Analysis of Statically Determinate Structures

ECE479 Structural Analysis II

Text Book

Structural Analysis

by

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Lecture Outlines

- Idealized Structure
- Equations of Equilibrium
- Determinacy and Stability

Intended Learning Outcomes

By the end of today's session student's should be able to:

- Idealize a structure
- Determine Determinacy and Stability of structure

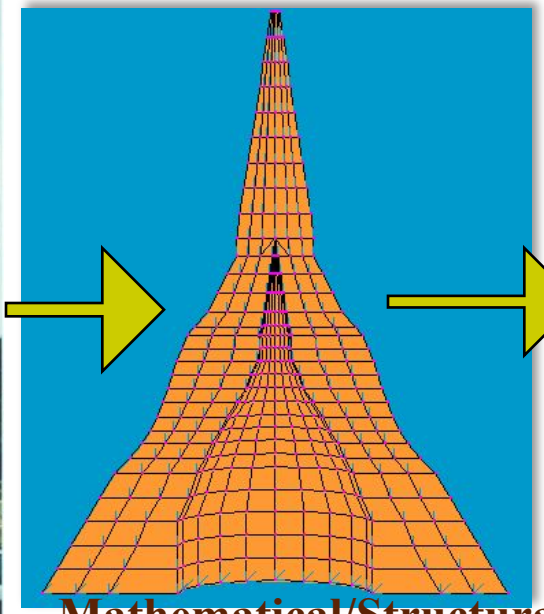
Why Idealize Structure?

- Exact analysis --- Not possible
  - Estimate
    - Loading and its point of application
    - Strength of the Materials

EXCITATION

Loads
Vibrations
Settlements
Thermal Changes

Real Structure



Mathematical/Structural Model

RESPONSES

Displacements
Strains
Stress
Stress Resultants

Support Connections

Types --- Usually Three

- Pin supported connection
- Roller supported connection
- Fixed supported connection

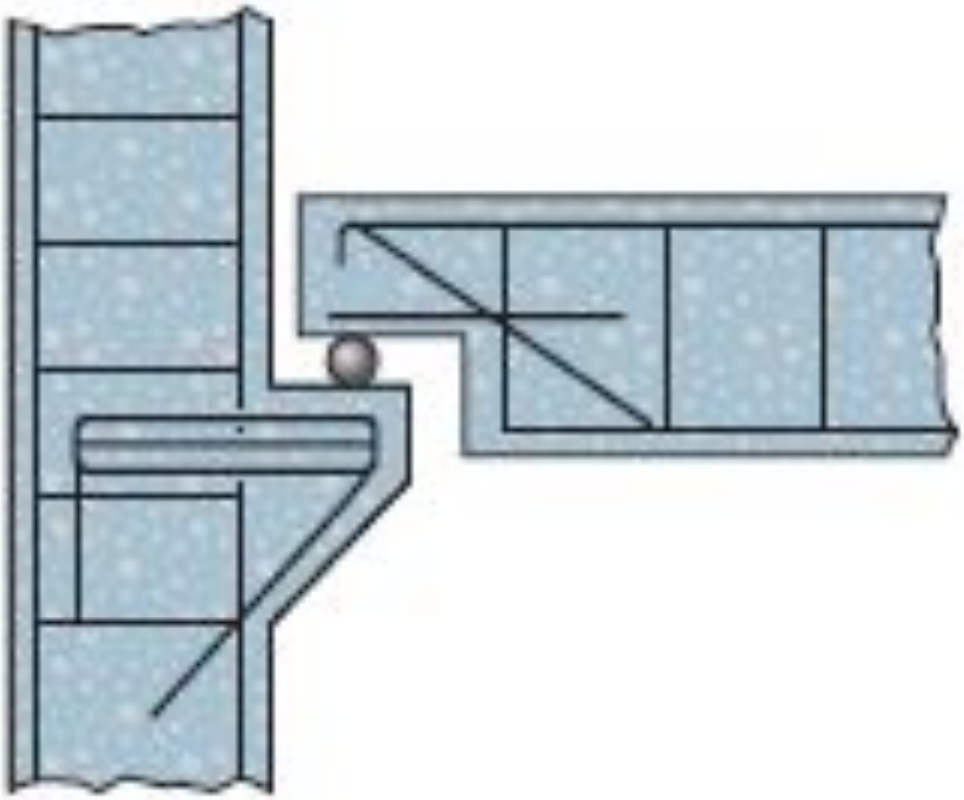
Support Connections- Roller support

- Roller support - Deck of concrete bridge (One section considered roller supported on other section)

Support Connections- Roller support

- Roller support - Used to supports prestressed girders of a highway bridge.

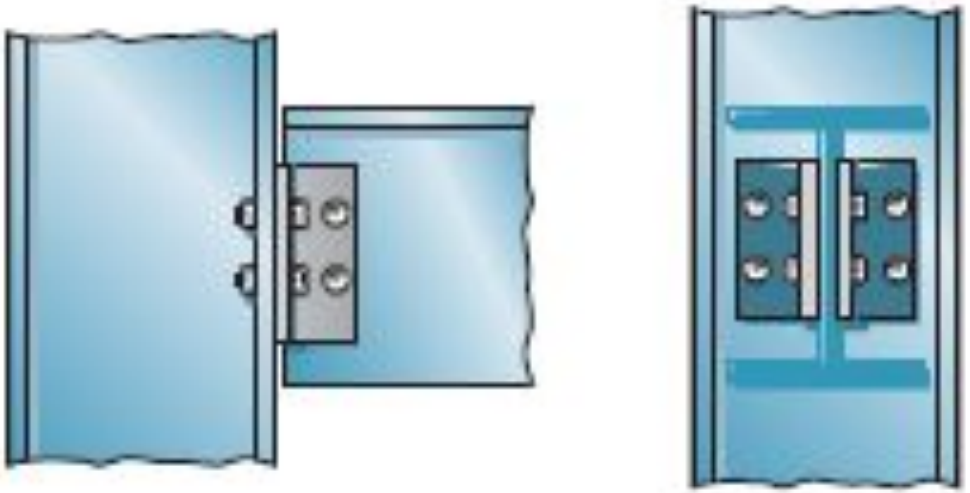
Support Connections- Roller support



- Roller supported Concrete connection

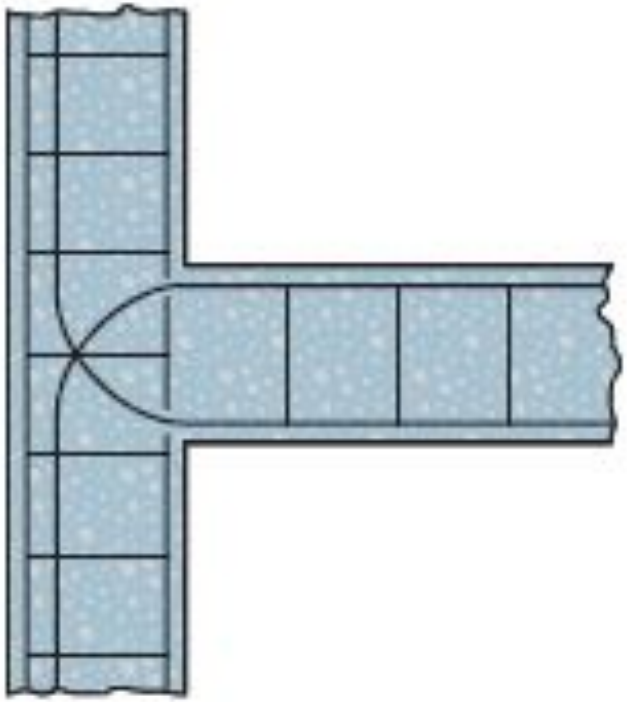
Support Connections – Pin support

Pin support - Steel girder Railway bridge

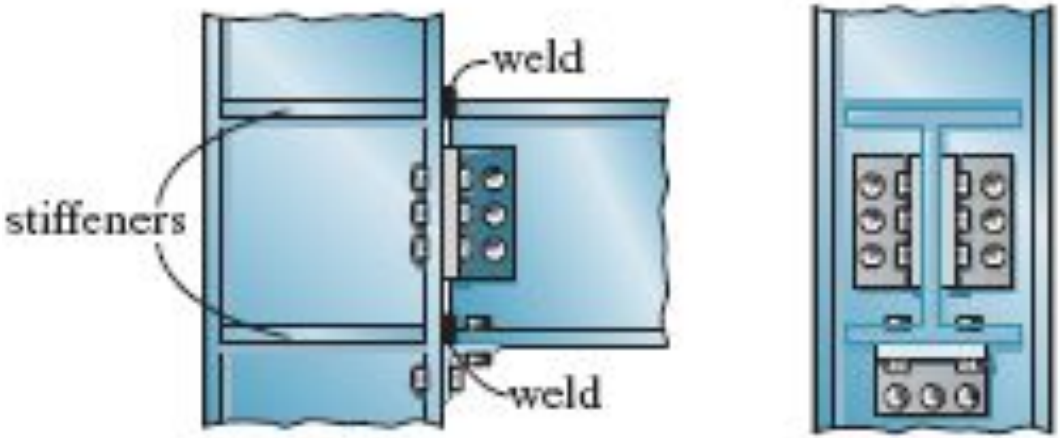


Pin supported Metal connection

Support Connections – Fixed support



Fixed supported
Concrete connection



Fixed supported
Metal connection

Hinge Support

Roller Support

Equations of Equilibrium

- For complete static equilibrium in 2D, three requirements must be met:

  1. External Horizontal forces balance (translation).

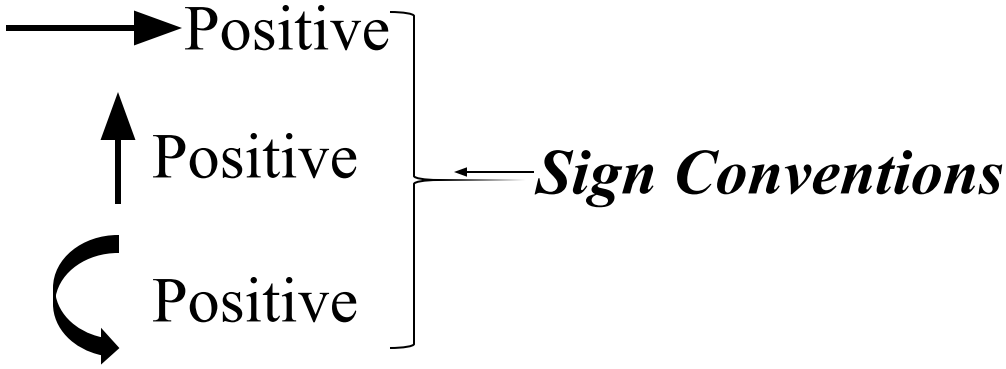
  2. External Vertical forces balance (translation).

  3. External Moments balance about any point (rotational).

Equations of Equilibrium

- For two-dimensional system of forces and moments, the equilibrium equations are:

1. $\Sigma F_x = 0$
2. $\Sigma F_y = 0$
3. $\Sigma M_z = 0$



Determinate vs Indeterminate Structure

- When all the forces in a structure can be determined from the equilibrium equations, the structure is referred to as *statically determinate*.
- When the unknown forces in a structure are more than the available equilibrium equations, that structure is known as *statically indeterminate*.

Determinacy

- For a coplanar structure, there are at most three equilibrium equations for each part.

  If there is a total of *n* parts and *r* force and moment reaction components, we have

  $r = 3n$ *statically determinate*

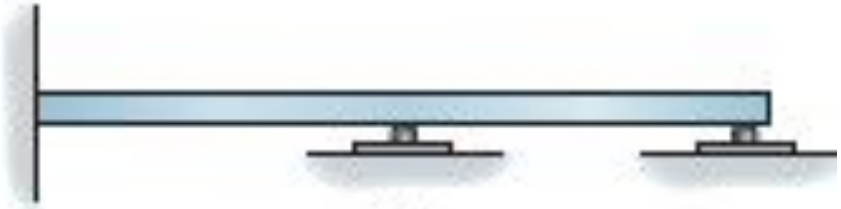
  $r > 3n$ *statically indeterminate*

Determinate vs Indeterminate Structure – Examples (Beams)

(a)

$r = 3, n = 1, 3 = 3(1)$

Statically determinate

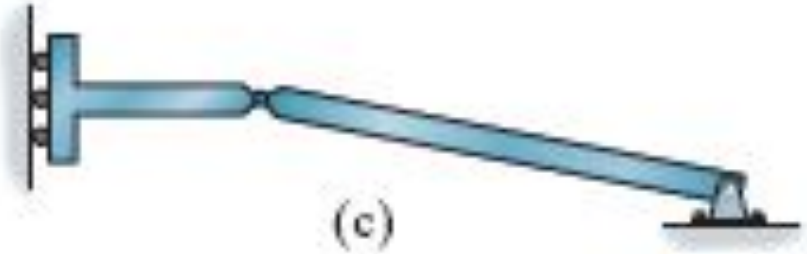


(b)

$r = 5, n = 1, 5 > 3(1)$

Statically indeterminate to the second degree

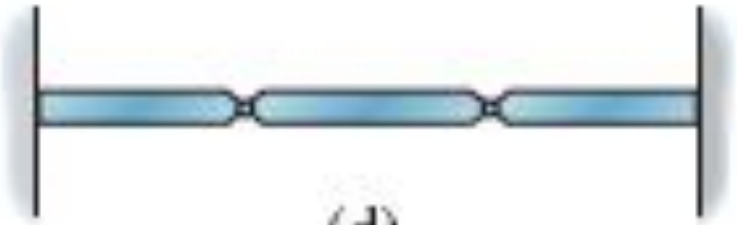
Determinate vs Indeterminate Structure – Examples (Beams)



(c)

$r = 6, n = 2, 6 = 3(2)$

Statically determinate

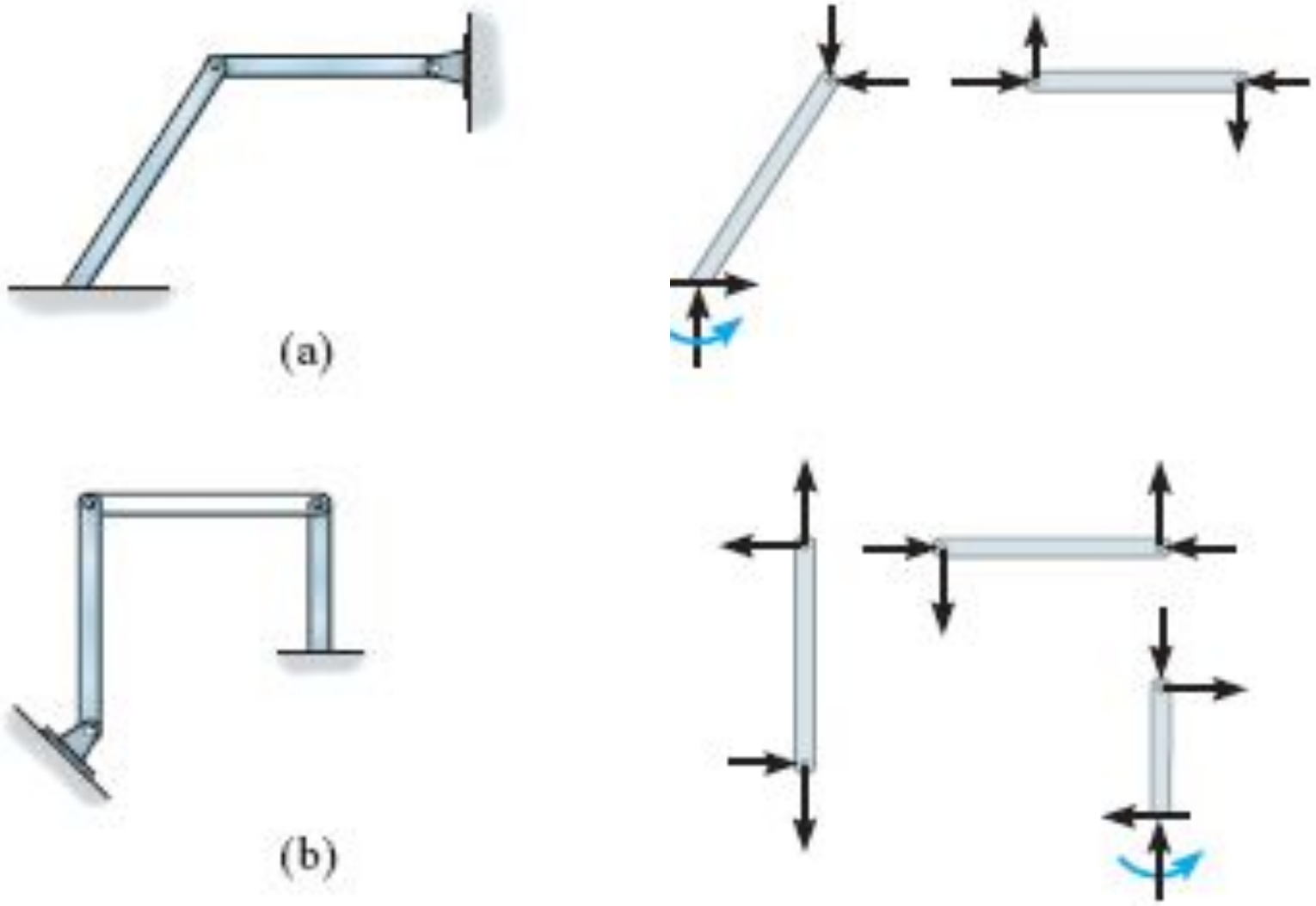


(d)

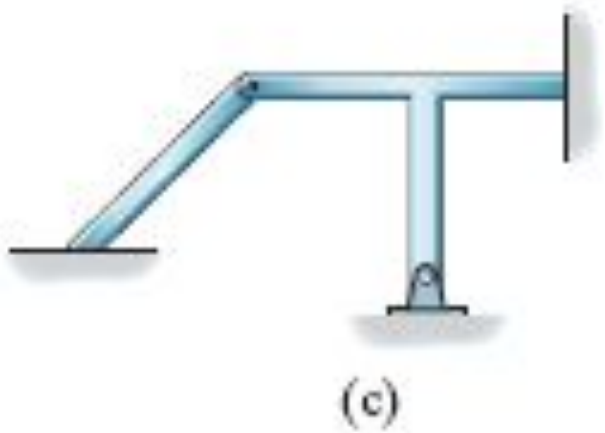
$r = 10, n = 3, 10 > 3(3)$

Statically indeterminate to the first degree

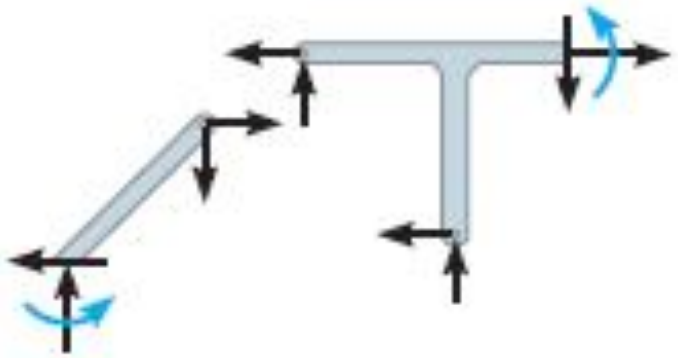
Determinate vs Indeterminate – Examples (Pin-connected structures)

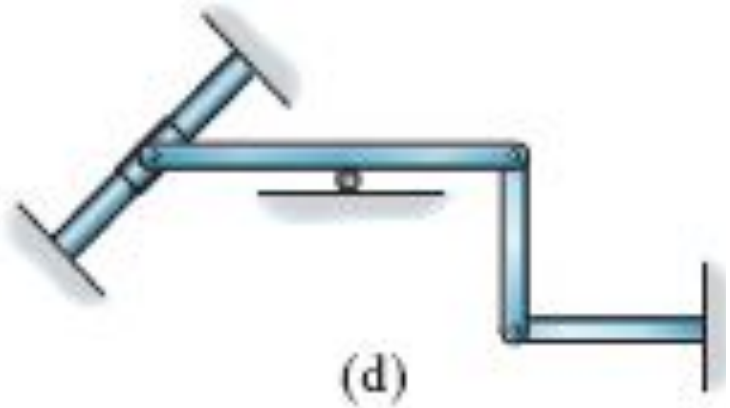


Determinate vs Indeterminate – Examples (Pin-connected structures)

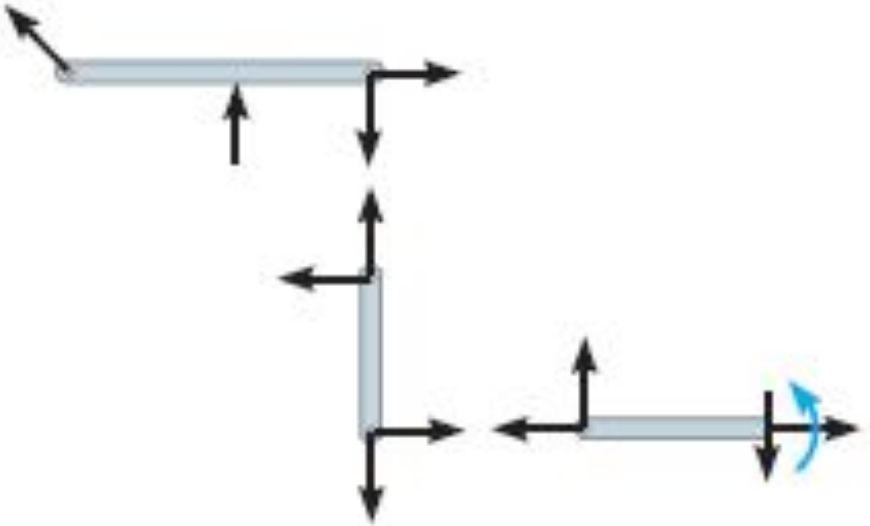


(c)

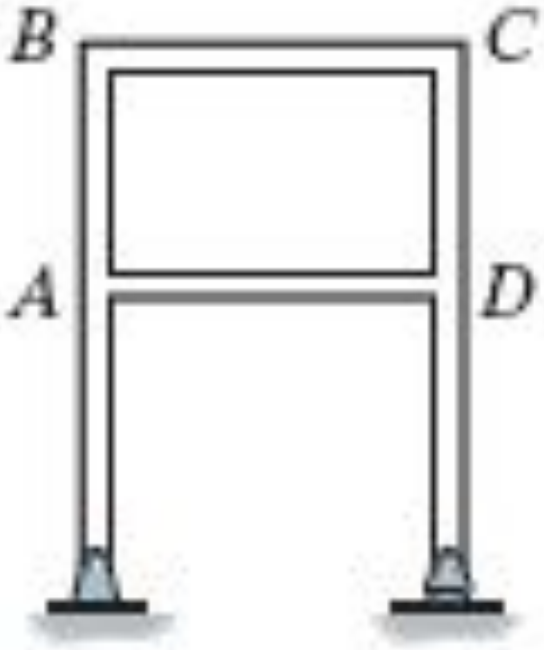


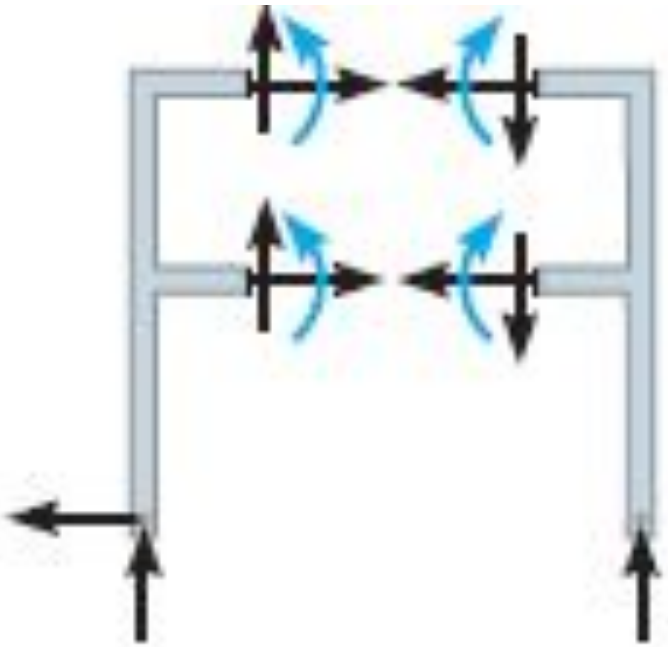


(d)



Determinate vs Indeterminate Structure – Examples (Frame)

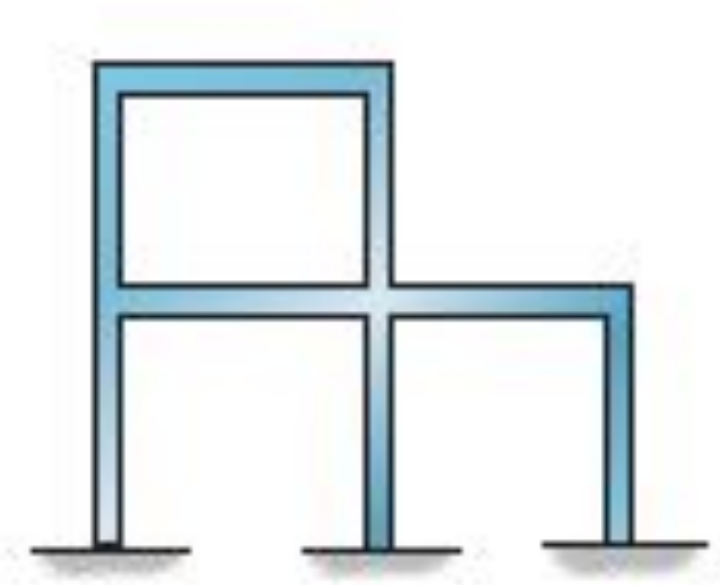


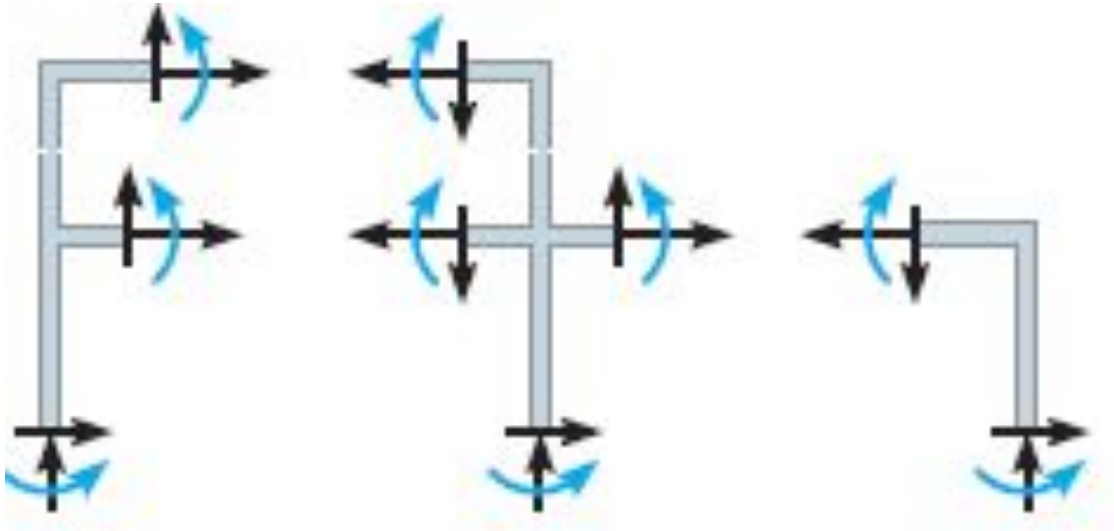


$r = 9, n = 2, 9 > 6,$
Statically indeterminate to the third degree

Ans.

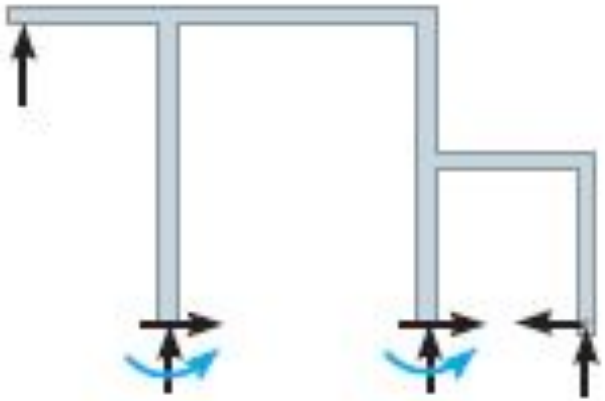
Determinate vs Indeterminate Structure – Examples (Frame)



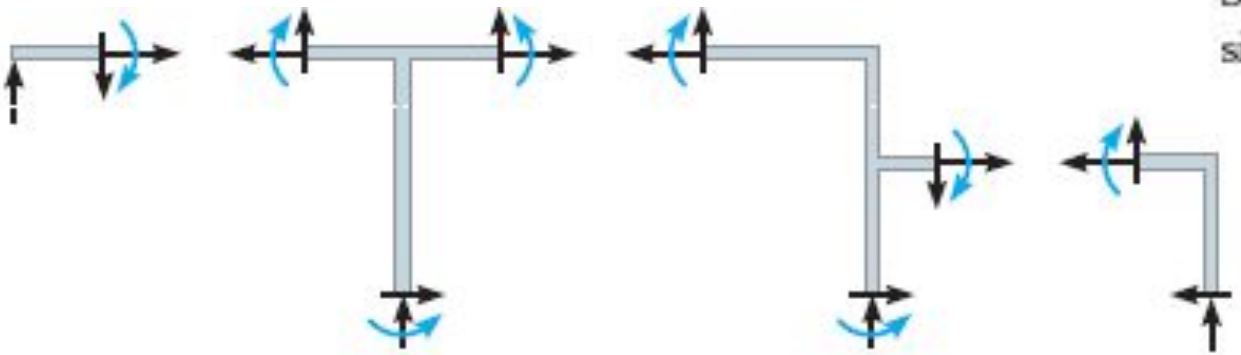


$r = 18,\ n = 3,\ 18 > 9,$
Statically indeterminate to the ninth degree *Ans.*

Determinate vs Indeterminate Structure – Examples (Frame)



$r = 9, n = 1, 9 > 3,$
Statically indeterminate to the sixth degree *Ans.*



(c)

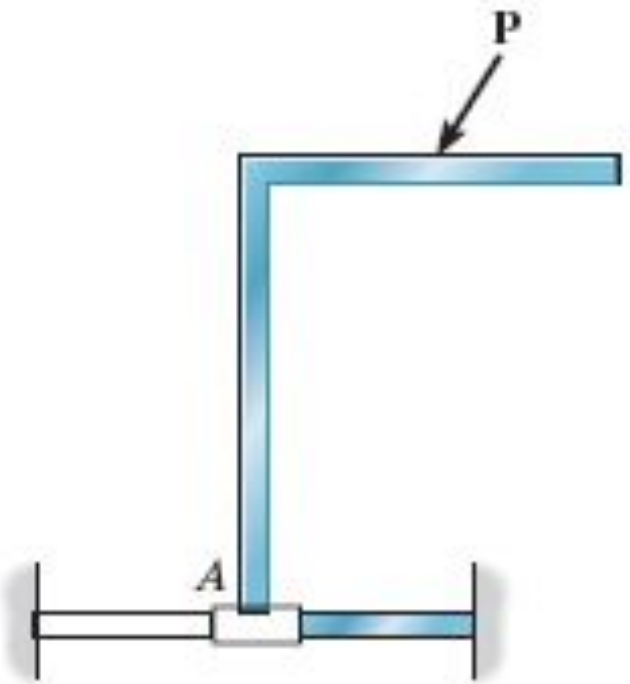
$r = 18, n = 4, 18 > 12,$
Statically indeterminate to the sixth degree *Ans.*

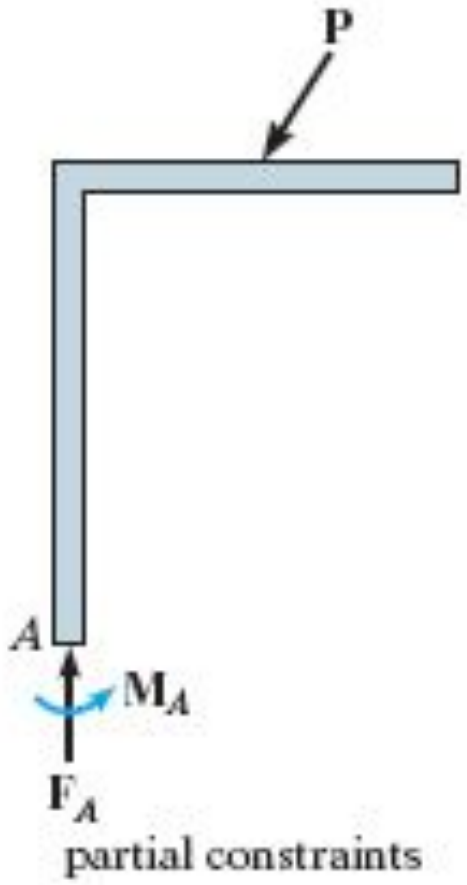
Stability

- What conditions are necessary To ensure equilibrium of a structure?
- A structure will be unstable if
- there are fewer reactive forces than equations of equilibrium **(Partial Constraints)**

  or
- there are enough reactions and instability will occur if the lines of action of reactive forces intersect at a common point or are parallel to one another **(Improper Constraints)**

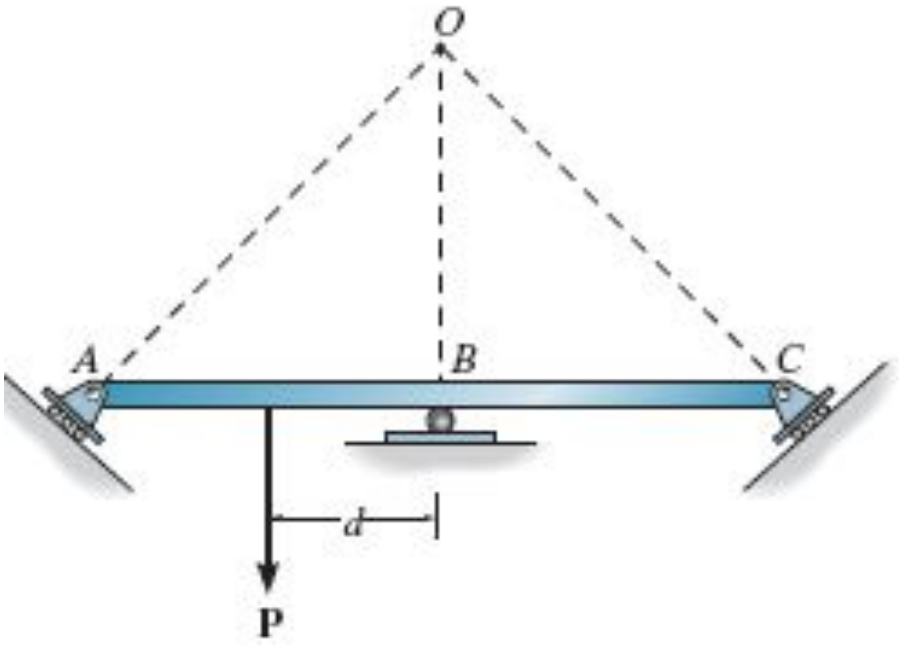
Stability – Example – Partial Constraints

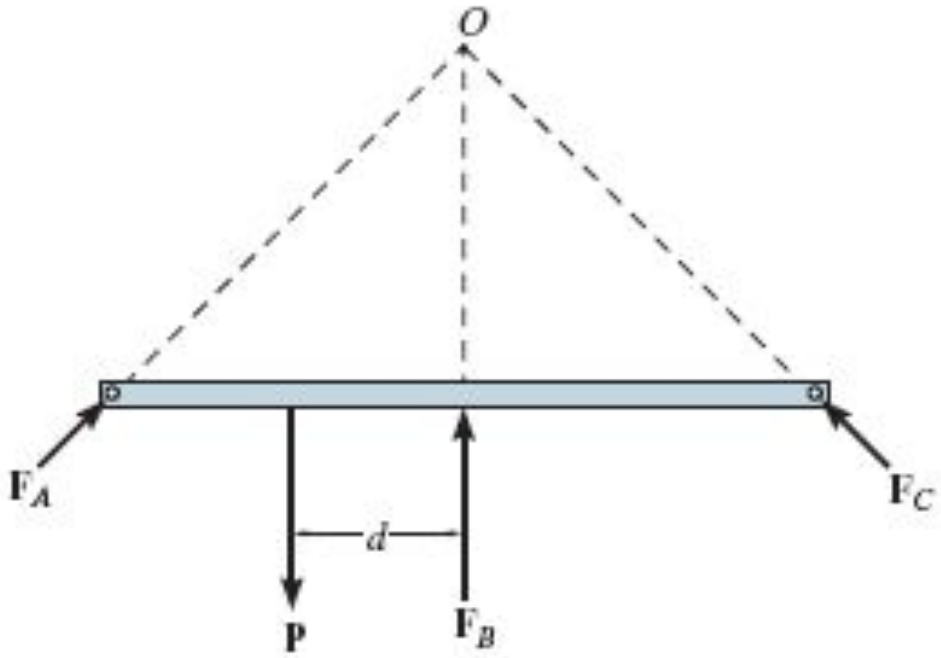




partial constraints

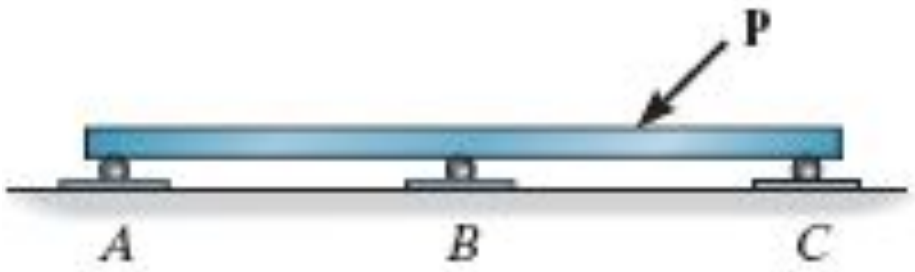
Stability – Example – Improper Constraints

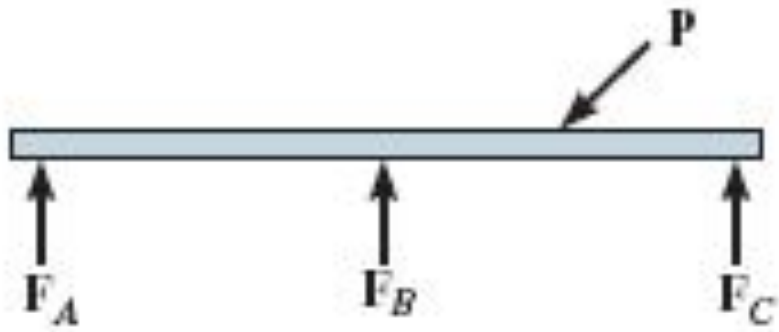




concurrent reactions

Stability – Example – Improper Constraints





parallel reactions

Stability

r < 3n unstable

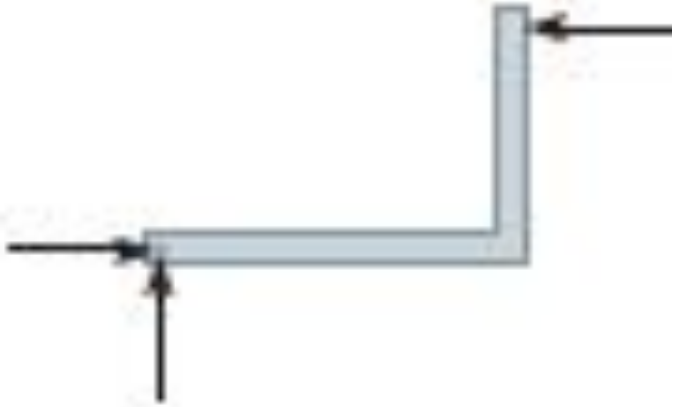
r ≥ 3n unstable if member reactions are concurrent or parallel or some of the components form a collapsible mechanism

r --- Unknown reactions

n--- Members

Unstable structures Must be avoided in practice

Stability – Examples



Stable

Unstable

Stability

$r < 3n$ unstable

$r \geq 3n$ unstable if member reactions are concurrent or parallel or some of the components form a collapsible mechanism

r --- Unknown reactions

n--- Members

Summary

Now You should be able to:

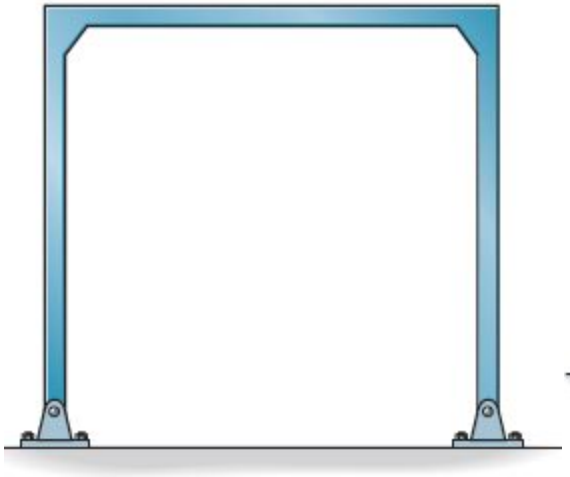
- Idealize a structure
- Determine Determinacy and Stability of structure

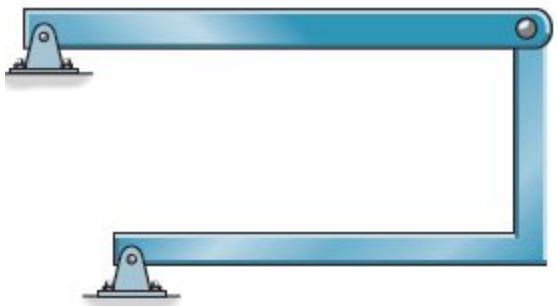
Assignment 1

Issue Date 16-1-2017

Submission Date 23-1-2017

- Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy





Assignment 1

Issue Date 23-1-2017

Submission Date 30-1-2017

- Classify each of the structures as statically determinate, statically indeterminate, or unstable. If indeterminate, specify the degree of indeterminacy