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By
Dr. Kishor Chandra Panda
Professor and Head
Department of Civil Engineering
GCEK, Bhawanipatna, Odisha

Influence Line Diagram

Dr. Kishor Chandra Panda
Professor and Head
Department of Civil Engineering
GCEK, Bhawanipatna, Odisha

Introduction

- A designer analyses the beams for various position of loads so as to get maximum shear force and bending moment values due to moving loads. To identify the positions of loads for maximum shear force and bending moment at specified sections, Influence Line Diagram (ILD) can be used.

- The Influence Line Diagram (ILD) is explained and used for finding maximum values of shear force and bending moment values.

Definitions of influence line

- In the literature, researchers have defined influence line in many ways. Some of the definitions of influence line are given below.
- An influence line is a diagram whose ordinates, which are plotted as a function of distance along the span, give the value of an internal force, a reaction, or a displacement at a particular point in a structure as a unit load move across the structure.
- An influence line is a curve the ordinate to which at any point equals the value of some particular function due to unit load acting at that point.
- An influence line represents the variation of either the reaction, shear, moment, or deflection at a specific point in a member as a unit concentrated force moves over the member.

- Influence line diagrams are drawn for various stress resultants like reaction, shear force, bending moment at specified points.
- Influence line diagram for a stress resultant is the one in which ordinate represent the value of the stress resultant for the position of unit load at the corresponding abscissa.
- For example If Figure 1 represents ILD for moment at section '*C*' in the beam *AB*, then the ordinate '*O*' represents the value of bending moment at '*C*' when a unit load is acting at section 1-1.

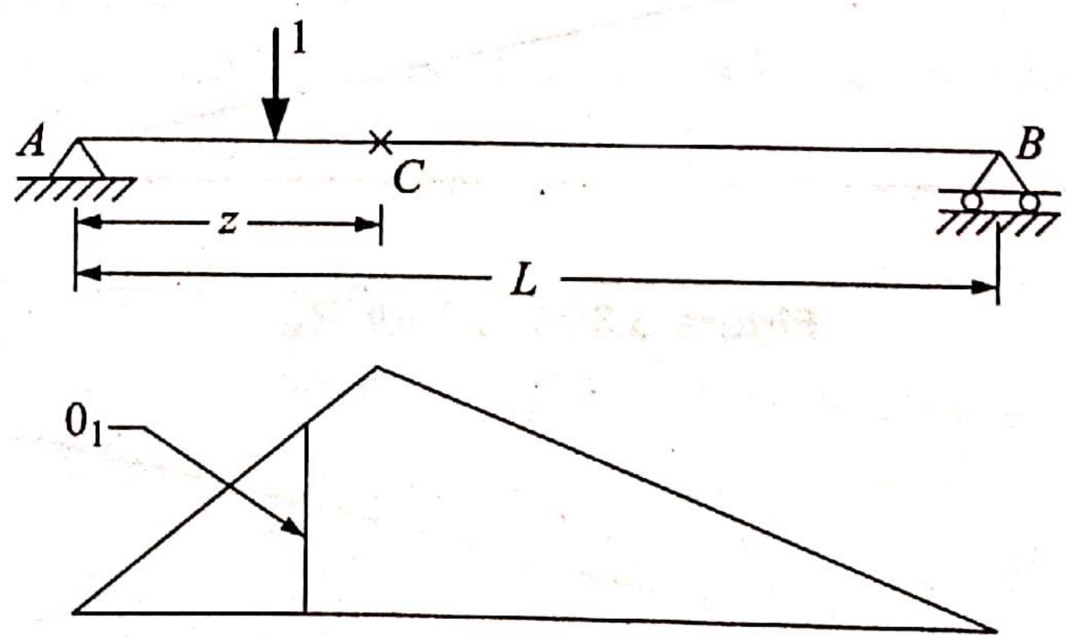


Figure 1: ILD for moment at '*C*'

Sign Convention

- Sign convention followed for shear force and bending moment

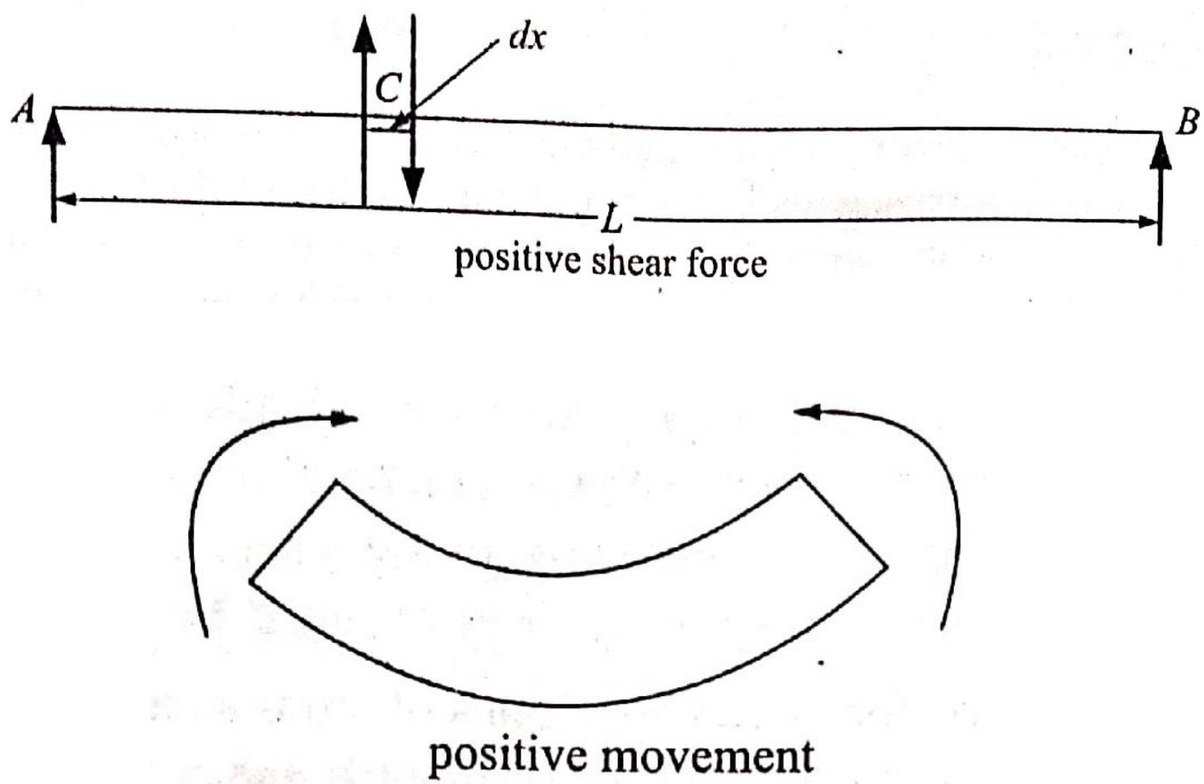


Figure 2: positive sense of SF and BM

Construction of Influence Lines

- The construction of influence lines can be done by using any one of the two approaches, one can construct the influence line at a specific point '*P*' in a member for any parameter (Reaction, Shear or Moment). In the present approaches it is assumed that the moving load is having dimensionless magnitude of unity.
- Classification of the approaches for construction of influence lines is given in Figure 3.

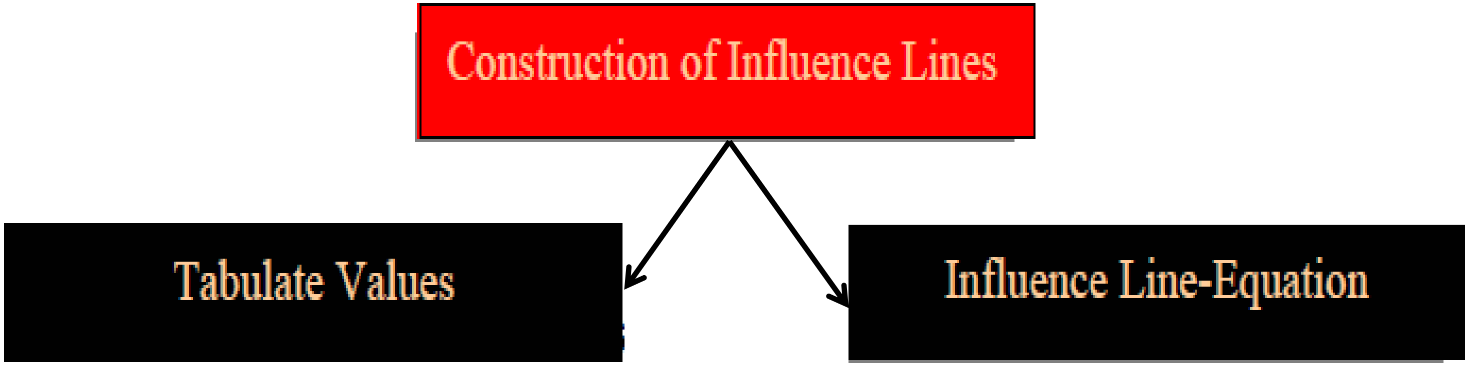


Figure 3: Classification of approach

Tabular values

- Apply a unit load at different locations along the member, say at ***x***., and these locations, apply statics to compute the value of parameter (reaction, shear, or moment) at the specified point. The best way to use this approach is to prepare a table, listing unit load at x versus the corresponding value of the parameter calculated at the specific point (i.e. Reaction R, Shear F or moment M) and plot the tabulated values so that influence line segments can be constructed.

Influence Line Equations

- Influence line can be constructed by deriving a general mathematical equation to compute parameters (e.g. reaction, shear or moment) at a specific point under the effect of moving load at a variable position ***x***.

Influence Line Diagrams for Simply supported Beams

By Influence Line Equation

- Influence line diagrams for reactions at support *A*, support *B*, and shear force and bending moment at a section at distance *z* from the end *A* are drawn.

ILD for reaction at A (R_A):

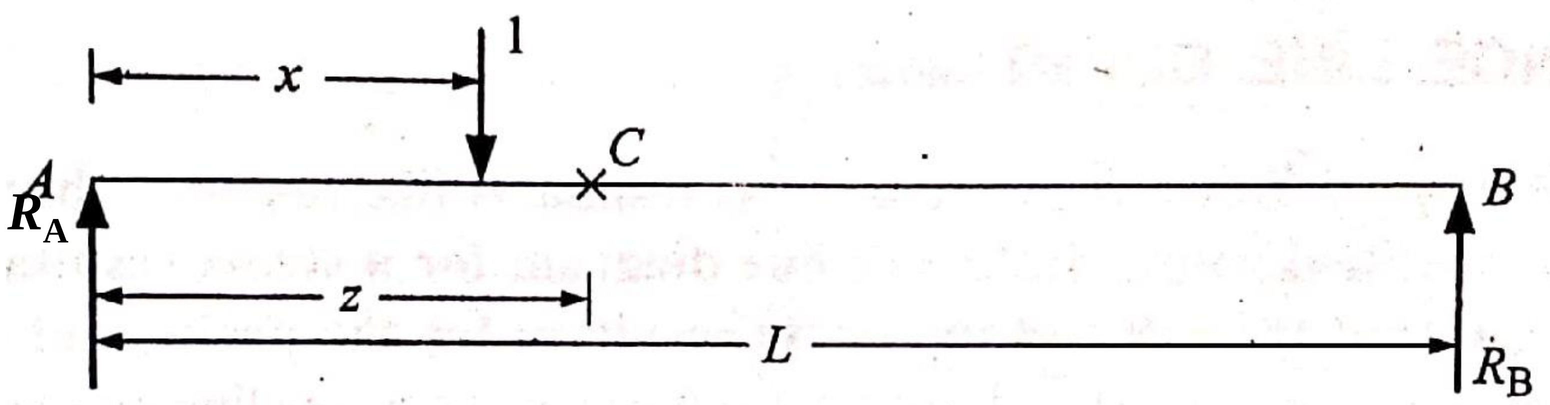


Figure 4: Beam with unit load

- Let the unit load be at a distance x from support A as shown in Figure 4.
- By taking moment about B, find out the reaction

$$R_A \times L = 1 \times (L\text{-}x)$$

$$R_A = \frac{1(L-x)}{L} = \left(1 - \frac{x}{L}\right), \text{ linear variation with } x$$

when $x = 0$, $R_A = 1$

when $x = L$, $R_A = 0$

- Hence, ILD for reaction at A (R_A) is as shown in Figure 4.

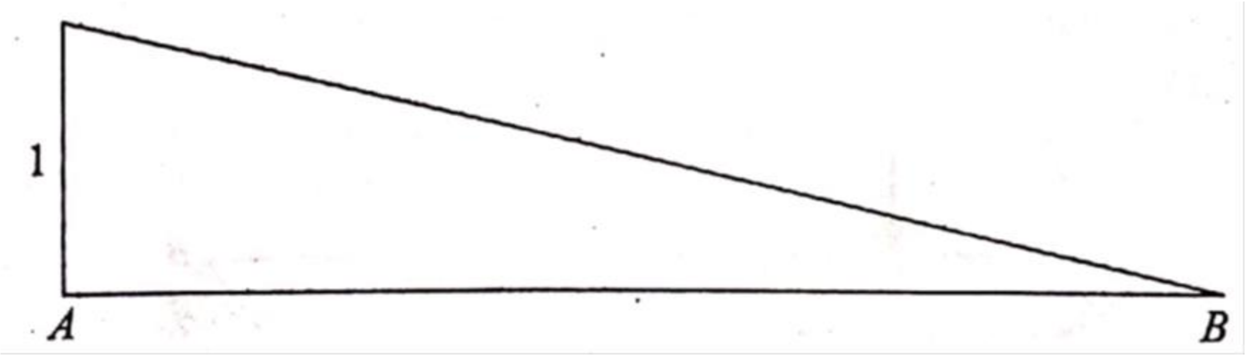


Figure 5: ILD for R_A

ILD for reaction at B (R_B):

- By taking moment about A, find out the reaction

$$R_B \times L = 1 \times x$$

$$R_B = \frac{x}{L}, \text{ linear variation}$$

when x = 0, $R_B = 0$

when x = L, $R_B = 1$

- Hence, ILD for reaction at *B* (R_B) is as shown in Figure 6.

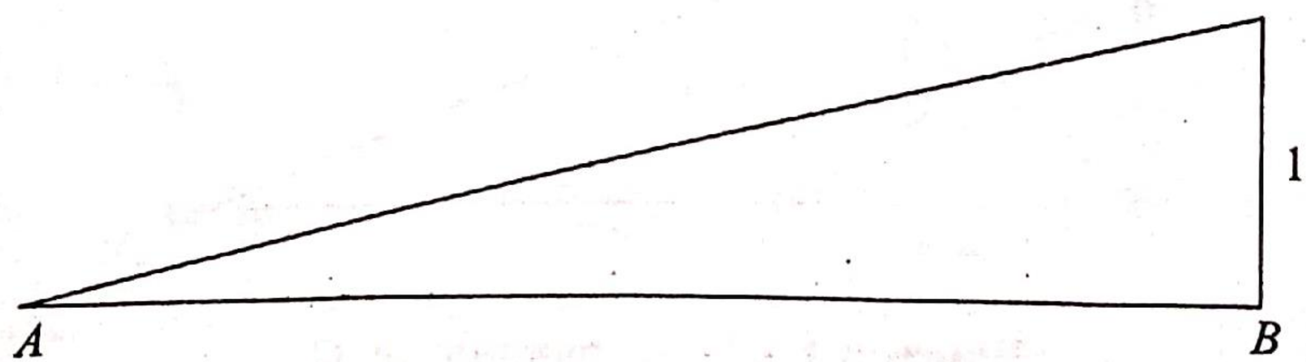


Figure 6: ILD for R_B

ILD for Shear Force at C (F_C):

- Let C be the section at a distance z from A as shown in Figure 4.
- **When $x < z$**

  Shear force at $C = F_C = -R_B = -\frac{x}{L}$, linear variation,

  when $x = 0$, $F = 0$

  when $x = z$, $F = -\frac{z}{L}$
- **When $x > z$**

  Shear force at $C = F_C = R_A = \frac{L-x}{L}$, linear variation

  when $x = z$, $F_c = \frac{L-z}{L}$

  when $x = L$, $F_C = 0$

  Hence, ILD for shear force at C (F_C) is as shown in Figure 7.

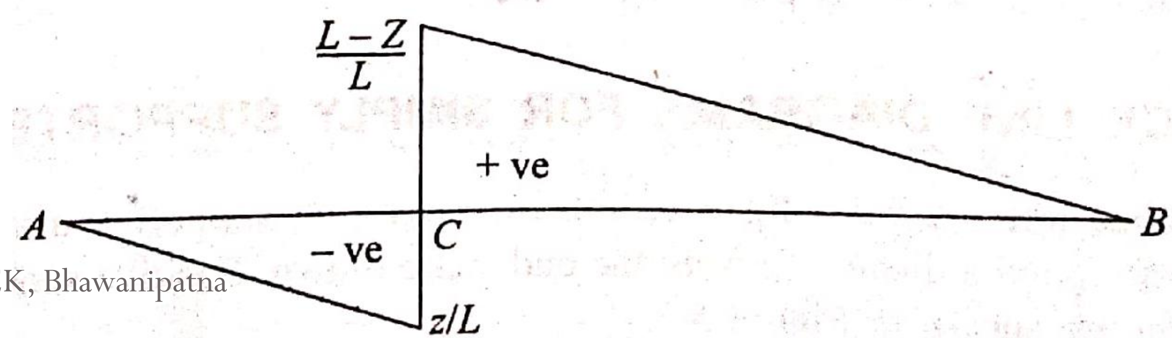


Figure 7: ILD for F_c

ILD for Moment at C (M_C):

- Let C be the section at a distance z from A as shown in Figure 4.

- **When $x < z$**

$$M_C = R_B (L-z) = \frac{X}{L}(L-z) \text{ linear variation with } x,$$

when $x = 0$, $M_C = 0$

when $x = z$, $M_C = \left(\frac{z(L-z)}{L}\right)$

- **When $x > z$**

$$M_C = R_A z = \left(\frac{L-x}{L}\right) z \text{ ; linear variation with } x$$

when $x = z$, $M_C = \frac{z(L-z)}{L}$

When $x = L$, $M_C = 0$

Hence, ILD for moment at C (M_C) is as shown in Figure 8.

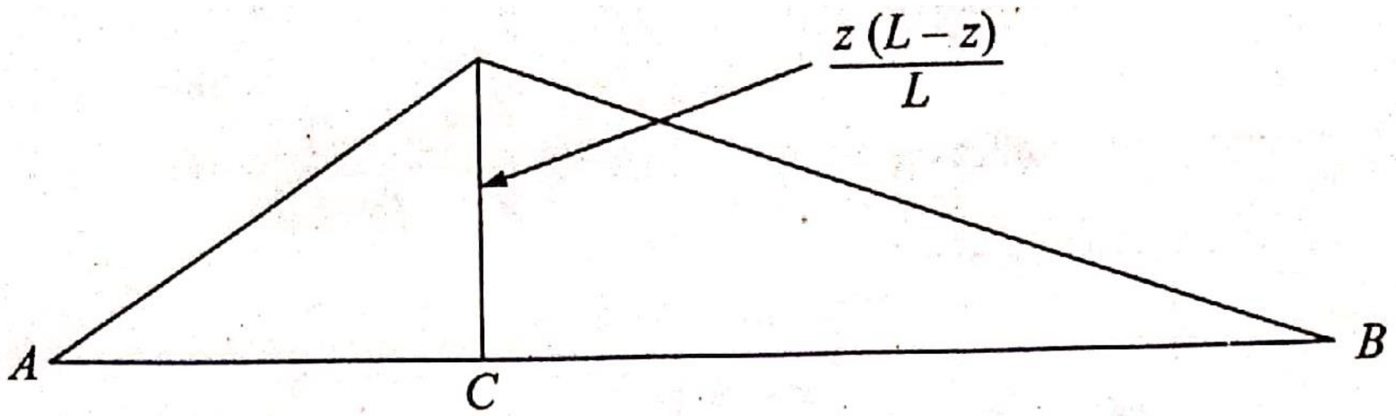


Figure 8: ILD for Moment at M_C

Influence Line Diagrams for Cantilever Beams

- Consider a cantilever beam of span *L* as shown in Figure 9.
- Influence line diagram for shear force and bending moment at fixed end *A* and at *C* are to be determined.
- Let a unit load act at a distance *x* from the free end *B*.

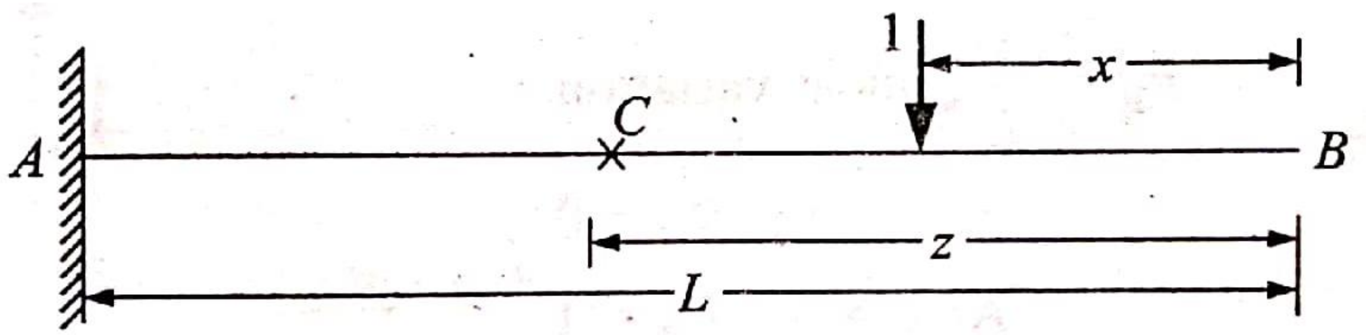
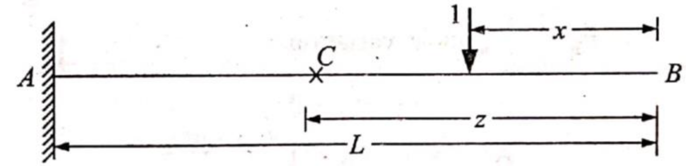


Figure 9: Cantilever with unit load

ILD for Shear Force at A (F_A):



Shear force at $A = F_A = 1$, Constant

Hence, ILD for F_A is as shown in Figure 10.

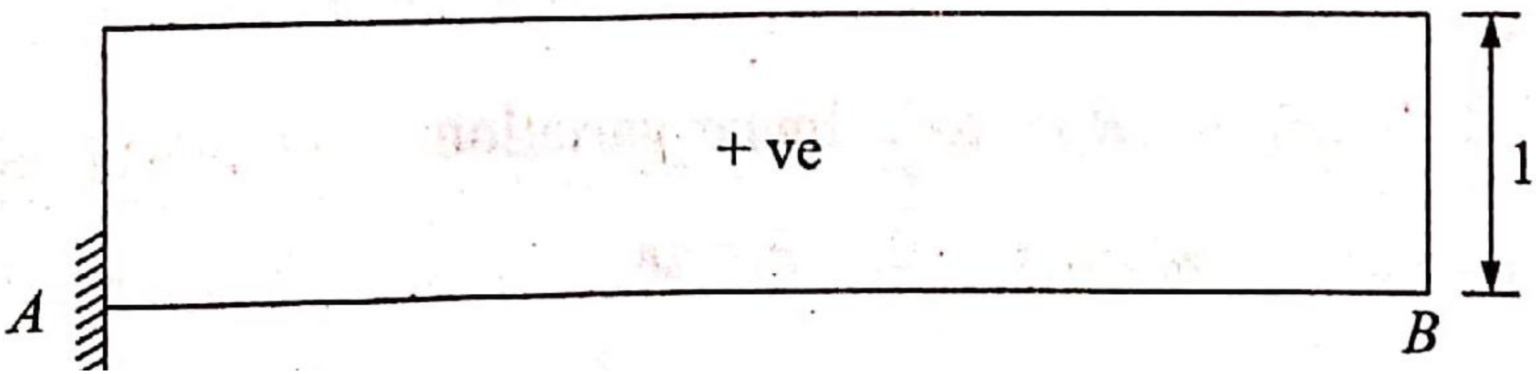


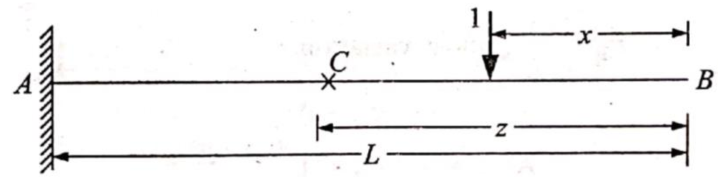
Figure 10: ILD for F_A

ILD for moment at A (M_A):

Moment at $A = M_A = -(L-x)$, Linear variation

when $x = 0$, $M_A = -L$

when $x = L$, $M_A = 0$



Hence, ILD for M_A is shown in Figure 11.

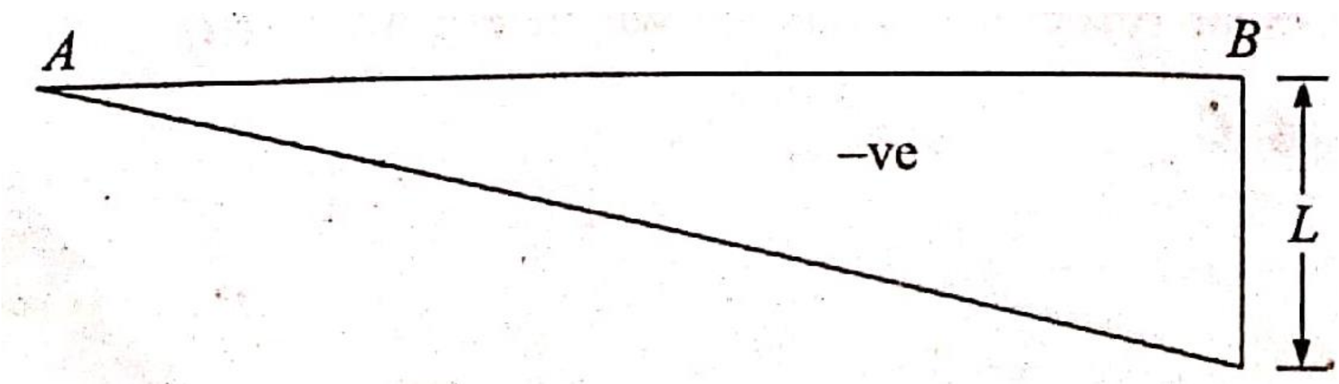
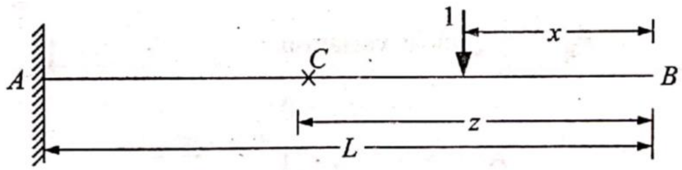


Figure 11: ILD for moment M_A

ILD for Shear Force at C (F_C):



- **When $x < z$**

  Shear force at C $= F_C = 1$ (Constant)

  when $x = 0$, $F_C = 1$ and when $x = z$, $F_C = 1$

- **When x > z**

  Shear force at $C = F_C = 0$

  when $x = z$, $F_C = 0$, when $x = L$, $F_C = 0$

Hence, ILD for shear force (F_C) is shown in Figure 12.

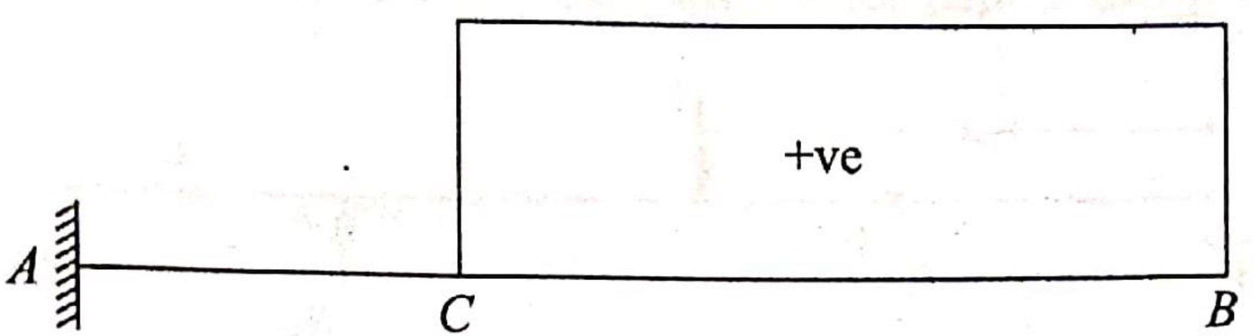
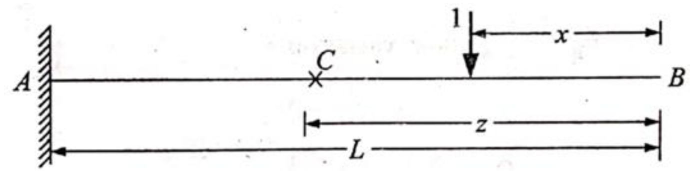


Figure 12: ILD for shear force at C (F_C)

ILD for Moment at C (M_C):



- **When $x \leq z$**

  Moment at C = M_C = -1 (z-x), Linear variation

  when x = 0, M_C = - z

  when x = z, M_C = 0

- **When $x > z$**

  Moment at C = M_C = 0, Constant

  Hence, ILD for moment at C (M_C) is shown in Figure 13.

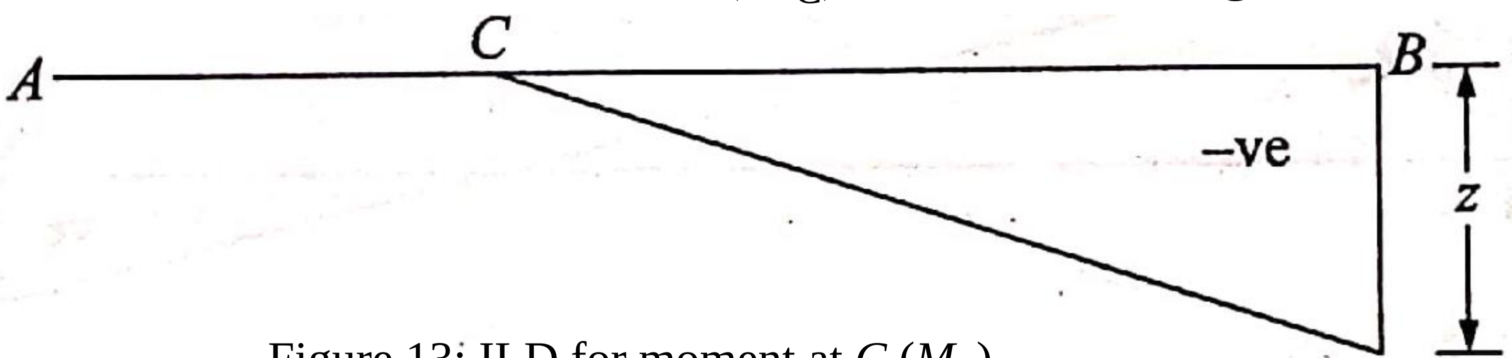


Figure 13: ILD for moment at C (M_C)

Thanks