جامعة بيرزيت
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Determinacy and Stability of Structural systems

Determinacy & Stability

- Criteria for the static classification of structures can be stated as
  - If there are more equations than there are unknowns → the structure is statically unstable
  - If there is the same number of equations as unknowns → the structure is statically determinate
  - If there are fewer equations than unknowns → the structure is statically indeterminate
- The first criterion is absolute, the second and third are conditions
- For a given 2D structural member, How many equilibrium equations can you develop?

Determinacy & Stability

- Structure is statically indeterminate when there are more reaction components available and/or member forces present than are necessary for the stability of the structure. The indeterminacy can be externally or internally.
- Redundant reaction/force: reaction or force that is an excess one, in other words unnecessary for the stability of the structure
  - Static indeterminacy refers the number of force quantities that must be determined in order to render the equilibrium solution complete

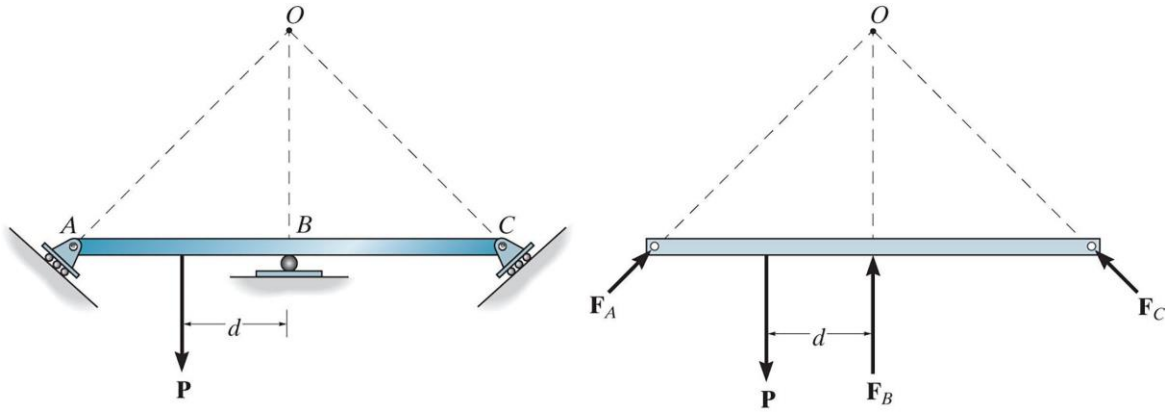
  - Kinematic indeterminacy refers to the number of displacement quantities (kinematic degrees of freedom) that are necessary to define the deformational response of the structure. (Bar element vs. Beam element)

Determinacy & Stability

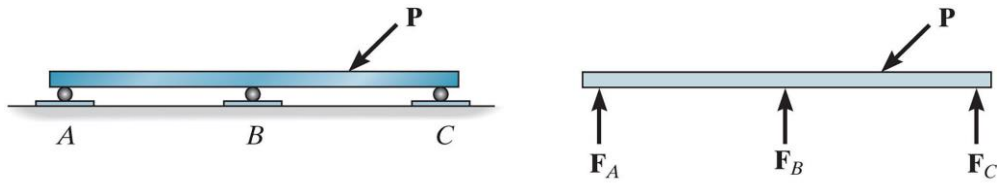
- Pros
  - Saving in material in the design stage, as maximum stresses and deflections of indeterminate structures are generally smaller than those of statically determinate structures
  - Statically indeterminate structure tends to redistribute its load to its redundant supports or members in cases of overloading or failure.
- Cons
  - Difficulty in analysis; it needs equilibrium and compatibility equations and force-displacement relations to solve an indeterminate system
  - Differential settlements and thermal action cause additional internal stresses in the structural members

Determinacy & Stability

- To ensure the equilibrium of a structure or its members, it is not only necessary to satisfy the equations of equilibrium, but the members must also be properly held or constrained by their supports.
- The following situations may occur, and they are examples of instability of structural systems



Concurrent reactions



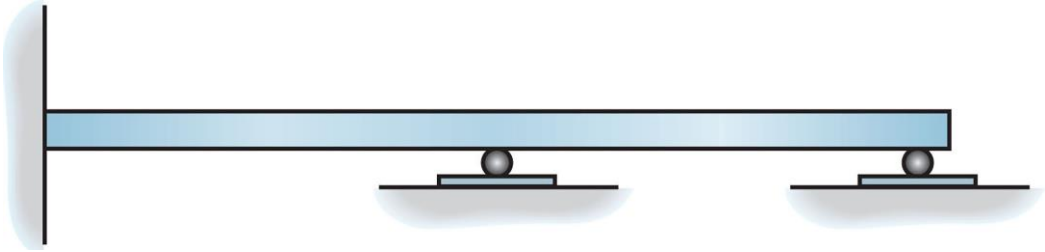
Parallel reactions

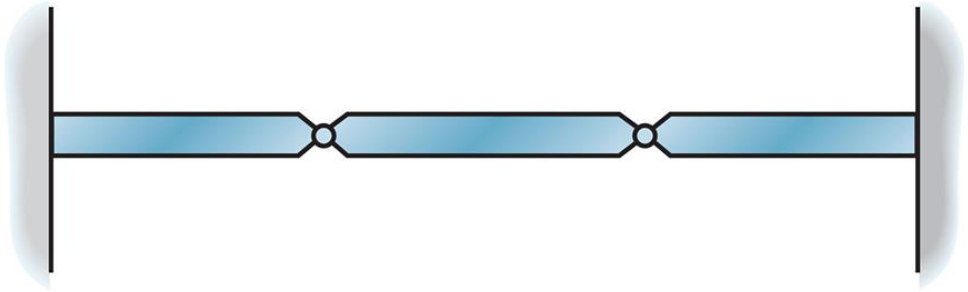
Determinacy & Stability

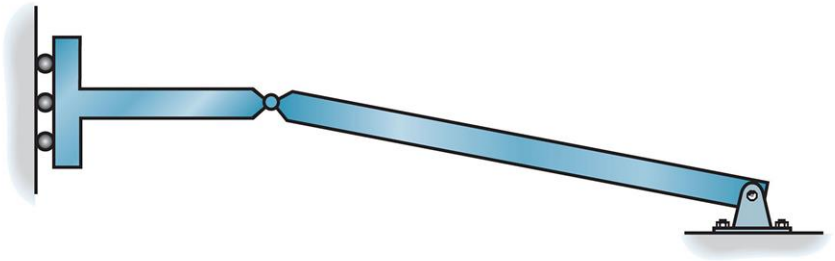
$r = 3n$, statically determinate

$r > 3n$, statically indeterminate

- Beams





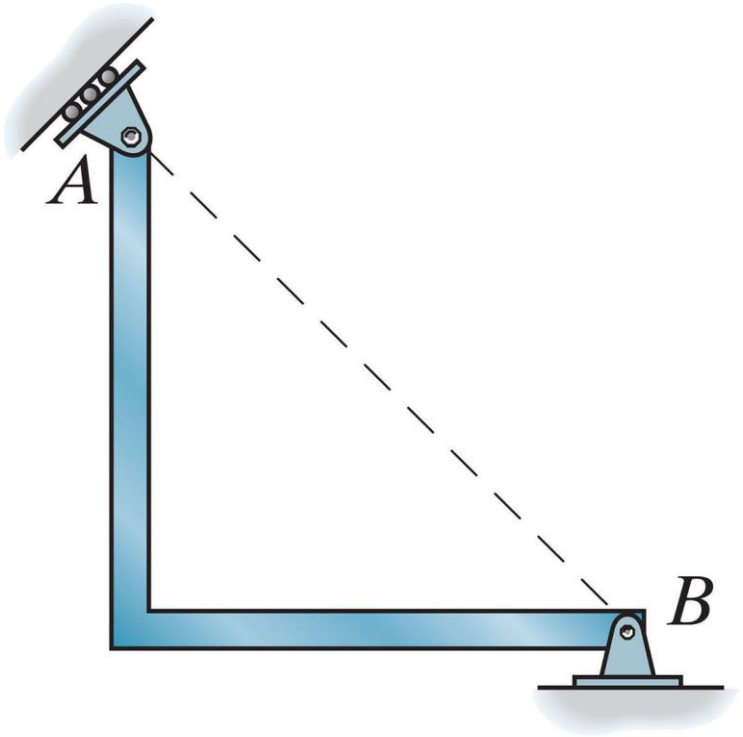


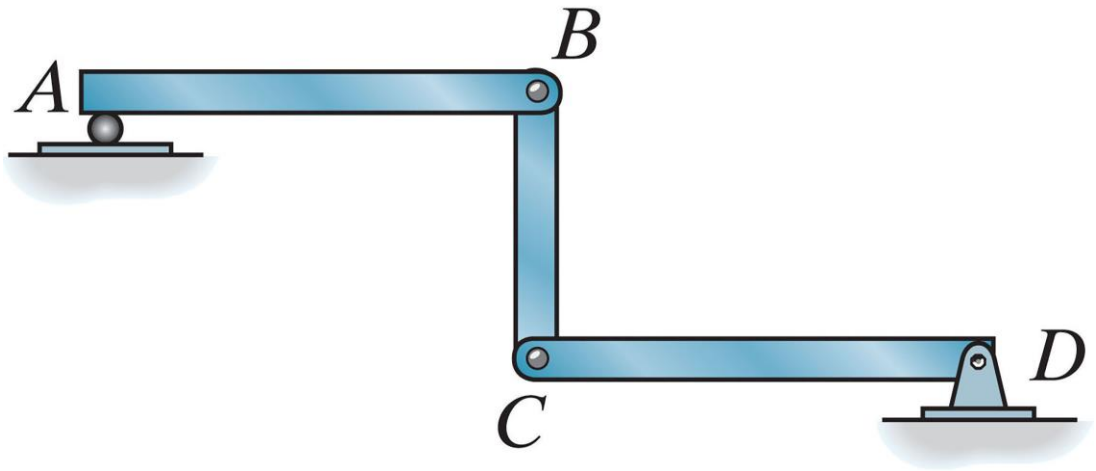
Determinacy & Stability

$r = 3n$, statically determinate

$r > 3n$, statically indeterminate

- Stable or Unstable ??



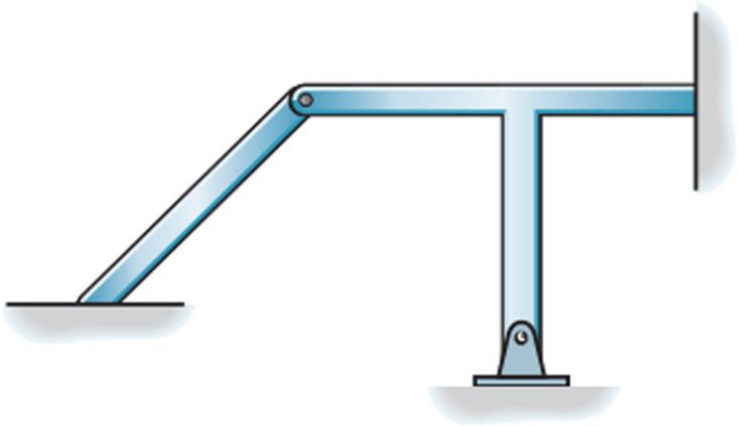


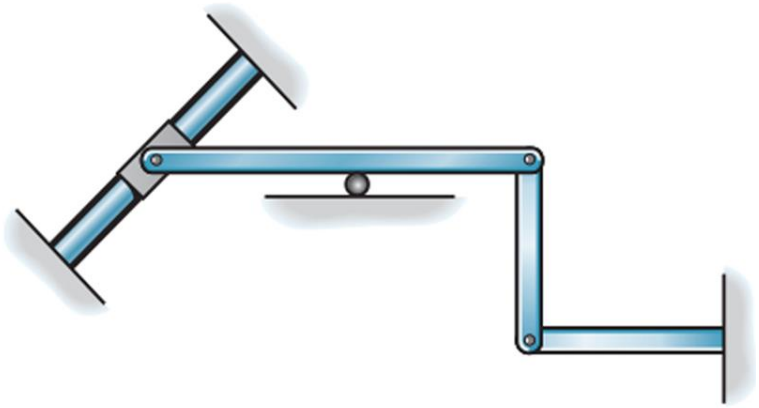
Determinacy & Stability

$r = 3n$, statically determinate

$r > 3n$, statically indeterminate

- Frames





External vs. Internal