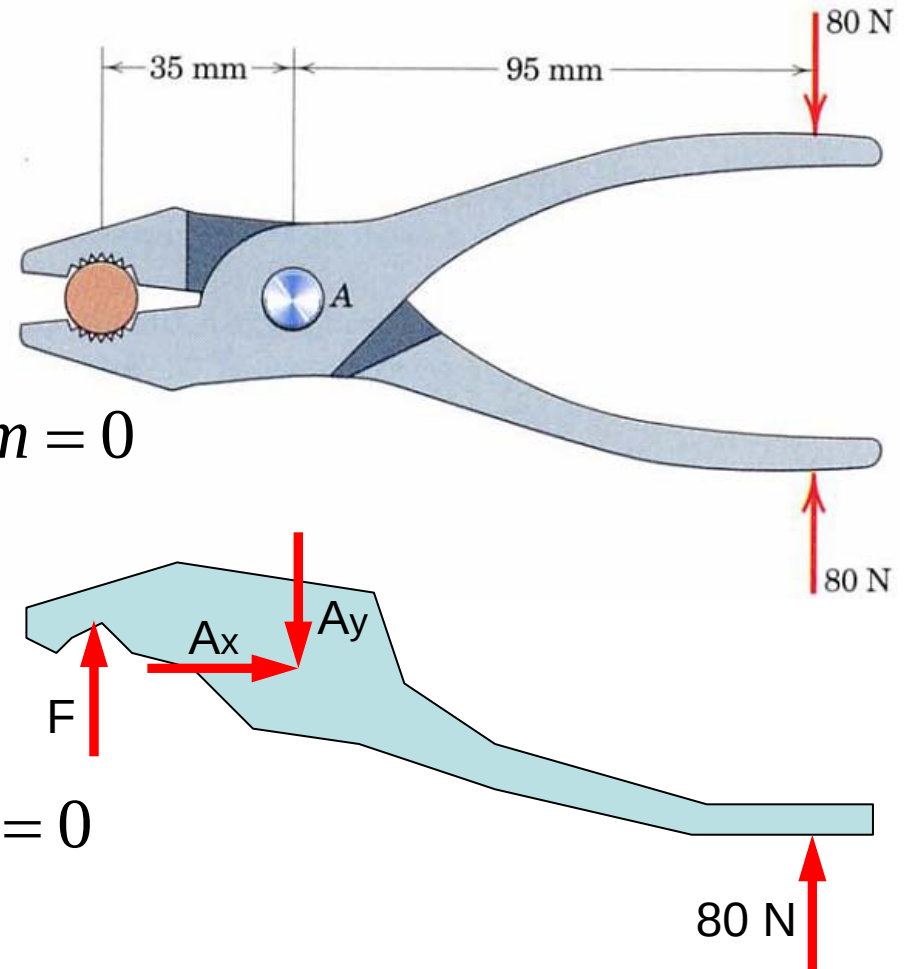
$$\sum F_x = 0: A_x = 0$$

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example 4.2

For the given situation determine the force F applied to the rod by each chaw of the pliers and the support force at A.



$$\sum M_A = 0: 80N \cdot 95mm - F \cdot 35mm = 0$$

$$F = 217.14N$$

$$\sum F_x = 0: A_x = 0$$

$$\sum F_y = 0: 80N + 217.14N - A_y = 0$$

$$A_y = 297.14N = A$$

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example 4.3

The boards are compressed by 200 N by the clamp. Determine the force in the threaded shaft BC and the pin reaction at D.

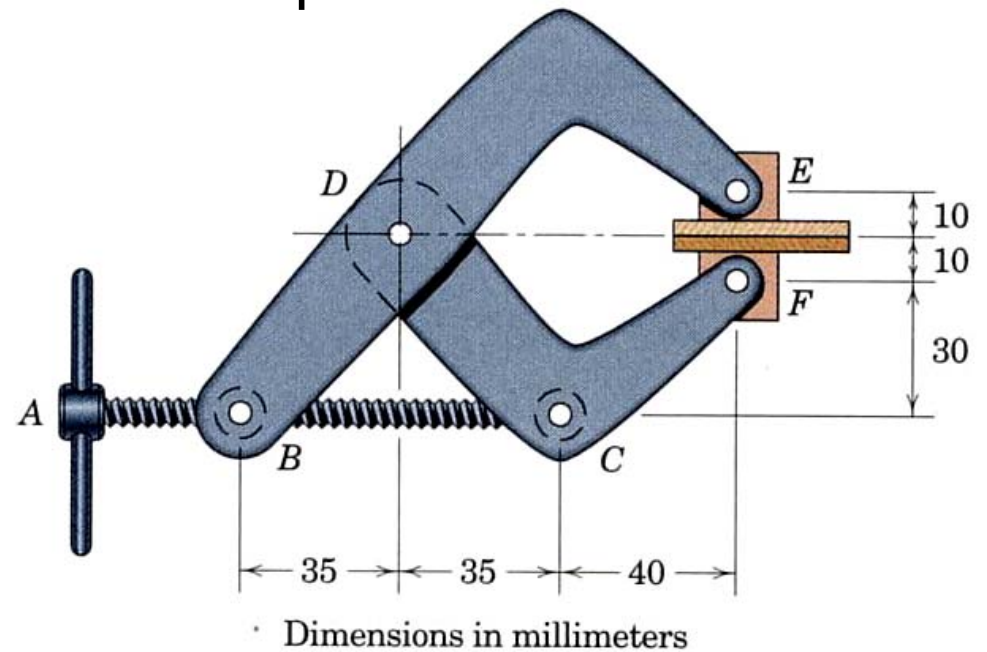


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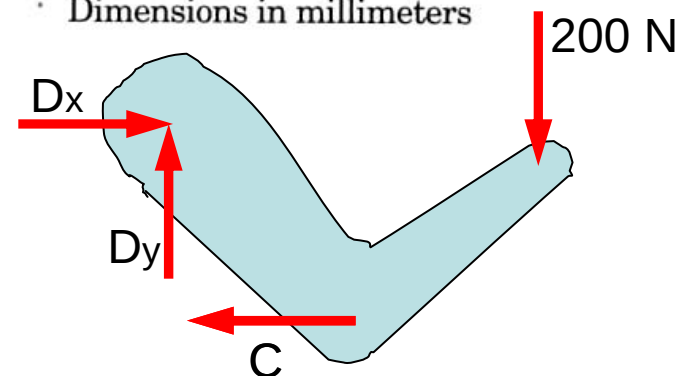
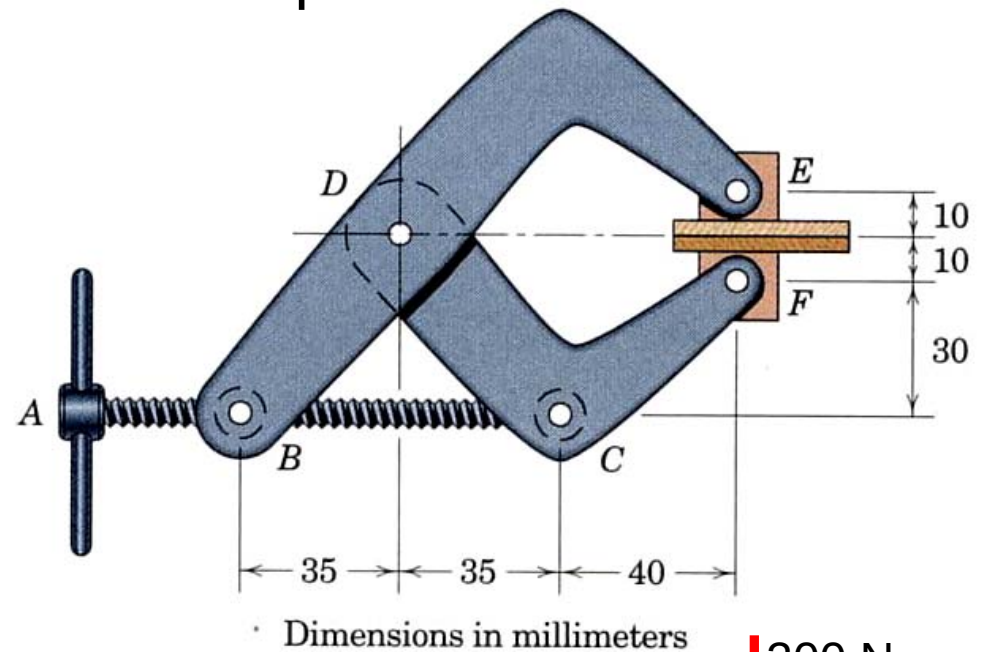


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example 4.3

The boards are compressed by 200 N by the clamp. Determine the force in the threaded shaft BC and the pin reaction at D.

$$\sum M_D = 0: -200 \text{ N } 75 \text{ mm} - C \text{ } 40 \text{ mm} = 0$$

$$C = -375 \text{ N} \text{ compression}$$

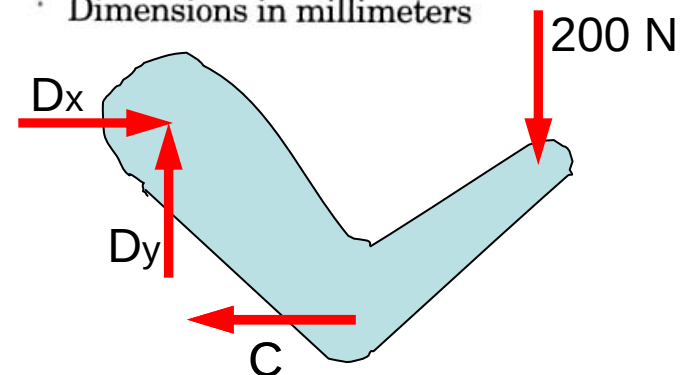
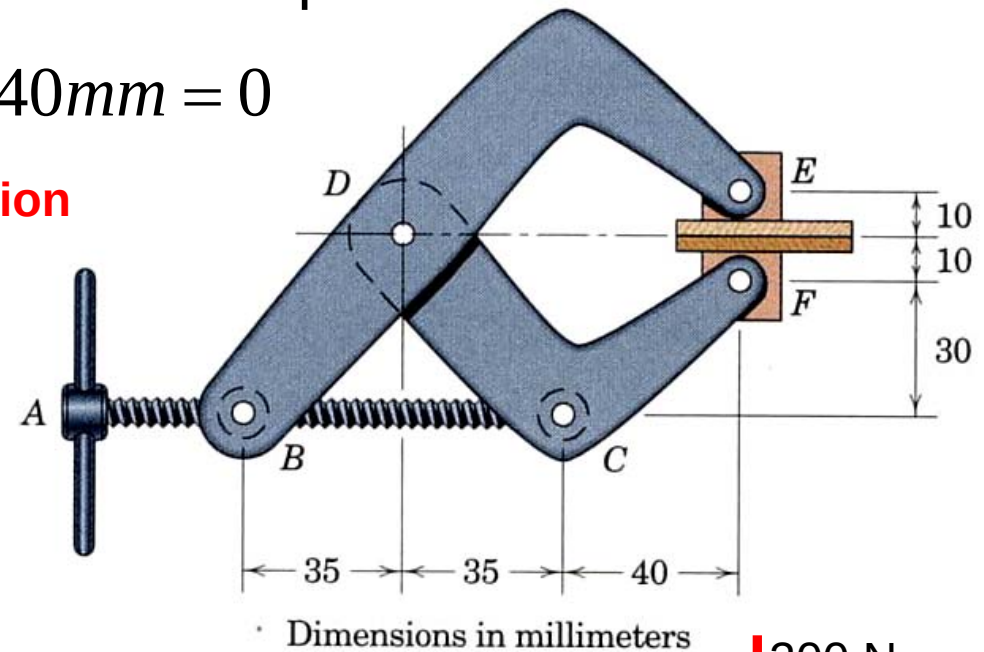


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$$\sum M_D = 0: -200\text{ N } 75\text{ mm} - C \ 40\text{ mm} = 0$$

$$C = -375\text{ N}$$

$$\sum F_x = 0: D_x - C = 0$$

$$D_x = -375\text{ N}$$

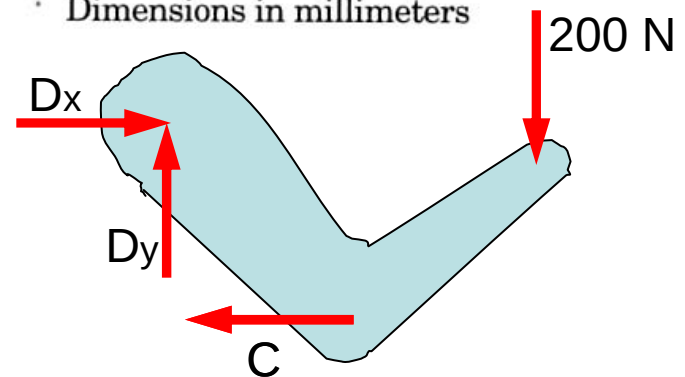
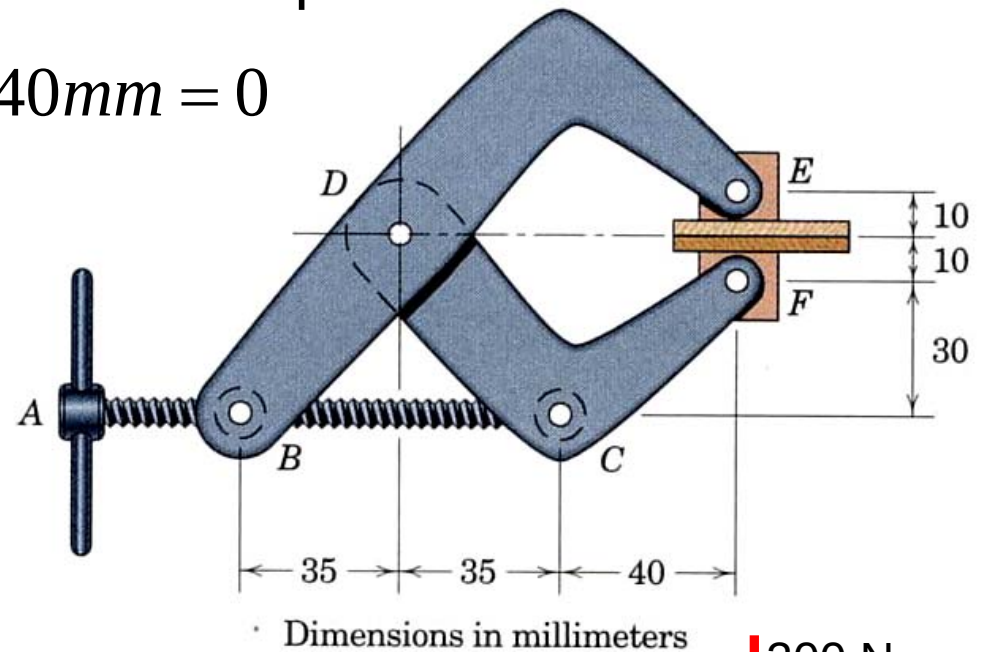


fig by J.L. Meriam, L.G. Kraige, Engineering Mechanics I



example 4.3

The boards are compressed by 200 N by the clamp. Determine the force in the threaded shaft BC and the pin reaction at D.

$$\sum M_D = 0: -200N \cdot 75mm - C \cdot 40mm = 0$$

$$C = -375N$$

$$\sum F_x = 0: D_x - C = 0$$

$$D_x = -375N$$

$$\sum F_y = 0: -200N + D_y = 0$$

$$D_y = 200N$$

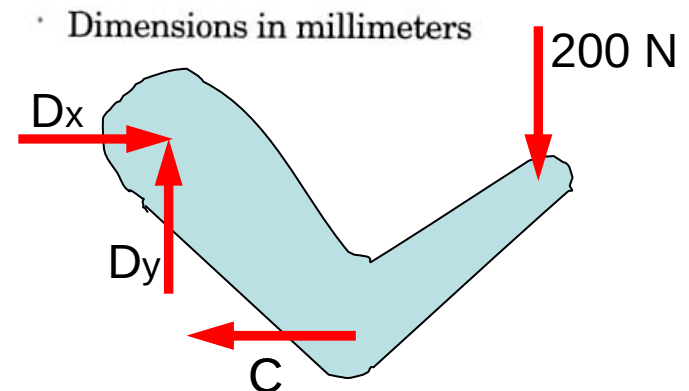
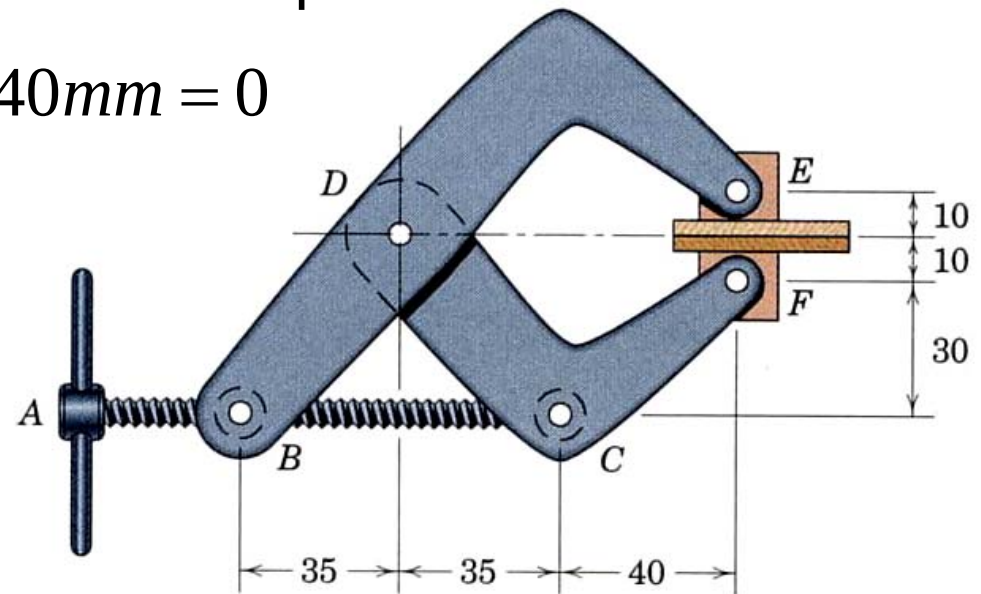


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The boards are compressed by 200 N by the clamp. Determine the force in the threaded shaft BC and the pin reaction at D.

$$\sum M_D = 0: -200N \cdot 75mm - C \cdot 40mm = 0$$

$$C = -375N$$

$$\sum F_x = 0: D_x - C = 0$$

$$D_x = -375N$$

$$\sum F_y = 0: -200N + D_y = 0$$

$$D_y = 200N$$

$$D = \sqrt{D_x^2 + D_y^2} = 425N$$

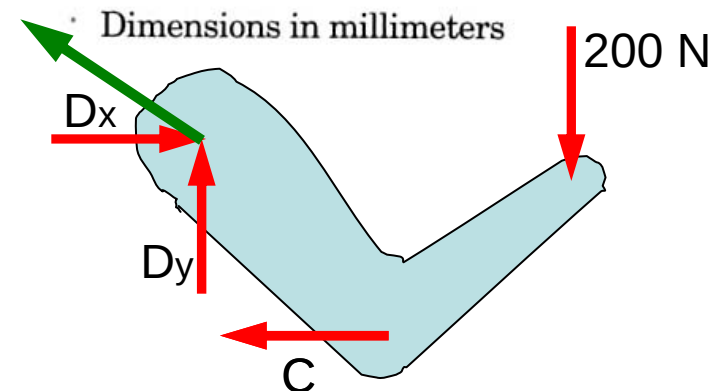
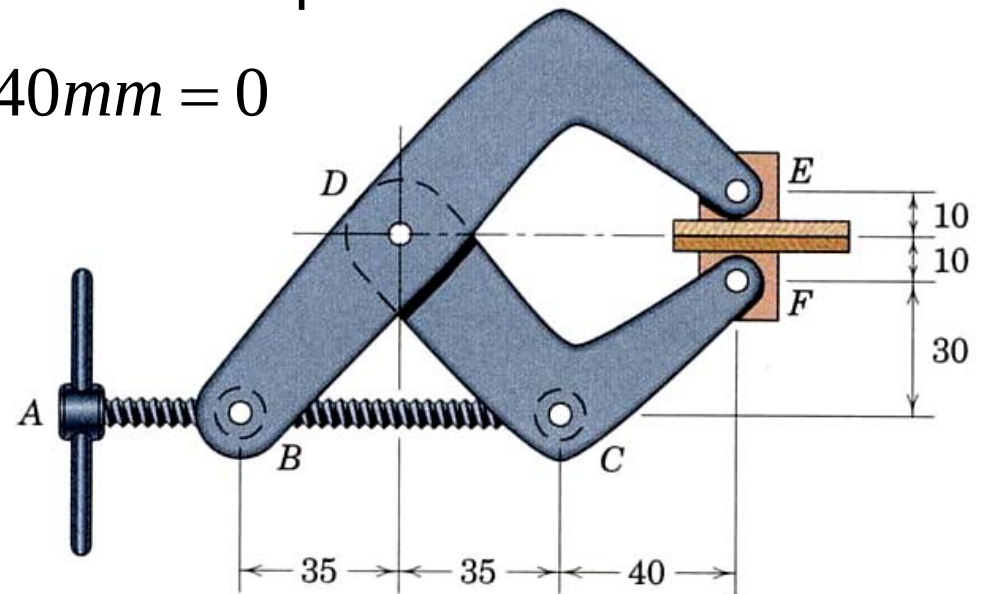


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example 4.4

The given frame supports a 400 kg mass. Determine the horizontal and vertical components of all forces acting on each member.

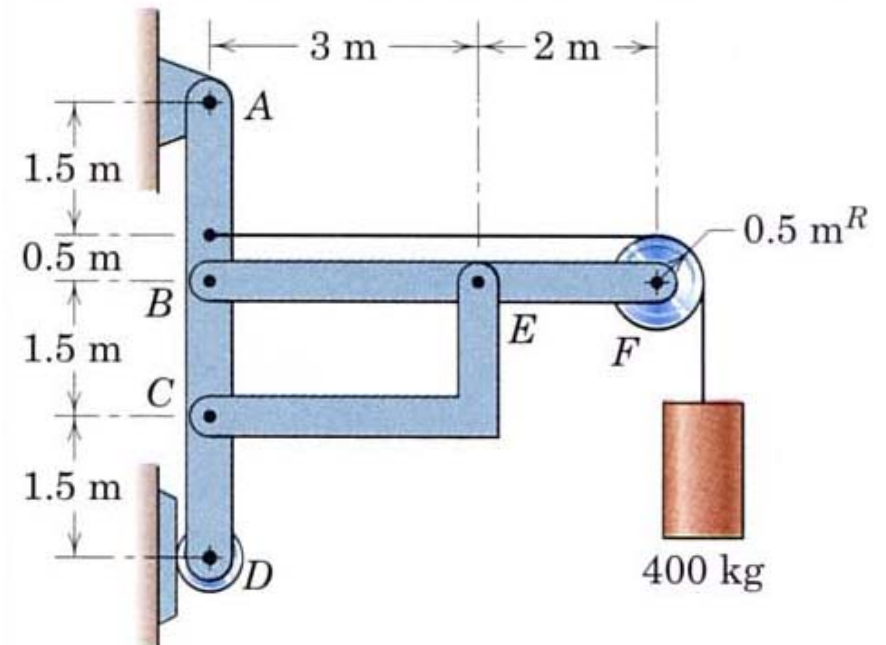


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example 4.4

The given frame supports a 400 kg mass. Determine the horizontal and vertical components of all forces acting on each member.

1. Determination of all support reactions (rigid frame)

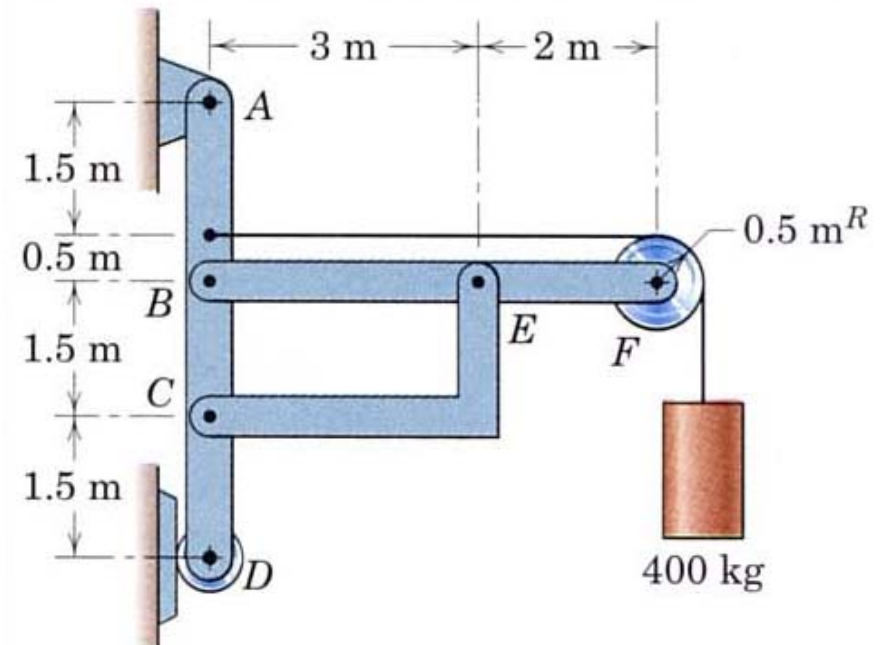


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1. Determination of all support reactions

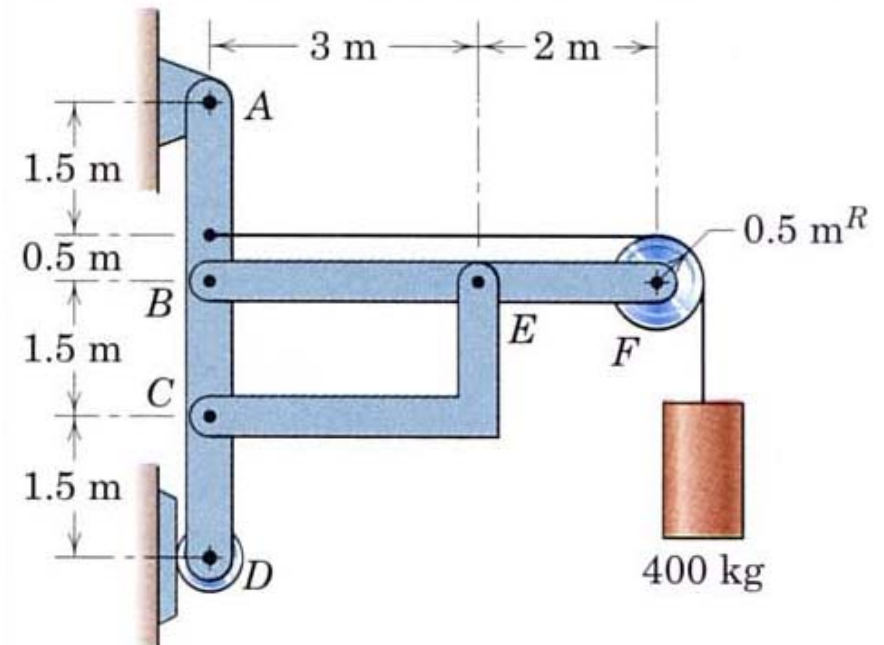
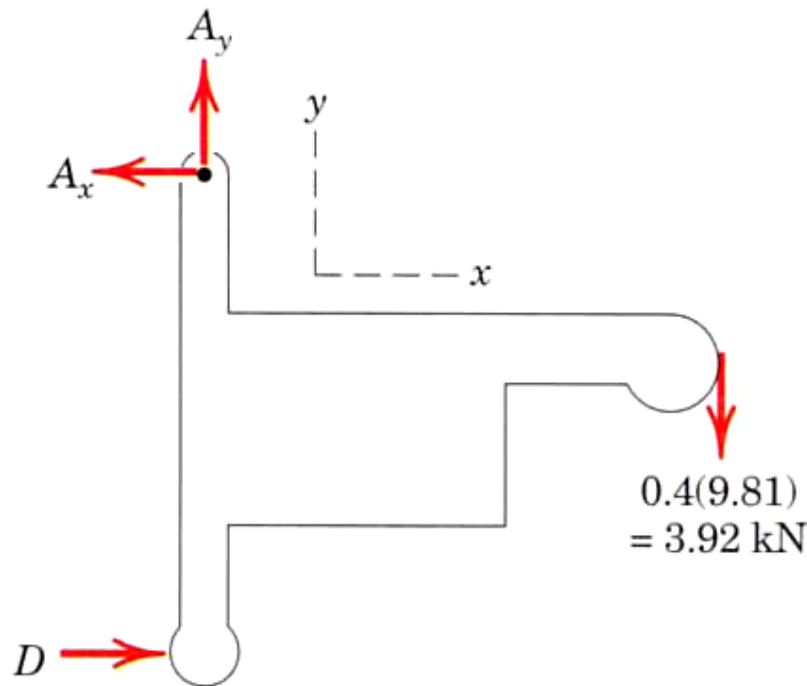


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example 4.4

The given frame supports a 400 kg mass. Determine the horizontal and vertical components of all forces acting on each member.

1. Determination of all support reactions

$$[\Sigma M_A = 0]$$

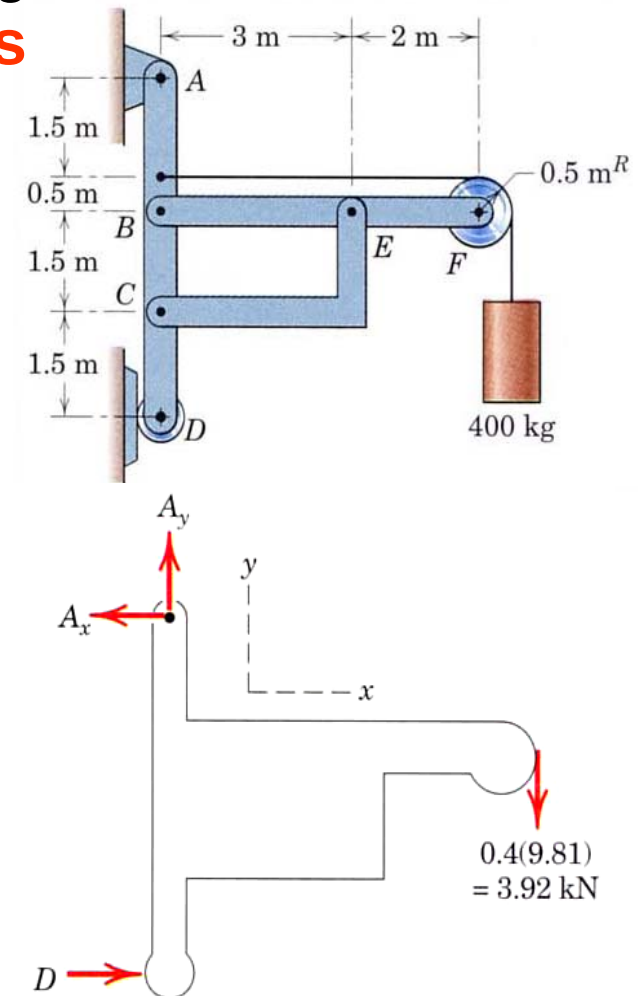
$$5.5(0.4)(9.81) - 5D = 0 \quad \boxed{D = 4.32 \text{ kN}}$$

$$[\Sigma F_x = 0]$$

$$A_x - 4.32 = 0 \quad \boxed{A_x = 4.32 \text{ kN}}$$

$$[\Sigma F_y = 0]$$

$$A_y - 3.92 = 0 \quad \boxed{A_y = 3.92 \text{ kN}}$$



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example 4.4

The given frame supports a 400 kg mass. Determine the horizontal and vertical components of all forces acting on each member.

1. Dismembering of frame

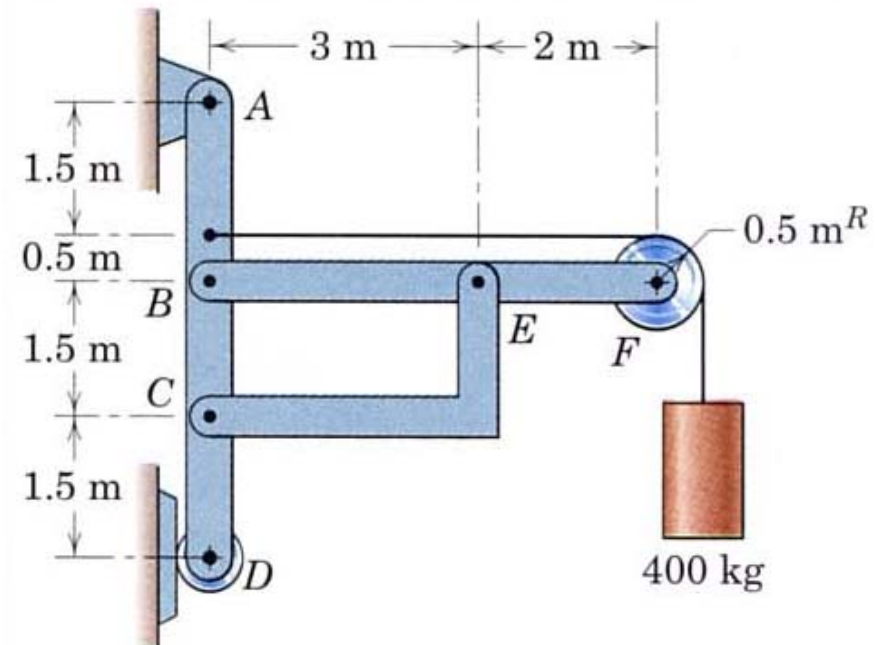


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1. Dismembering of frame

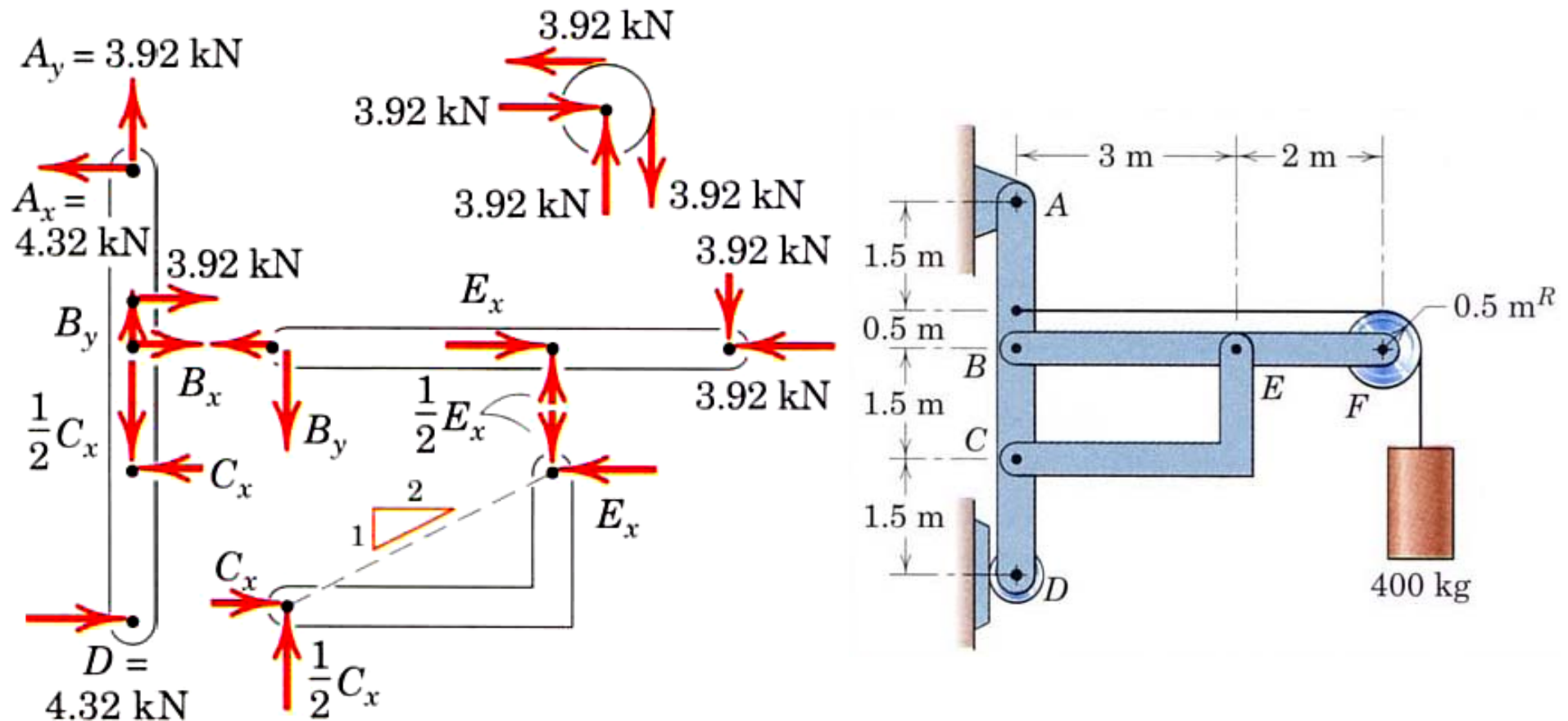


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example 4.4

equilibrium at member CE:

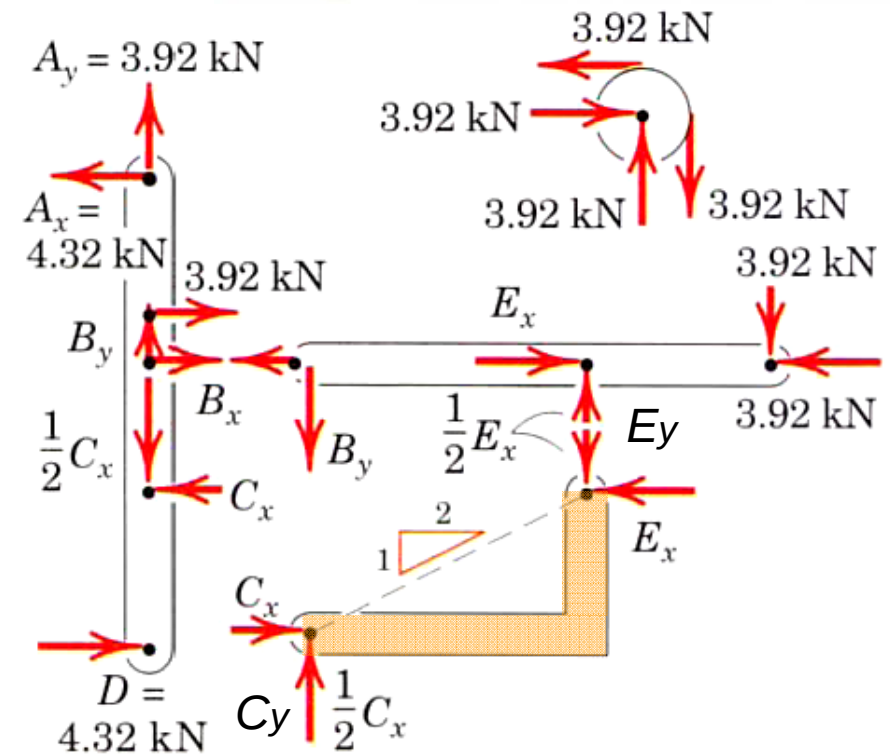
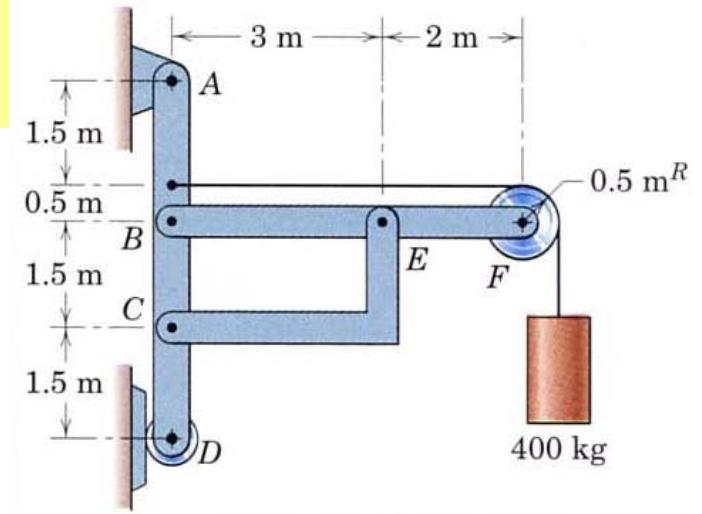


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example 4.4

equilibrium at member CE:

$$\sum M_C = 0: E_x \cdot 1.5 - E_y \cdot 3 = 0$$

$$E_y = 0.5E_x$$

$$\sum F_x = 0: C_x = E_x$$

$$\sum F_y = 0: C_y = E_y = 0.5E_x$$

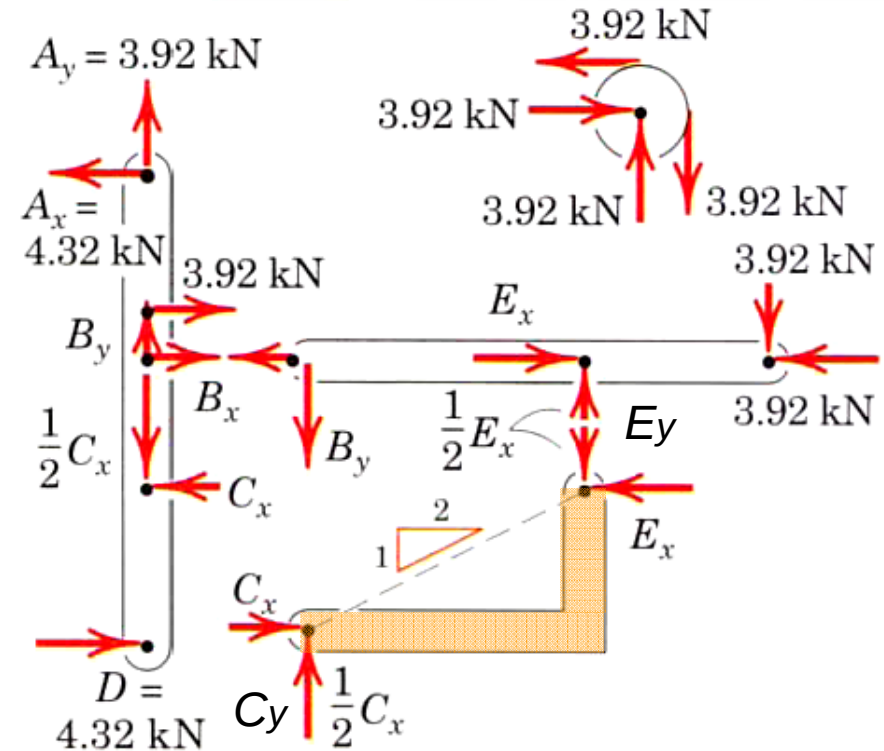
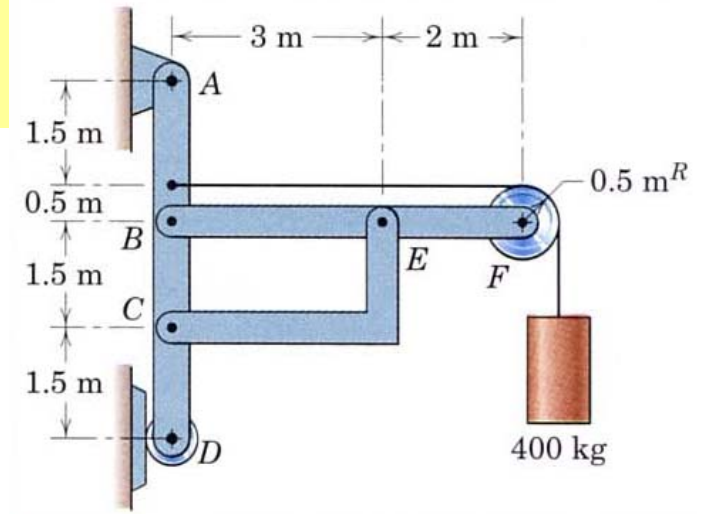


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example 4.4

equilibrium at member BF:

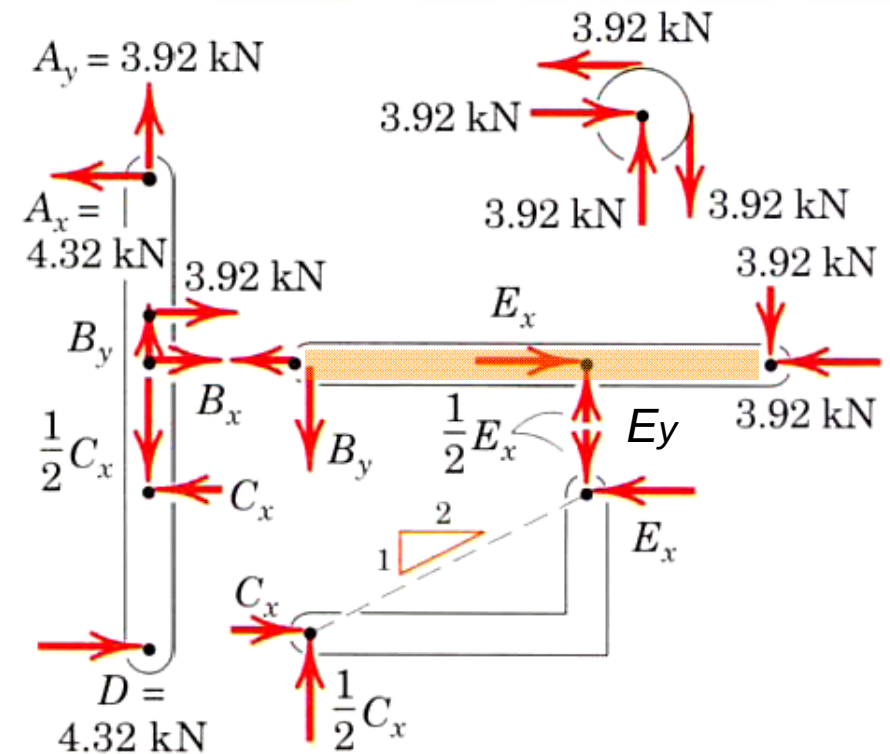
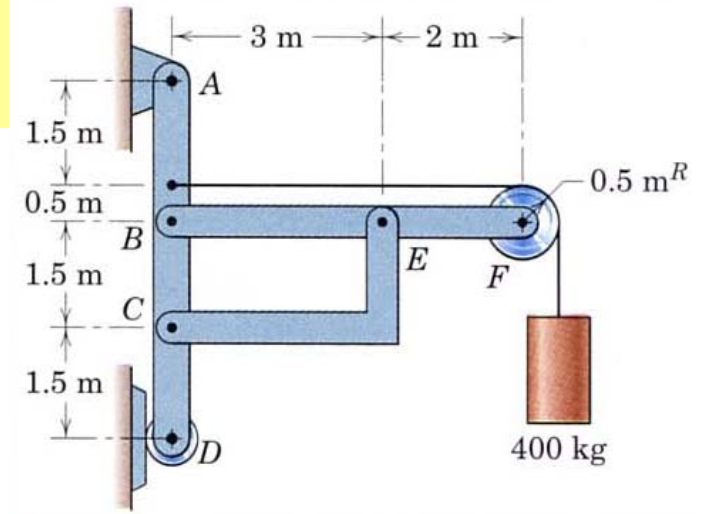


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example 4.4

equilibrium at member BF:

$$[\sum M_B = 0]$$

$$3.92(5) - \frac{1}{2}E_x(3) = 0 \quad \boxed{E_x = 13.08 \text{ kN}}$$

$$[\sum F_y = 0]$$

$$B_y + 3.92 - 13.08/2 = 0 \quad \boxed{B_y = 2.62 \text{ kN}}$$

$$[\sum F_x = 0]$$

$$B_x + 3.92 - 13.08 = 0 \quad \boxed{B_x = 9.15 \text{ kN}}$$

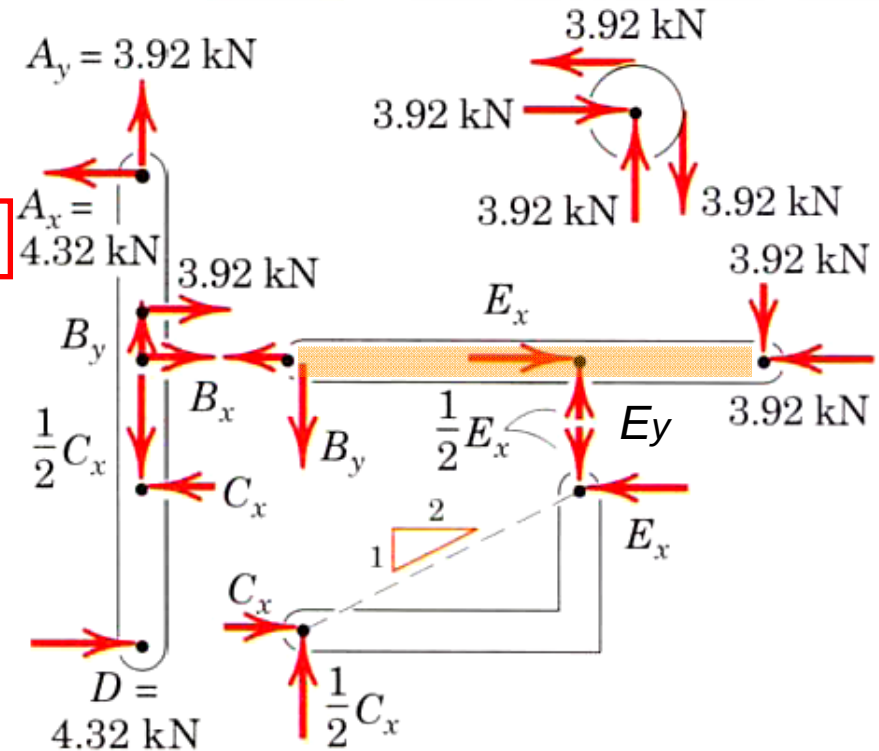
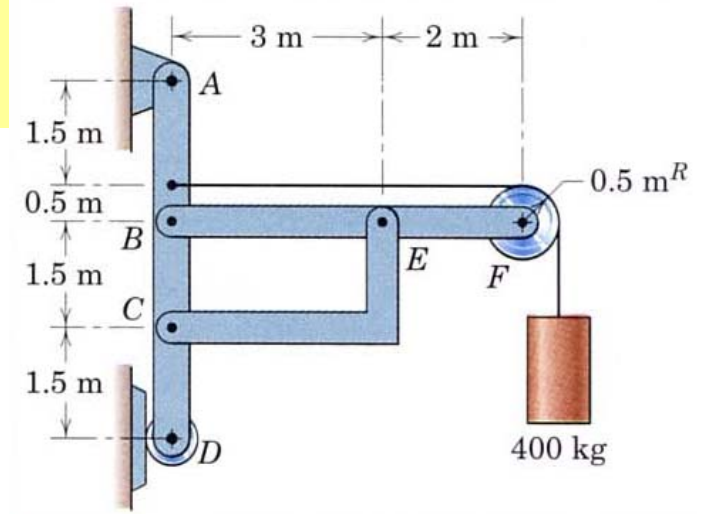


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example 4.4

equilibrium at member AD
(check the obtained results):

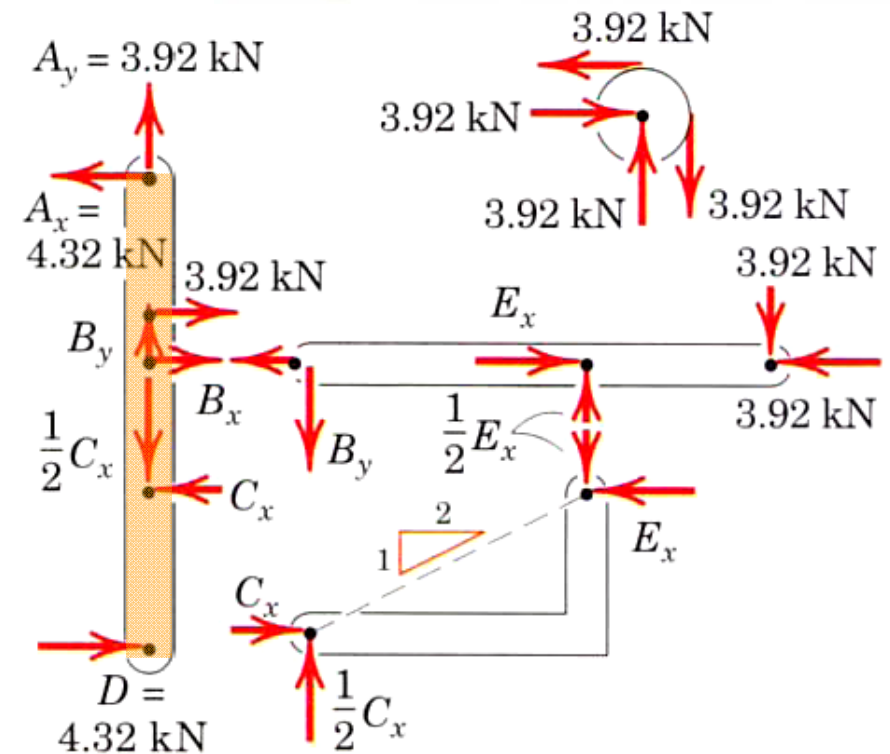
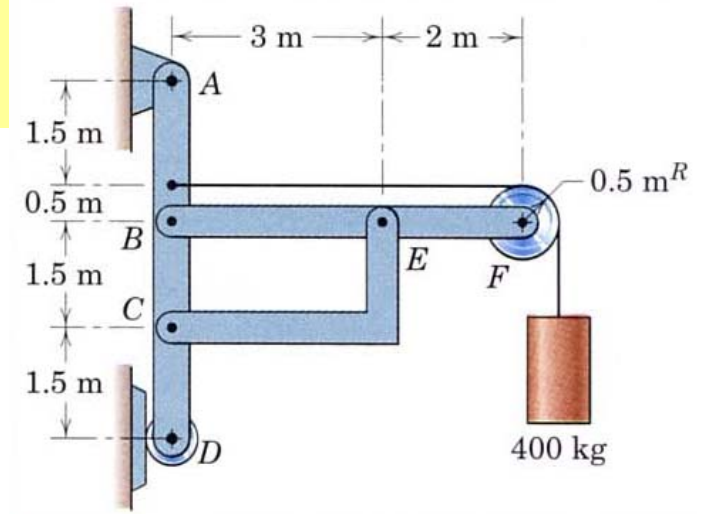


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example 4.4

equilibrium at member AD
(check the obtained results):

$\curvearrowright [\Sigma M_C = 0]$

$$4.32(3.5) + 4.32(1.5) - 3.92(2) - 9.15(1.5) = 0$$

$\rightarrow [\Sigma F_x = 0]$

$$4.32 - 13.08 + 9.15 + 3.92 + 4.32 = 0$$

$\uparrow [\Sigma F_y = 0]$

$$-13.08/2 + 2.62 + 3.92 = 0$$

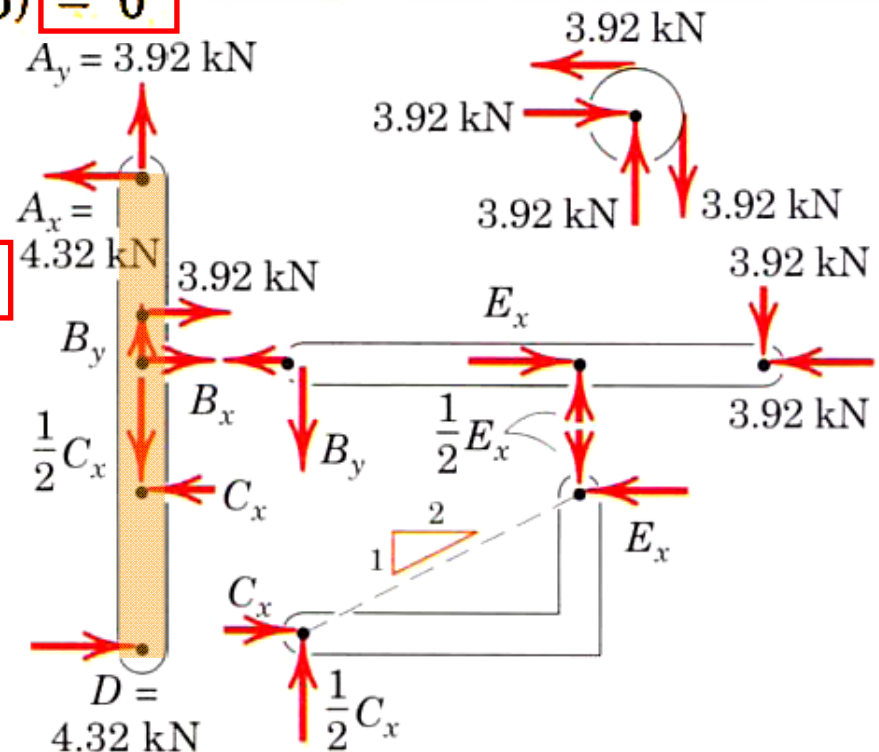
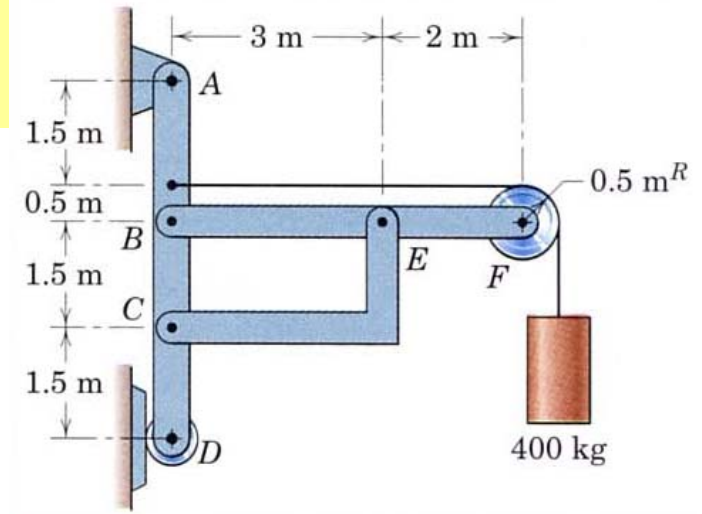


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exam:

Sunday, 18th January 8:00 am

rooms will be posted at pre-eng. department

bring ID cards to be checked

**no mobile phones, pagers, calculators with
graphical displays allowed**

no books or any written information allowed

good luck!

