

# Constructing Influence Lines

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# Why Do We Construct Influence Lines ?



In addition to supporting fixed gravity loads (Dead Load), structures must also support gravity loads that can vary in magnitude and position (Live Loads).

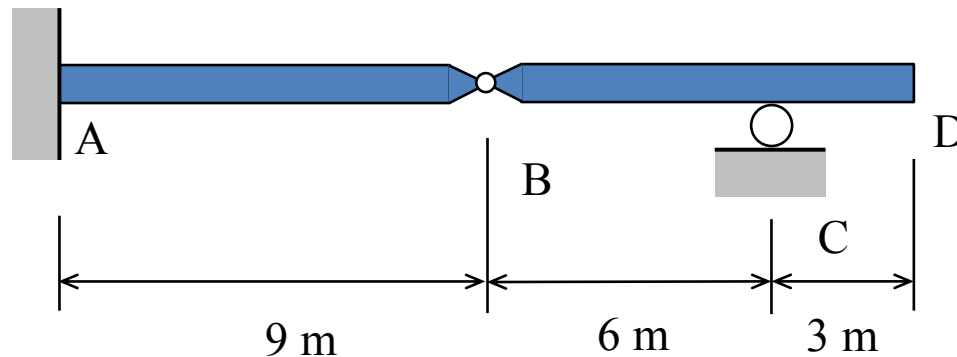
To design the components of a structure, it is important to understand how to place live loads to produce the maximum response for important design quantities (e.g. support reactions, internal shear, bending moment, axial force).

The Influence Line for a response quantity is a tool to help place live loads to find the maximum response

# Construction of Influence Lines

The overhanging beam shown has a fixed support at A, a roller support at C and an internal hinge at B. Construct influence lines for:

1. The roller support at C;
2. The vertical reaction at the fixed support at A;
3. The moment reaction at the fixed support at A



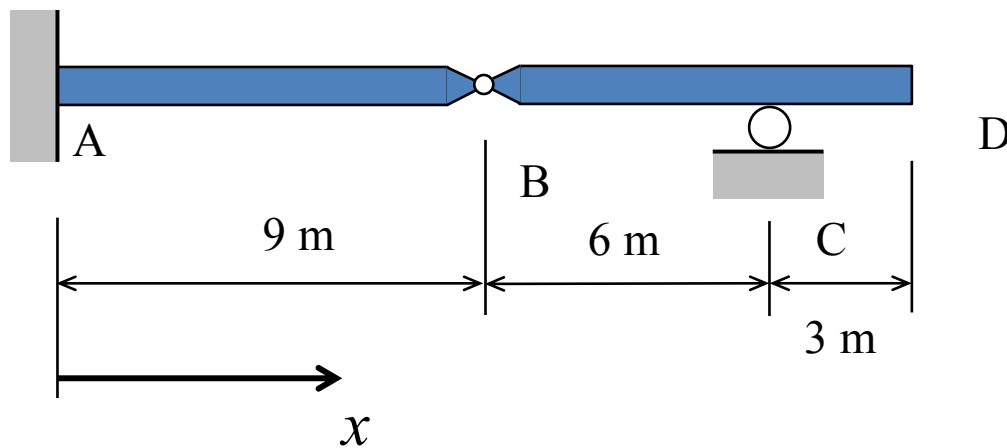
## General procedure for the construction of influence lines

1. Choose a reference coordinate;
2. Choose a sign convention for each diagram;
3. Place a unit, dimensionless load on the structure;
4. Use equilibrium analysis to find the response quantity (e.g. support reaction, internal force) at the position of the unit, dimensionless, load;
5. Move unit load to another position and repeat Step 4;
6. Plot the value of the response quantity versus the position of the unit, dimensionless, load.

# Choose Reference Coordinate and Sign Convention

The overhanging beam shown has a fixed support at A, a roller support at C and an internal hinge at B. Construct influence lines for:

1. The roller support at C;
2. The vertical reaction at the fixed support at A;
3. The moment reaction at the fixed support at A



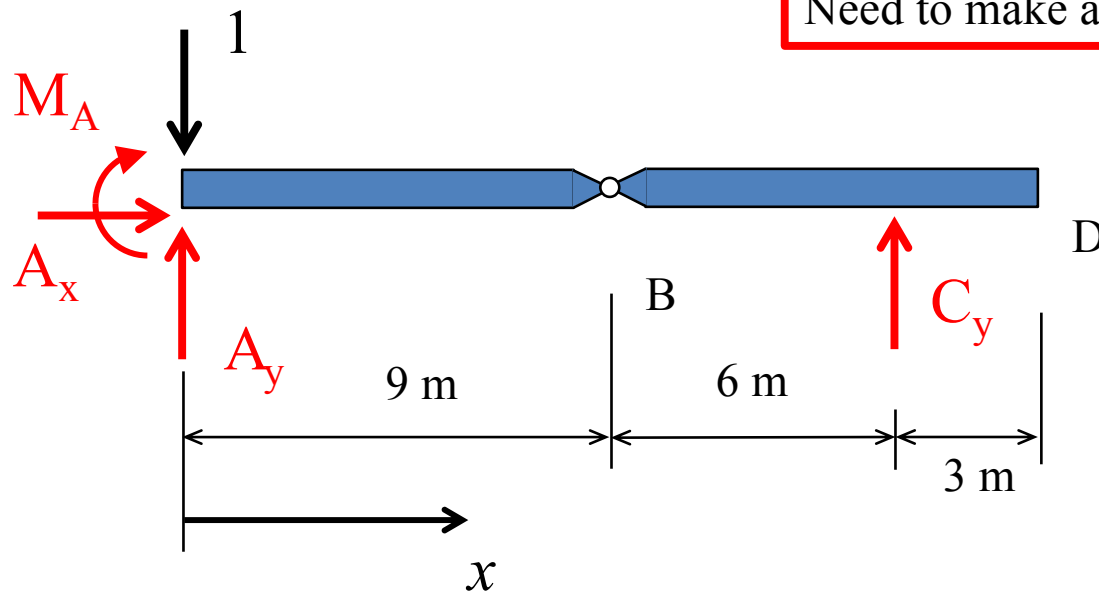
Sign Convention for Positive Support Reactions



Place Unit Load at  $x = 0$  (Point A)

Free-body Diagram

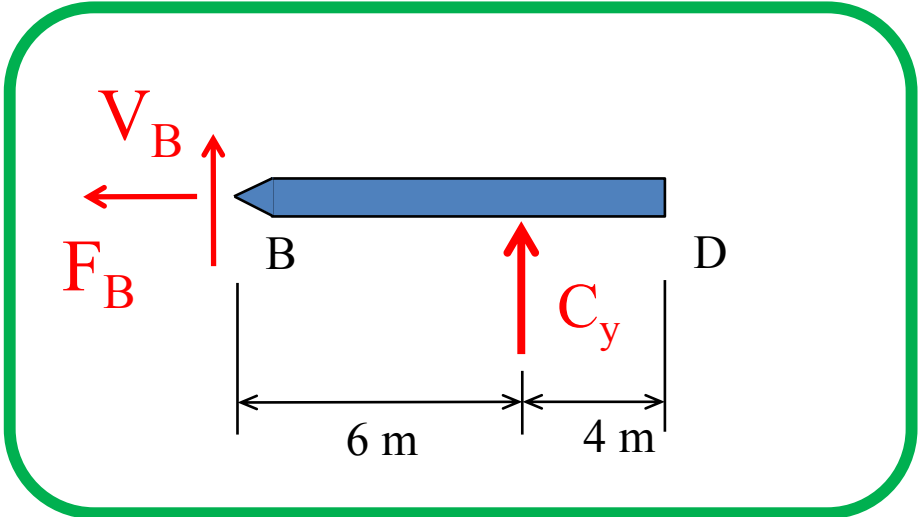
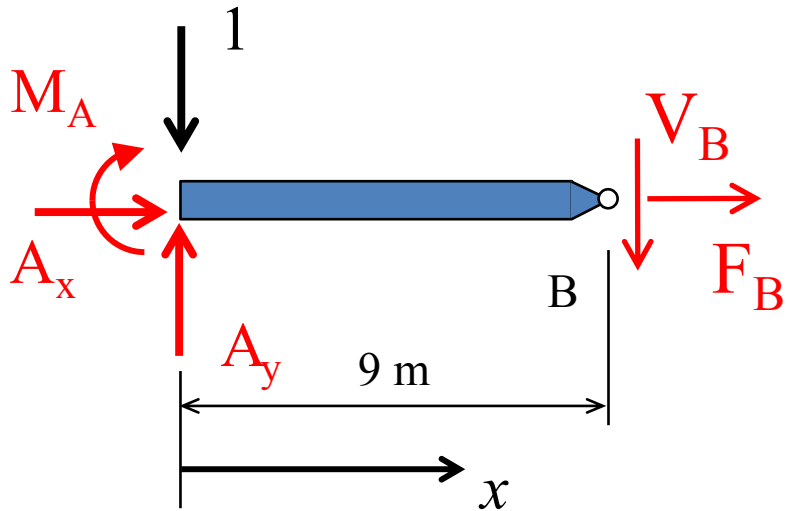
4 Unknowns – 3 Equations of Equilibrium  
Need to make a cut at the hinge at B



# Place Unit Load at $x = 0$ (Point A)

Free-body Diagrams

6 Unknowns – 6 Equations of Equilibrium



$$\curvearrowright \sum M_A = 0 \rightarrow \boxed{M_A = 0}$$

$$\curvearrowright \sum M_B = 0 \rightarrow \boxed{C_y = 0}$$

$$\rightarrow \sum F_x = 0 \rightarrow A_x = 0 \quad \leftarrow$$

$$\rightarrow \sum F_x = 0 \rightarrow F_B = 0$$

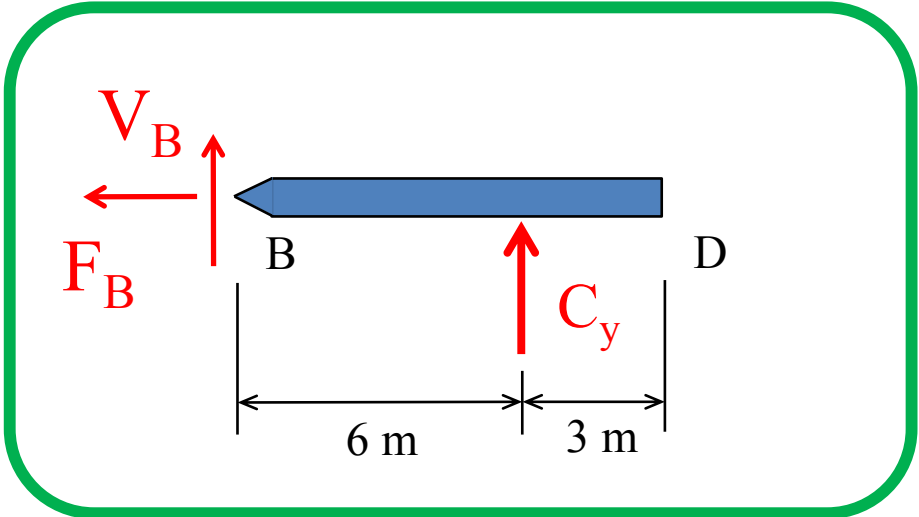
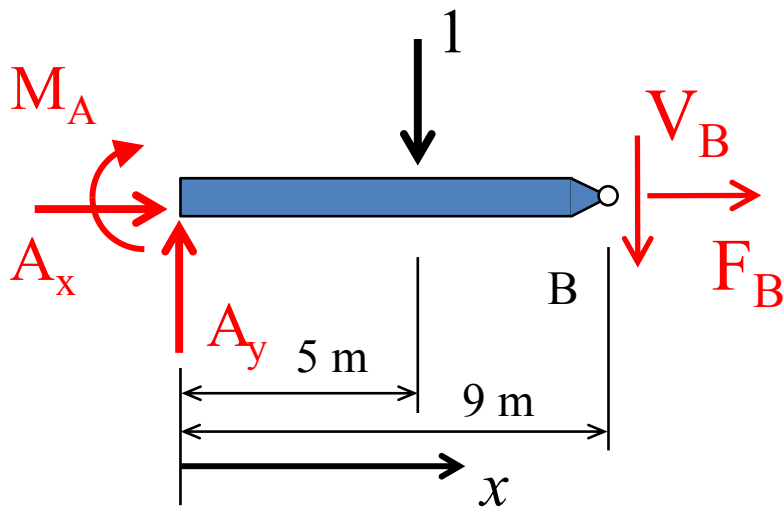
$$+\uparrow \sum F_y = 0 \rightarrow \boxed{A_y = 1}$$

$$+\uparrow \sum F_y = 0 \rightarrow V_B = 0$$

# Place Unit Load at $x = 5 \text{ m}$

## Free-body Diagrams

6 Unknowns – 6 Equations of Equilibrium



$$\curvearrowright \sum M_A = 0 \rightarrow \boxed{M_A = -5 \text{ m}}$$

$$\curvearrowright \sum M_B = 0 \rightarrow \boxed{C_y = 0}$$

$$\rightarrow \sum F_x = 0 \rightarrow A_x = 0 \quad \leftarrow$$

$$\rightarrow \sum F_x = 0 \rightarrow F_B = 0$$

$$\uparrow \sum F_y = 0 \rightarrow \boxed{A_y = 1}$$

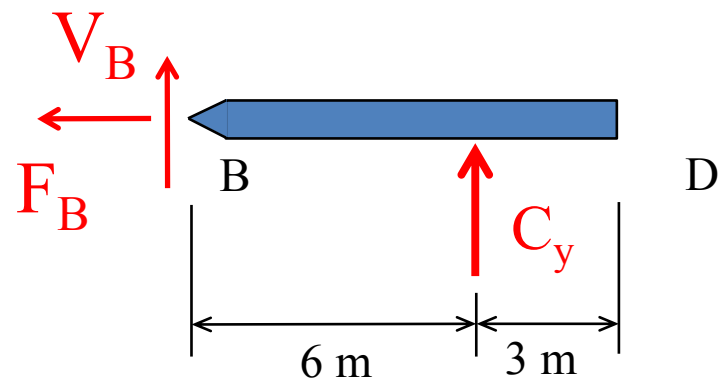
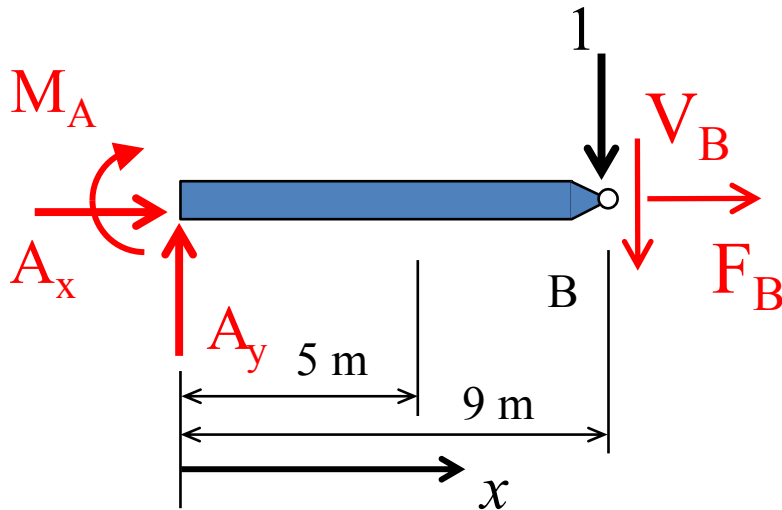
$$\uparrow \sum F_y = 0 \rightarrow V_B = 0$$



# Place Unit Load at $x = 9^-$ m

Free-body Diagrams

6 Unknowns – 6 Equations of Equilibrium



$$\curvearrowright \sum M_A = 0 \rightarrow M_A = -9 \text{ m}$$

$$\curvearrowright \sum M_B = 0 \rightarrow C_y = 0$$

$$\rightarrow \sum F_x = 0 \rightarrow A_x = 0$$

$$\rightarrow \sum F_x = 0 \rightarrow F_B = 0$$

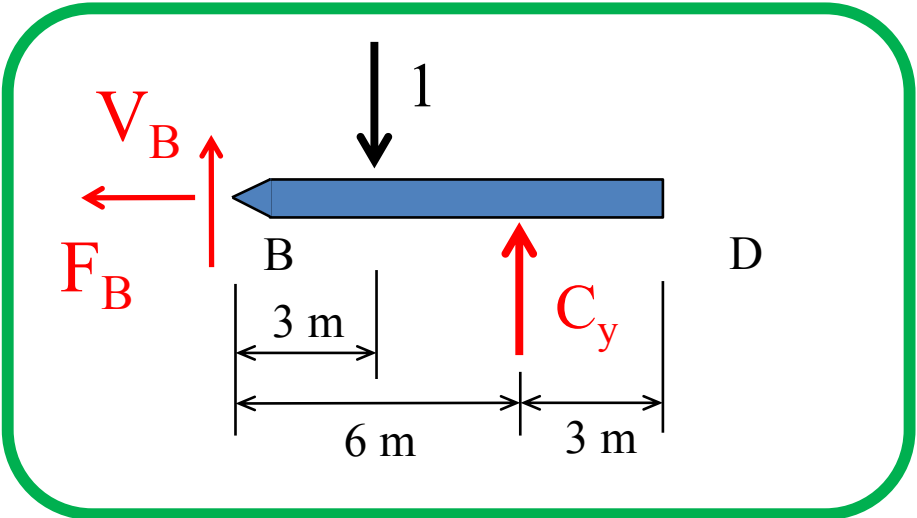
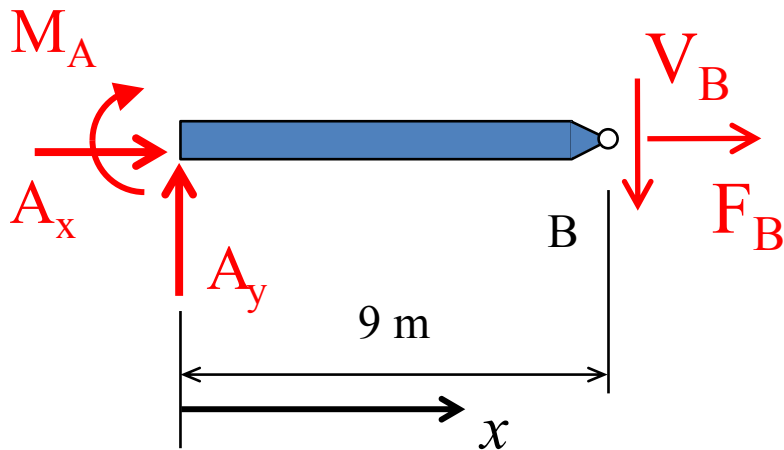
$$+\uparrow \sum F_y = 0 \rightarrow A_y = 1$$

$$+\uparrow \sum F_y = 0 \rightarrow V_B = 0$$

# Place Unit Load at $x = 12$ m

Free-body Diagrams

6 Unknowns – 6 Equations of Equilibrium



$$\curvearrowleft + \sum M_A = 0 \rightarrow \boxed{M_A = -4.5 \text{ m}}$$

$$\curvearrowleft + \sum M_B = 0 \rightarrow \boxed{C_y = 0.5}$$

$$\rightarrow + \sum F_x = 0 \rightarrow A_x = 0 \leftarrow$$

$$\rightarrow + \sum F_x = 0 \rightarrow F_B = 0$$

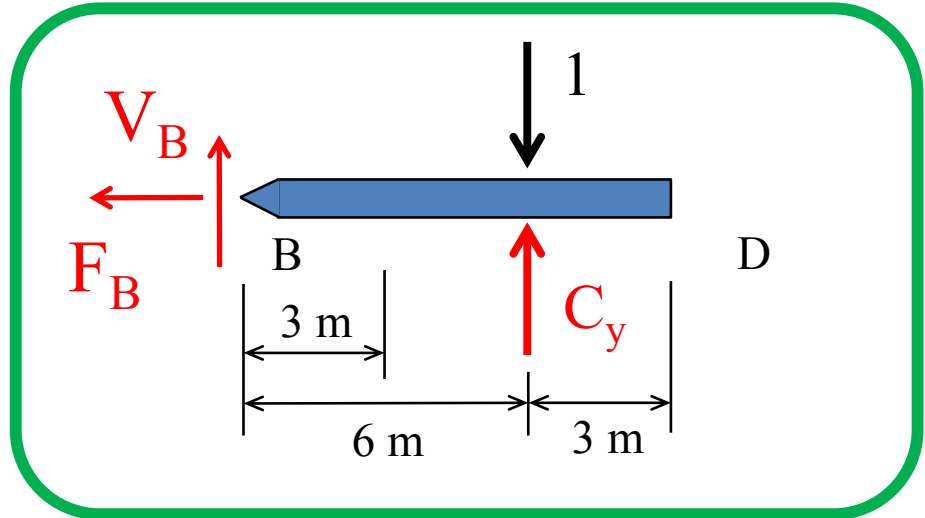
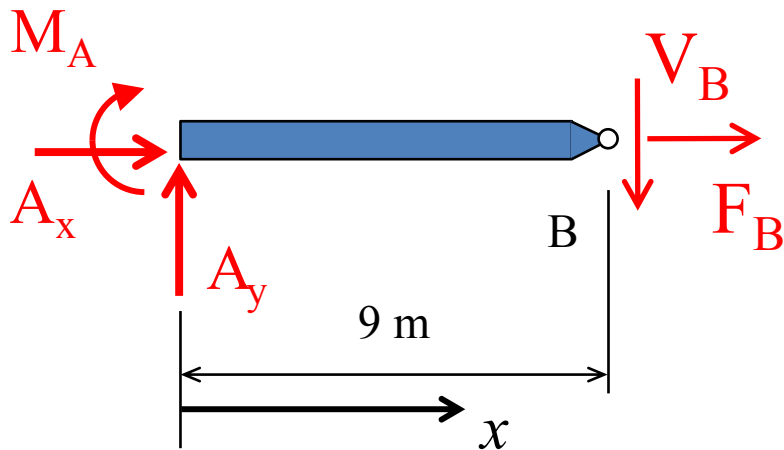
$$\uparrow + \sum F_y = 0 \rightarrow \boxed{A_y = 0.5}$$

$$\uparrow + \sum F_y = 0 \rightarrow V_B = 0.5$$

# Place Unit Load at $x = 15$ m

Free-body Diagrams

6 Unknowns – 6 Equations of Equilibrium



$$\curvearrowleft + \sum M_A = 0 \rightarrow \boxed{M_A = 0}$$

$$\curvearrowleft + \sum M_B = 0 \rightarrow \boxed{C_y = 1}$$

$$\rightarrow + \sum F_x = 0 \rightarrow A_x = 0 \quad \leftarrow$$

$$\rightarrow + \sum F_x = 0 \rightarrow F_B = 0$$

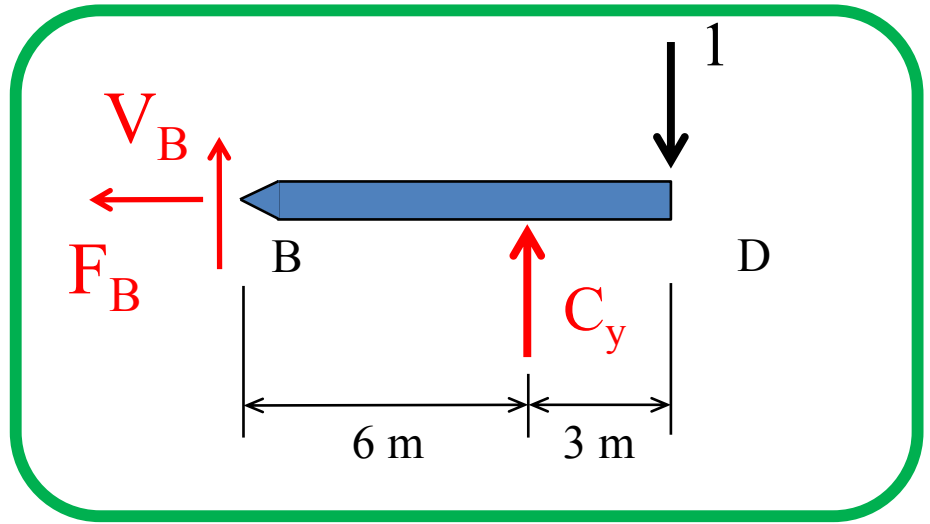
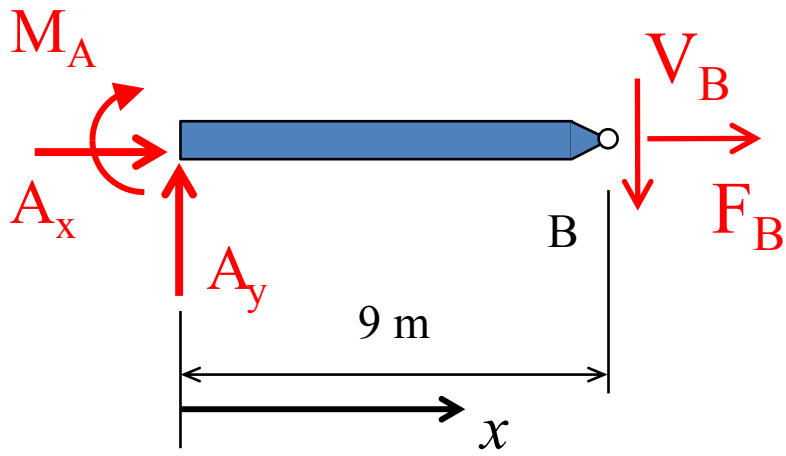
$$\uparrow + \sum F_y = 0 \rightarrow \boxed{A_y = 0}$$

$$\uparrow + \sum F_y = 0 \rightarrow V_B = 0$$

# Place Unit Load at $x = 18$ m

Free-body Diagrams

6 Unknowns – 6 Equations of Equilibrium



$$\curvearrowleft + \sum M_A = 0 \rightarrow \boxed{M_A = 4.5 \text{ m}}$$

$$\curvearrowleft + \sum M_B = 0 \rightarrow \boxed{C_y = 1.5}$$

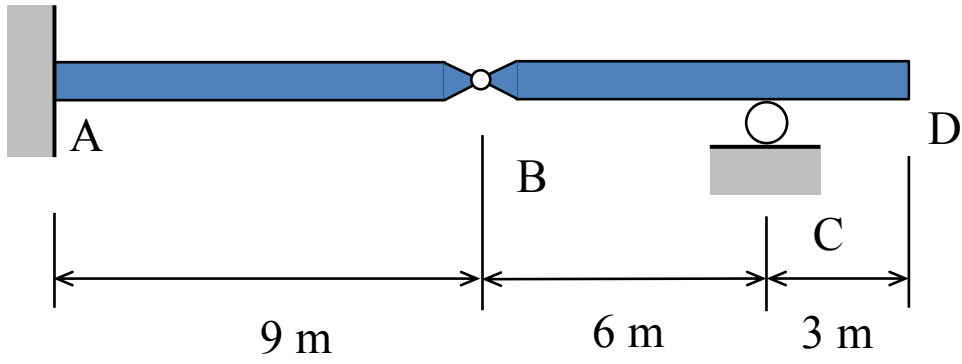
$$\rightarrow + \sum F_x = 0 \rightarrow A_x = 0 \quad \leftarrow$$

$$\rightarrow + \sum F_x = 0 \rightarrow F_B = 0$$

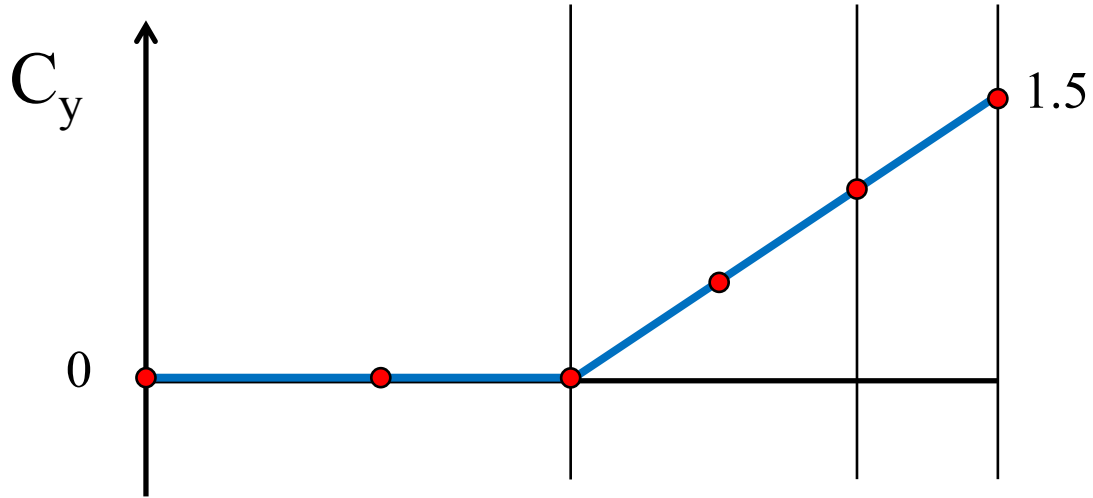
$$\uparrow + \sum F_y = 0 \rightarrow \boxed{A_y = -0.5}$$

$$\uparrow + \sum F_y = 0 \rightarrow V_B = -0.5$$

# Plot the Influence Line for $C_y$

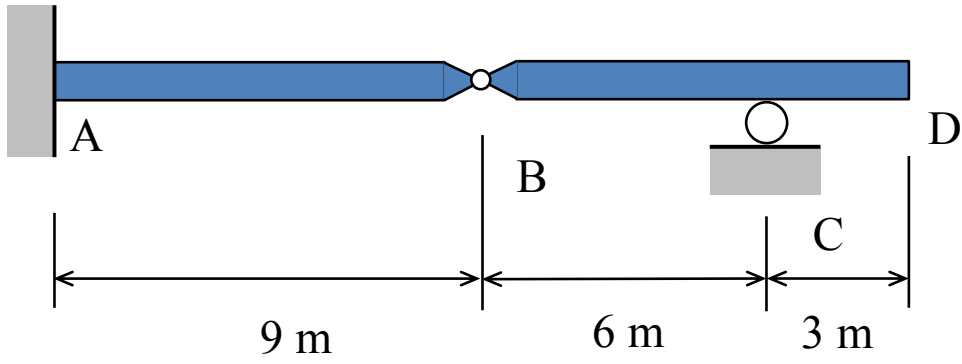


$x =$	$C_y$
0	0
5 m	0
9 m	0
12 m	0.5
15 m	1.0
18 m	1.5

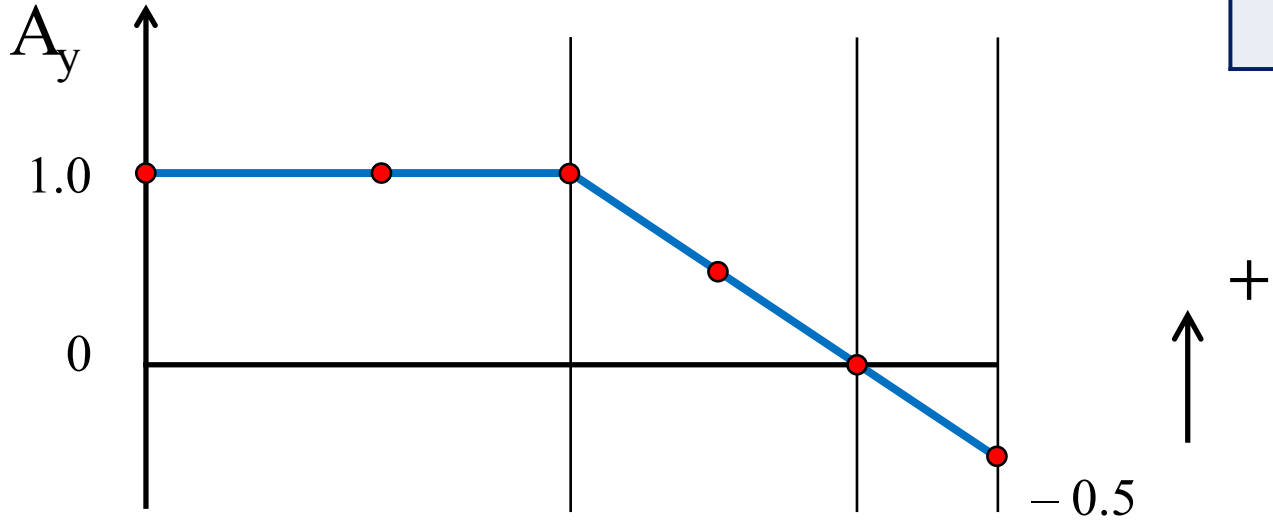


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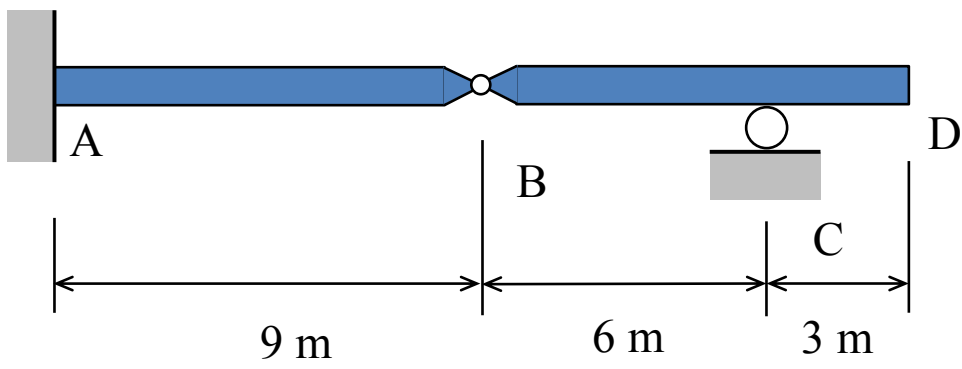
# Plot the Influence Line for $A_y$



$x =$	$A_y$
0	1
5 m	1
9 m	1
12 m	0.5
15 m	0
18 m	-0.5



# Plot the Influence Line for $M_A$



$x =$	$M_A$
0	0
5 m	-5 m
9 m	-9 m
12 m	-4.5 m
15 m	0
18 m	4.5 m

