UNIT- V
INFLUENCE LINE DIAGRAMS

PREPARED BY

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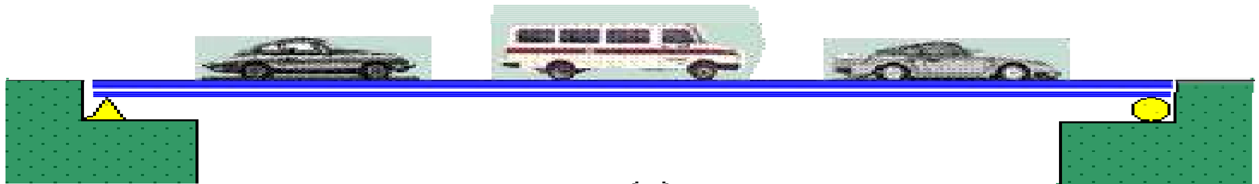
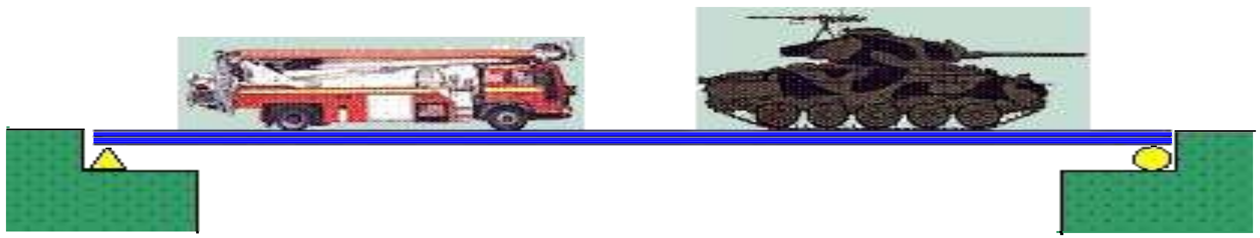
Topics

- Introduction to Influence lines
- Influence lines for Beams
- Qualitative Influence lines
- Maximum Influence at a point due to Series of concentrated Loads
- Absolute maximum shear and moment

Introduction



(a)



(b)

Influence lines offer a quick and easy way of performing multiple analyses for a single structure. Response parameters such as *shear force* or *bending moment at a point* or *reaction at a support* for several load sets can be easily computed using influence lines

Influence Lines

- If Structure is subjected to moving load, the variation of the shear and bending moment in the member is best described using the Influence line.
- Once the IL constructed, one can tell at glance where the moving load should be placed on the structure so that it creates the greatest influence.
- Further more, magnitude of the associated reaction, shear, moment or deflection at the pt can be calculate from the ordinates of the ILD.
- So, that its play an important part in the design of bridges, industrial crane rails, conveyors and other structure where loads moves across the span.

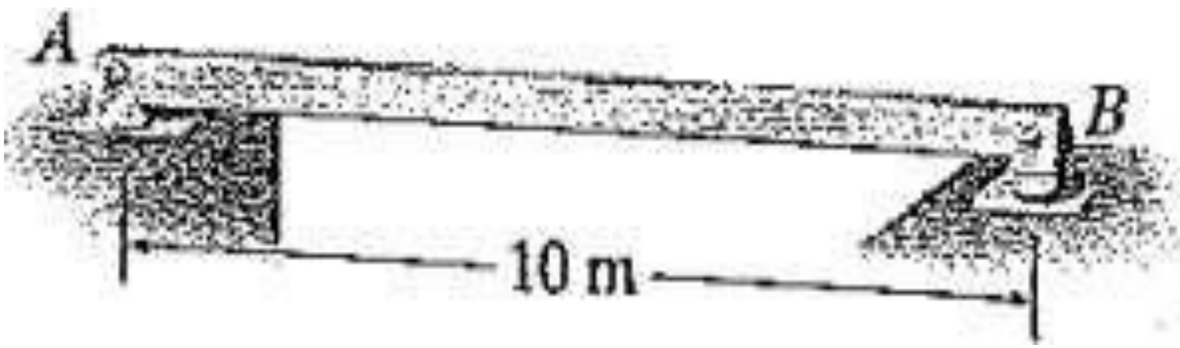
Construction IL using Equilibrium Methods

- The most basic method of obtaining influence line is described below.

  - For a particular location of the unit load, solve for the equilibrium of the whole system and if required, as in the case of an internal force, also for a part of the member to obtain the response parameter for that location of the unit load. This gives the ordinate of the influence line at that particular location of the load.
  - Repeat this process for as many locations of the unit load as required to determine the shape of the influence line for the whole length of the member. It is often helpful if we can consider a generic location (or several locations) x of the unit load.
  - Joining ordinates for different locations of the unit load throughout the length of the member, we get the influence line for that particular response parameter.

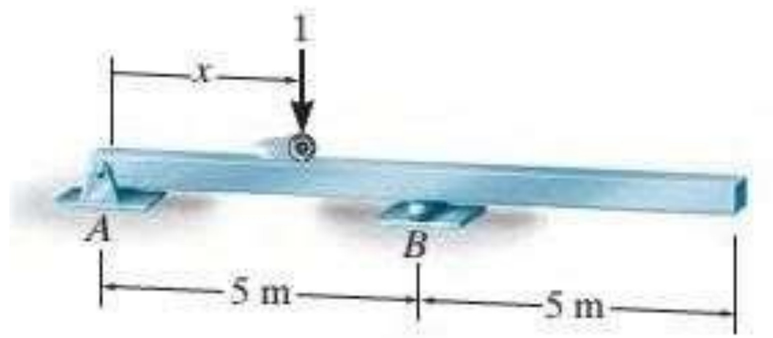
Example 8.1

Construct the influence line for the vertical reaction at A of the beam in Fig.



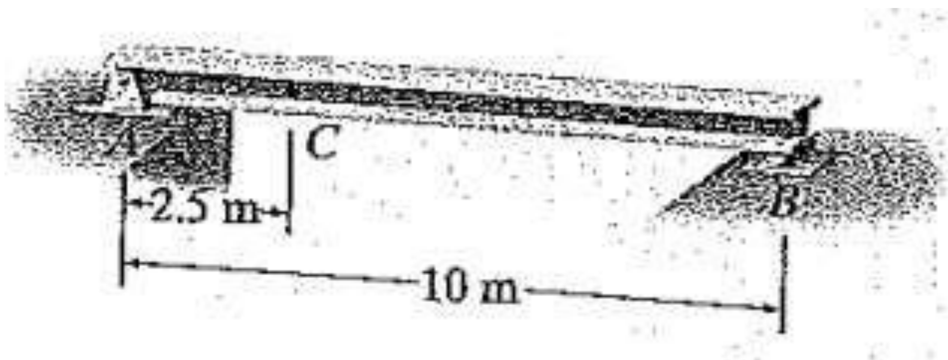
Example 8.2

Construct the influence line for the vertical reaction at B of the beam in Fig.



Example 8.3

Construct the influence line for the shear and moment at C of the beam in Fig.

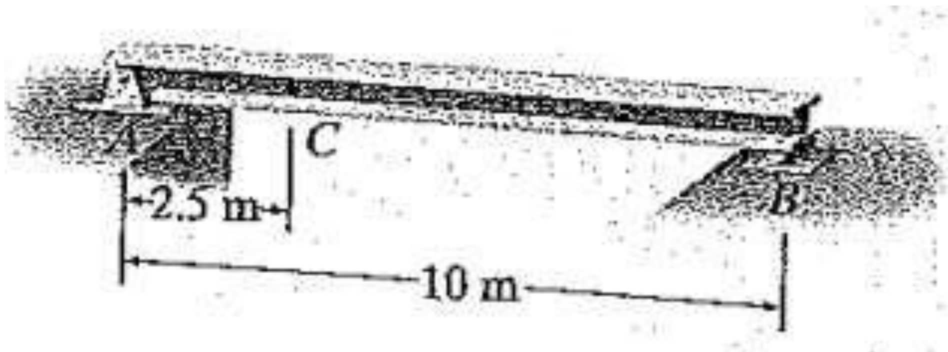


Influence Lines for Beams

- **Loading:** Once the Influence line for a function (reaction, shear or moment) has been constructed, then it will be possible to position the live load on the beam which will produce the maximum value of the function. Two types of loadings will be considered.
  - **concentrated force**
  - **uniform load**

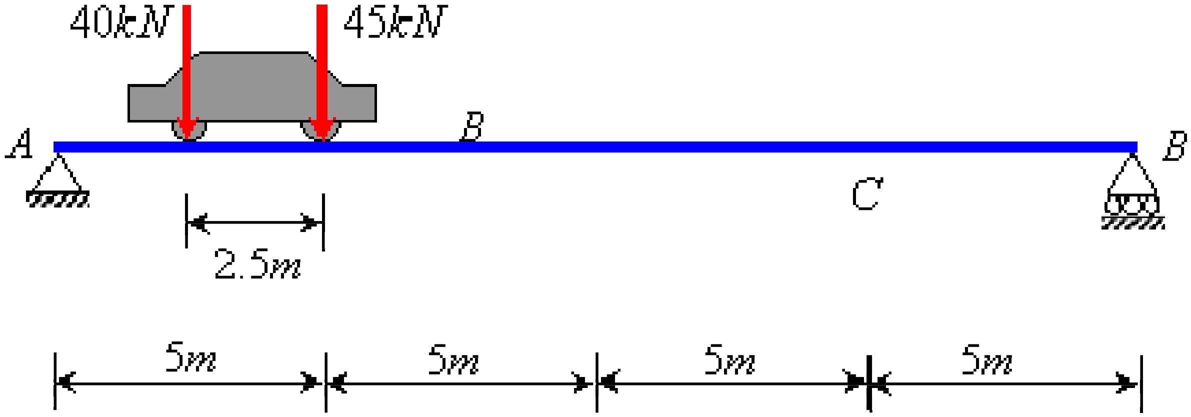
Example 8.4

Determine the maximum positive live shear that can be developed at point C in the beam shown in fig. due to a concentrated moving load of 4kN and a uniform moving load of 2 kN/m.



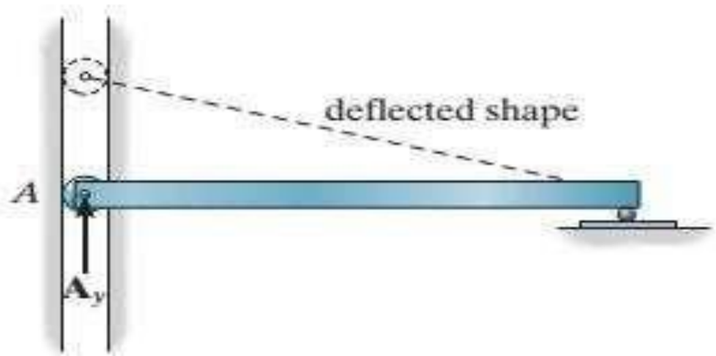
Homework 8.1

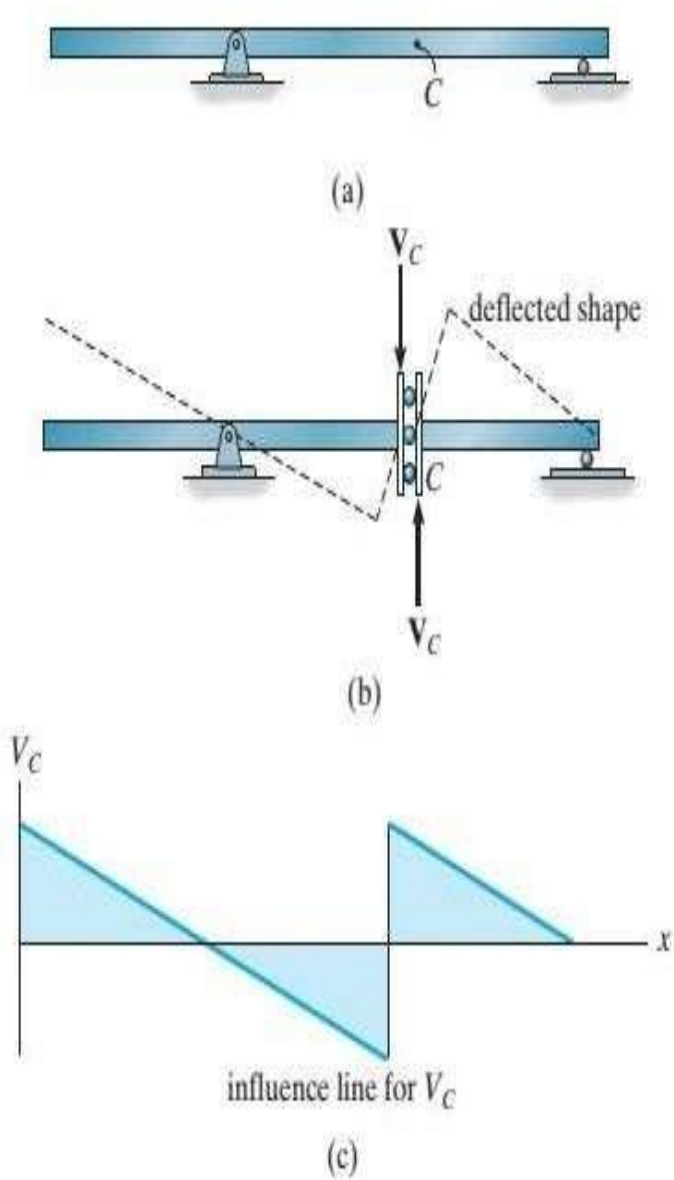
Find the maximum shear force at C for the moving load combination in fig. (**Ans: 58.75 kN**)

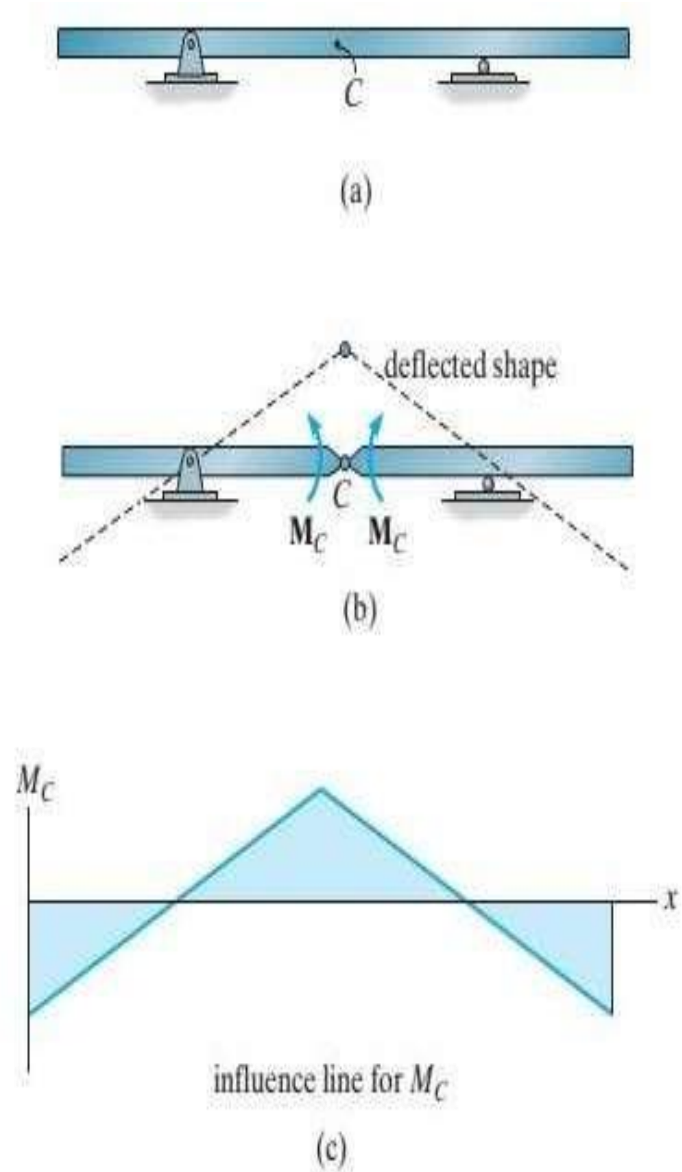


Qualitative Influence Lines

- In 1886, Muller Breslau developed a technique for rapidly constructing the shape of an IL.
- Muller Breslau Principle: *The IL for a function is to the same scale as the deflected shape of the beam when the beam is acted upon by the function.*

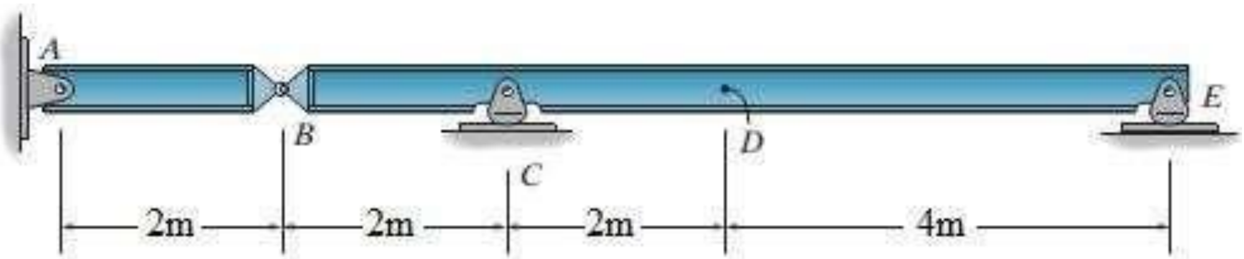



C
(a)
V_C
deflected shape
C
V_C
(b)
V_C
x
influence line for V_C
(c)

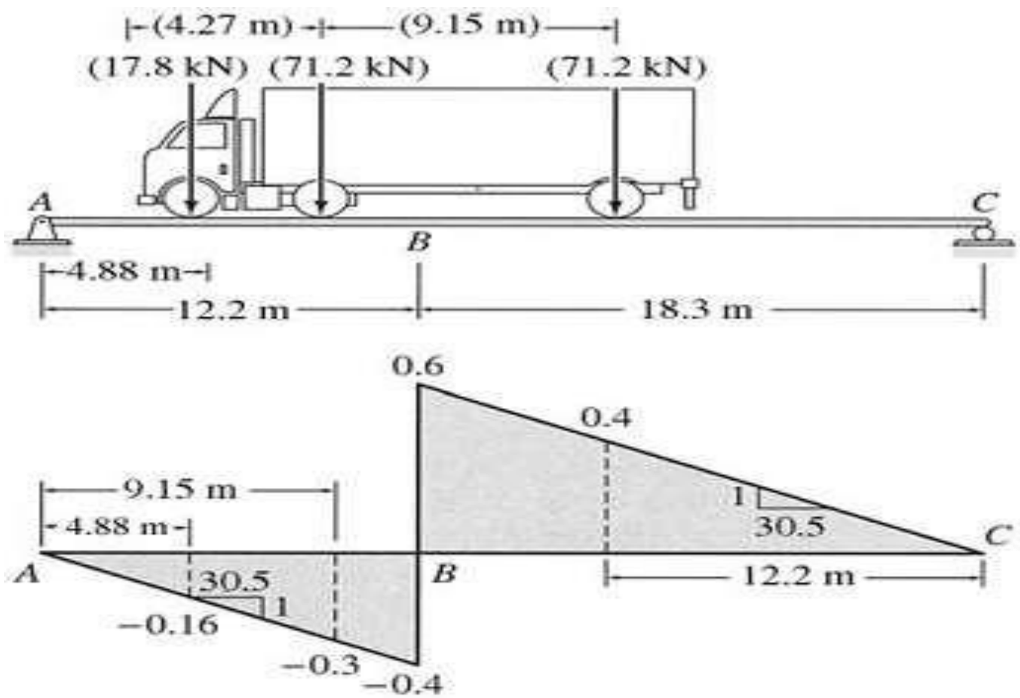

C
(a)
deflected shape
C
M_C
M_C
(b)
M_C
x
influence line for M_C
(c)

Example 8.5

Determine the maximum positive moment that can be developed at point D in the beam shown in fig. due to concentrated moving load of 16 kN, a uniform moving load of 3 kN/m and beam weight of 2 kN/m.



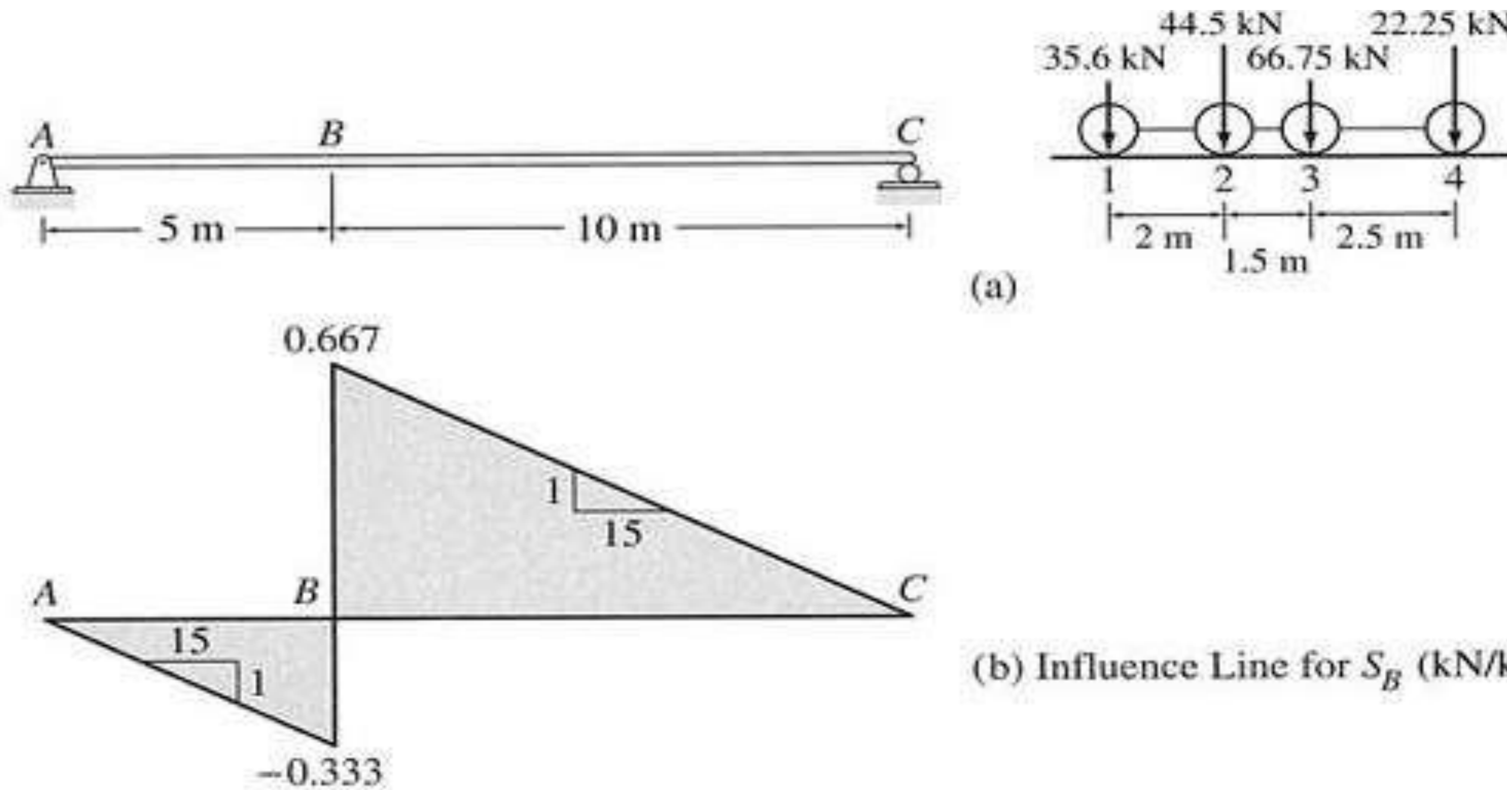
Maximum Influence at a point due to Series of concentrated Loads



Influence Line for S_B kN/kN

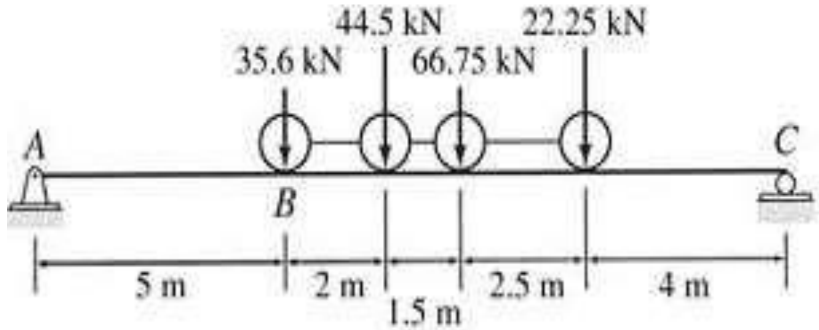
$$S_B = -17.8(0.16) - 71.2(0.3) + 71.2(0.3) = 4.272 \text{ kN}$$

Example 8.6

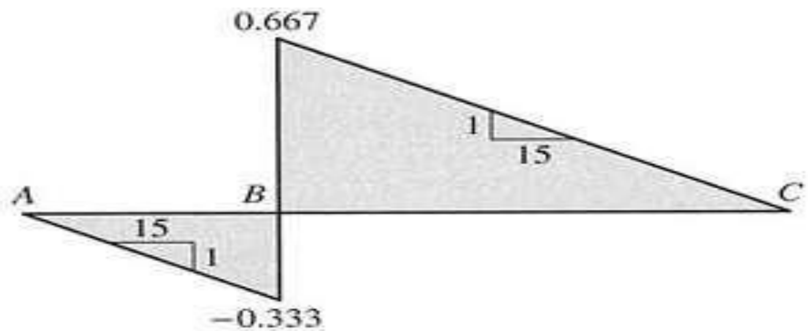


(a)

(b) Influence Line for S_B (kN/kN)

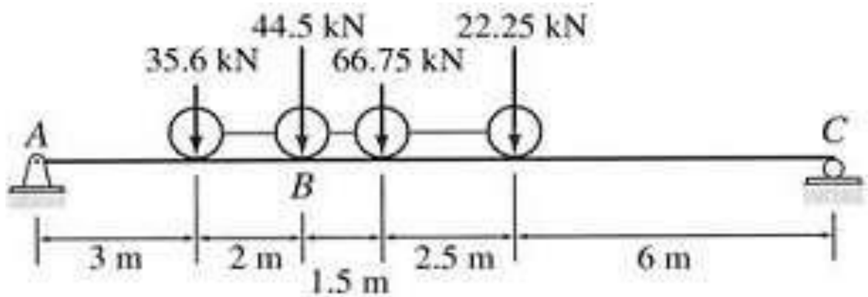


(c) Loading Position 1

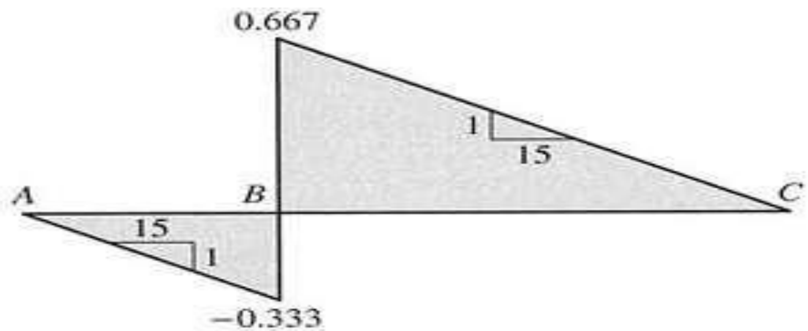


$$S_B = 35.6(10)\left(\frac{1}{15}\right) + 44.5(8)\left(\frac{1}{15}\right) + 66.75(6.5)\left(\frac{1}{15}\right) + 22.25(4)\left(\frac{1}{15}\right)$$

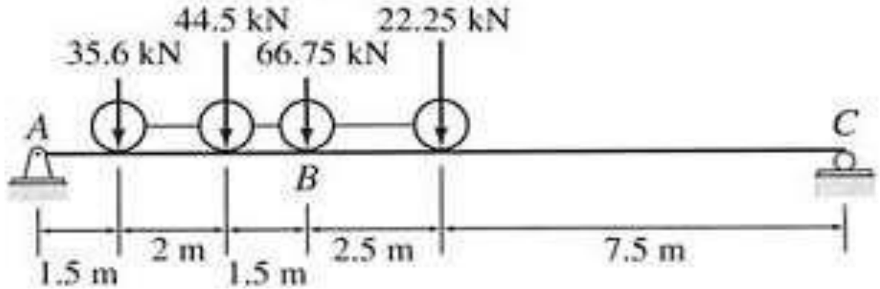
$$= 82.32 \text{ kN}$$



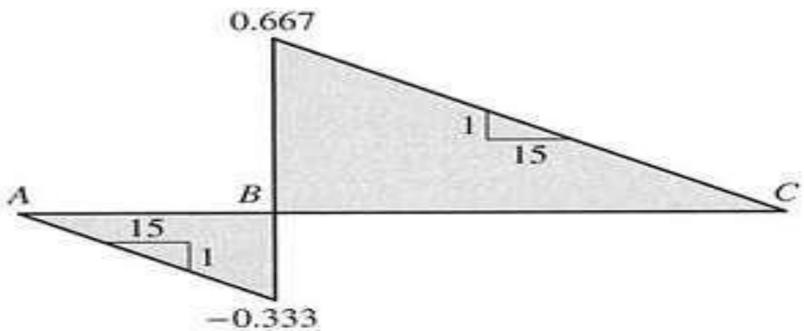
(d) Loading Position 2



$$S_B = -35.6(3)\left(\frac{1}{15}\right) + 44.5(10)\left(\frac{1}{15}\right) + 66.75(8.5)\left(\frac{1}{15}\right) + 22.25(6)\left(\frac{1}{15}\right)$$
$$= 69.28 \text{ kN}$$

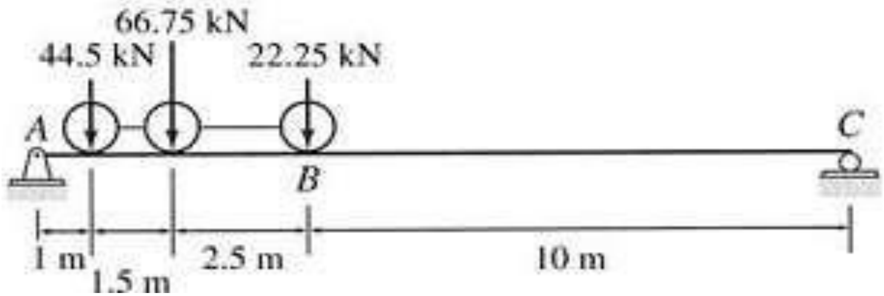


(e) Loading Position 3

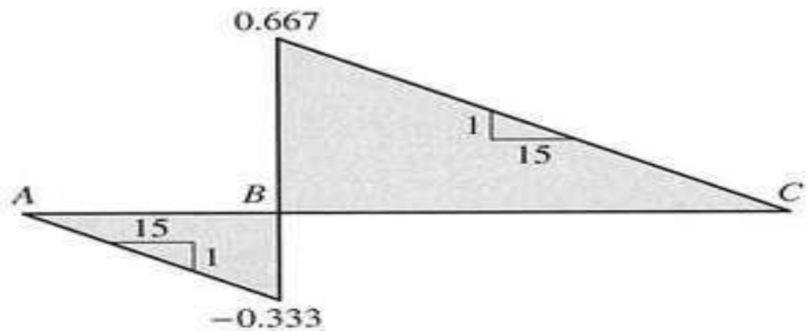


$$S_B = -35.6(1.5)\left(\frac{1}{15}\right) - 44.5(3.5)\left(\frac{1}{15}\right) + 66.75(10)\left(\frac{1}{15}\right) + 22.25(7.5)\left(\frac{1}{15}\right)$$

$$= 41.68 \text{ kN}$$



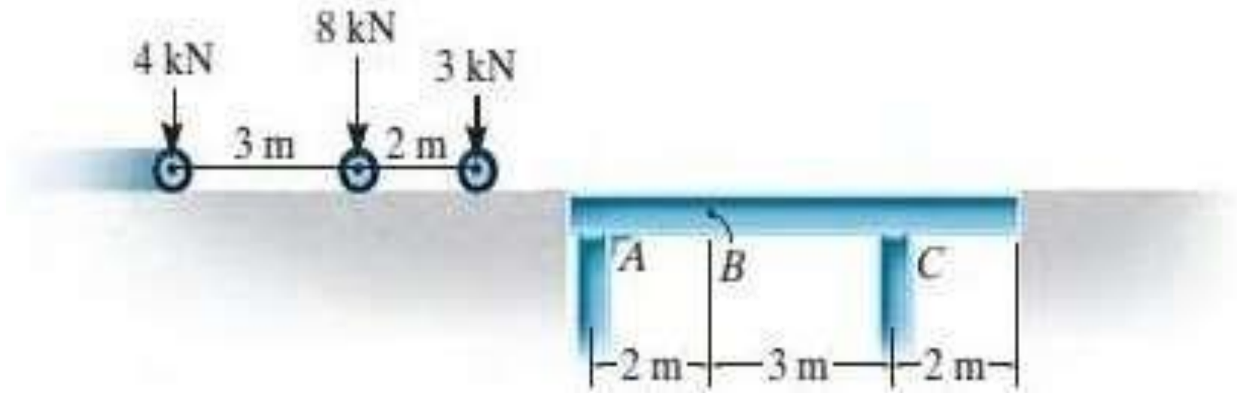
(f) Loading Position 4



$$S_B = -44.5(1)\left(\frac{1}{15}\right) - 66.75(2.5)\left(\frac{1}{15}\right) + 22.25(10)\left(\frac{1}{15}\right) = 0.742 \text{ kN}$$

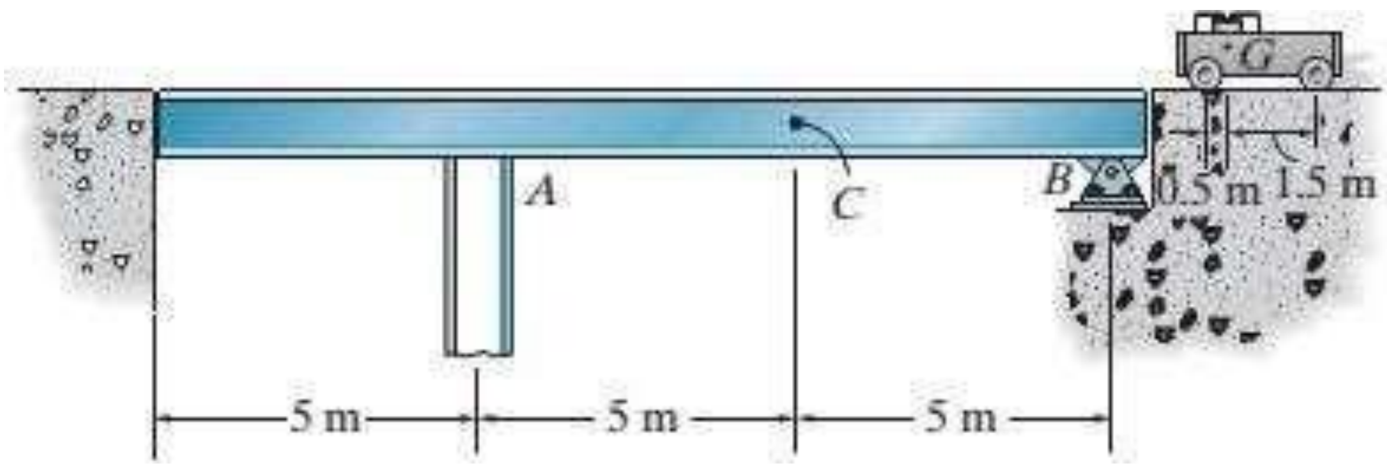
Homework 8.2

- Determine the maximum positive moment created at point B in the beam shown in Fig. due to wheel loads of the crane.

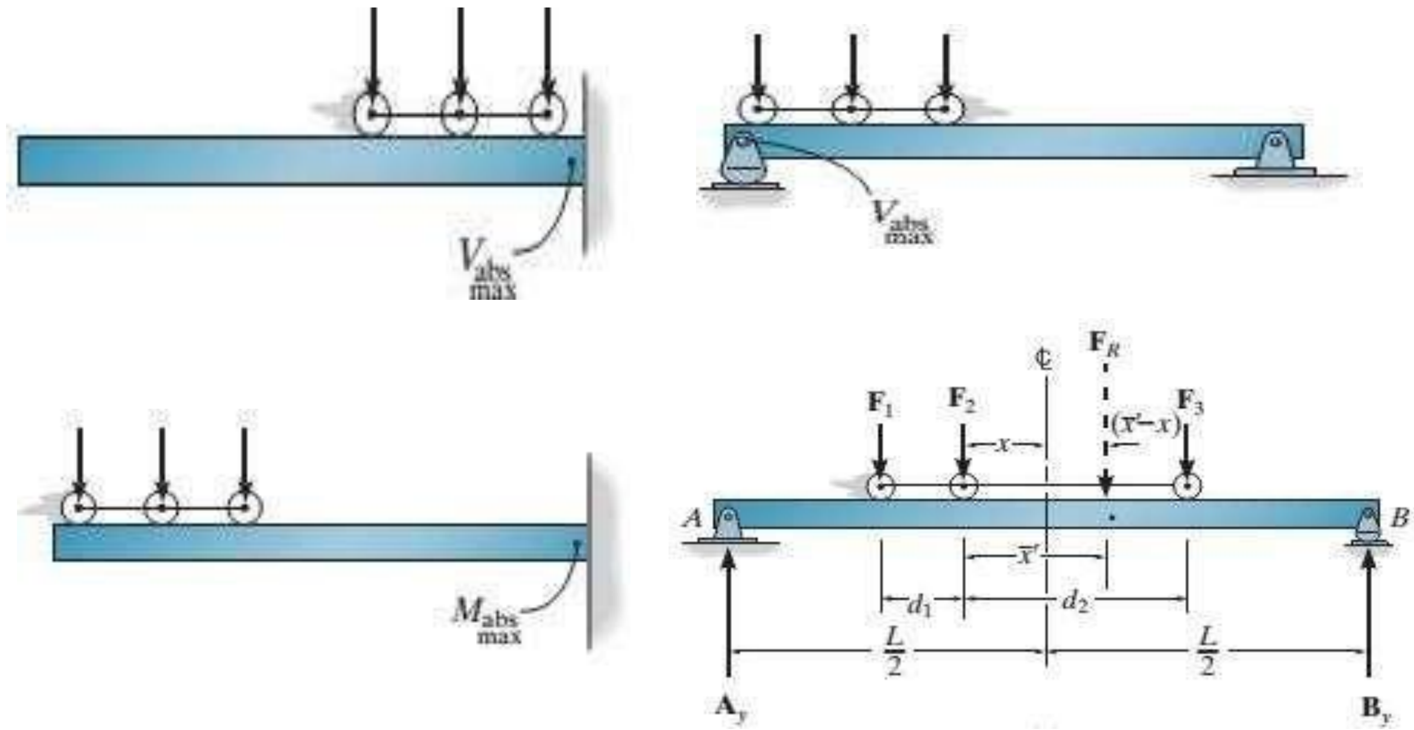


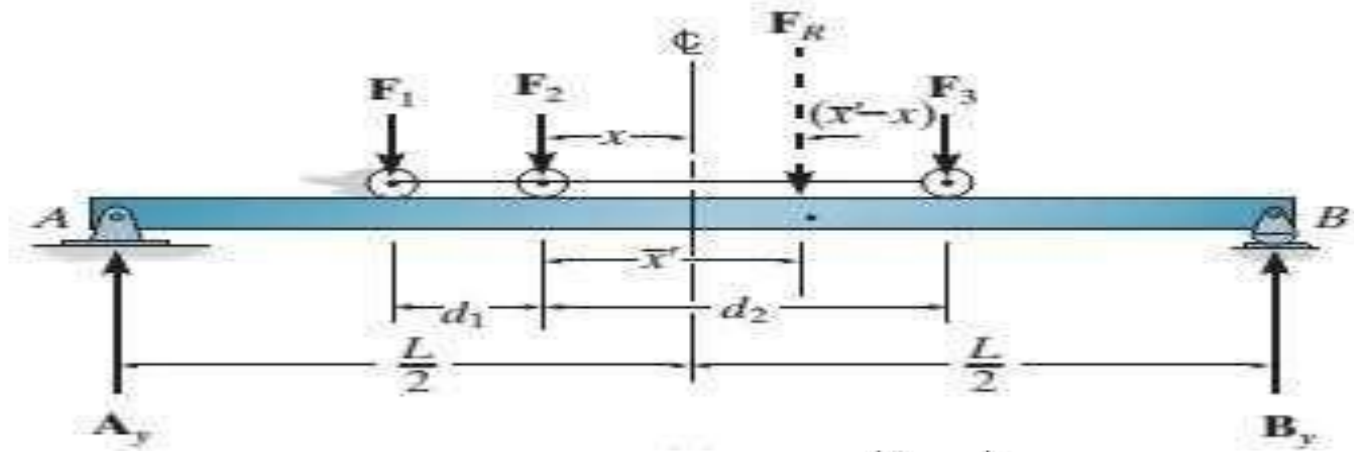
Homework 8.3

- Determine the maximum moment at C on the single girder caused by the moving dolly that has a mass of 2 Mg and a mass center at G. Assume A is a roller.



Absolute maximum shear and moment



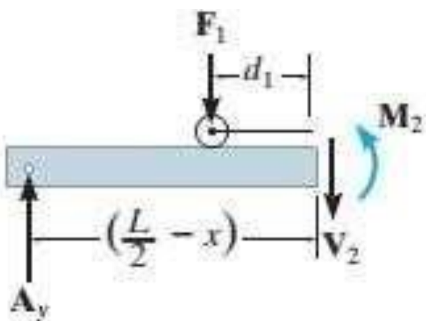


$\Sigma M_B = 0;$ $\qquad A_y = \frac{1}{L}(F_R)\left[\frac{L}{2} - (\bar{x}' - x)\right]$

$\Sigma M = 0;$ $\qquad M_2 = A_y\left(\frac{L}{2} - x\right) - F_1 d_1$

$$= \frac{1}{L}(F_R)\left[\frac{L}{2} - (\bar{x}' - x)\right]\left(\frac{L}{2} - x\right) - F_1 d_1$$

$$= \frac{F_R L}{4} - \frac{F_R \bar{x}'}{2} - \frac{F_R x^2}{L} + \frac{F_R x \bar{x}'}{L} - F_1 d_1$$



For maximum M_2 we require

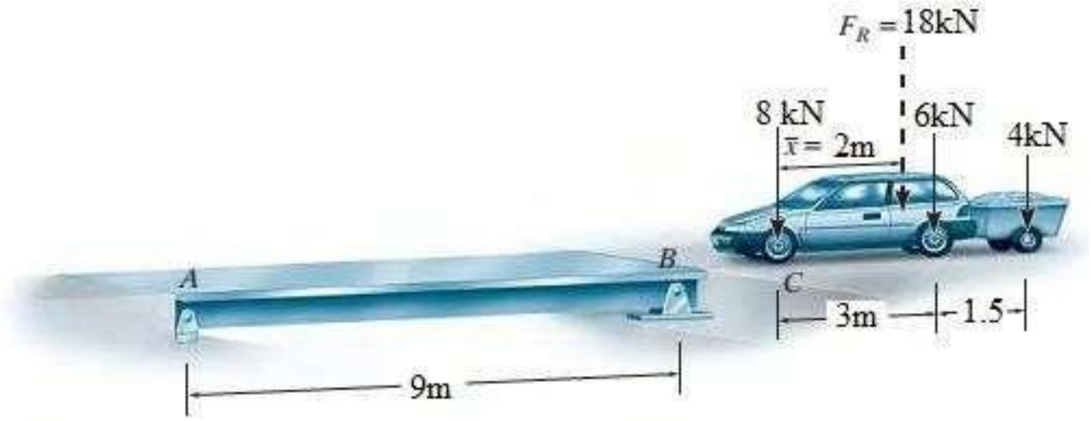
$$\frac{dM_2}{dx} = \frac{-2F_R x}{L} + \frac{F_R \bar{x}'}{L} = 0$$

or

$$x = \frac{\bar{x}'}{2}$$

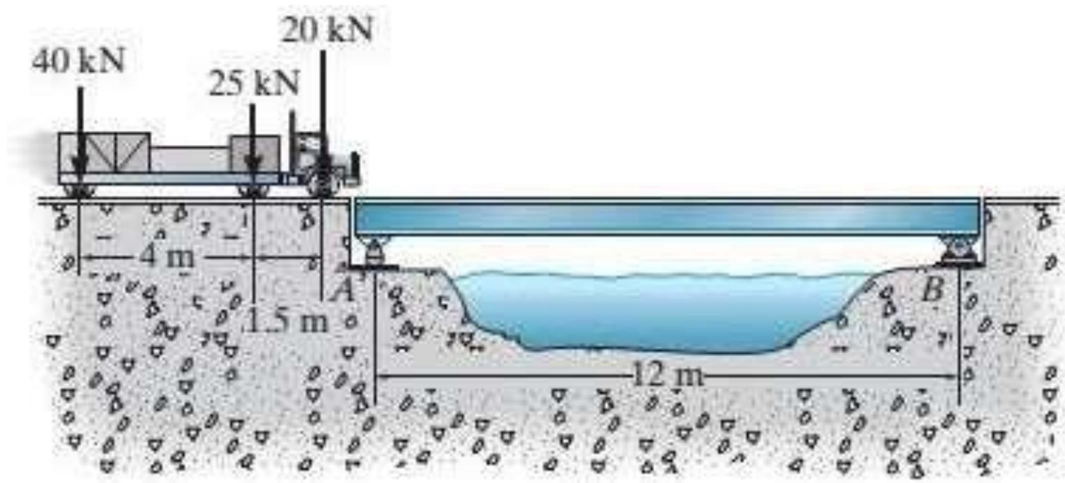
Example 8.7

- Determine the absolute maximum moment in the simply supported bridge deck shown in fig.



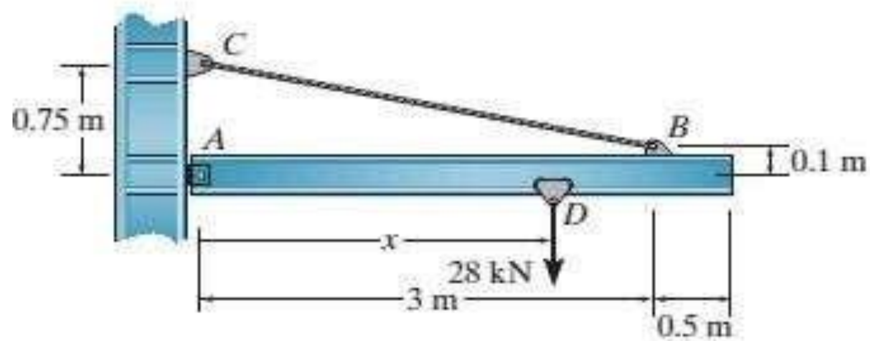
Homework 8.4

- Determine the absolute maximum shear and moment in the simply supported beam shown in fig.



Project Problem

- The chain hoist on the wall crane can be placed anywhere along the boom (0.1m <x< 3.4m) and has a rated capacity of 28 kN. Use an impact factor of 0.3 and determine the absolute moment in the boom and the maximum force developed in the tie rod BC.



- 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.

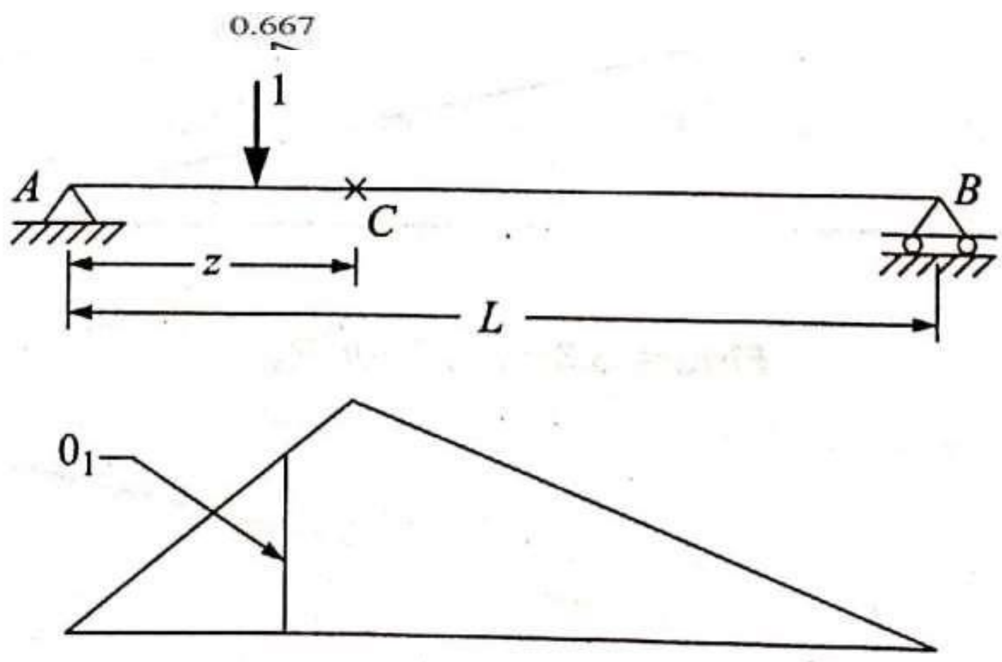
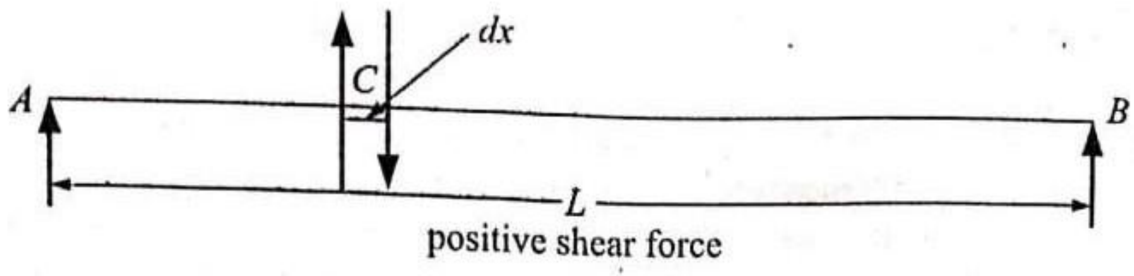


Figure 1: ILD for moment at '*C*'

Sign Convention

- Sign convention followed for shear force and bending moment



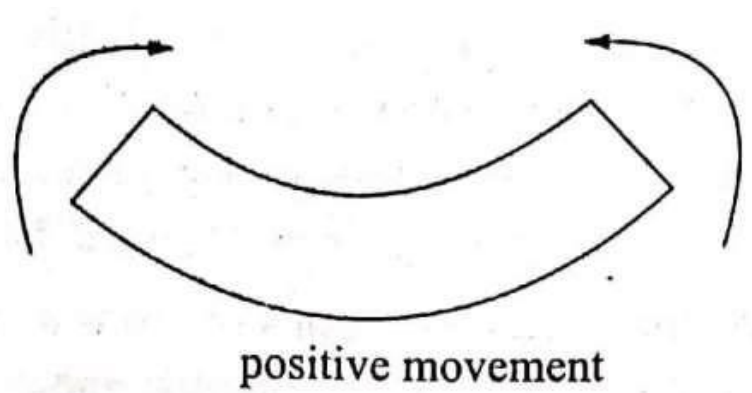


Figure 2: positive sense of SF and BM

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.

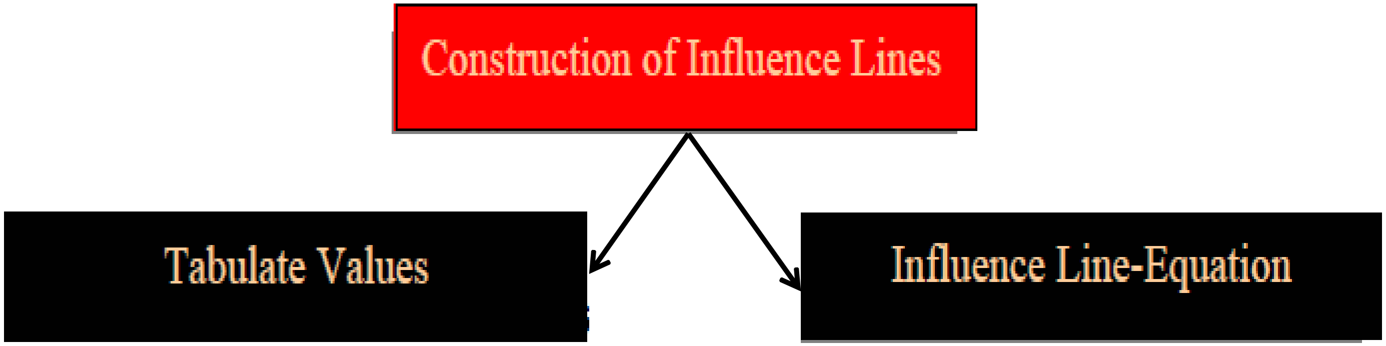


Figure 3: Classification of approach

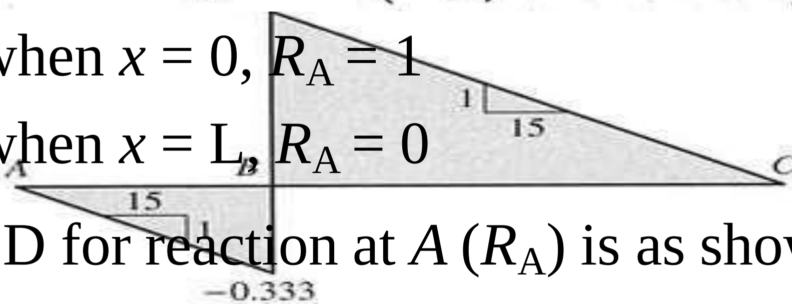
- Let the unit load be at a distance x from support A as shown in Figure 4.
- By taking moment about B, find out the reaction

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

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

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

when $x = \mathrm{L}$, $R_A = 0$



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

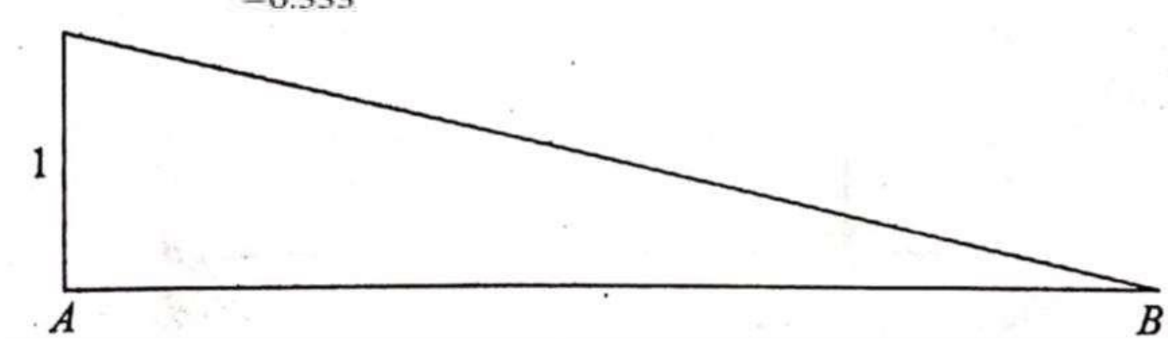


Figure 5: ILD for R_A

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.

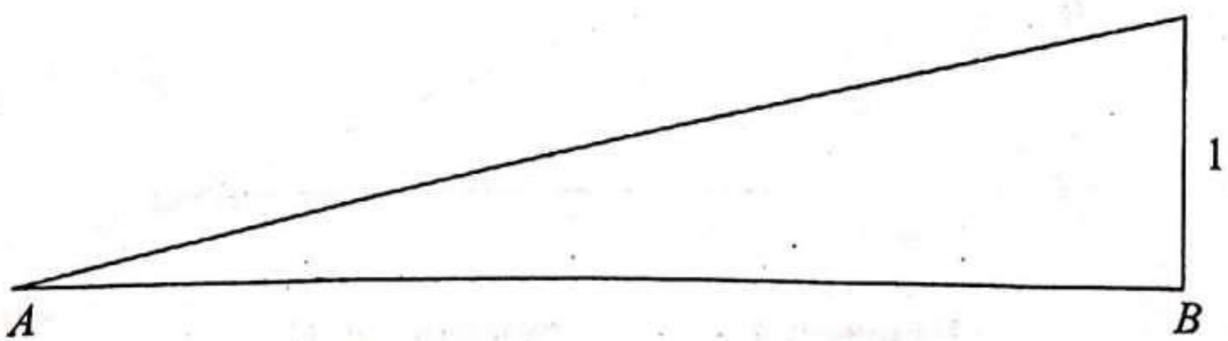


Figure 6: ILD for R_B

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.

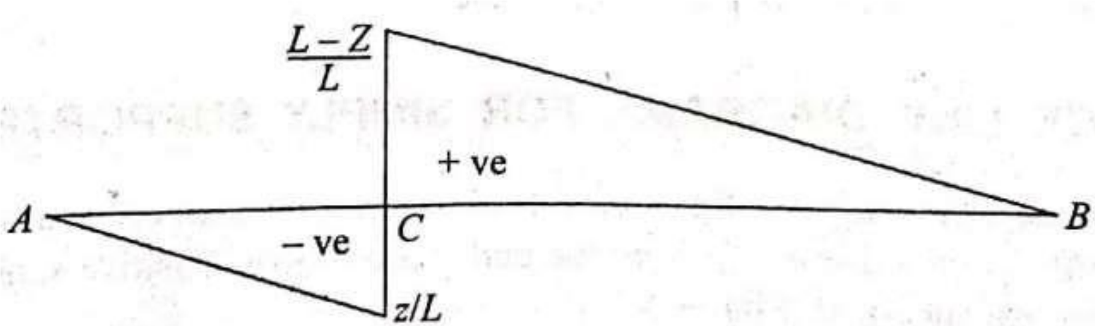


Figure 7: ILD for F_c

ILD for Moment at C (M_C):

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

- **When $x < z$**

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

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

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

- **When $x > z$**

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

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

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

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

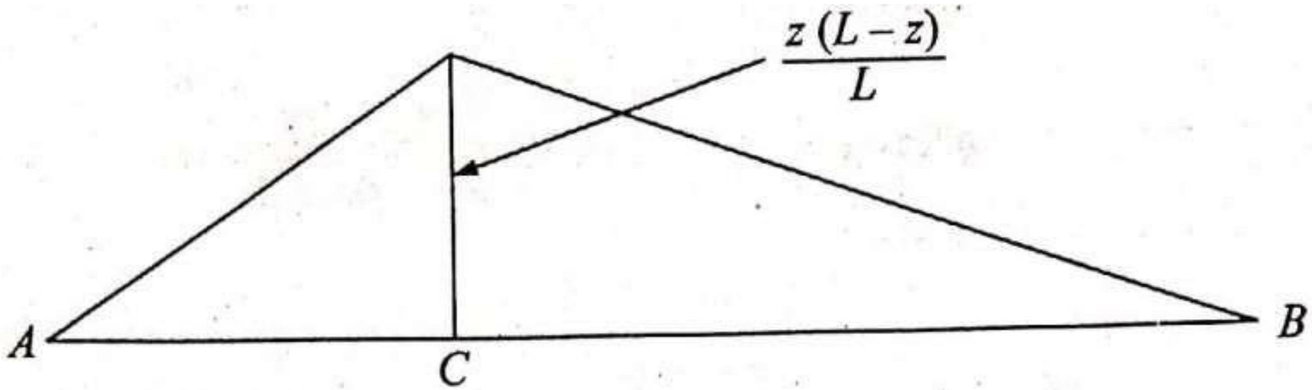


Figure 8: ILD for Moment at M_C

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.

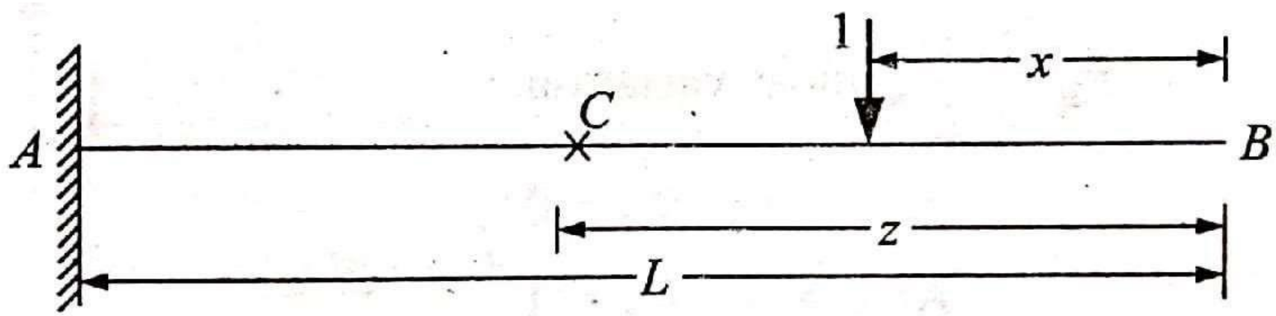
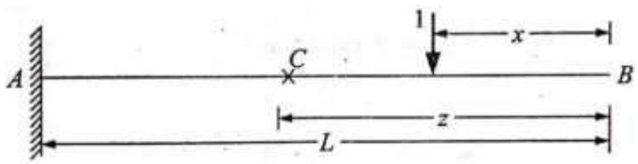


Figure 9: Cantilever with unit load

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.

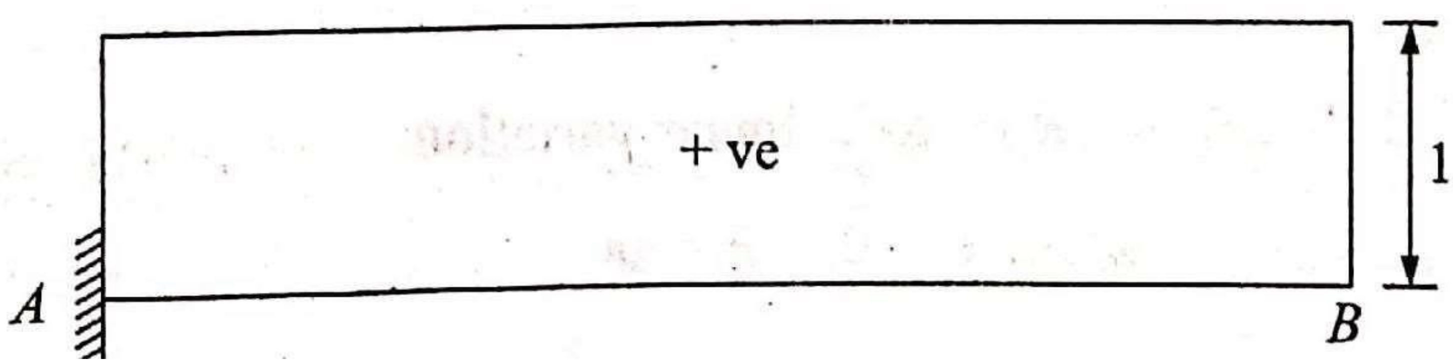
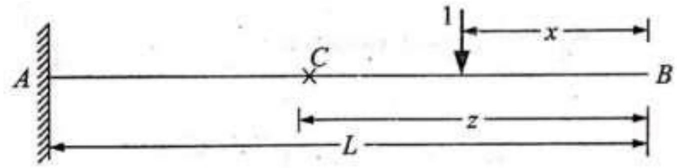


Figure 10: ILD for F_A

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.

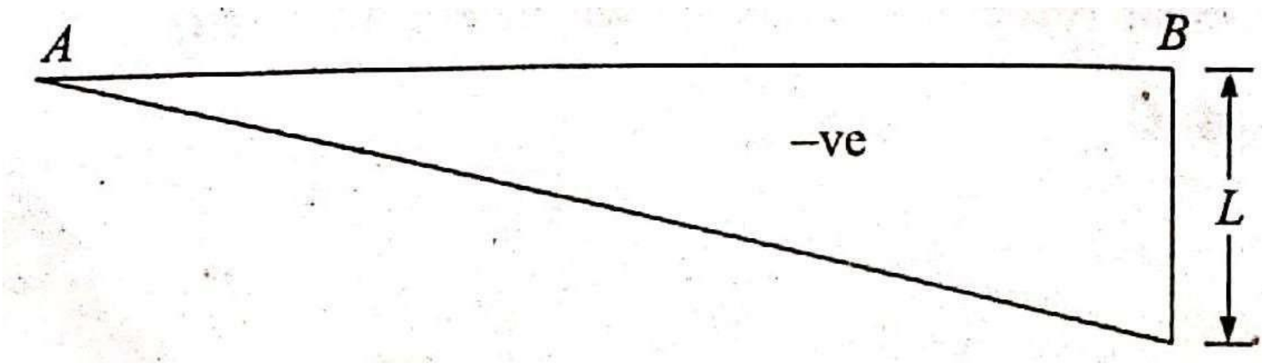
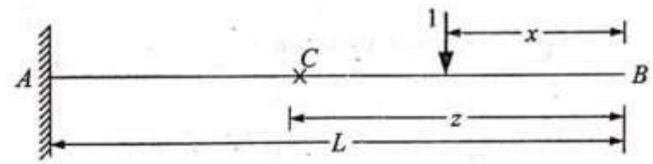


Figure 11: ILD for moment M_A

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.

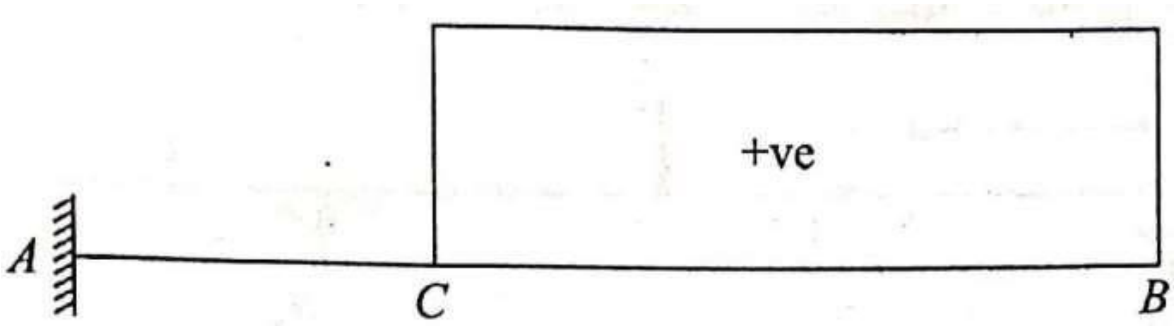
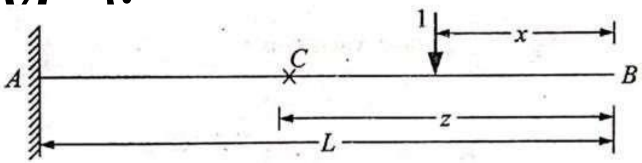


Figure 12: ILD for shear force at C (F_C)

ILD for Moment at C (M_C):



- **When $x \le z$**

  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.

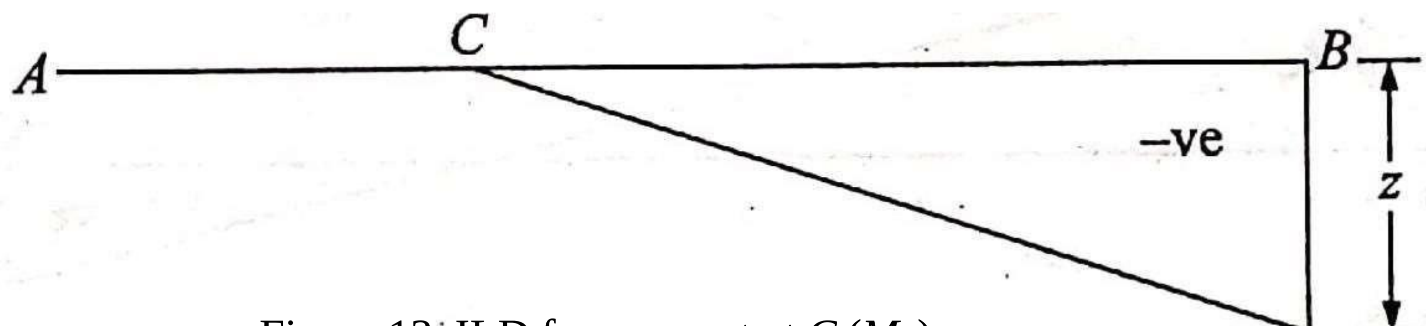


Figure 13: ILD for moment at C (M_C)

THANK YOU