BIRZEIT UNIVERSITY

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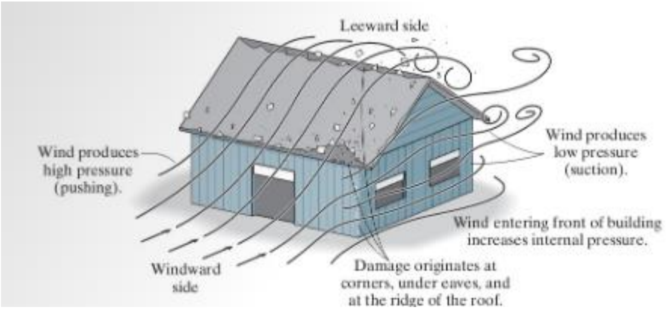
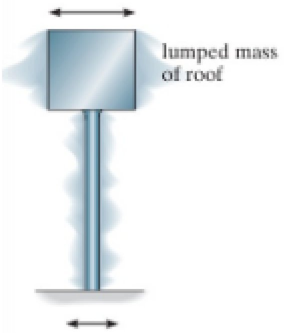
Influence lines

Influence line, why?

- Types of loads: ??





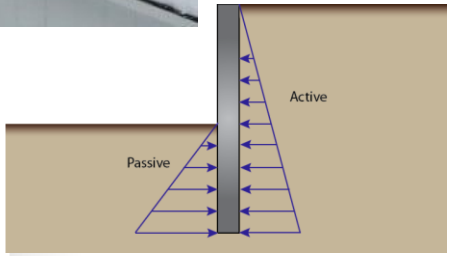


TABLE 1.4 Minimum Live Loads*

Occupancy or Use	Live Load psf	Live Load kN/m²	Occupancy or Use	Live Load psf	Live Load kN/m²
Assembly areas and theaters			Residential		
Fixed seats	60	2.87	Dwellings (one- and two-family)	40	1.92
Movable seats	100	4.79	Hotels and multifamily houses		
Garages (passenger cars only)	40	1.92	Private rooms and corridors	40	1.92
Office buildings			Public rooms and corridors	100	4.79
Lobbies	100	4.79	Schools		
Offices	50	2.40	Classrooms	40	1.92
Storage warehouse			First-floor corridors	100	4.79
Light	125	6.00	Corridors above first floor	80	3.83
Heavy	250	11.97			

*Minimum Live Loads, Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10, American Society of Civil Engineers.

TABLE 1.2 Minimum Densities for Design Loads from Materials*

	lb/ft³	kN/m³
Aluminum	170	26.7
Concrete, plain cinder	108	17.0
Concrete, plain stone	144	22.6
Concrete, reinforced cinder	111	17.4
Concrete, reinforced stone	150	23.6
Clay, dry	63	9.9
Clay, damp	110	17.3
Sand and gravel, dry, loose	100	15.7
Sand and gravel, wet	120	18.9
Masonry, lightweight solid concrete	105	16.5
Masonry, normal weight	135	21.2
Plywood	36	5.7
Steel, cold-drawn	492	77.3
Wood, Douglas Fir	34	5.3
Wood, Southern Pine	37	5.8
Wood, spruce	29	4.5

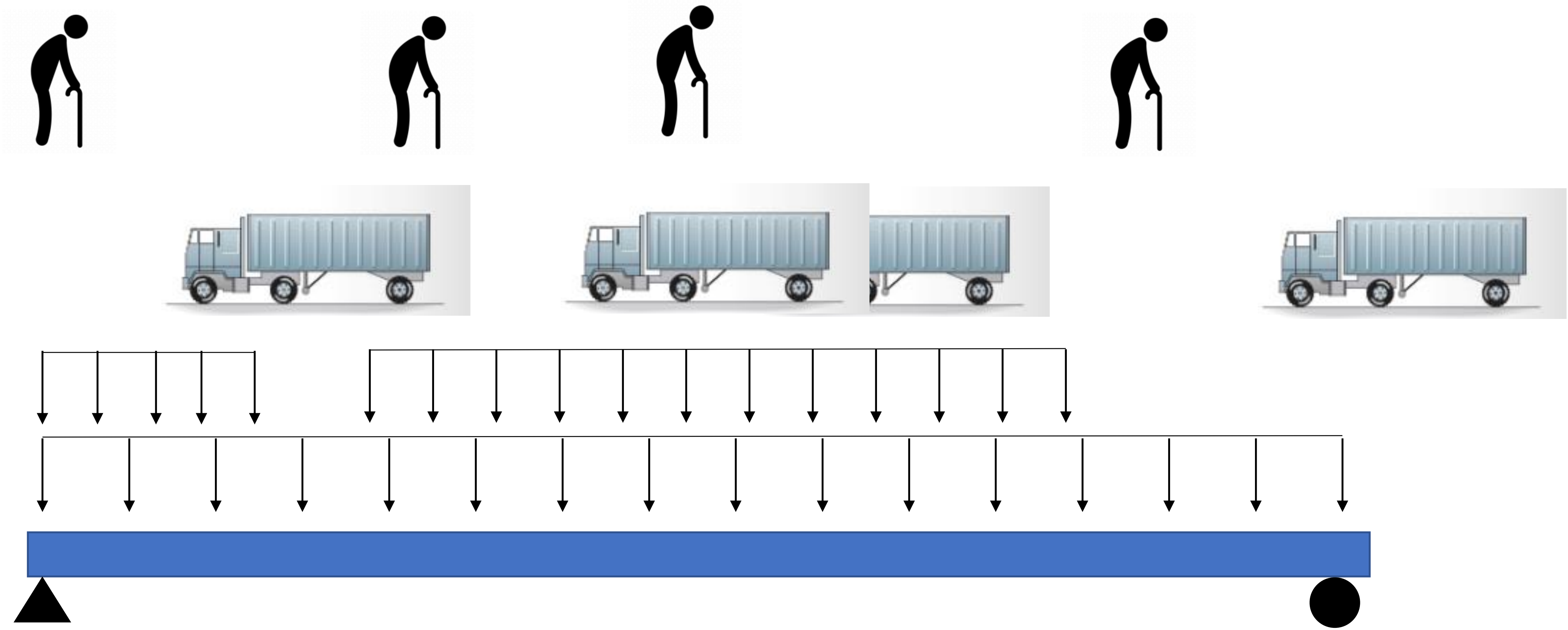
*Minimum Densities for Design Loads from Materials, Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10. Copies of this standard may be purchased from ASCE at www.pubs.asce.org, American Society of Civil Engineers.

TABLE 1.3 Minimum Design Dead Loads*

Walls	psf	kN/m²
4-in. (102 mm) clay brick	39	1.87
8-in. (203 mm) clay brick	79	3.78
12-in. (305 mm) clay brick	115	5.51
Frame Partitions and Walls		
Exterior stud walls with brick veneer	48	2.30
Windows, glass, frame and sash	8	0.38
Wood studs 2 × 4 in. (51 × 102 mm), unplastered	4	0.19
Wood studs 2 × 4 in. (51 × 102 mm), plastered one side	12	0.57
Wood studs 2 × 4 in. (51 × 102 mm), plastered two sides	20	0.96
Floor Fill		
Cinder concrete, per inch (mm)	9	0.017
Lightweight concrete, plain, per inch (mm)	8	0.015
Stone concrete, per inch (mm)	12	0.023
Ceilings		
Acoustical fiberboard	1	0.05
Plaster on tile or concrete	5	0.24
Suspended metal lath and gypsum plaster	10	0.48
Asphalt shingles	2	0.10
Fiberboard, ½-in. (13 mm)	0.75	0.04

*Minimum Design Dead Loads, Reproduced with permission from American Society of Civil Engineers *Minimum Design Loads for Buildings and Other Structures*, ASCE/SEI 7-10, American Society of Civil Engineers.

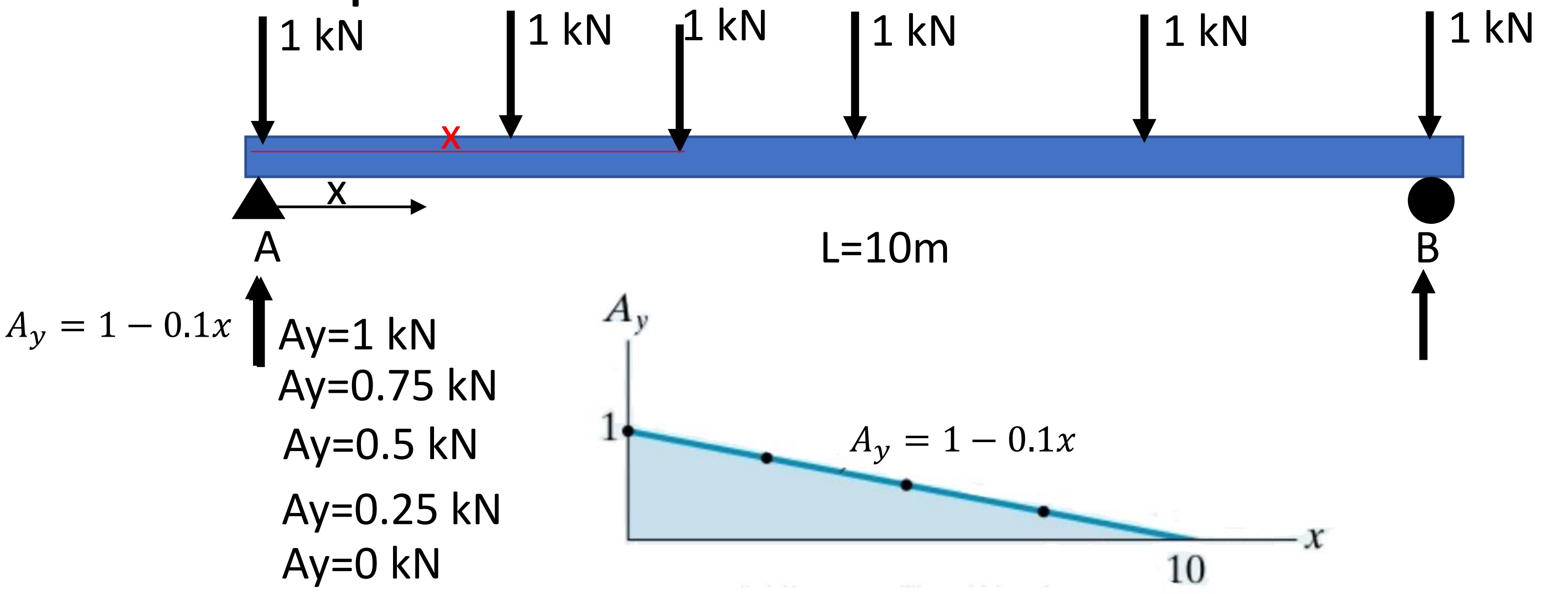
Moving load location ??



Influence line

- An influence line shows the variation of either the reaction, axial, shear, or moment at a specific point in the structure due to the movement of a concentrated force along the structure.

- Example: Draw influence line of the reaction at A



X (load location)	Ay (kN)
0	1
2.5	0.75
5	0.5
7.5	0.25
10	0

Sign convention

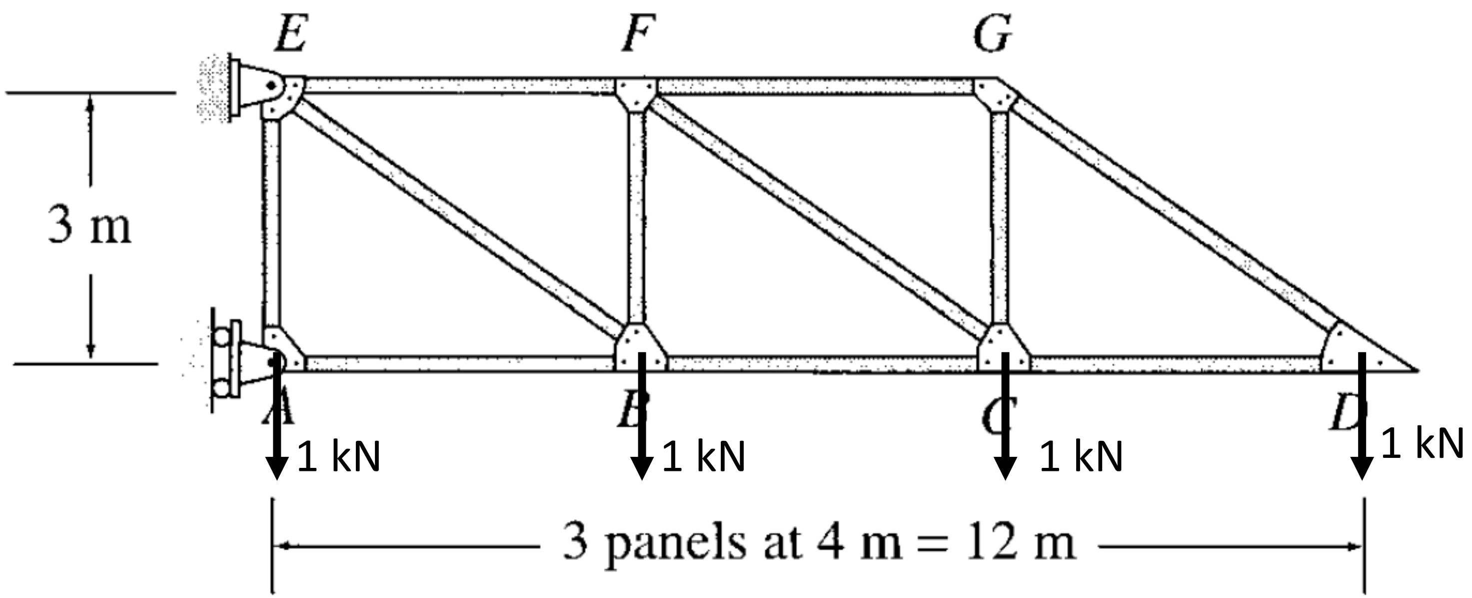
- Reactions: upward ↑ positive

- Shear and moments

Steps

- Place a unit load at various locations on the structure and calculate the quantity of interest for each load location
- Tabulate your results (x vs. $$)
- Draw the variation of $$ with x (x on the x axis and $$ on the y axis)
- You can get an equation for the line representing the variation of $$ with load location by placing a unit load at distance x from the reference and get $$ in terms of x.
- For determinate structures Influence lines are straight lines (1st order)

Influence line for trusses

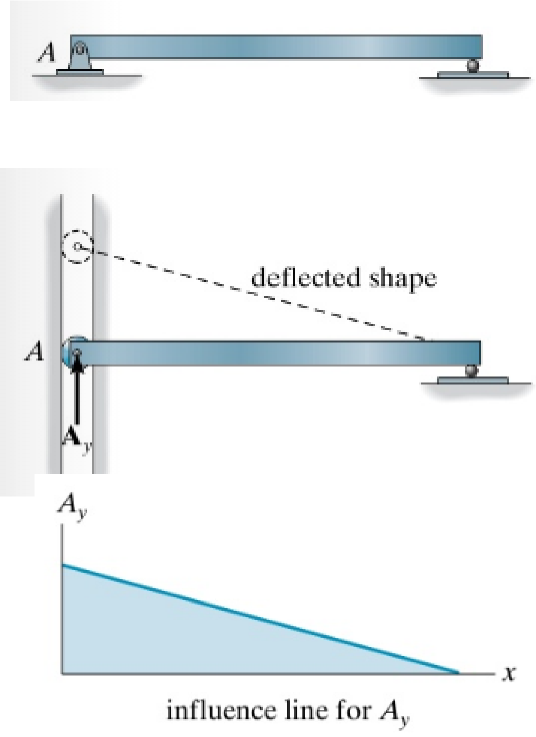


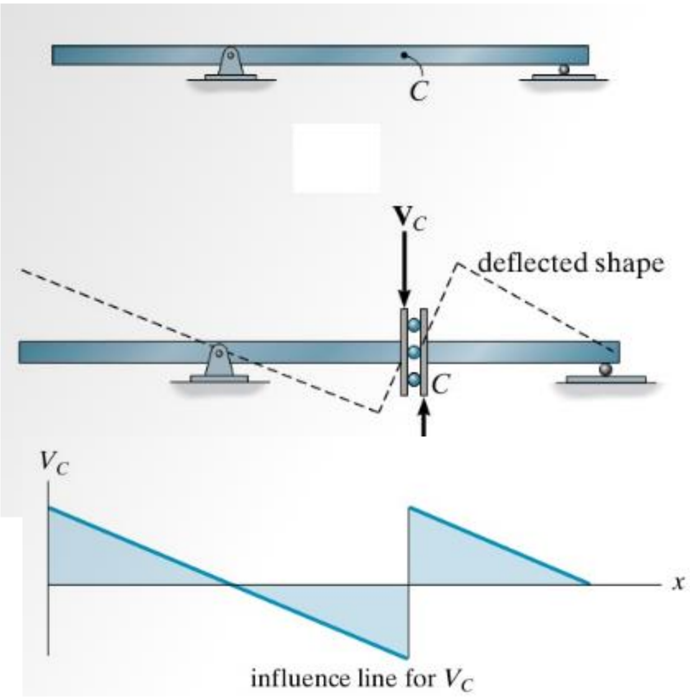
X	Axial load
0	
4	
8	
.	
.	

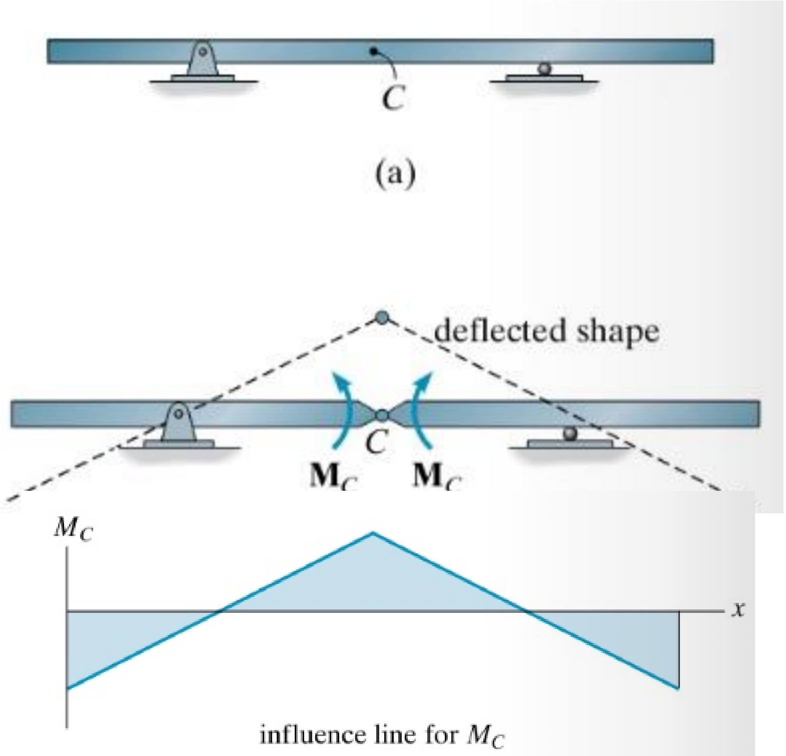
Qualitative influence lines

- Mǖller-Breslua Principle

  The influence line of a beam is to the same scale as the deflected shape of the beam when acted upon by the function



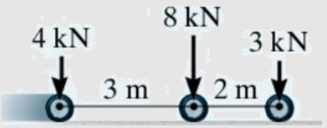




How to use Influence lines

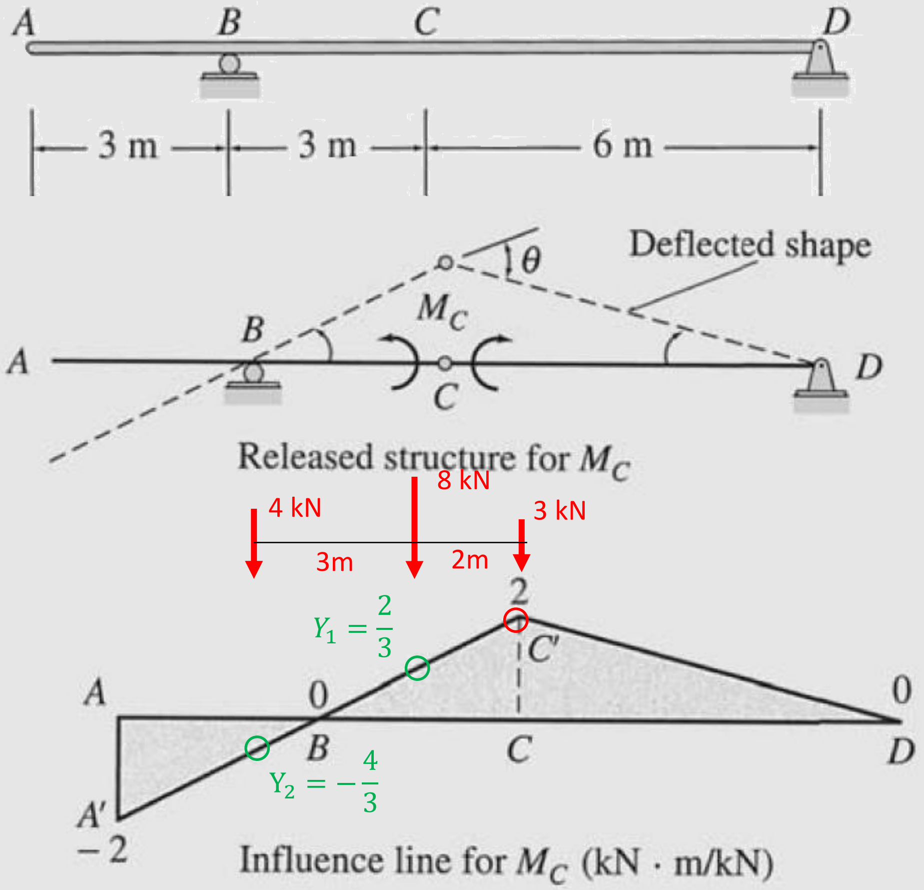
- Concentrated load/s
  - What is the maximum moment at C when a concentrated live load of 20 kN is applied?
    - Max +ve
      - Location (at point c) -> $M_{c(max)}$ =2*20=40 kN.m
    - Max –ve
      - Location (At point A) -> $M_{c(max)}$ =-2*20=-40 kN.m

  - Series of loads (Truck load)



  - positive Moment (3 possible cases truck travelling from left to right + 3 truck going from right to left)
    - Case 1: Location (3kN at c)

$$M_c = 3*2+8*(2/3)+4*(-4/3)=5.92 kN.m$$



How to use Influence lines

- Case 2: Location (8kN at c)

  $M_c = 3*(4/3)+8*(2)+4*(0)=20kN.m$

- Case 3: Location (4kN at c)

  $M_c = 3*(1/3)+8*(1)+4*(2)=17kN.m$

- Case 4: reverse order, Location (3kN at c)

  $M_c = 3*(2)+8*(4/3)+4*(1/3)=18kN.m$

- Case 5: reverse order, Location (8kN at c)

  $M_c = 3*(2/3)+8*(2)+4*(1)=22kN.m$

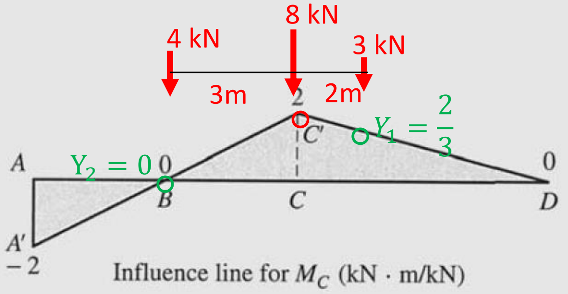
- Case 6: reverse order, Location (4kN at c)

  $M_c = 3*(-4/3)+8*(0)+4*(2)=4kN.m$

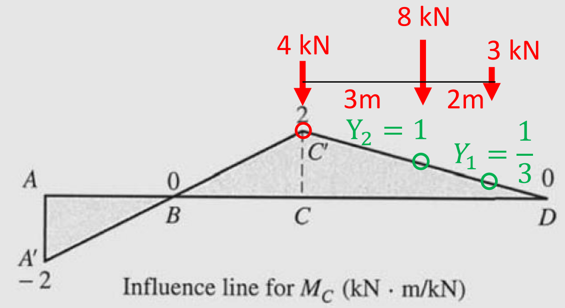
Load case 5 maximizes the moment at c $\rightarrow +ve\ M_{c(max)} = 22\ kN.m$

The same can be done to maximize the –ve moment at c

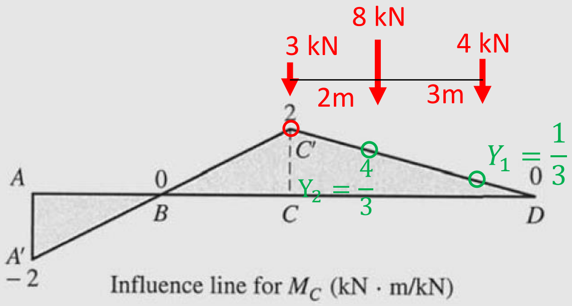
(Note: in some load cases, not all loads will act on the beam)



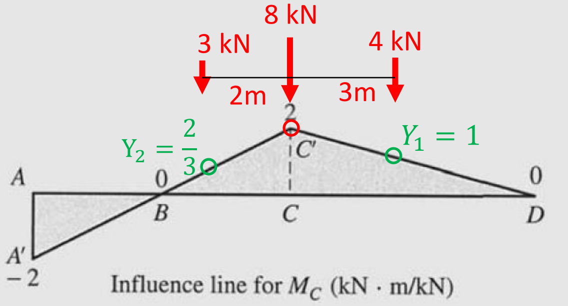
CASE 2



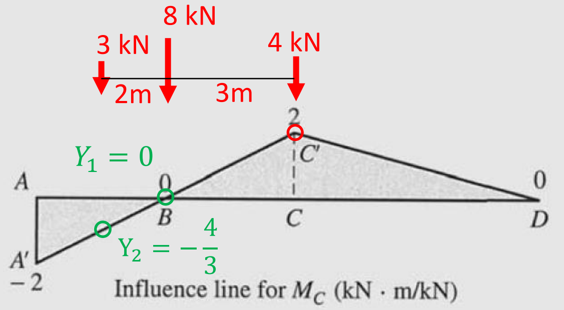
CASE 3



CASE 4



CASE 5



CASE 6

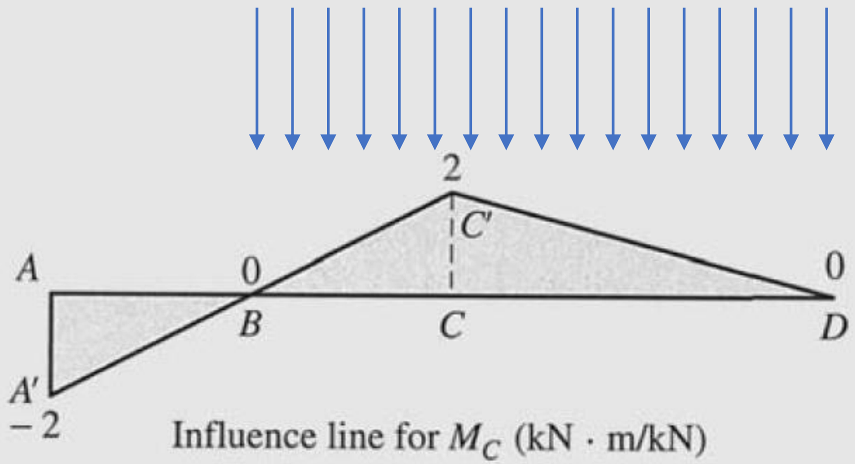
How to use Influence lines

- Uniform loads
  - What is the maximum moment at C when a uniform live load of 10 kN is applied?

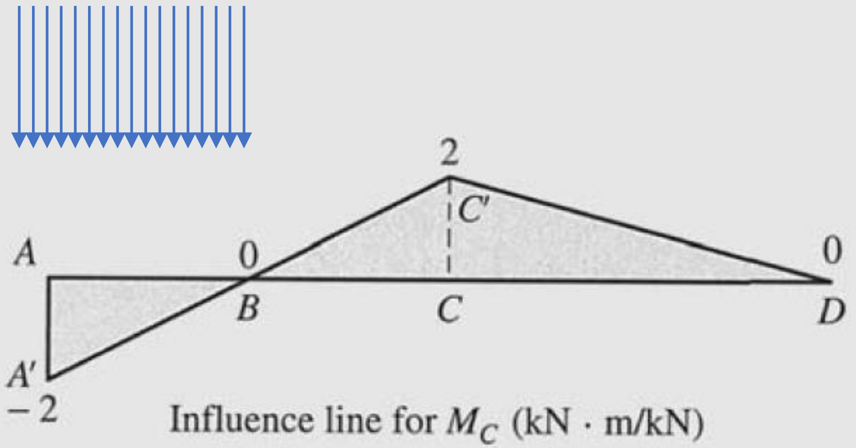
Uniform loads are a series of concentrated forces -> the length these loads can be adjusted

- To maximize positive moment we apply the uniform load to all possible locations that causes a positive moment at point C
  - To get the total moment at C we need to multiply each load by its corresponding influence line value OR multiply the Area under the Influence line by the uniform load
  - $M_{c(max)} = \left(0.5 * 2(kN.\frac{m}{kN}) * 3(m) + 0.5 * 2(kN.\frac{m}{kN}) * 6(m)\right) * 10\frac{kN}{m} = 90\ kN.m$

- To maximize negative moment we apply the uniform load to all possible locations that causes a negative moment at point C
  - multiply the Area under the Influence line by the uniform load
  - $M_{c(max)} = \left(0.5 * -2(kN.\frac{m}{kN}) * 3(m)\right) * 10\frac{kN}{m} = -30\ kN.m$



Influence line for M_C (kN · m/kN)



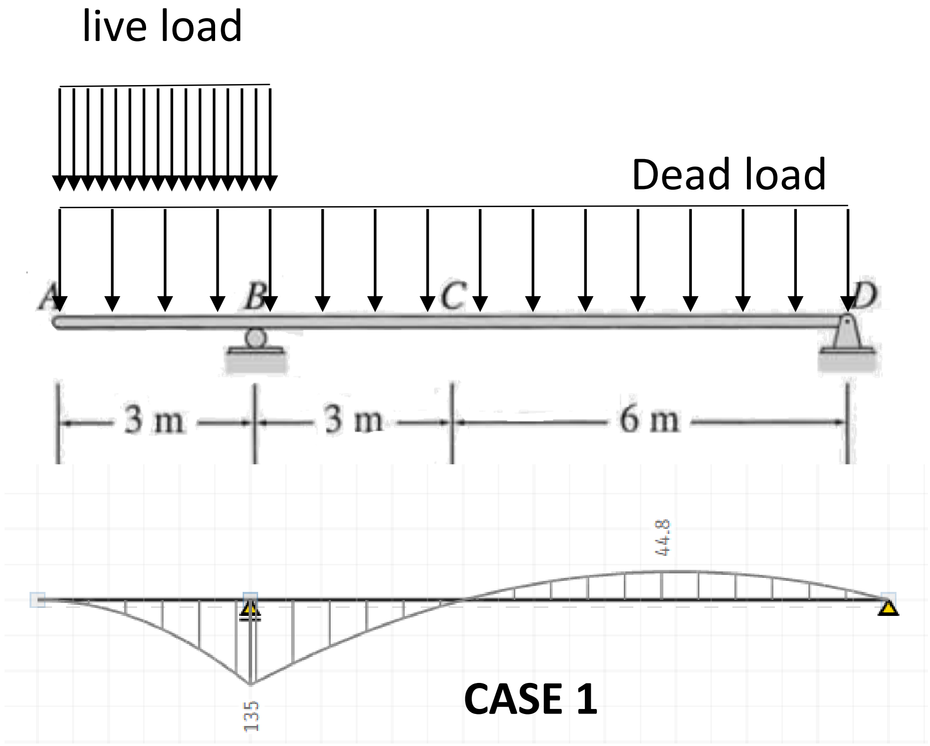
Influence line for M_C (kN · m/kN)

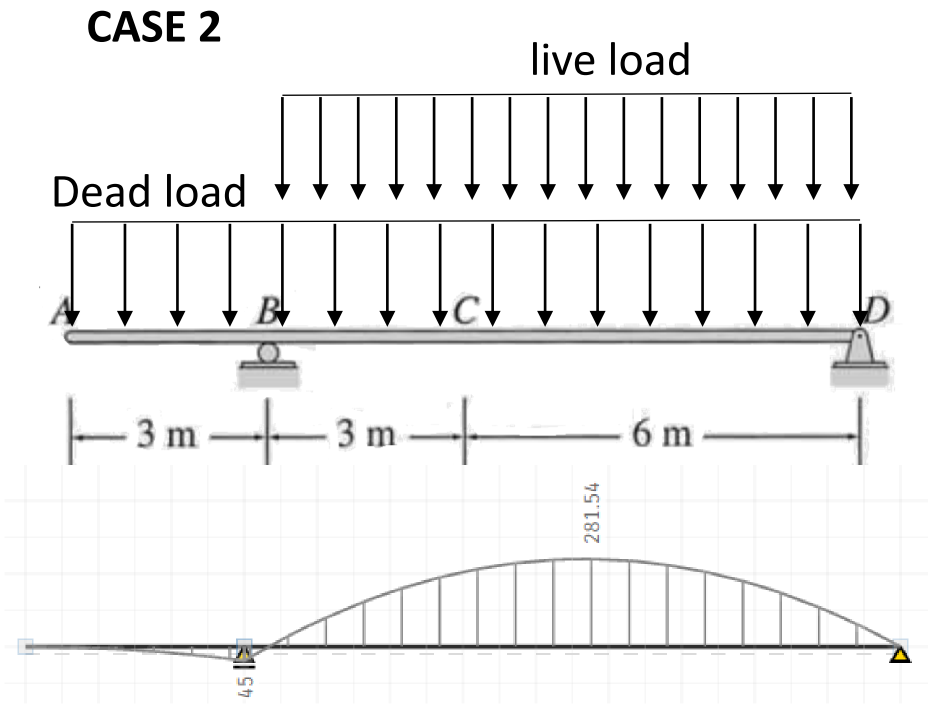
Load cases and envelopes

- Uniform live load and dead load (design for moment)
  - Dead load location cannot be changed, only live load location can change

    Load case 1: Maximizes the negative moment at B

    Load case 2: Maximizes the positive moment in span BD

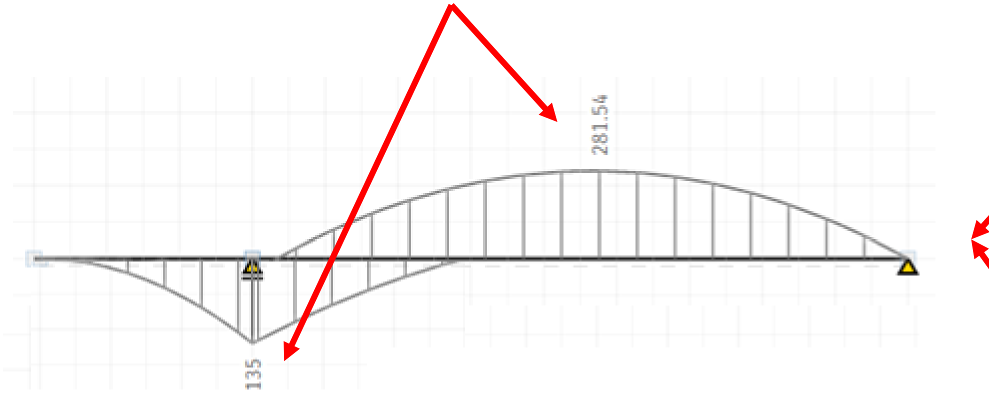




Load cases and envelopes

- Uniform live load and dead load (design for moment)

Design moments



Moment envelope of the beam