INFLUENCE LINES FOR STATICALLY DETERMINATE STRUCTURES 8

8.1 INTRODUCTION

Influence lines have important application for the **design of structures** that resist **large live loads**. The theory is applied to:

1. Structures subjected to a **distributed load**.
2. Structures subjected to a **series of concentrated forces**.
3. Specific applications to **floor girders** and **bridge trusses**.
4. The determination of the **absolute maximum live shear** and **moment** in a member.

If a structure is subjected to a **live** or **moving load**, however, the variation of the **shear** and **bending moment** in the member is best described using the **influence line**.

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

Furthermore, the **magnitude** of the associated **reaction, shear, moment**, or **deflection** at the point **can then be calculated** from the **ordinates** of the **influence-line diagram**.

For these reasons, influence lines play an important part in the design of bridges, industrial crane rails, conveyors, and other structures where loads move across their span.

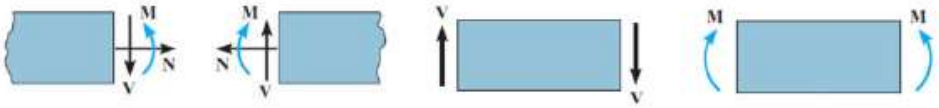
It is worthwhile to mention that **influence lines** represent the effect of a **moving load only** at a **specified point** on a member, whereas **shear** and **moment diagrams** represent the effect of **fixed loads** at **all points** along the axis of the member.

Procedure for Analysis — Influence Lines for Statically Determinate Structures

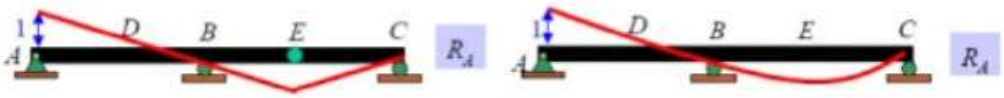
There are two procedures to construct the influence line at a specific point P in a member for any function (**reaction**, **shear**, or **moment**). For both of these procedures we will choose the moving force to have a **dimensionless magnitude of unity**.

Tabulate Values

- Place a **unit load** at various locations, x, along the member, and at each location use statics to determine the value of the function (**reaction**, **shear**, or **moment**) at the specified point.
- If the influence line for a vertical force reaction at a point on a beam is to be constructed, consider the **reaction** to be **positive** at the point when it acts **upward** on the beam.
- If a shear or moment **influence line** is to be drawn for a point, take the **shear** or **moment** at the point as **positive** according to the same **sign convention** used for drawing **shear** and **moment diagrams**.



- All **statically determinate** beams will have influence lines that consist of **straight line segments**.



Statically Determinate Beam — Statically Indeterminate Beam

- To avoid errors, it is recommended that one first construct a table, listing "$unit\ load\ at\ x$" versus the corresponding value of the function calculated at the specific point; that is, "$reaction\ R$," "$shear\ V$," or "$moment\ M$." Once the load has been placed at various points along the span of the member, the tabulated values can be plotted and the influence-line segments constructed.

Influence-Line Equations

- The influence line can also be constructed by placing the **unit load** at a **variable position** x on the member and then computing the **value** of R, V, or M at the point as a **function** of x. In this manner, the equations of the various line segments composing the influence line can be determined and plotted.

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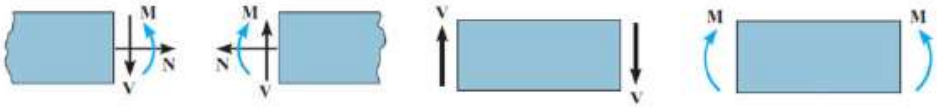

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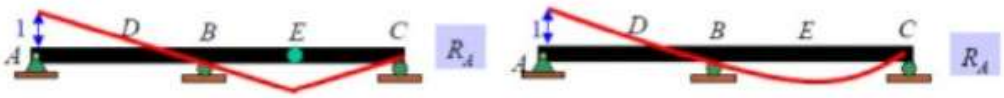

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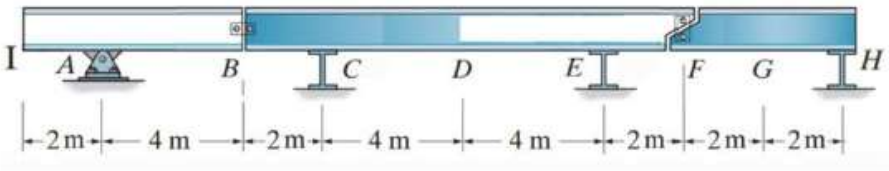
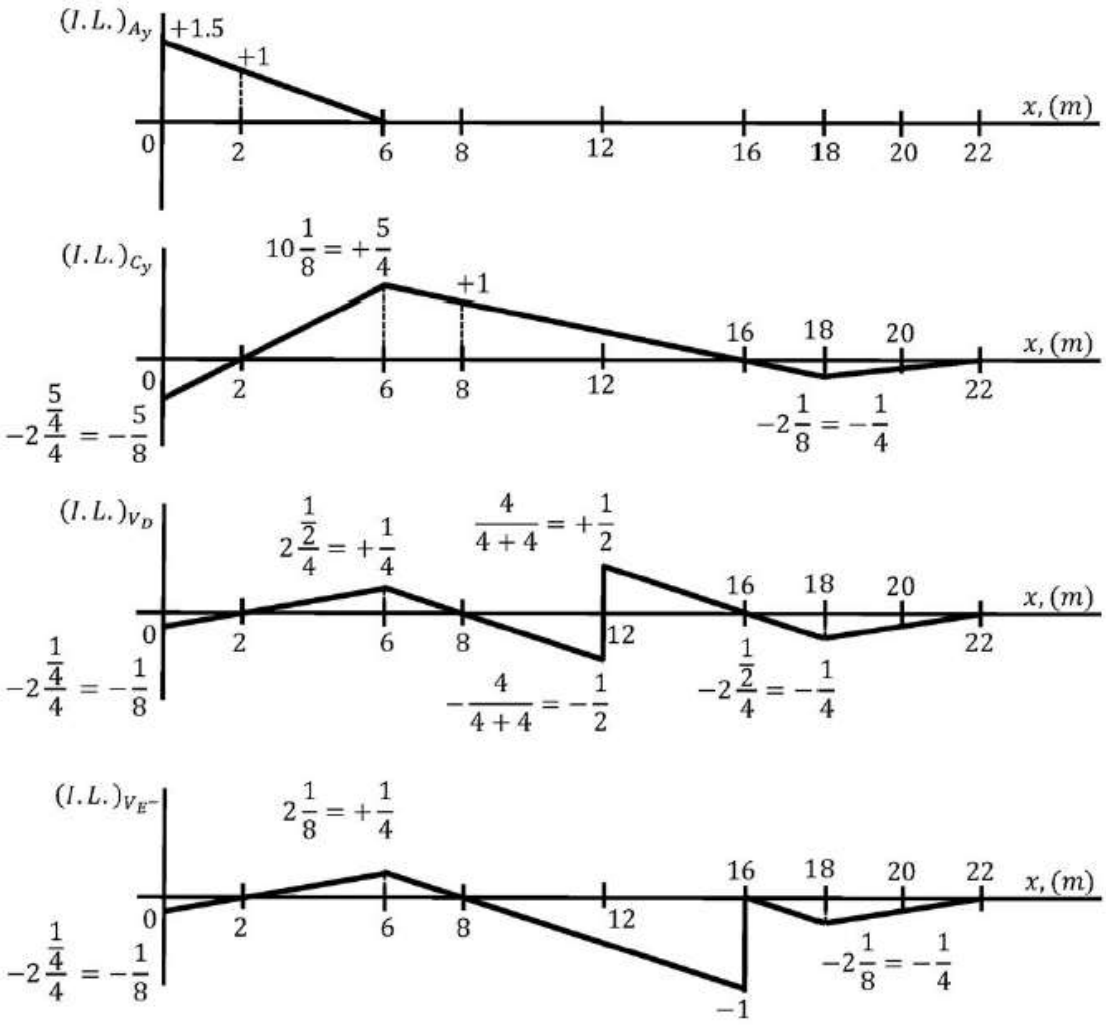
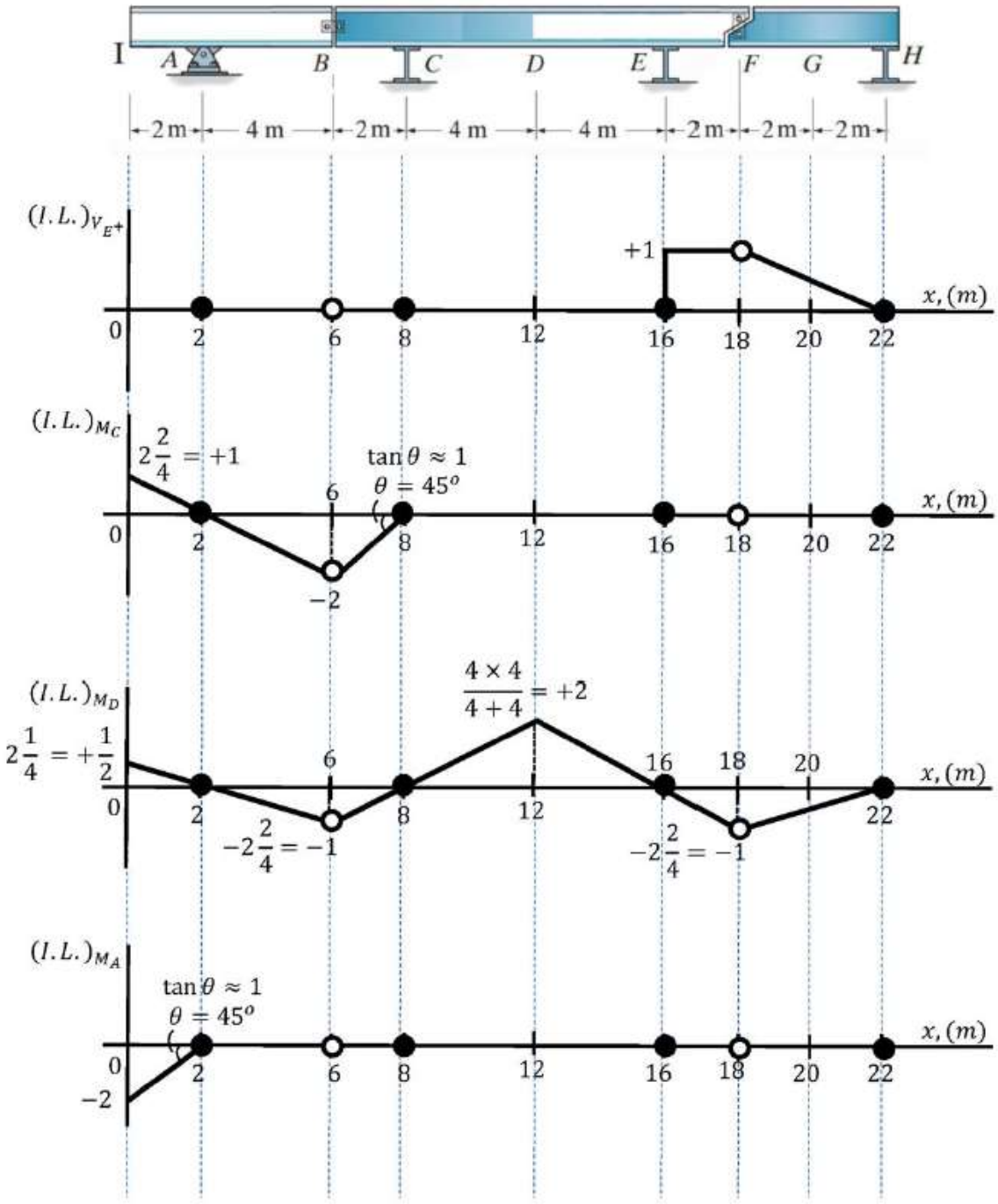
Example 8.16 **Quantitative Influence Lines, Müller-Breslau Principle**

Draw the influence lines for $A_y, C_y, V_D, V_{E^-}, V_{E^+}, M_C, M_D, M_G$ and M_A.



Solution




I
A
B
C
D
E
F
G
H
2m
4 m
2m
4 m
4 m
2m
2m
2m
$(I.L.)_{V_E}$
+1
x, (m)
0
2
6
8
12
16
18
20
22
$(I.L.)_{M_C}$
$2\frac{2}{4} = +1$
$\tan\theta \approx 1$
$\theta = 45^o$
−2
$(I.L.)_{M_D}$
$2\frac{1}{4} = +\frac{1}{2}$
$\frac{4 \times 4}{4+4} = +2$
$-2\frac{2}{4} = -1$
$-2\frac{2}{4} = -1$
$(I.L.)_{M_A}$
$\tan\theta \approx 1$
$\theta = 45^o$
−2