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THEORY OF STRUCTURES

CHAPTER 1 : DETERMINACY
PART 2

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Chapter 1 : Part 2 - Determinacy

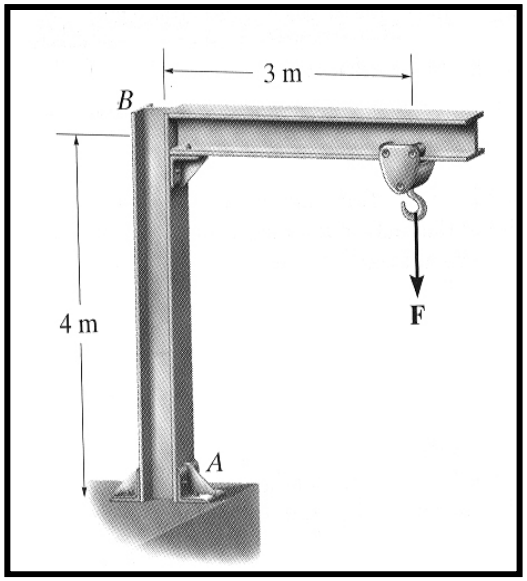
- Aims
  - Identified the determinacy criteria of structure
  - Determine the number of redundancy for the structure.
  - Draw FBD for structures

- Expected Outcomes :
  - Able to identify the stability and determinacy of structures

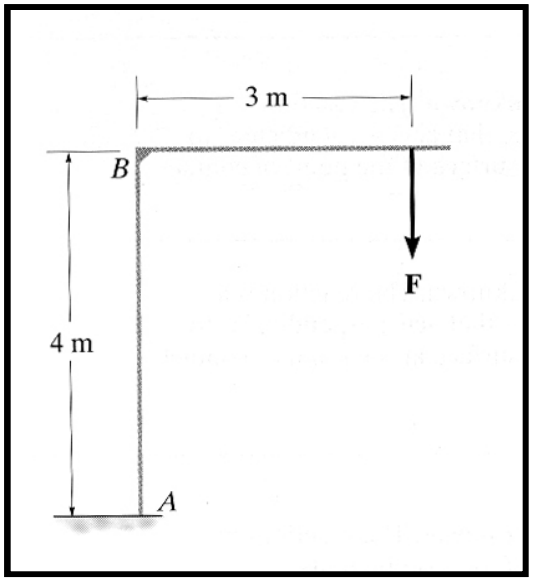
- References

  - Mechanics of Materials, R.C. Hibbeler, 7th Edition, Prentice Hall
  - Structural Analysis, Hibbeler, 7th Edition, Prentice Hall
  - Structural Analysis, SI Edition by Aslam Kassimali,Cengage Learning
  - Structural Analysis, Coates, Coatie and Kong
  - Structural Analysis - A Classical and Matrix Approach, Jack C. McCormac and James K. Nelson, Jr., 4th Edition, John Wiley

1.1 ACTUAL AND IDEALIZED STRUCTURE



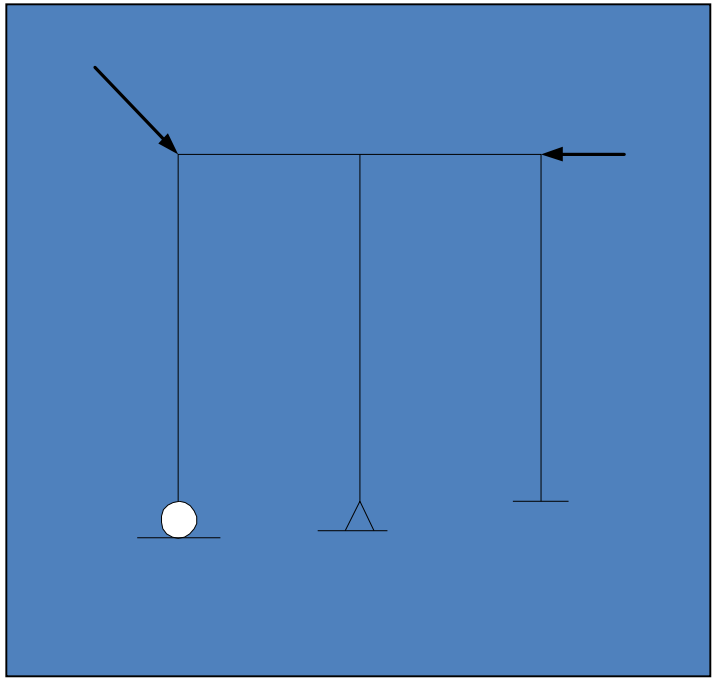
a) Actual Structure



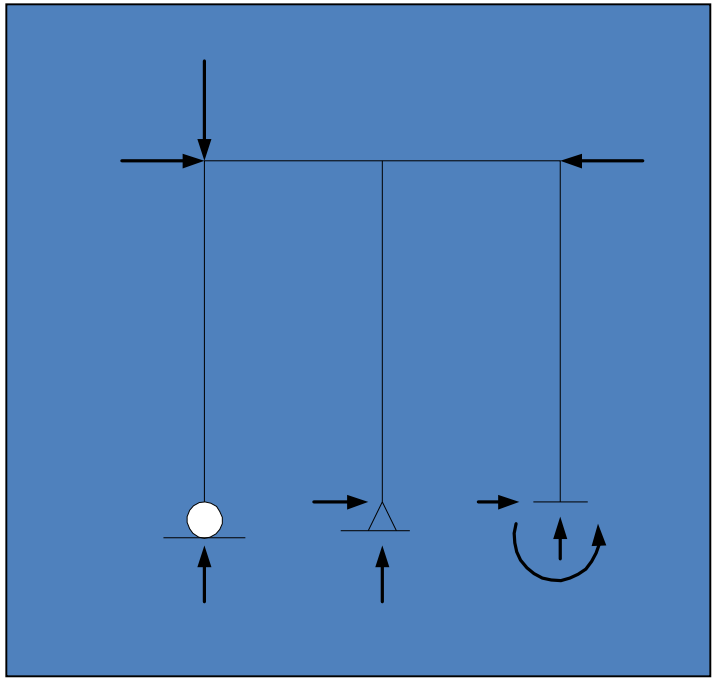
b) Idealized Structure

1.2 FREE BODY DIAGRAM

- Any force system acting on a structure is easily analyzed if the appropriate reactions required to maintain equilibrium are inserted in a diagrams



FBD



1.3 EQUATION OF EQUILIBRIUM

- When the force act in the x-y plane, the equation will be

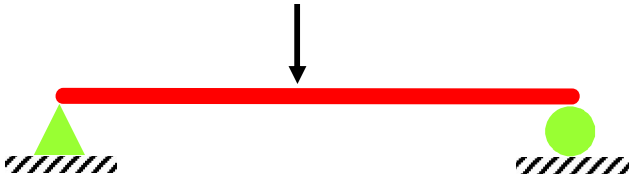
$$F_x = 0$$
$$F_y = 0$$
$$M_z = 0$$

1.4 CONDITION OF DETERMINANCY FOR BEAMS

- To state of static equilibrium, it is necessary to establish the DETERMINACY and STABILITY
- Equilibrium equation provide sufficient conditions for equilibrium. All forces can be determined strictly from these equation
- Structure is referred as STATICALLY DETERMINATE
- However, structure having more unknown forces than available equilibrium equation referred as STATICALLY INDETERMINATE
- This can be determined using a free body diagram

1.4 CONDITION OF DETERMINANCY FOR BEAMS

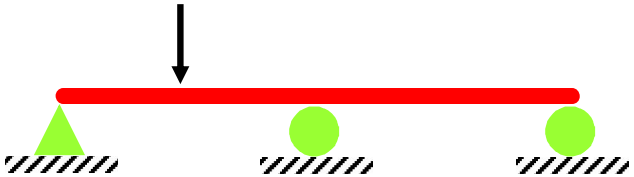
Examples:



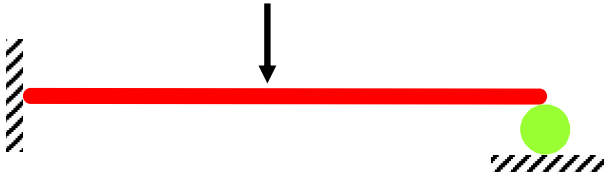
a) Simply Supported Beam

b) Cantilever Beam

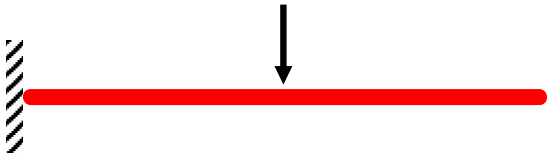
c) Overhanging Beam



a) Continuous Beam



b) End-support or Propped Cantilever Beam



c) Built-in Beam

1.4.1 CONDITION OF DETERMINANCY FOR TRUSSES

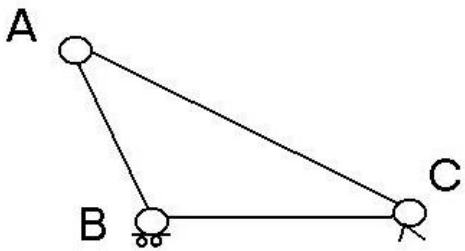
Planar Trusses

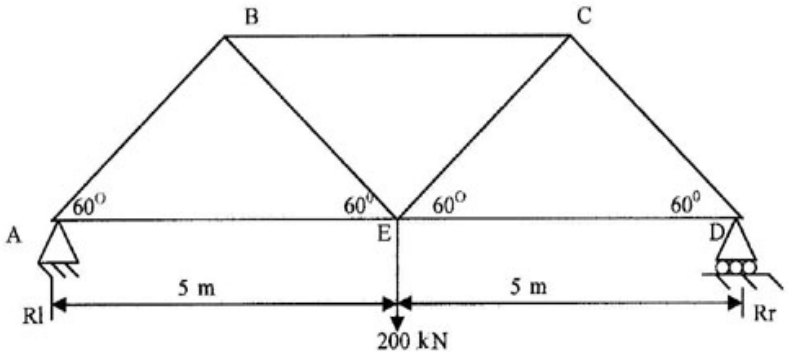
- Simple truss
- Compound truss
- Complex truss

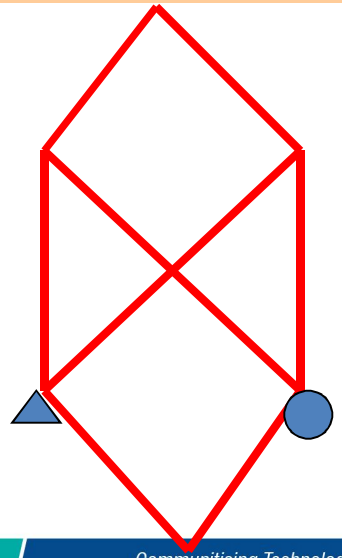
The simplest framework that is rigid and stable – triangle.

foamed by connecting two or more simple truss.

Its cannot be classified either simple or compound truss.

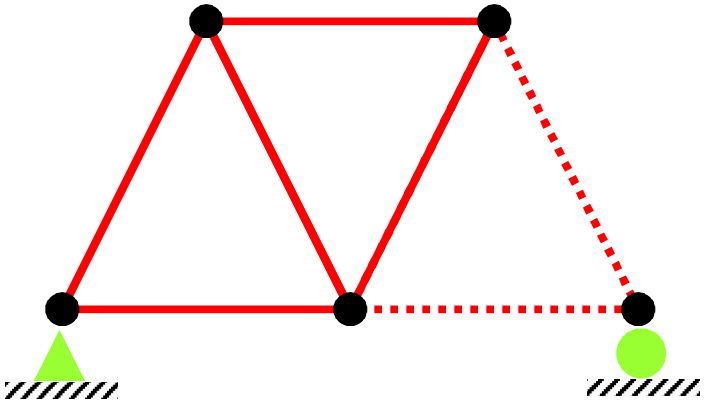


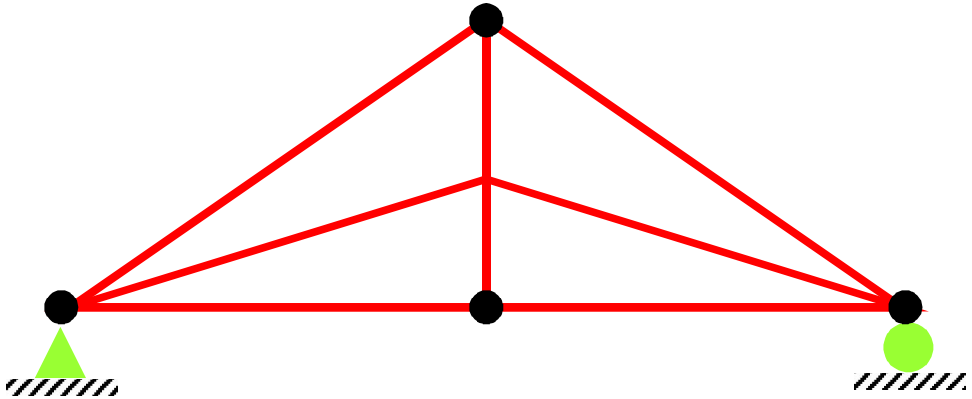


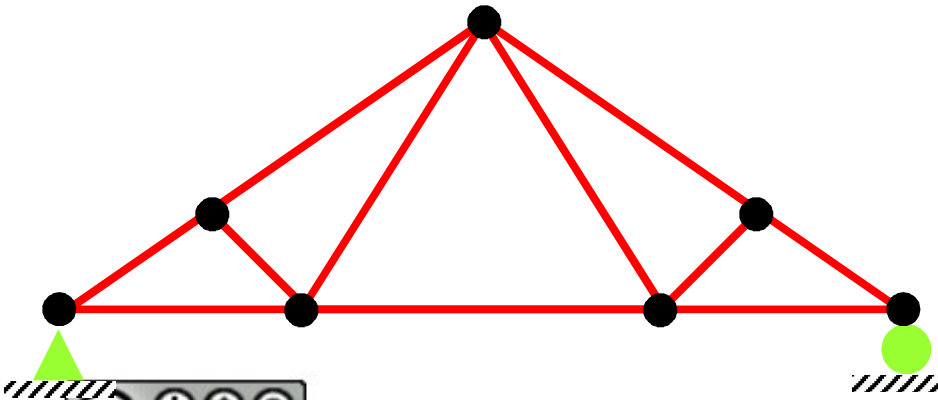


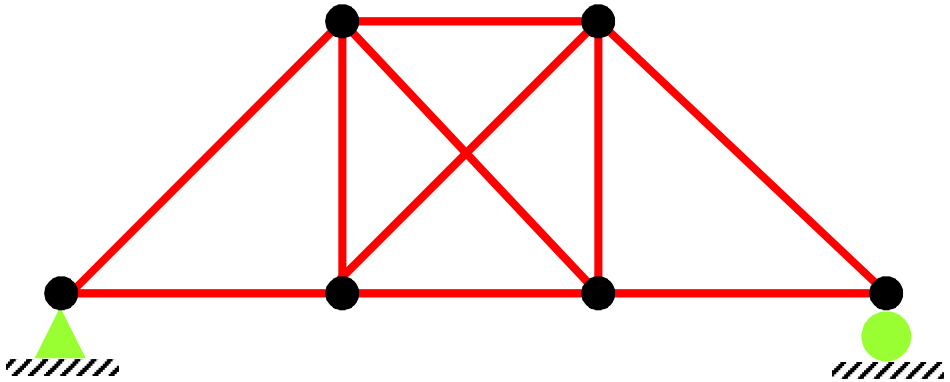
1.4.1 CONDITION OF DETERMINANCY FOR TRUSSES

☞Examples:









1.5 DETERMINACY OF BEAM

• Beam, pin connected and frame are classified as determinate depending upon the internal forces in the member or external support reaction.

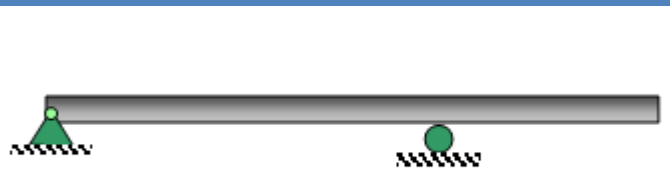
$r = 3n$, statically determinate

$r > 3n$, statically indeterminate

n = the total parts of structure members.

r = the total number of unknown reactive force and moment components

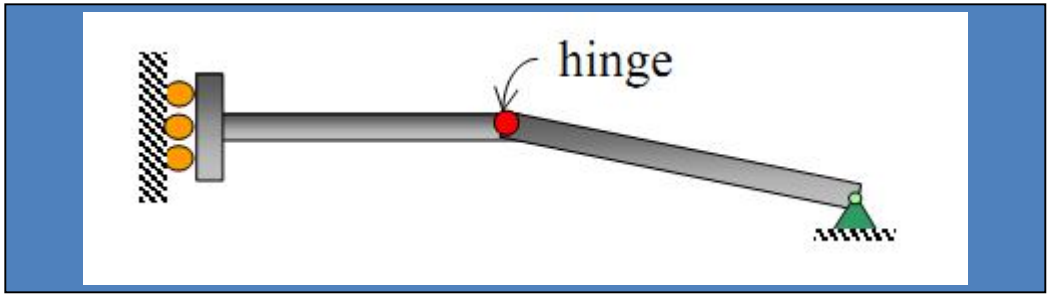
Example 1

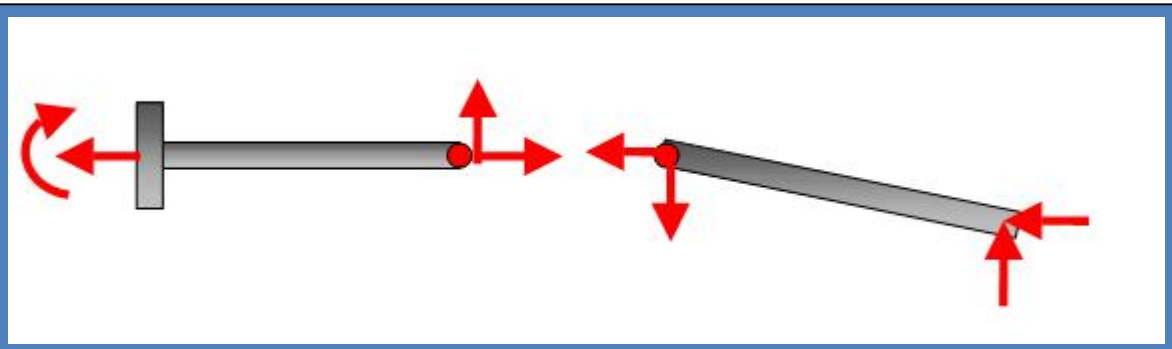


$$r = 3,\ n = 1,\ 3 = 3(1)$$

Statically **determinate**

Example 2



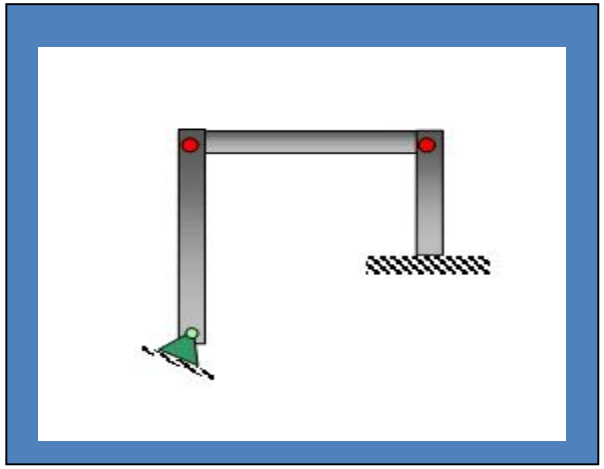


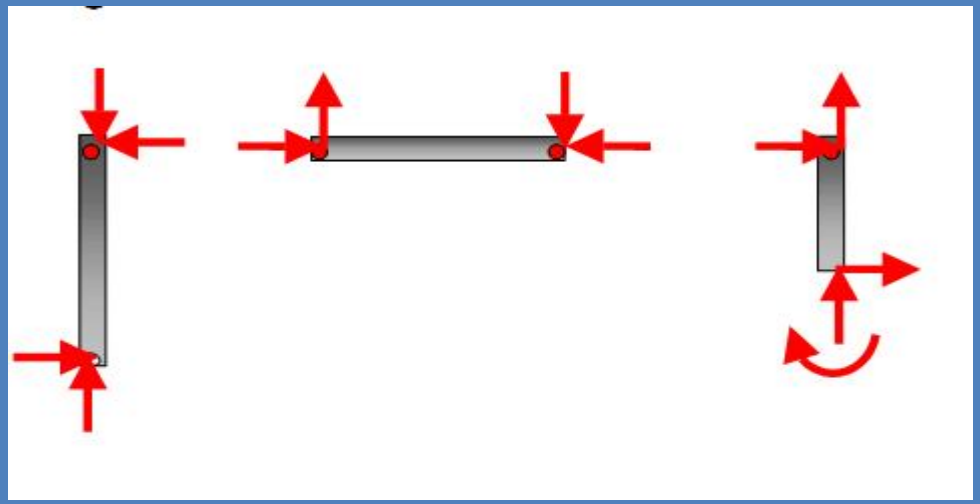
HINGE CONNECTION CONSIDERED TO HAVE 2 REATION

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

Statically **determinate**

Example 3

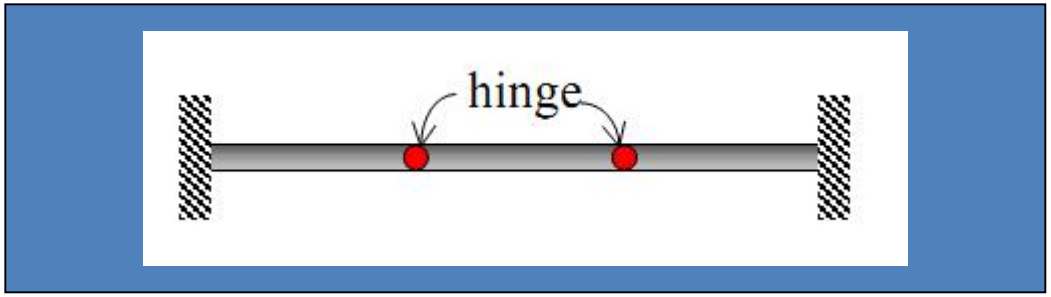


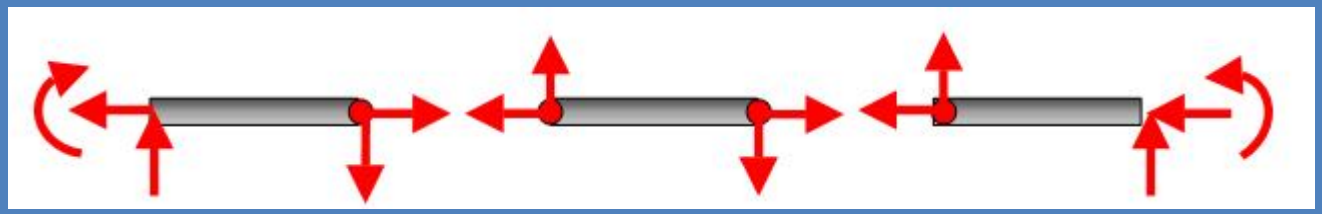


$r = 9, n = 3, 9 = 3(3)$

Statically **determinate**

Example 4



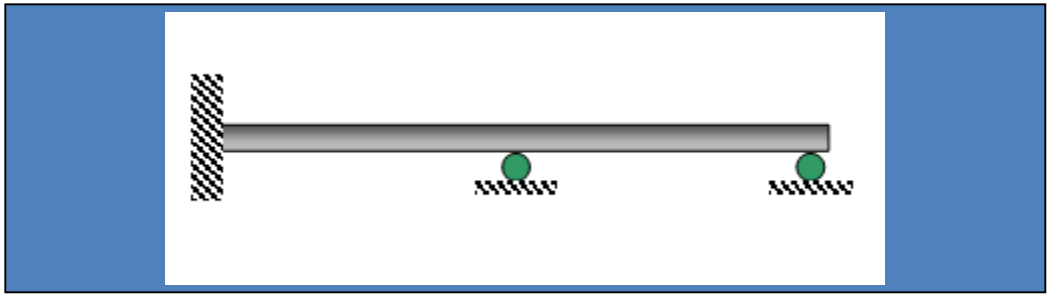


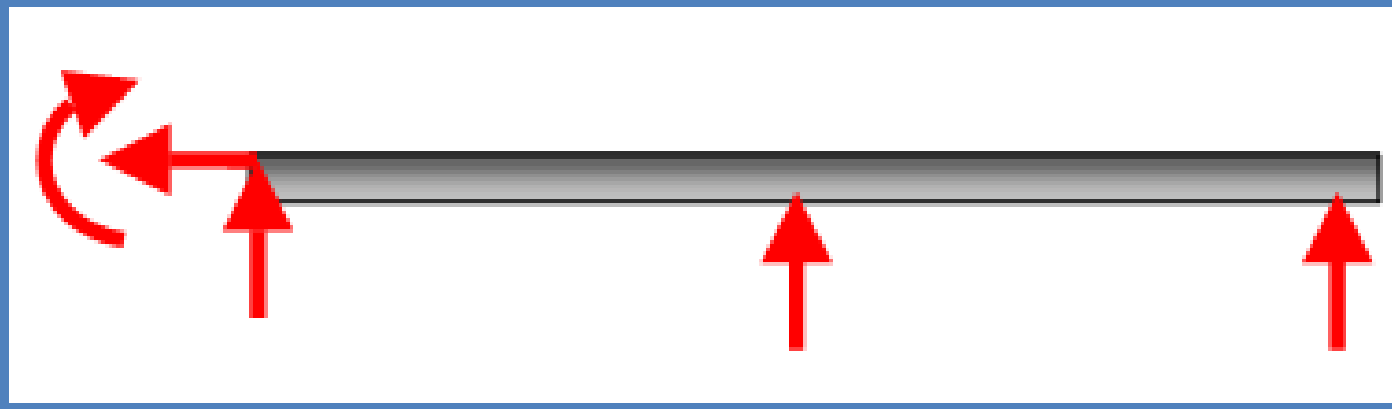
$$r = 10, n = 3$$

10 ≠ 9

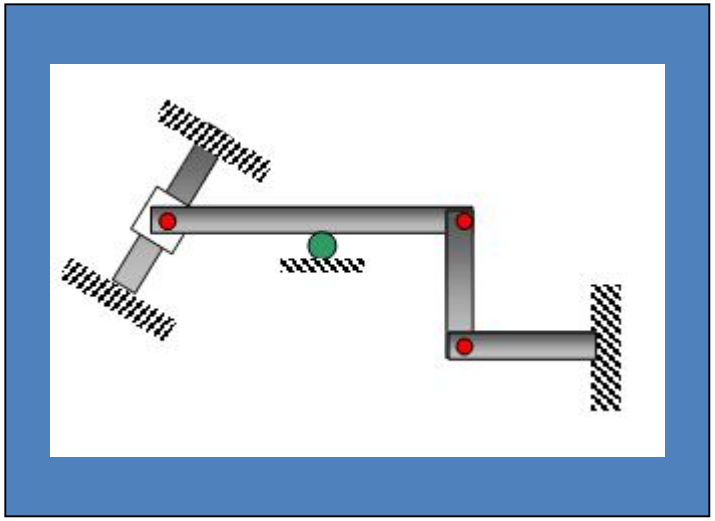
Statically **indeterminate**

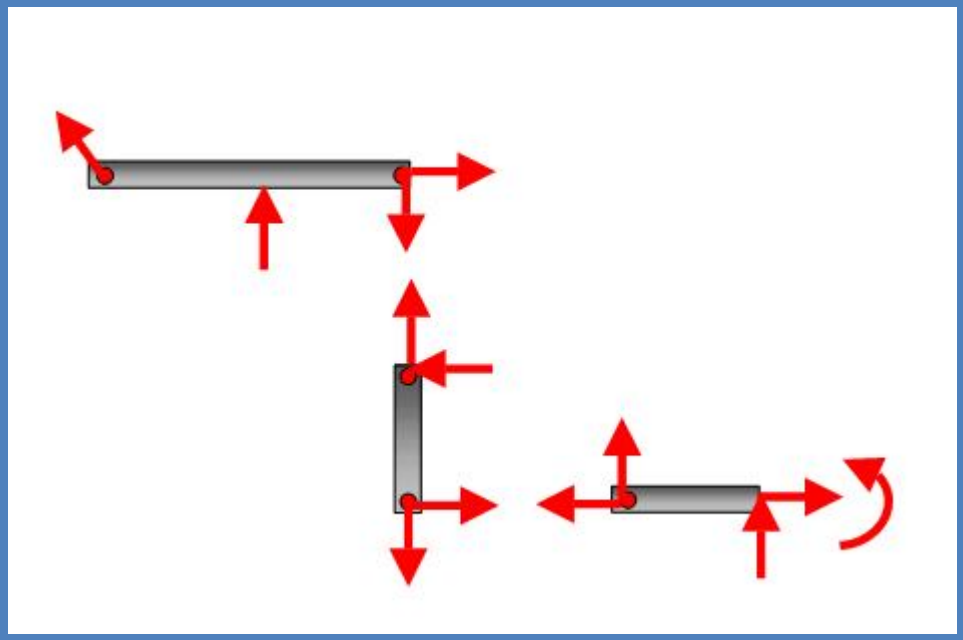
Exercise 1





Exercise 2





1.6.2 Trusses

• Trusses also classified as determinate depending external support reaction.

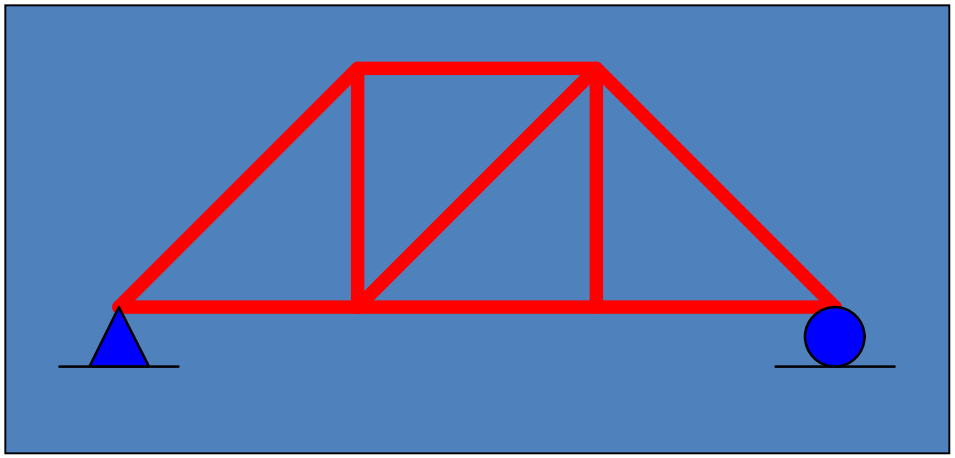
$$2j = b + r$$

j = number of JOINT/S

b = number of MEMBER/S of the trusses

r = is number of REACTION/S

Example 3



b = 9 j = 6 r = 3

Unknown b+ r = 12

Equation 2(J) = 12

0

the structure is just stiff (statically determinate)

1.7 DETERMINACY CRITERIA FOR STRUCTURES

- Three categories of determinacy for structures

Under stiff

If there are more equilibrium equation than the unknown forces, the system is not a structure and it is unstable.

Just stiff

If the equilibrium equation is equal to unknown forces.

Over stiff

If the equilibrium equation is less than to unknown forces.

1.7.1 Redundancy

Frame / beam

r = 3n (just stiff / statically determinate)

r > 3n (under stiff / forms a mechanism)

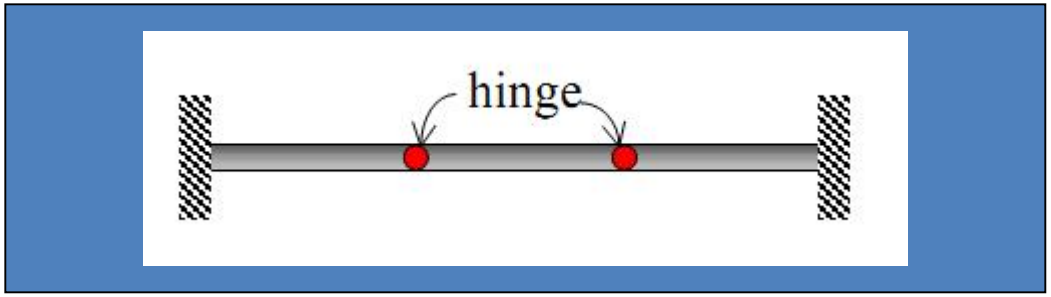
r < 3n (over stiff / statically indeterminate)

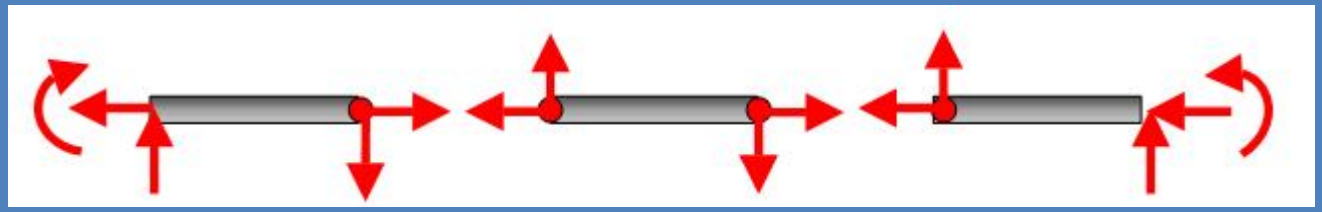
or

Check the number of redundancy

Number of redundancy = r – 3n

Example 1





$r = 10, n = 3$

10 ≠ 9

Statically **indeterminate**

$10 - 3(3) = 1$

Statically **indeterminate** to the first degree

Trusses

$2j = b + r$ (just stiff / statically determinate)

$2j > b + r$ (under stiff / forms a mechanism)

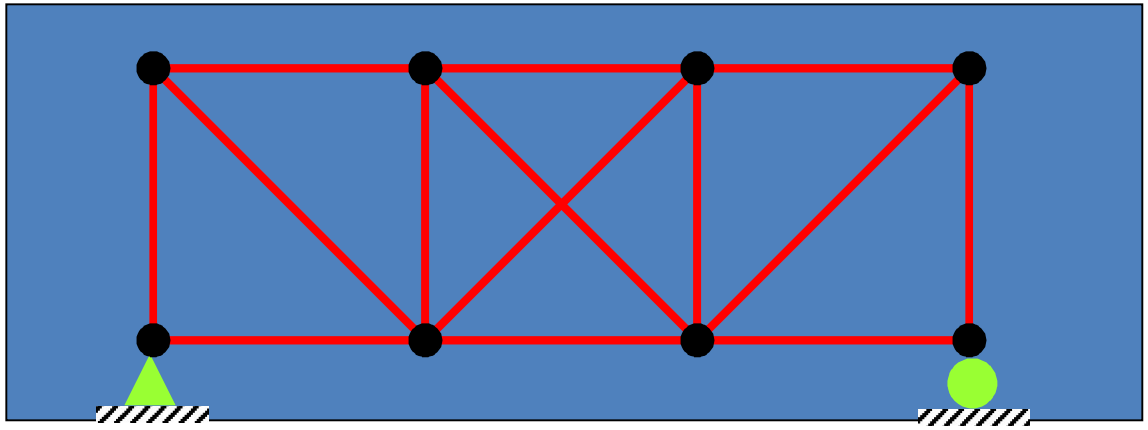
$2j < b + r$ (over stiff / statically indeterminate)

or

Check the number of redundancy

Number of redundancy = $b + r - 2j$

Example



b = 14 j = 8 r = 3

Unknown b + r = 17

Equation 2(J) = 16

1

the structure is over stiff (statically determinate) to 1st degree

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THANKS

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