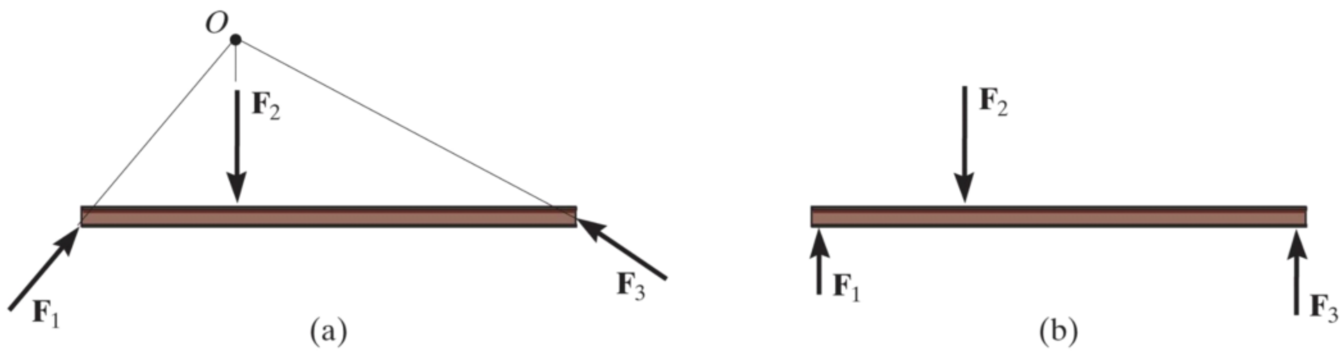
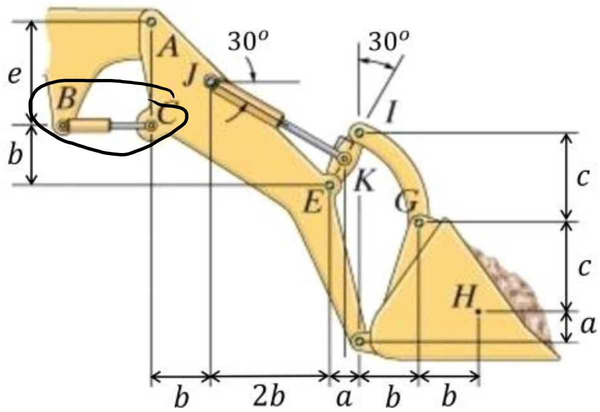
Three-force members

As the name implies, three-force members have forces applied at only three points.

Moment equilibrium can be satisfied only if the three forces are concurrent or parallel force system



Three-force member

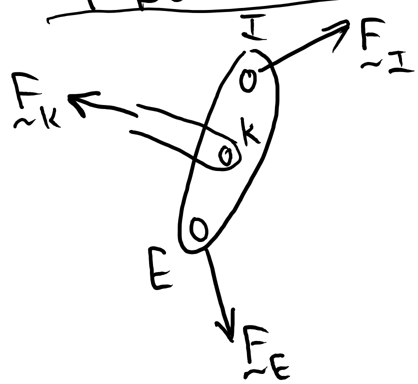


How many "two-force" members in this system?

A) 0
B) 1
C) 2
D) 3
E) 4

BC
JK
IG

FBD of EI



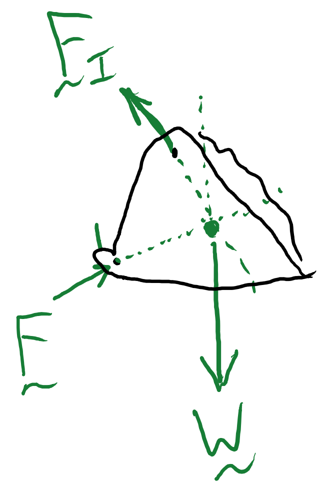
How many 3-force members are there?

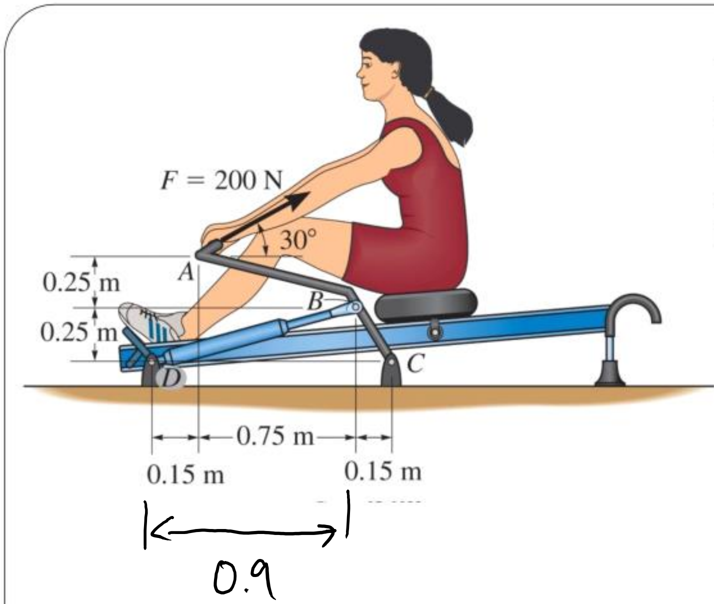
A) 0
B) 1
C) 2
D) 3
E) 4

IKE
Bucket

Since the bucket is a 3-force member and the applied loads are not parallel, they must be <u>concurrent</u>. That is, their lines of action must all intersect at a single point.

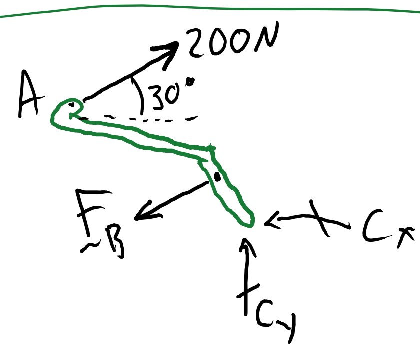
FBD of Bucket

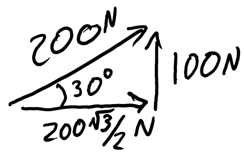




The woman exercises on the rowing machine. If she exerts a holding force of $F = 200$ N on the handle ABC, determine the reaction force at pin C and the force developed along the hydraulic cylinder BD on the handle.

FBD on handle $\overline{ABC}$





$$\underset{\sim}{F}_A = 200N\left(\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right)$$

$$= 100N\left(\sqrt{3}\,\hat{i} + \hat{j}\right)$$

$$\underset{\sim}{F}_B = F_B \cdot \hat{u}_{BD}$$

$$\hat{u}_{BD} = \frac{-0.9\,\hat{i} - 0.25\,\hat{j}}{\sqrt{(0.9)^2 + (0.25)^2}}$$

$$\Rightarrow \underset{\sim}{F}_B = F_B\left(-0.9635\,\hat{i} - 0.2676\,\hat{j}\right)$$

Sum moments about C to solve for F_B.

$$\sum M_c = \underset{\sim}{r}_{CB} \times \underset{\sim}{F}_B + \underset{\sim}{r}_{CA} \times \underset{\sim}{F}_A$$

r_{CA} F

$$\sum M_C = \underset{\sim}{r}_{CB} \times \underset{\sim}{F}_B + \underset{\sim}{r}_{CA} \times \underset{\sim}{F}_A$$

$$= \underbrace{(-0.15\hat{i} + 0.25\hat{j})m}_{\underset{\sim}{r}_{CB}} \times \underbrace{F_B (-0.9635\hat{i} - 0.2676\hat{j})}_{\underset{\sim}{F}_B} + \underbrace{(-0.9\hat{i} + 0.5\hat{j})m}_{\underset{\sim}{r}_{CA}} \times \underbrace{100N(\sqrt{3}\hat{i} + \hat{j})}_{\underset{\sim}{F}_A} = 0$$

$$\therefore F_B \cdot (0.25 \cdot 0.9635 + 0.15 \cdot 0.2676)\hat{k} - (90\,N)\hat{k} - 50\sqrt{3}\,N\hat{k} = 0$$

$$F_B \cdot (0.2409 + 0.04015) = 176.6\,N$$

$$\boxed{F_B = 628\,N}$$

Solve for the reaction forces at C:

$$\sum F_x = 100\sqrt{3}\,N - (628N)(0.9635) - C_x = 0$$

$$\Rightarrow \boxed{C_x = -432\,N}$$

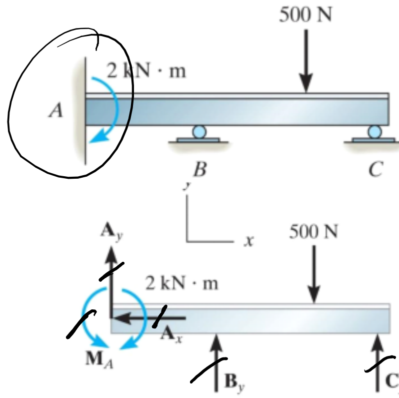
$$\sum F_y = C_y + 100N - (628N)(0.2676) = 0$$

$$\Rightarrow \boxed{C_y = 68.1\,N}$$

Constraints

To ensure equilibrium of a rigid body, it is not only necessary to satisfy equations of equilibrium, but the body must also be properly constrained by its supports

- **Redundant constraints**: the body has more supports than necessary to hold it in equilibrium; the problem is STATICALLY INDERTERMINATE and cannot be solved with statics alone



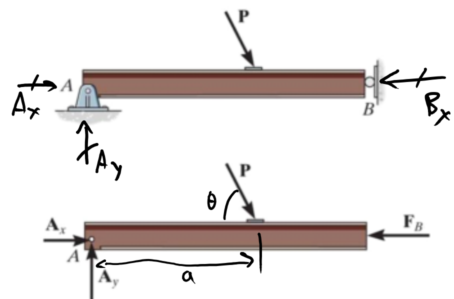
How many unknowns are there?

A) 3
B) 4
C) 5 A_x, A_y, M_A, B_y, C_y
D) 6
E) 7

How many equilibrium equations do we have?

A) 2
B) 3 $\Sigma F_x, \Sigma F_y, \Sigma M_A$
C) 4
D) 5
E) 6

- **Improper constraints:** In some cases, there may be as many unknown reactions as there are equations of equilibrium. However, if the supports are not properly constrained, the body may become unstable for some loading cases.



$$\Sigma M_A = -a \cdot P \cdot \sin\theta \neq 0$$