Statics - TAM 210 & TAM 211

Lecture 14

February 16, 2018

Announcements

- Structured office hours of working through practice problems will be held during Sunday office hours, starting Sunday February 24
- Students are encouraged to practice drawing FBDs, writing out equilibrium equations, and solving these by hand (especially if you have not taken a course with linear (matrix) algebra or programming in MATLAB).
  - Expending large amounts of time trying to de-bug MATLAB code is not the focus of this course. All problems can be solved by hand. Quiz questions are timed for solution by hand.

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- Upcoming deadlines:
- Friday (2/16)
  - Mastering Engineering Tutorial 6
- Tuesday (2/20)
  - PL Homework 5
- Quiz 3 (2/21-23)

Chapter 5: Equilibrium of Rigid Bodies

Focus on 2D problems

Sections 5.1-5.4, 5.7

TAM 211 students will cover 3D problems (sections 5.5-5.6) in week 13

Goals and Objectives

- Introduce the free-body diagram for a 2D rigid body
- Develop the equations of equilibrium for a 2D rigid body
- Solve 2D rigid body equilibrium problems using the equations of equilibrium
- Introduce concepts of
  - Reaction forces due to support
  - Two- and three-force members
  - Constraints and determinacy

Recap: Support reactions

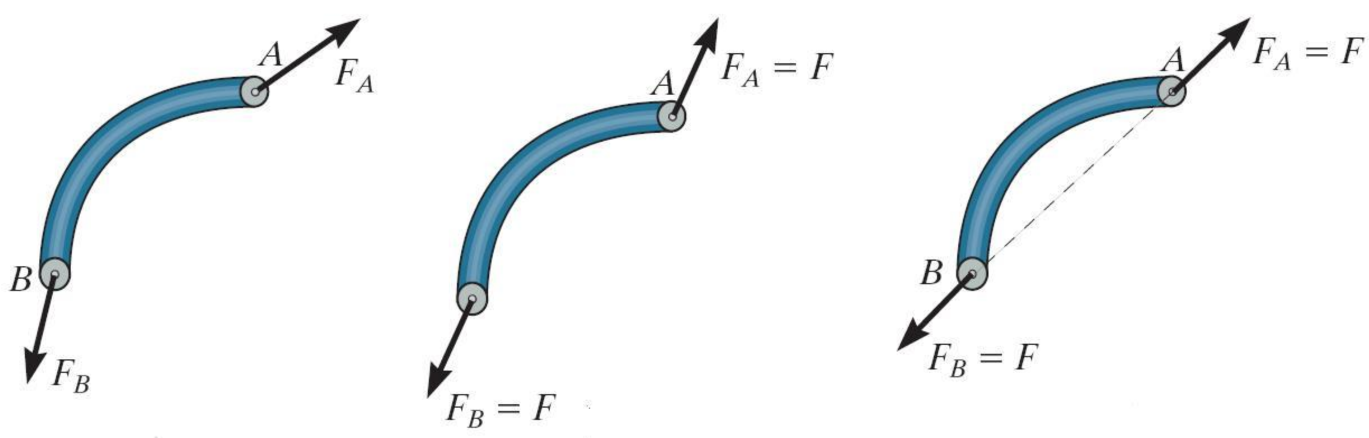
http://rayonroskar.com/

https://greatist.com/move/foam-roller-exercises-the-best-moves-for-strength

Two-force members

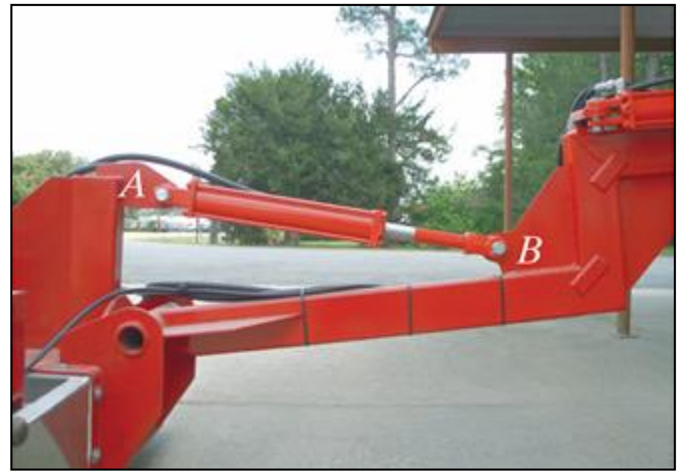
As the name implies, two-force members have forces applied at only two points.

If we apply the equations of equilibrium to such members, we can quickly determine that **the resultant forces at A and B must be equal in magnitude and act in the opposite directions along the line joining points A and B.**

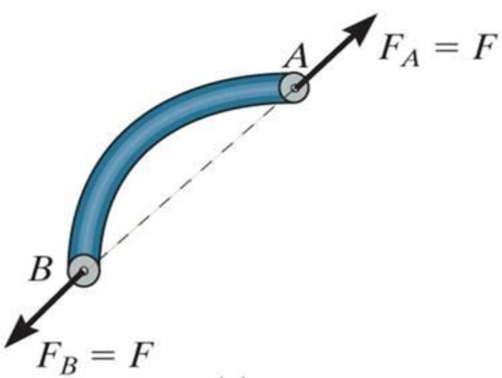


Two-force member: the two forces at ends are equal, opposite, collinear

Examples of two-force members



In the cases above, members AB can be considered as two-force members, provided that their weight is neglected.

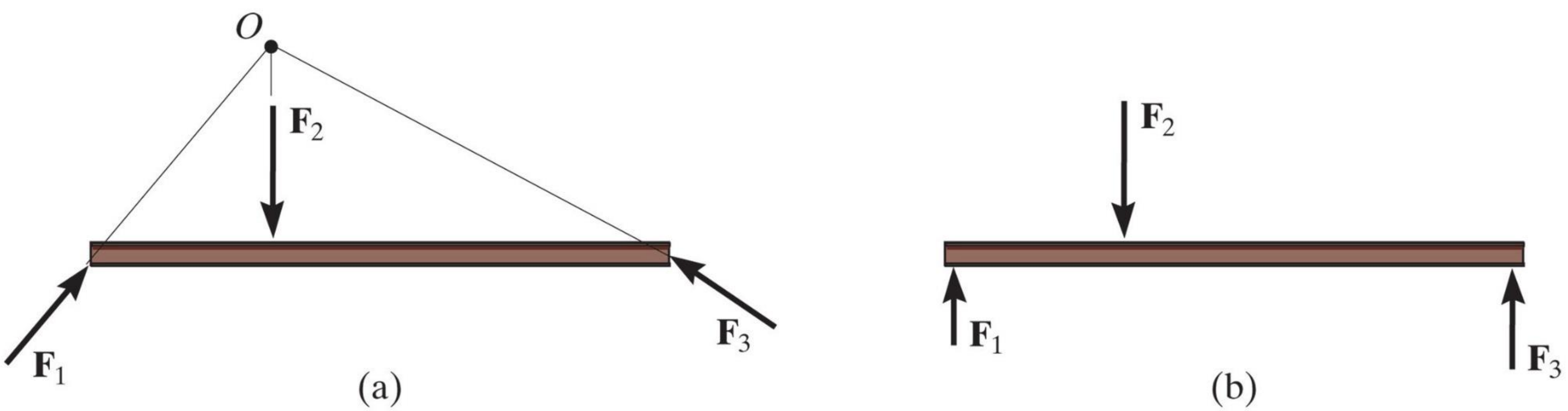


Two-force members **simplify** the equilibrium analysis of some rigid bodies since the directions of the resultant forces at A and B are thus known (along the line joining points A and B).

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: a force system where the three forces

1. meet at the same point (point O), or
2. are parallel

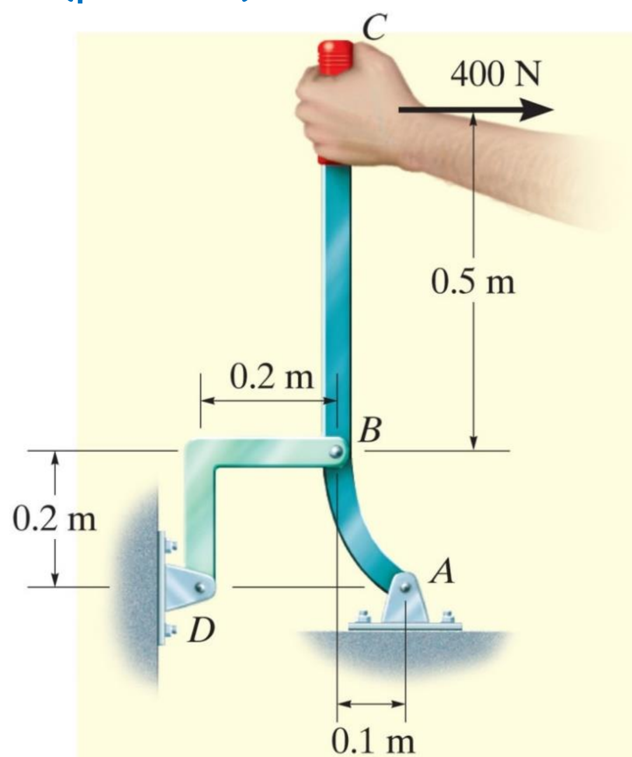
Two-force and three-force members

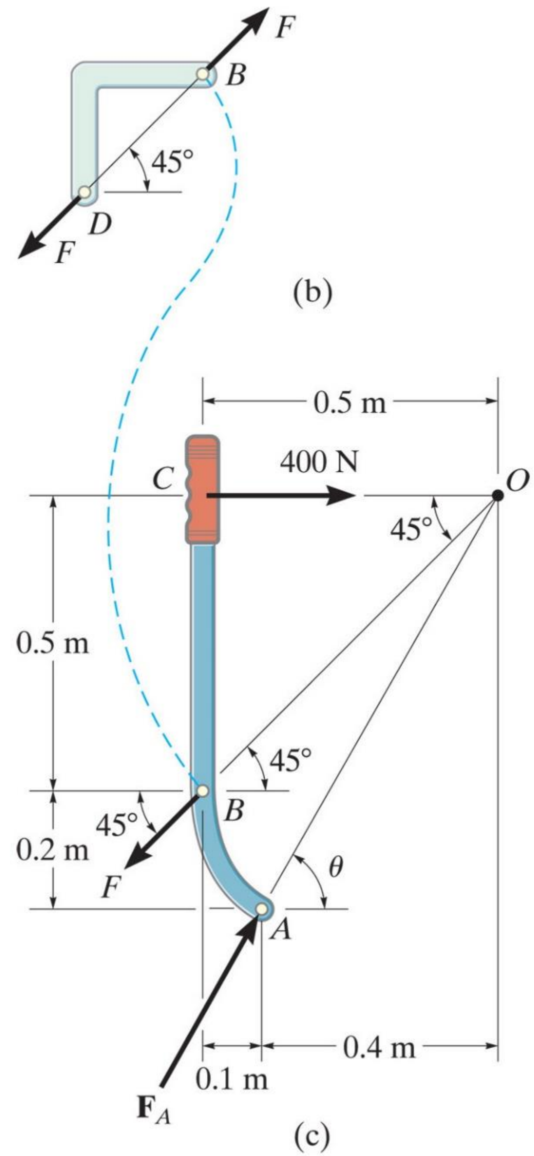
One can use these concepts to quickly identify the direction of an unknown force.

Two-force member:
the two forces at ends are equal, opposite, collinear

Three-force member: a force system where the three forces

1. meet at the same point (point O)
2. are parallel



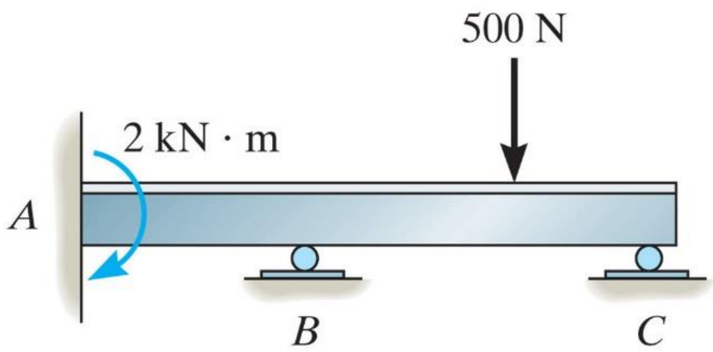


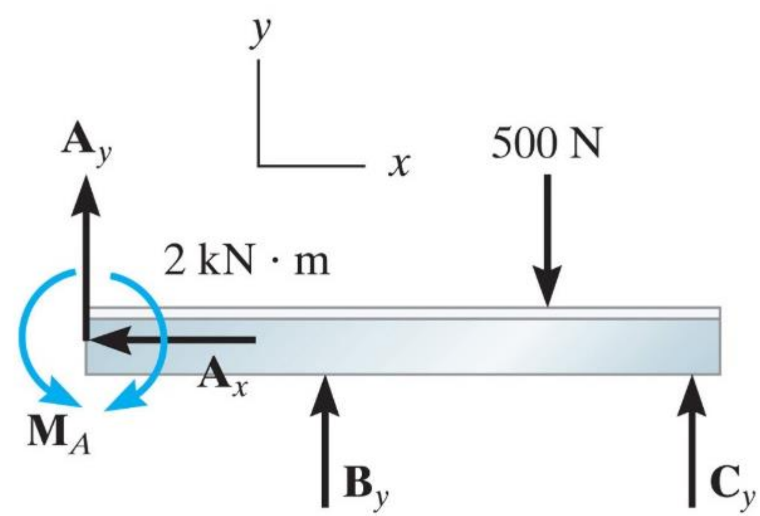
See Example 5.13 in text

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

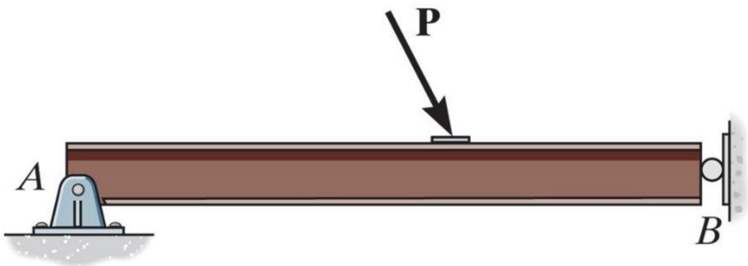
- **Redundant constraints**: the body has more supports than necessary to hold it in equilibrium; the problem is STATICALLY INDERTERMINATE and cannot be solved with statics alone. Too many unknowns, not enough equations

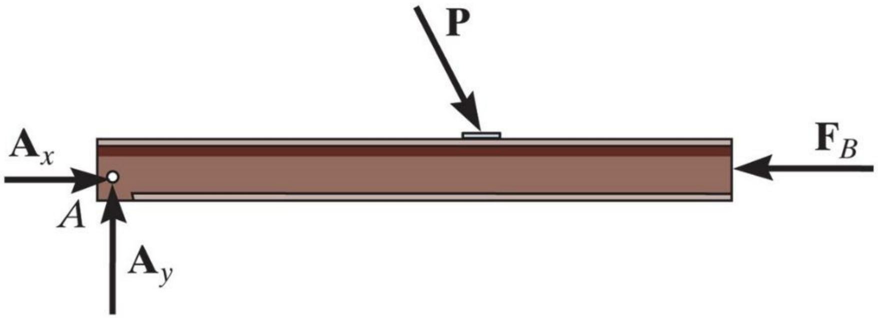




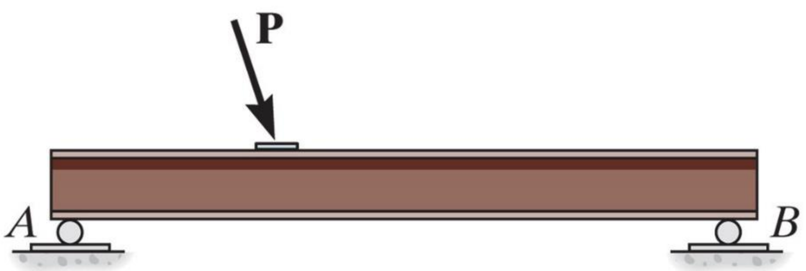
Constraints

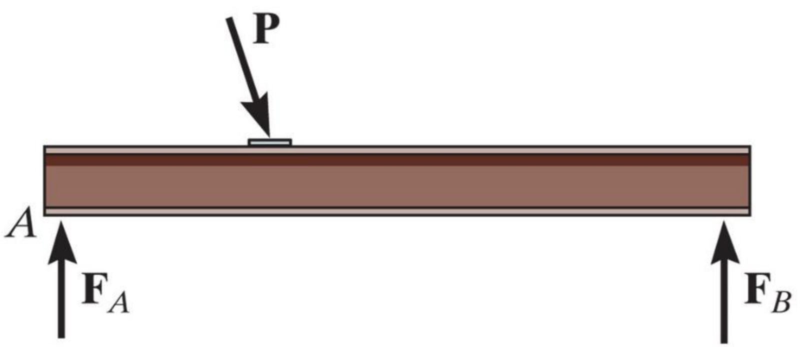
- **Improper constraints:** In some cases, there may be as many unknown reactions as there are equations of equilibrium (statically determinate). However, if the supports are not properly constrained, the body may become unstable for some loading cases.
  - BAD: Reactive forces are concurrent at same point (point A) or line of action



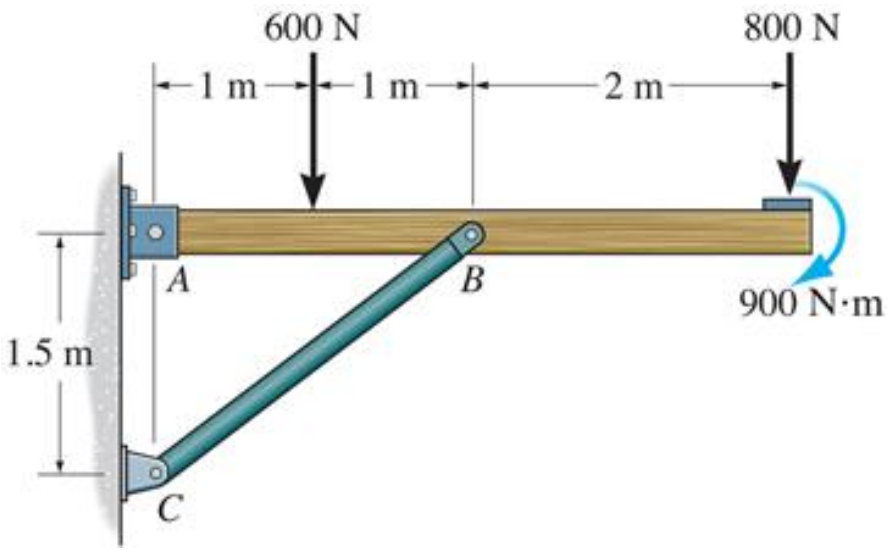


- BAD: Reactive forces are parallel

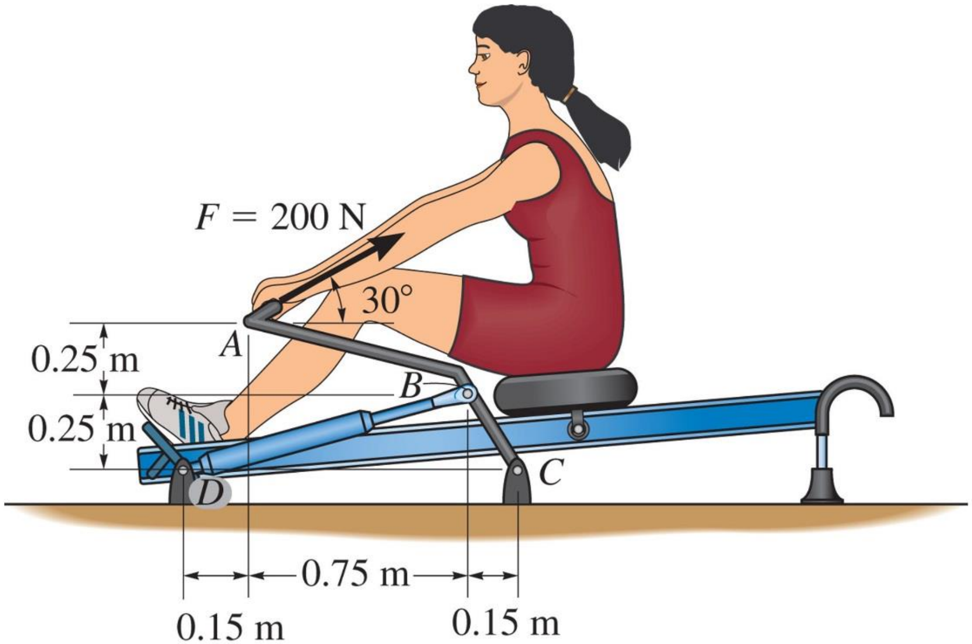




Stable body: lines of action of reactive forces
do not intersect at common axis, and are not parallel

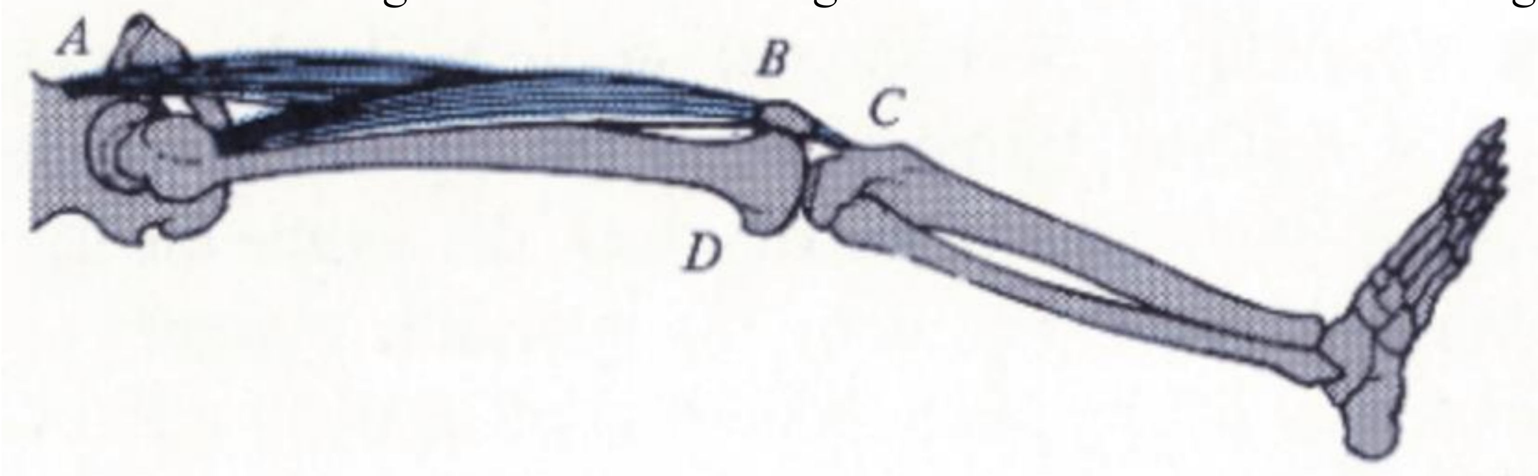


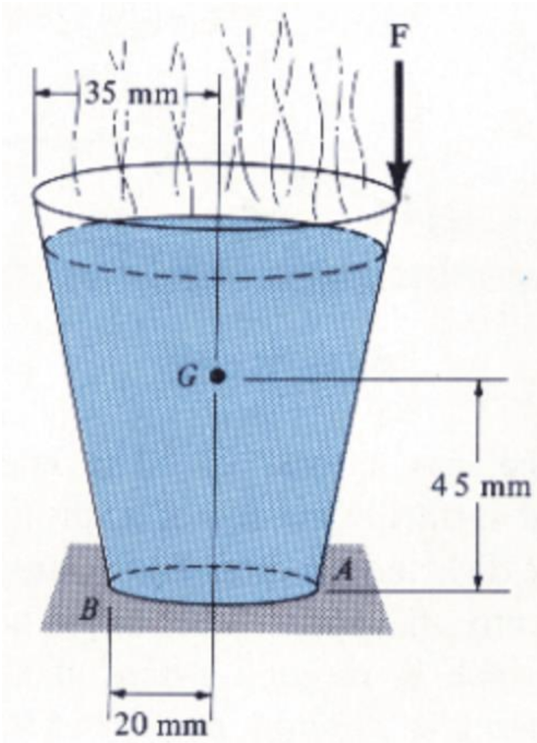
The overhanging beam is supported by a pin at A and the strut BC. Determine the horizontal and vertical components of reaction at A and the reaction at B on the beam.



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

A skeletal diagram of the lower leg is shown. Model the lower leg and determine the tension T in the quadriceps and the magnitude of the resultant force at the femur (pin) at D in order to hold the lower leg in the position shown. The lower leg has a mass of 3.2 kg and the foot has a mass of 1.6 kg.





The cup is filled with 125 g of liquid. The mass center is located at G. If a vertical force F is applied to the rim of the cup, determine its magnitude so the cup is on the verge of tipping over.