Influence Lines

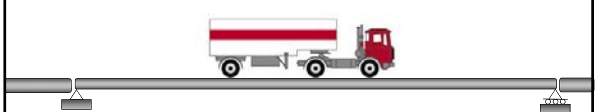
- ***Influence lines*** are important in the design of structures that resist large live loads.
- In our work up to this point, we have discussed analysis techniques for structures subjected to ***dead*** or ***fixed loads***.

Influence Lines

- We learned that shear and moment diagrams are important in determining the maximum internal force in a structure.
- If a structure is subjected to a ***live*** or ***moving load***, the variation in shear and moment is best described using ***influence lines***.

Influence Lines

Consider a transport truck moving over a simply-support bridge beam.



Influence Lines

Definition of an ***influence line***:

An ***influence line*** represents the variation of the reaction, shear, moment, or deflection at a ***specific point*** in a member as a concentrated force moves over the member.

Influence Lines

- Once the ***influence line*** is drawn, the location of the live load which will cause the greatest influence on the structure can be found very quickly.
- Therefore, ***influence lines*** are important in the design of a structure where the loads move along the span (bridges, cranes, conveyors, etc.).

Influence Lines

- Although the procedure for constructing an ***influence line*** is rather simple, it is important to remember the difference between constructing an influence line and constructing a shear or moment diagram

Influence Lines

- ***Influence lines*** represent the effect of a moving load **only at a specified point** on a member.
- Whereas shear and moment diagrams represent the effect of fixed loads at **all points** along the member.

Influence Lines

Tabular Procedure for determining the ***influence line*** at a point **P** for any function (reaction, shear, or moment).

1. Place a unit load (a load whose magnitude is equal to one) at a point, *x*, along the member.
2. Use the equations of equilibrium to find the value of the function (reaction, shear, or moment) at a specific point **P** due the concentrated load at *x*.

Influence Lines

Tabular Procedure for determining the ***influence line*** at a point **P** for any function (reaction, shear, or moment).

3. Repeat Steps 1 and 2 for various values of *x* over the whole beam.
4. Plot the values of the reaction, shear, or moment for the member.

Influence Lines

Influence-Line Equations Procedure for determining the ***influence line*** at a point **P** for any function (reaction, shear, or moment).

1. Place a unit load (a load whose magnitude is equal to one) at a point, *x*, along the member.
2. Use the equations of equilibrium to find the value of the reaction, shear, or moment at a specific point **P** due the concentrated load as a function of *x*.

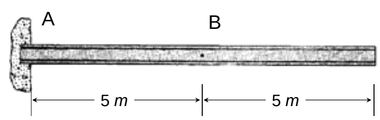
Influence Lines

Influence-Line Equations Procedure for determining the ***influence line*** at a point **P** for any function (reaction, shear, or moment).

3. Plot the values of the reaction, shear, or moment for the member.

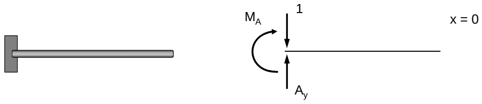
Influence Lines

Example: Let's draw an ***influence line*** for the reaction, shear, and moment for both points A and B using the tabular method.



Influence Lines

Example: First, let's construct the ***influence line*** for the vertical reaction at point A

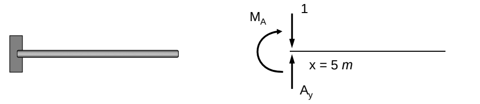


$$^{+}\uparrow \sum F_y = 0 = A_y - 1$$

$A_y = 1$

Influence Lines

Example: First, let's construct the ***influence line*** for the vertical reaction at point A

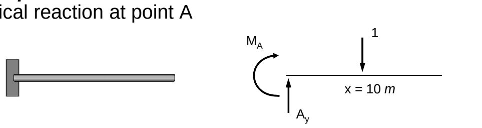


$$^{+}\uparrow \sum F_y = 0 = A_y - 1$$

$A_y = 1$

Influence Lines

Example: First, let's construct the ***influence line*** for the vertical reaction at point A

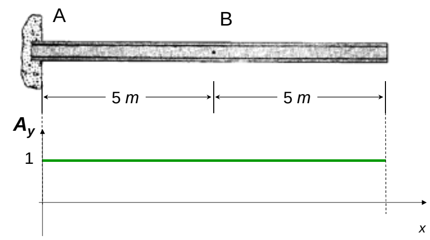


$$^{+}\uparrow \sum F_y = 0 = A_y - 1$$

$A_y = 1$

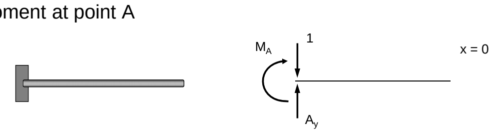
Influence Lines

Example: First, let's construct the ***influence line*** for the vertical reaction at point A



Influence Lines

Example: Construct the ***influence line*** for the bending moment at point A

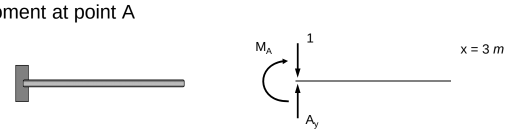


$$\circlearrowleft^{+} \sum M_A = 0 = -M_A - 1(0\ m)$$

$M_A = 0$

Influence Lines

Example: Construct the ***influence line*** for the bending moment at point A

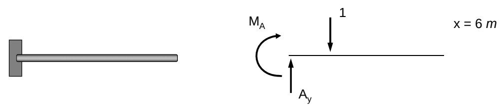


$$\circlearrowleft^{+} \sum M_A = 0 = -M_A - 1(3\ m)$$

$M_A = -3\ m$

Influence Lines

Example: Construct the ***influence line*** for the bending moment at point A

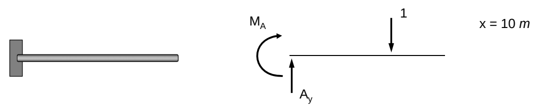


$$\circlearrowleft^{+}\sum M_A = 0 = -M_A - 1(6\ m)$$

M_A = -6 *m*

Influence Lines

Example: Construct the ***influence line*** for the bending moment at point A

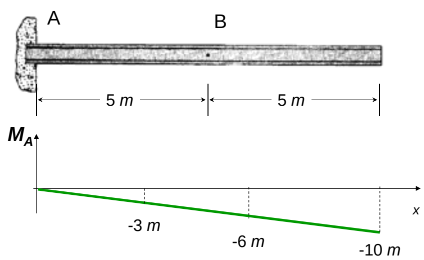


$$\circlearrowleft^{+}\sum M_A = 0 = -M_A - 1(10\ m)$$

M_A = -10 *m*

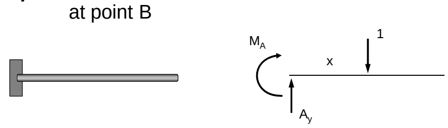
Influence Lines

Example: Construct the ***influence line*** for the bending moment at point A



Influence Lines

Example: Construct the ***influence line*** for the shear at point B

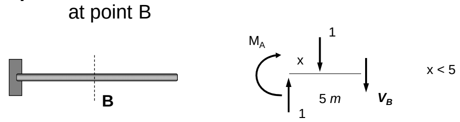


$$^{+}\uparrow\sum F_y = 0 = A_y - 1$$

A_y = 1

Influence Lines

Example: Construct the ***influence line*** for the shear at point B

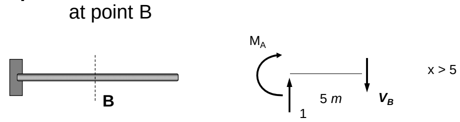


$$^{+}\uparrow\sum F_y = 0 = -V_B - 1 + 1$$

V_B = 0

Influence Lines

Example: Construct the ***influence line*** for the shear at point B

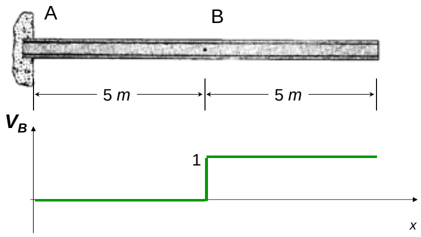


$$^{+}\uparrow\sum F_y = 0 = -V_B + 1$$

V_B = 1

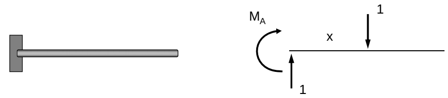
Influence Lines

Example: Construct the ***influence line*** for the shear at point B



Influence Lines

Example: Construct the ***influence line*** for the bending moment at point B

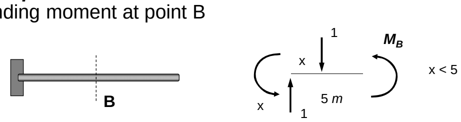


$$\circlearrowleft^{+} \sum M_A = 0 = -M_A - 1x$$

$M_A = -x$

Influence Lines

Example: First, let's construct the ***influence line*** for the bending moment at point B

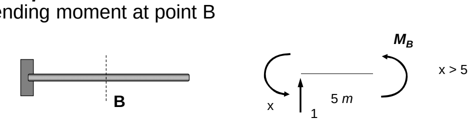


$$\circlearrowleft^{+} \sum M_{cut} = 0 = M_B + x - 5 + (5 - x)$$

$M_B = 0$

Influence Lines

Example: First, let's construct the ***influence line*** for the bending moment at point B

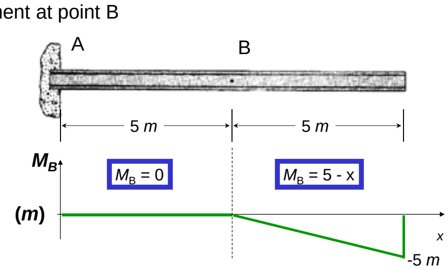


$$\circlearrowleft^{+} \sum M_{cut} = 0 = M_B + x - 5$$

$M_B = 5 - x$

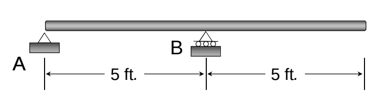
Influence Lines

Example: Construct the ***influence line*** for the bending moment at point B



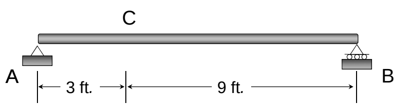
Influence Lines

Example: Construct the ***influence line*** for the reaction at B



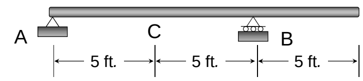
Influence Lines

Example: Construct the ***influence line*** for the shear at C



Influence Lines

Example: Construct the ***influence line*** for the moment at C



Influence Lines

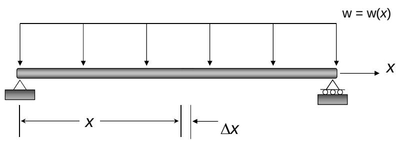
- Since beams or girders are usually major load–carrying members in large structures, it is important to draw ***influence lines*** for reaction, shear, and moment at specified points.
- Once an ***influence line*** has been drawn, it is possible to locate the live loads on the beam so that the maximum value of the reaction, shear, or moment is produced.
- This is very important in the design procedure.

Influence Lines

Concentrated Force - Since we use a unit force (a dimensionless load), the value of the function (reaction, shear, or moment) can be found by multiplying the ordinate of the influence line at the position x by the magnitude of the actual force **P**.

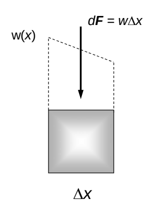
Influence Lines

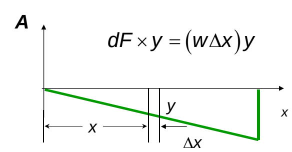
Uniform Force - consider the portion of the beam Δx



Influence Lines

Let's examine the interval Δx





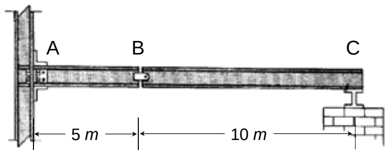
$$dF \times y = (w\Delta x)y$$

$$\int (w\Delta x)y = w\int y dx$$

$\int y dx$ is the area under the influence line

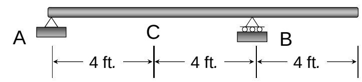
Influence Lines

Example: The beam below is subject to a dead load of 1.5 *kN/m* and a single live load of 10 *kN*. Determine the maximum ***negative*** moment created by these loads at point A and the maximum ***positive*** shear at point B.



Influence Lines

Example: Determine the maximum ***positive*** moment that can be developed at point C on the beam shown below due to a single concentrated live load of 8 k, a uniform live load of 3 k/ft., and a beam weight (dead load) of 1 k/ft.



End of Influence Lines – Part 1

Any questions?