Theory of structure

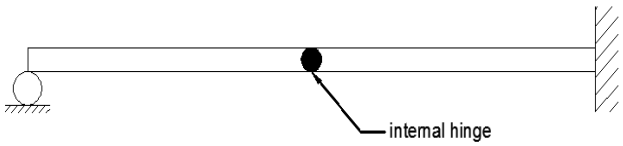
Stability and determinacy of structures

Beams

- Total equation of equilibrium of beam
  $\sum F_X = 0$
  $\sum F_Y = 0$
  $\sum M = 0$

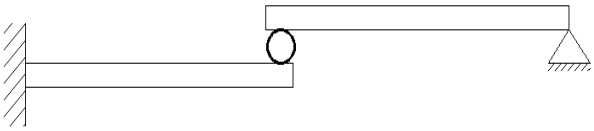
- Equation of condition
  Internal hinge:-

$\sum M = 0$



C=1
C = m - 1

Roller:-
$\sum M = 0$
$\sum F_X = 0$
C=2

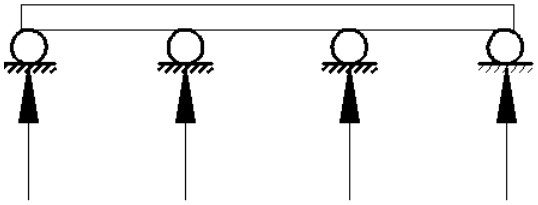


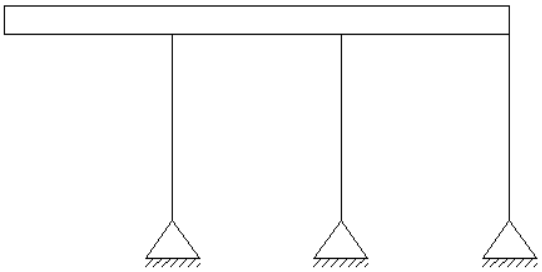
Let r= No. of reaction
1- If r < c+3, unstable
2- r = c+3, determine if stable
3- r> c+3, indeterminate if stable
Let (m) degree of indeterminate
m= r- (c+3)

- the structure is said to be unstable if one of the following facts couter

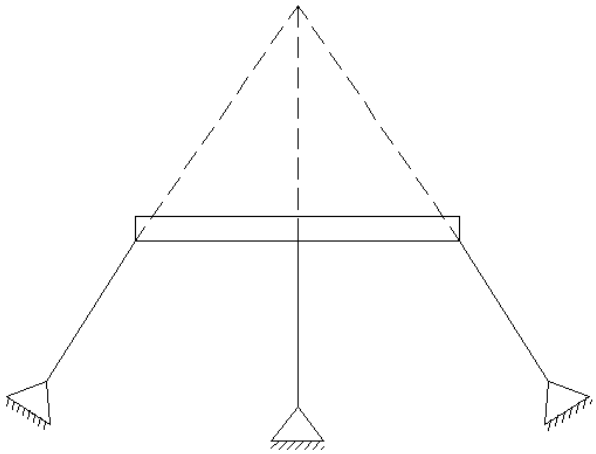
1- $r < c+3$

2- The reaction element constitutes a parallel force system.





3- The reaction element constitutes a concurrent force system.



4- Internal geometric instability:-

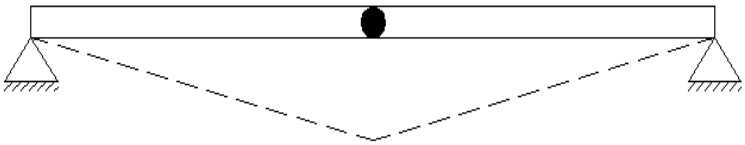
Example

r = 4

c =1

r = c+3

4=4



The beam is unstable because the Internal geometric instability

Example

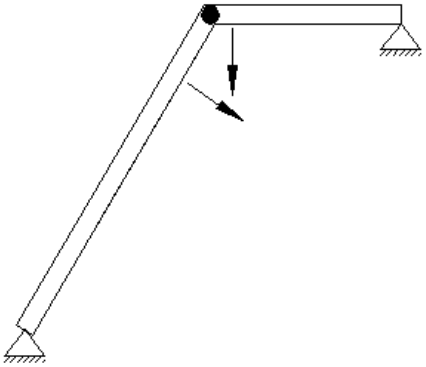
r = 4

c = m-1, c =1

r = c+3

4=4

The beam is determiate if stable



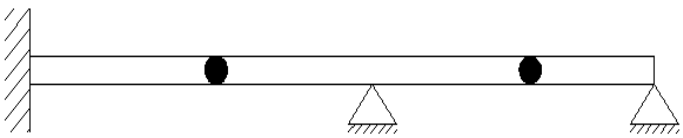
Example

r= 7

c= 2

r>c+3

7>5



The beam is indeterminate 2nd degree if stable

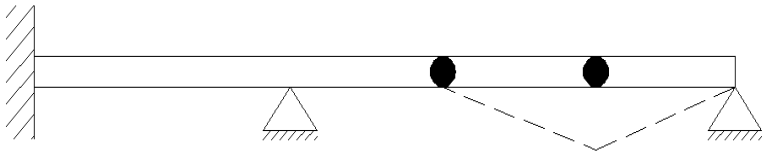
Example

r= 7

c= 2

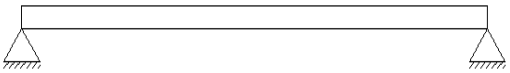
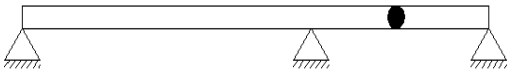
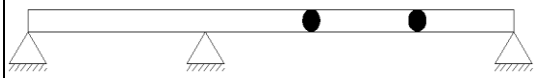
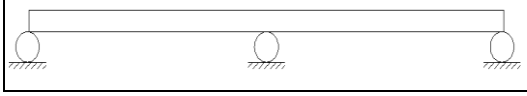
r>c+3

7>5



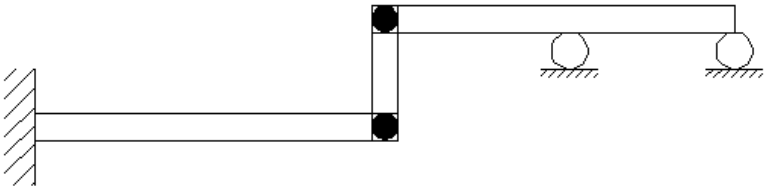
The beam is unstable

Examples:-

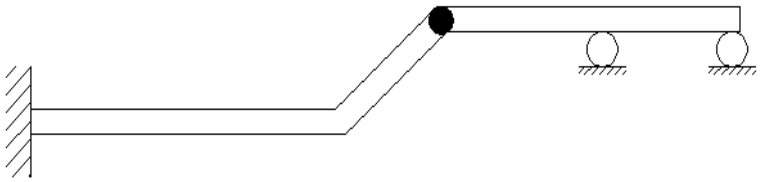
Beam	r	c	c+3	state	Stability & determinate.
	3	0	3	r=c+3	Stable & deter.
	4	0	3	r>c+3	Stable & indeter. First degree
	6	1	4	r>c+3	Stable &indeter. Second degree
	6	2	5	r>c+3	unstable
	3	0	3	r =c+3	unstable

Home Works

H.W1: Find the stability and determinacy of beam.



H.W2: Find the stability and determinacy of beam.



Stability and Determinacy of Trusses

b + r = unknown

j = equations

1- b + r < 2j, the truss is unstable
2- b + r = 2j, the truss is determinate if stable
3- b + r > 2j, the truss is indeterminate if stable

Let (m) equal to the degree of indeterminate
m= (b + r) – 2j

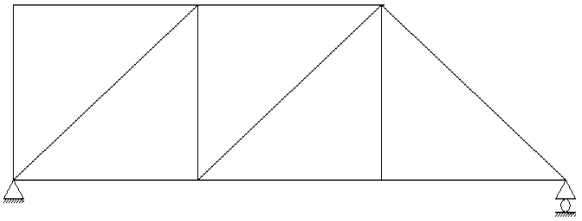
b = No. of bars

r = No. of reactions

j = No. of joints

Examples: - Find the stability and determinacy of trusses below.

Ex1



r = 3, b = 11, j = 7

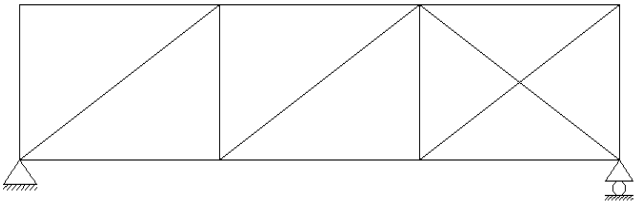
b+r =14

2j= 14

b+r = 2j

The truss is stable &determinate

Ex2



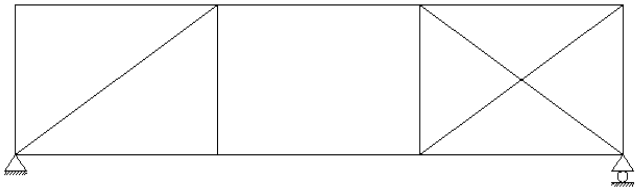
r = 3, b =14, j = 8

b+r = 17

2j = 16

b+r > 2j, the truss is stable& indeterminate 1st degree

Ex3

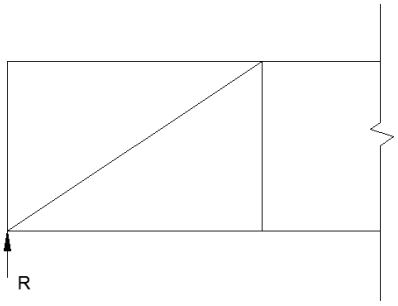


r = 3

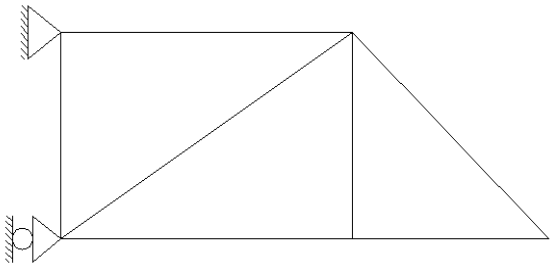
b = 13

2j = 16

b+r = 2j, the truss is unstable because of $\sum F_y \neq 0$, in this section



Ex4



r = 3, b = 7, j = 5

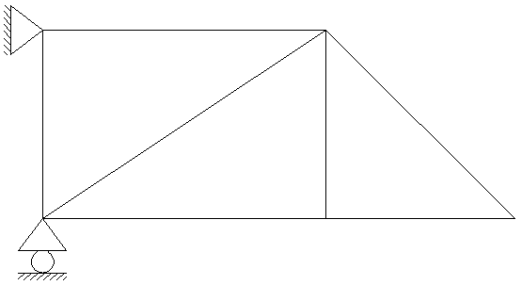
b + r = 10

2 j = 10

b + r = 2j

The truss is stable & determinate

Ex5



r = 3, b = 7, j = 5

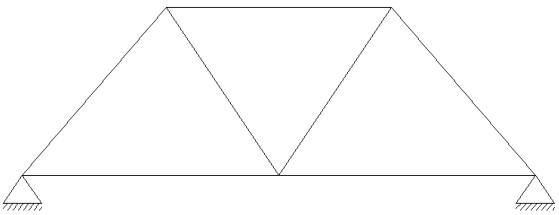
b + r = 10

2 j = 10

b + r = 2j

The truss is unstable

Ex6



r = 4, b = 7, j = 5

b + r = 11

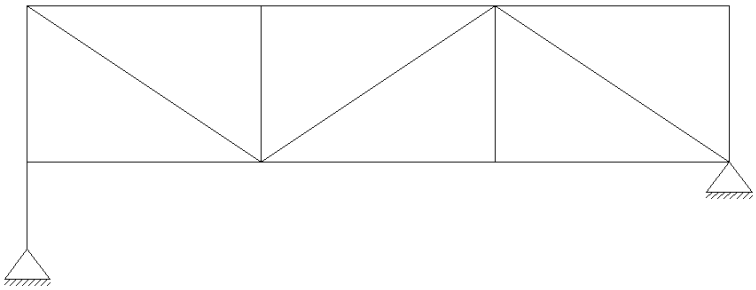
2 j = 10

b + r > 2j

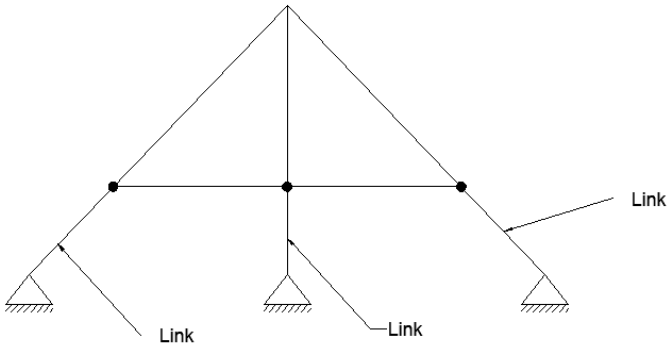
The truss is stable & indeterminate 1st degree

Home works

H.W1



H.W2



Stability and Determinacy of Frames

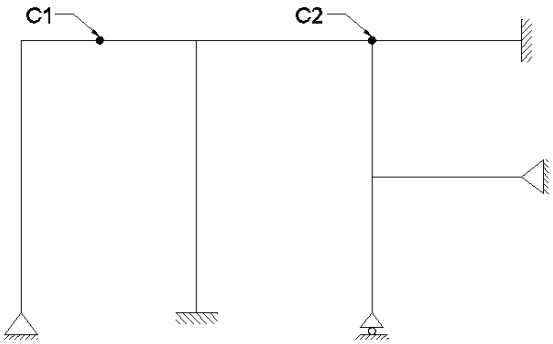
1- Open frames

r < C+3, unstable

r = C+3, determinate if stable

r > C+3, indeterminate if stable

Ex1:- Find the stability and determinacy of frame below



C_1 = m-1, C_1 = 2-1 = 1

C_2 = m-1, C_2 = 3-1 = 2

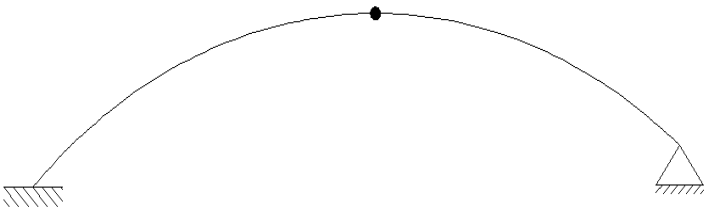
C = C_1+C_2, C = 3

r = 11

C+3 = 6

r > C+3, the frame is stable& indeterminate 5^{th} degree.

Ex2:-

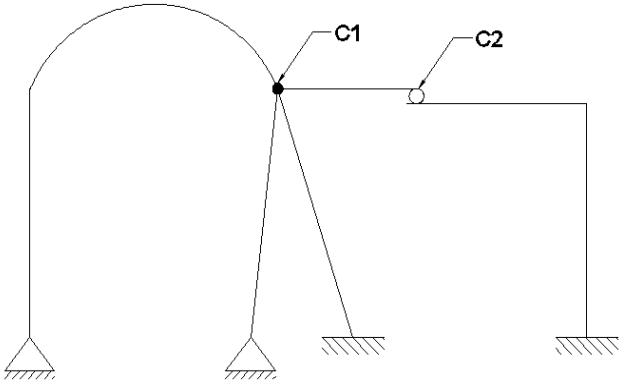


r = 5

C = 2-1 = 1

r > C+3, the frame is stable & indeterminate 1st degree.

Ex3:-



C_1 = m-1, C_1 = 4-1 = 3

C_2 = 2

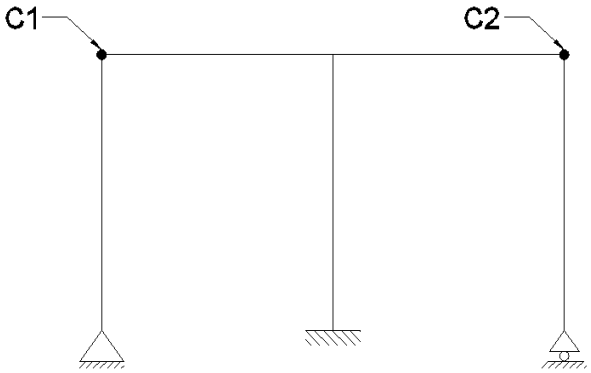
C = C_1+C_2, C = 5

r = 10

C+3 = 8

r > C+3, the frame is stable & indeterminate 2nd degree.

Ex4:-



r = 6

C = 2

r > C+3

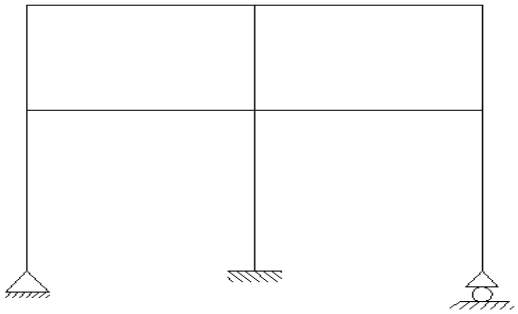
The frame is unstable because of internal geometric instability

2- Closed Frames:-

3b+r < 3j+c, unstable
3b+r = 3j+c, determinate if stable
3b+r >3j+c, indeterminate if stable

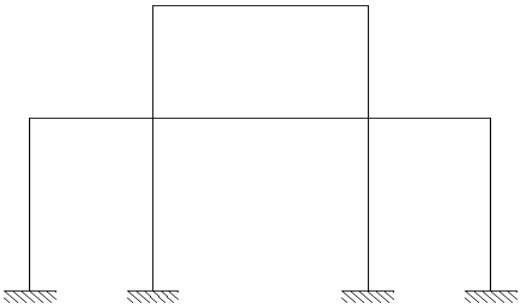
Where,
3b+r = unknown
3j+c = equations
b = No. of members
r = No. of reactions
j = No. of joints

Ex1:-



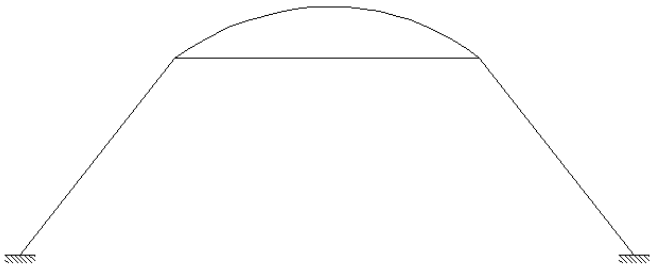
b = 10
r = 6
j = 9
3b+r = 36
3j+c = 27
3b+r > 3j+c, stable & indeterminate 9^{th} degree

Ex2:-



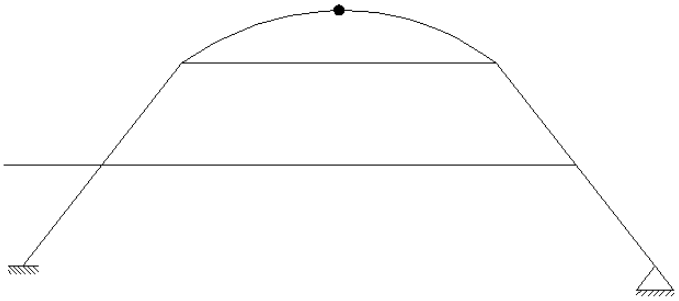
b = 10
r = 12
j = 10
3b+r = 42
3j+c = 30
3b+r > 3j+c, stable & indeterminate 12^{th} degree

Ex3:-



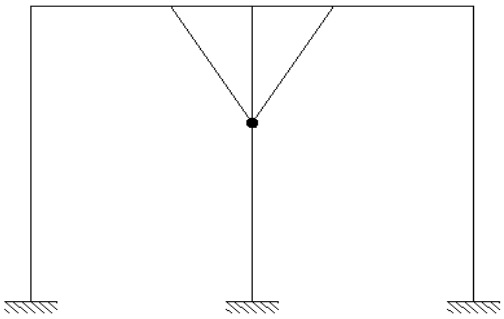
b = 4
r = 6
j = 4
c = 0
3b+r = 18
3j+c = 12
3b+r > 3j+c, stable & indeterminate 6^{th} degree

Ex4:-



b = 9
r = 5
j = 7
c = m-1 => c = 1
3b+r = 32
3j+c = 22
3b+r > 3j+c, stable & indeterminate 10^{th} degree

Ex5:-



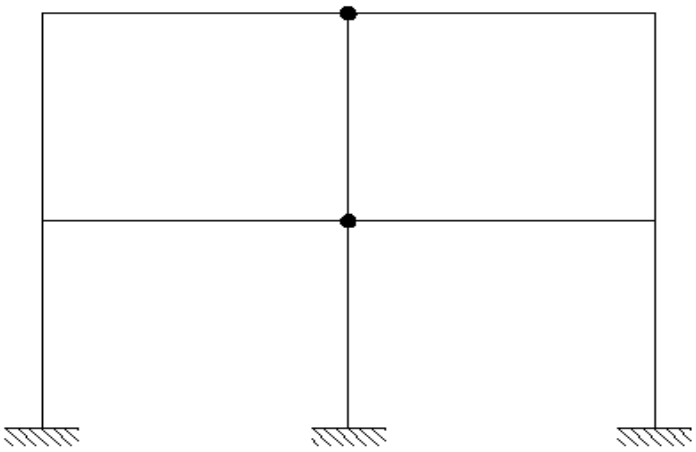
b = 10
r = 9
j = 9
c = m-1 => c = 4-1=> c = 3
3b+r = 39
3j+c = 30

3b+r > 3j+c, stable & indeterminate 9^{th} degree

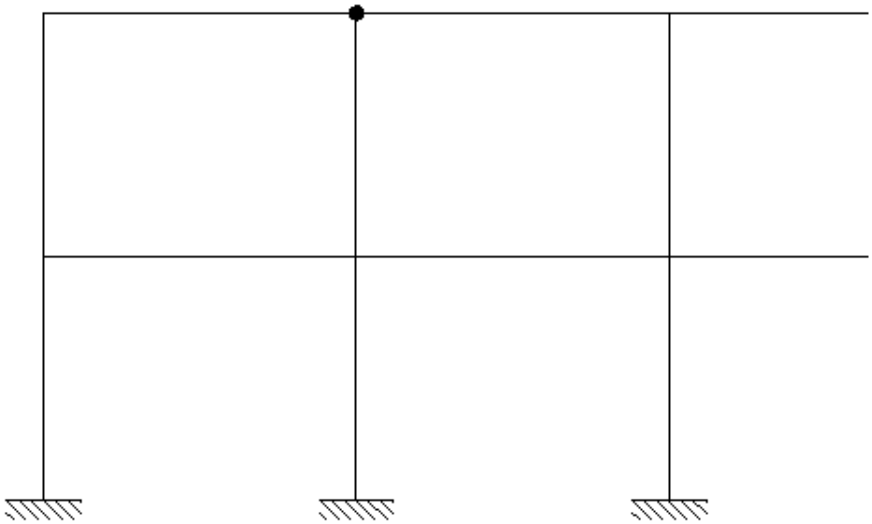
ملاحظة:- اذا جاء ال internal hinge في بداية او نهاية الضلع فيحسب منه (c &j) اما
اذا جاء في داخل الضلع فيحسب منة c فقط

Home work:

H.W1: Find the stability and determinacy of frame below



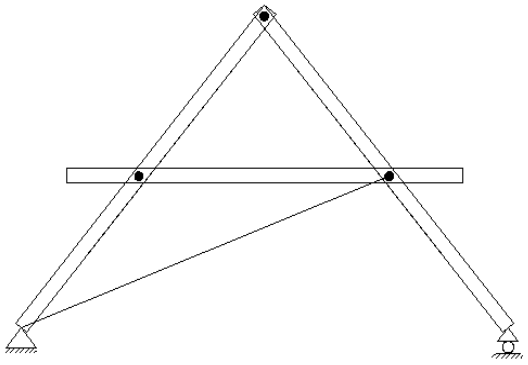
H.W2: Find the stability and determinacy of frame below



Stability and Determinacy of Composite Structure

Unknowns	Equations
1- Each truss member give one unknown	1- each member carry moment give (3 equations)
2- reactions	2- each joint connect truss members only give (2 equations)
3- each joint connect member carry moment give unknown in these equation (2*(m-1))	

Ex1:- Find the stability and determinacy of composite structure as shown below.



Solution:

Equations

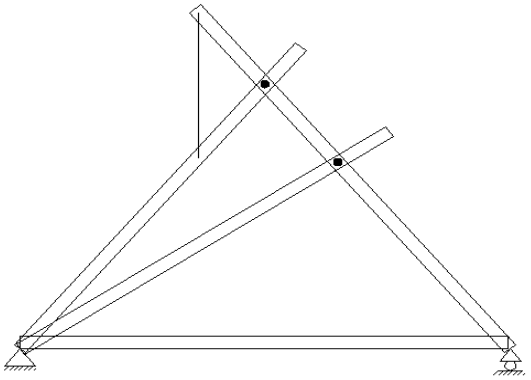
(3*3) +0 = 9

Unknowns

1+3+ (3*(2(2-1))) = 10

Unknowns > Equations, Stable & indeterminate 1st degree

Ex2:- Find the stability and determinacy of composite structure as shown below.



Solution:

Equations

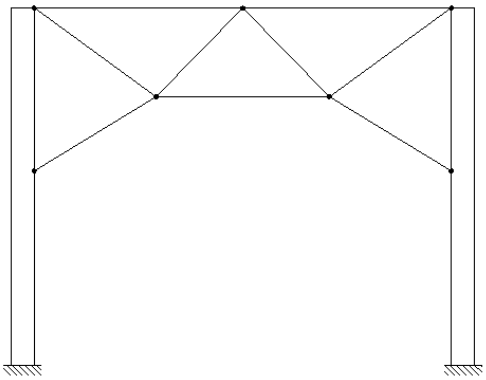
(4*3) +0 = 12

Unknowns

1+3+ (3*(2(2-1))) + (2(3-1)) = 14

Unknowns > Equations, Stable & indeterminate 2nd degree

Ex3:- Find the stability and determinacy of composite structure as shown below.



Solution:

Equations

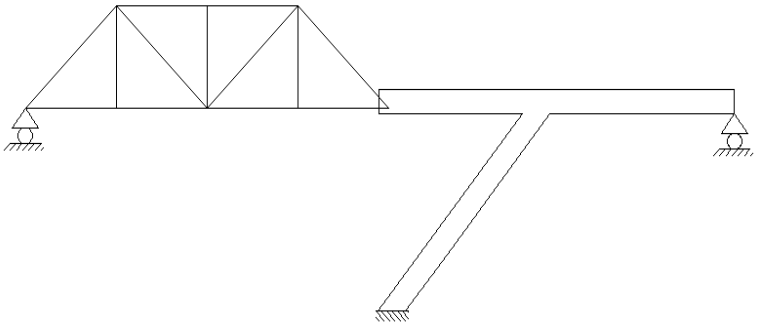
(2*3) + (3*2) = 12

Unknowns

9+6+ 0 = 15

Unknowns > Equations, Stable & indeterminate 2nd degree

Ex4:- Find the stability and determinacy of composite structure as shown below.



Solution:

Equations

(1*3) + (7*2) = 17

Unknowns

13+5+ 0 = 18

Unknowns > Equations, Stable & indeterminate 1st degree

H.w: Find the stability and determinacy of composite structure as shown below.