PANA ACADEMY

NEPAL ENGINEERING COUNCIL
LICENSE EXAM PREPARATION COURSE

FOR

CIVIL ENGINEERS

PANA ACADEMY

4. Structural Mechanics

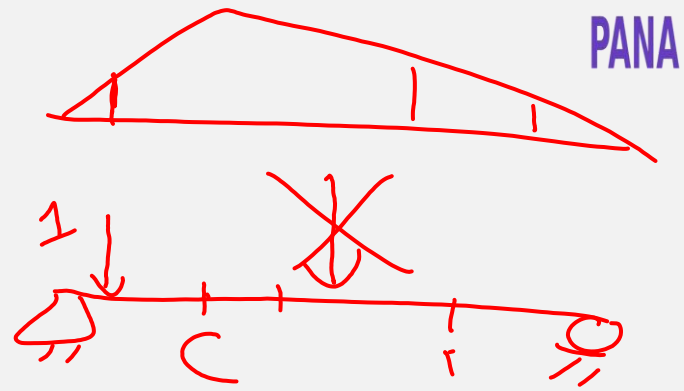
4.5 Determinate structure-2

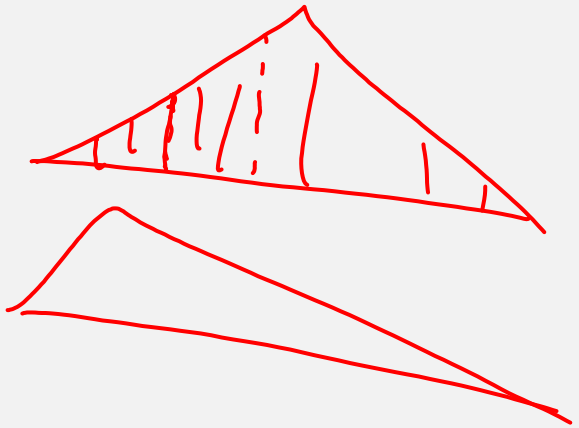
Sub topics

- Influence Lines for Simple Structure
  Point load and UDL

- Analysis of three hinged arches.

- Two hinged parabolic arches.
- ILD for continuous beam





ILD for BM at C

Influence Lines

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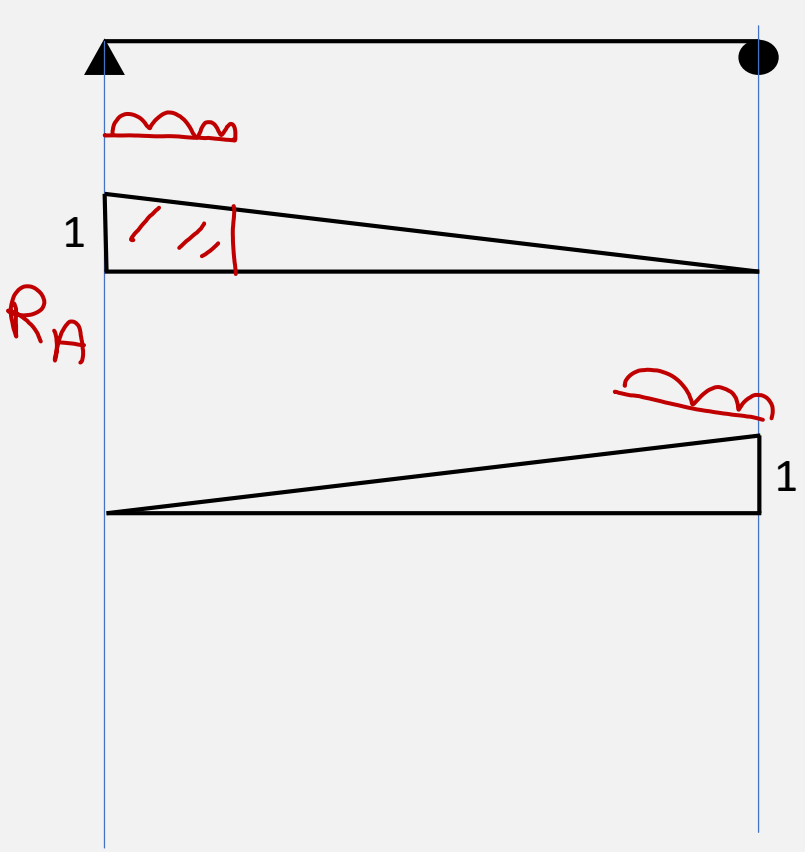
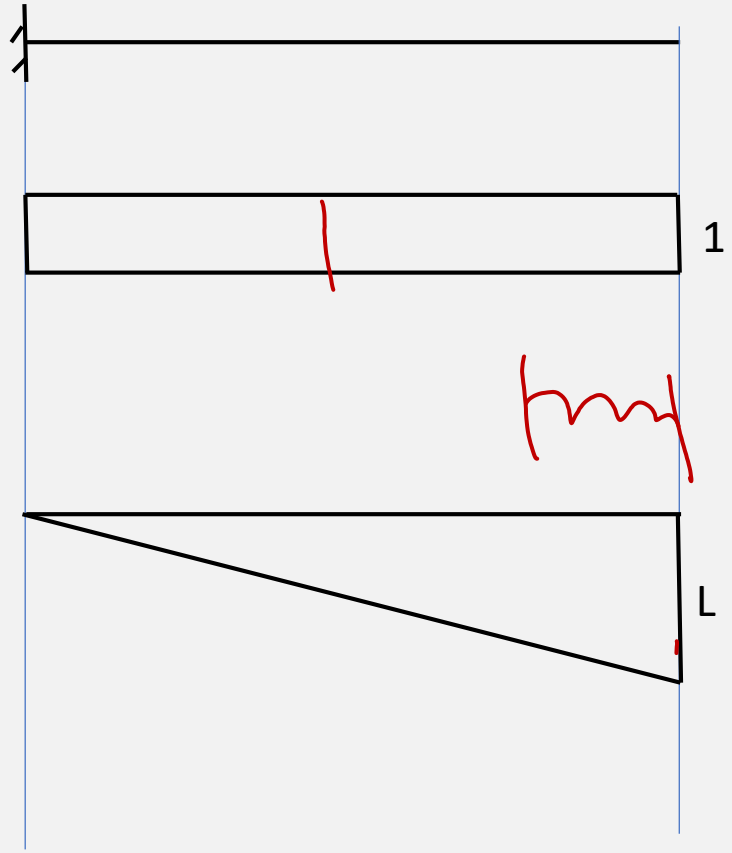
Influence Line Diagram shows the influence or effect of loads or reaction on the span.

It shows reaction, shear force and bending moment at a particular section when unit load moves throughout the span.

ILD for reaction of beam





ILD for SF and BM of beam

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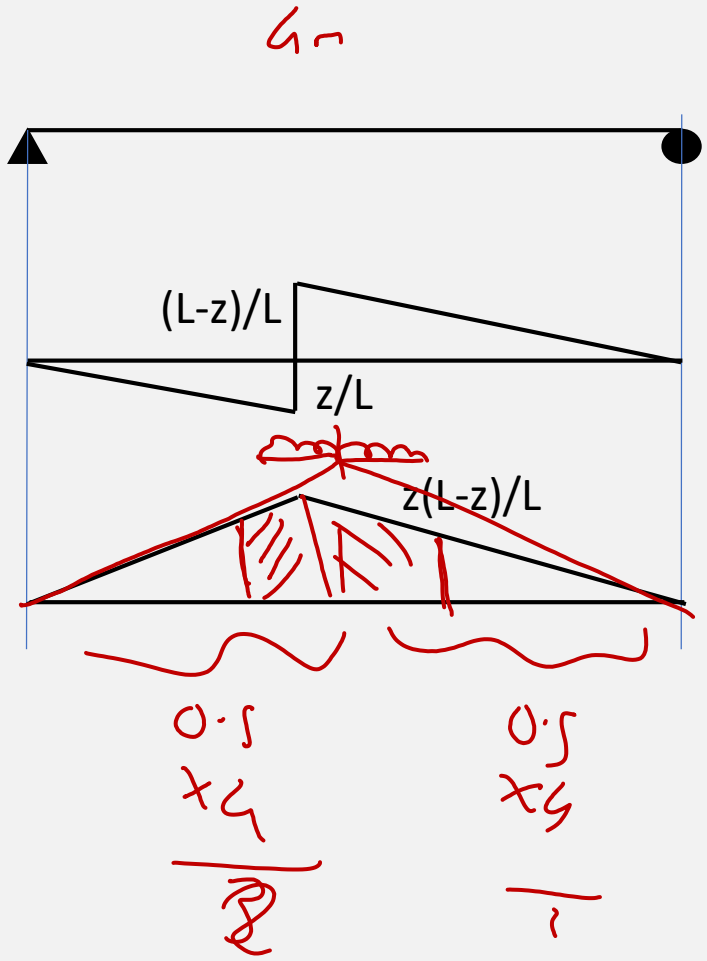

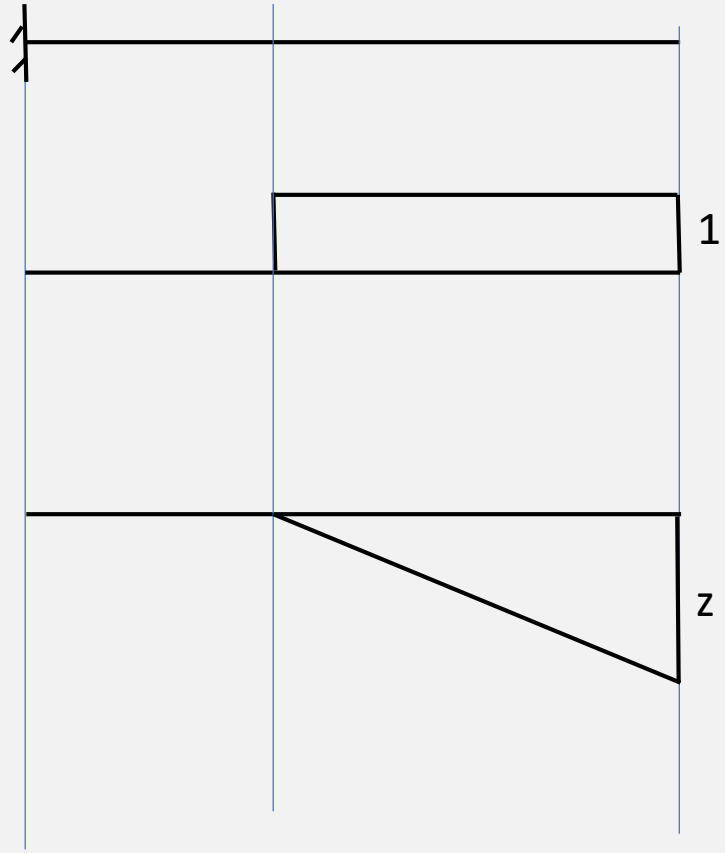

ILD using Muller-Breslau Principle

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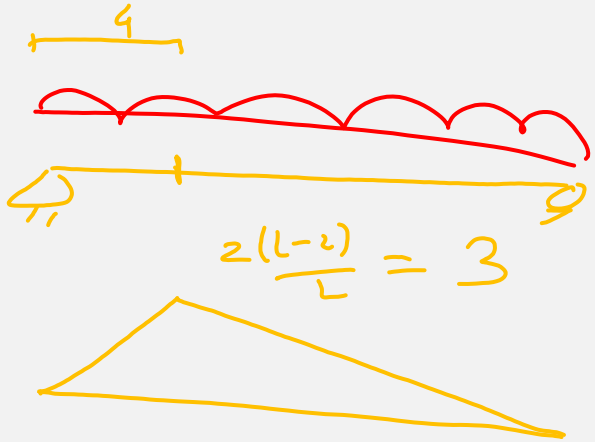
Total height of shear diagram at section where ILD is drawn is 1.

Height of reaction is 1 at support whose ILD is computed

For ILD of BM it gives qualitative ILD

Rotation at section is 1

Uniformly distributed load of intensity 2 t/m longer than the span crosses the girder from left to right. The girder has length 16m. Find the maximum moment at section 4m from left support.



$M = 2 \times \left(\frac{1}{2} \times 16 \times 3\right)$

$= 48$ t-m

Since ILD is of triangular shape, its area

A = (1/2) × Base × Height;

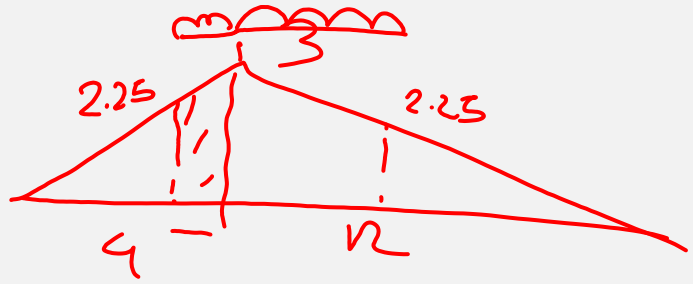
Maximum BM = 2 × (½) × 16 × 3 = 48 t-m

Uniformly distributed load of intensity 2 t/m longer than the span crosses the girder from left to right. The girder has length 16m. Find the maximum moment in girder.

$M = 2 \times \left(\frac{1}{2} \times 16 \times 4\right)$

$= 2 \times 32 = 64\ tm$

Uniformly distributed load of intensity 2 t/m having length 4m crosses the girder from left to right. The girder has length 16m. Find the maximum moment at section 4m from left support.



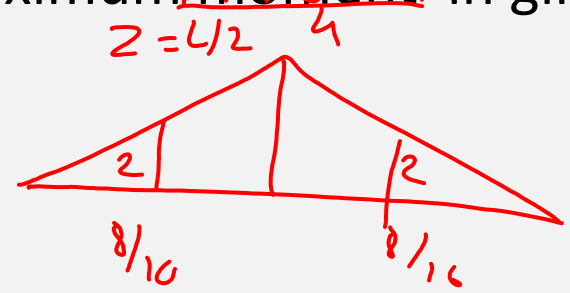
$\frac{4}{16} = \frac{1}{4}$ $\frac{12}{16} = \frac{3}{4}$

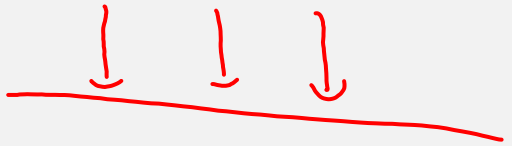
$M = w \times Area$

$= 2 \times \frac{1}{2} \times \left(\frac{2.25+3}{2}\right) + 2 \times 3 \times \left(\frac{2.25+3}{2}\right)$

$= 2 \times 4 \times \left(\frac{2.25+3}{2}\right) = 21 kNm$

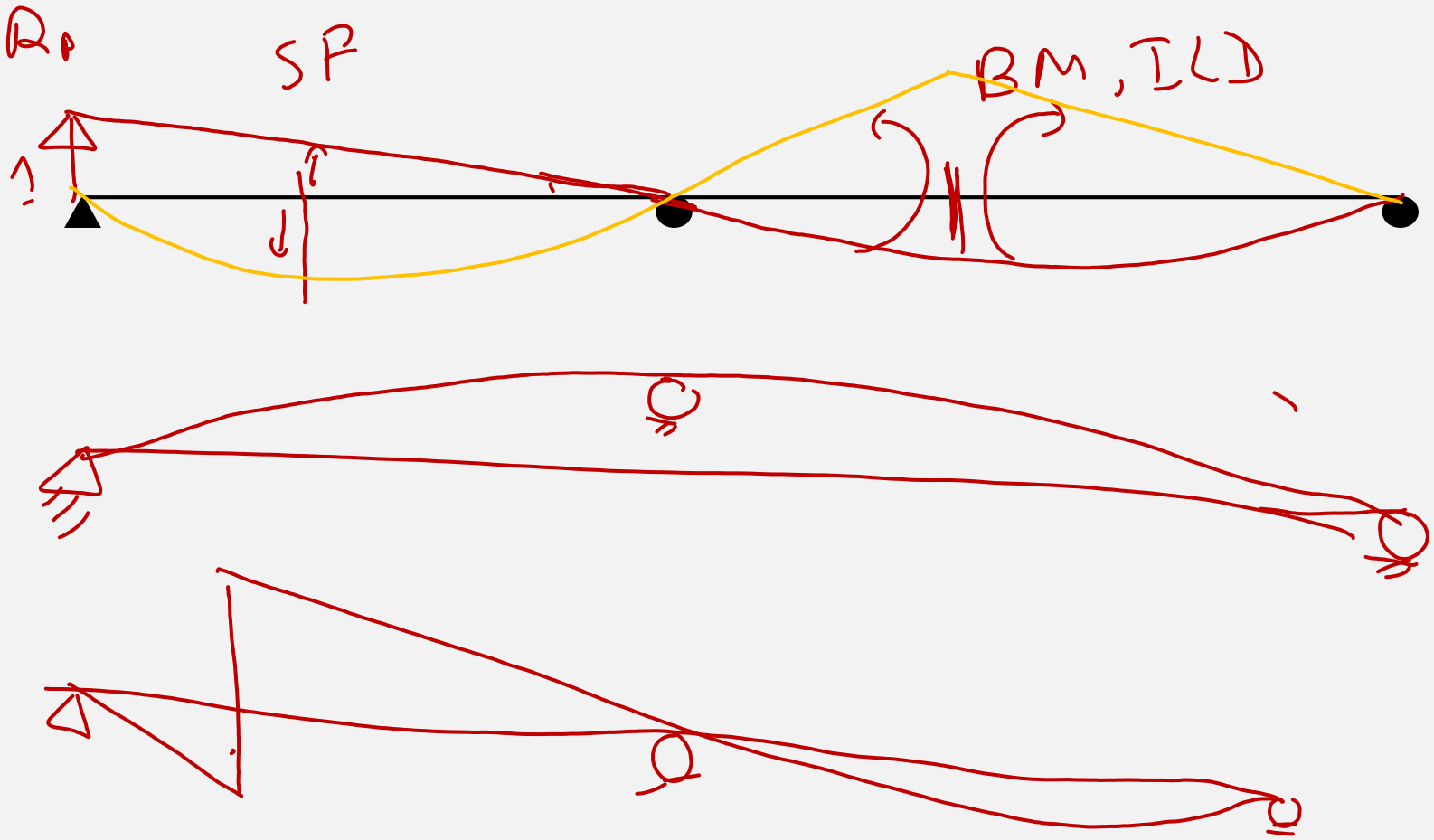
Uniformly distributed load of intensity 2 t/m having length 4m crosses the girder from left to right. The girder has length 16m. Find the maximum ~~moment~~ in girder.

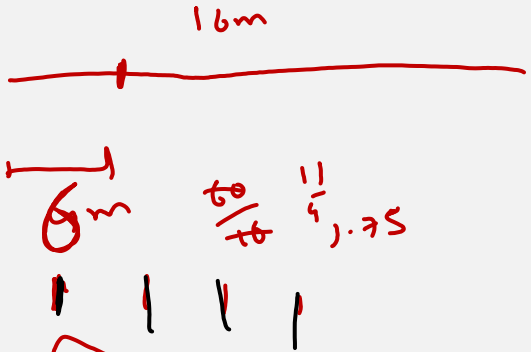


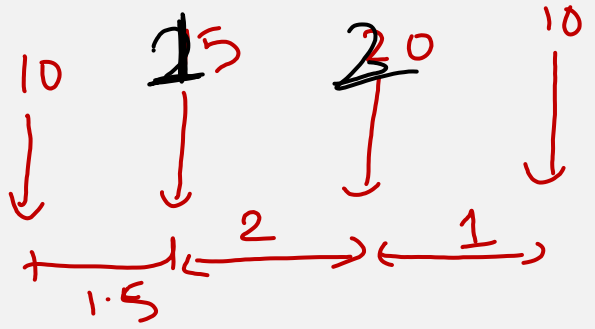


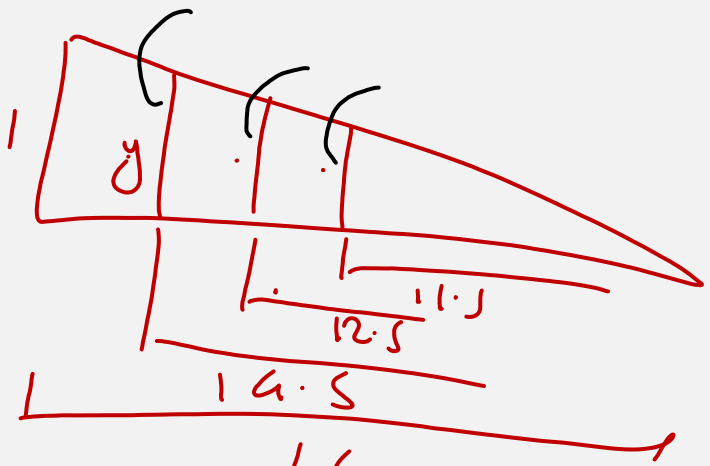
$$M = 2 \times 4 \times 3 = 24\ kNm$$

ILD for continuous beam









Case I

16 ↓ 1.1 ↓ 2 1 = 1

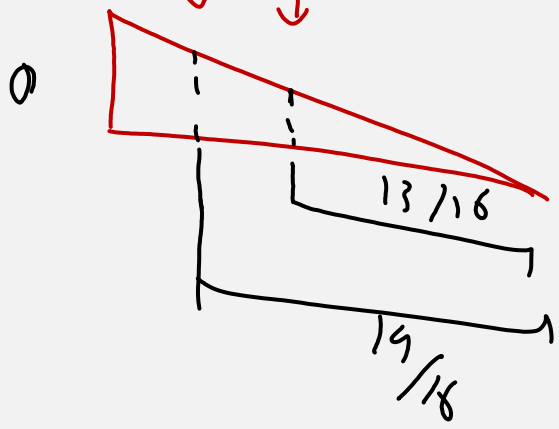
$R_A = 37.9$

48.3

$\frac{y}{1} = \frac{14.5}{16}$

10 15 20 10

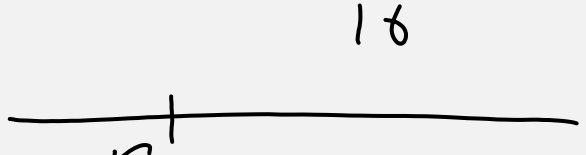
↓ ↓ 2→ ↓ ↓

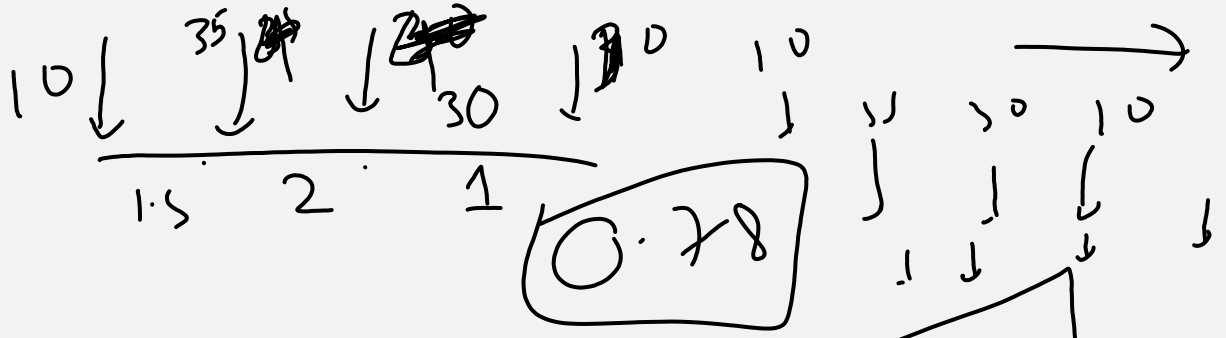


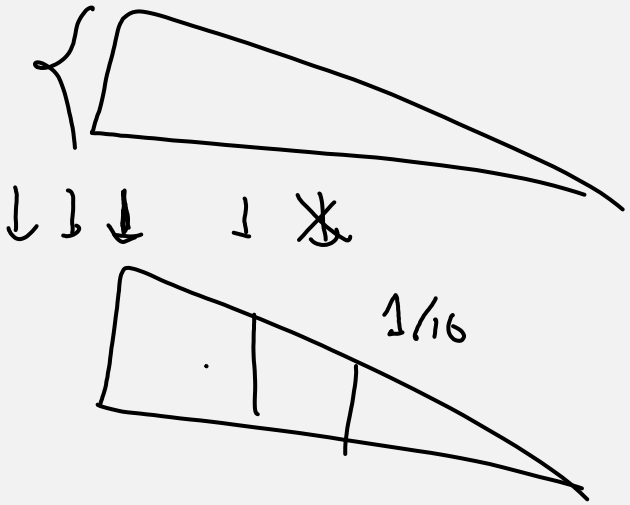
→

$R_A = 10 \times 0 + 15 \times 1 + 20 \times \frac{14}{16} + 10 \times \frac{13}{16}$

$= 40.625$







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$\Delta x = 1.5$

$S = 1/16$

$\Delta V_{1-2} = -10x1 + S x \Delta x x (\quad)$

$= -10 + \frac{1}{16} x 1.5 (35 + 30 + 10)$

$= -2.9$

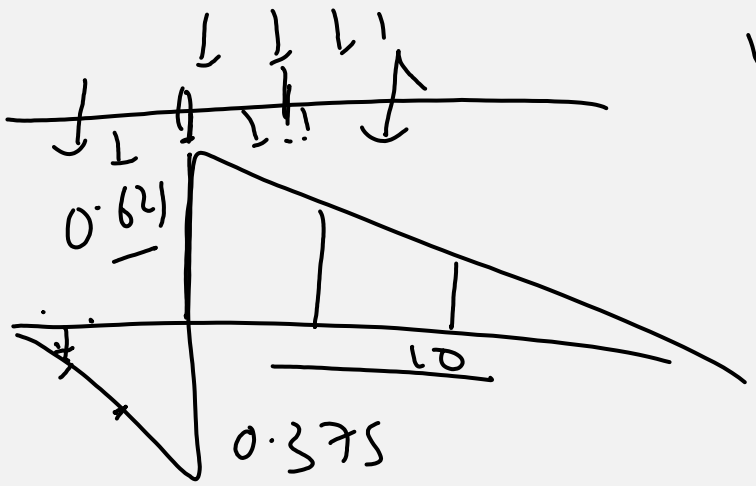
ΔV_{2-3} $\Delta x = 2\,m$ $S = 1/16$

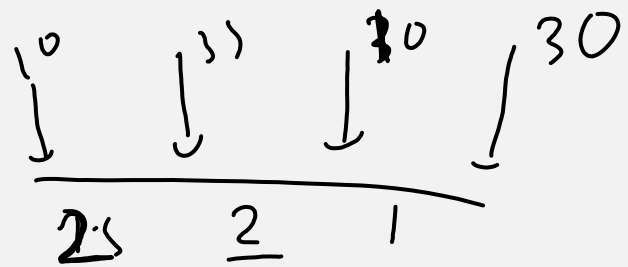
$= -35x1 + \frac{1}{16} x 2 x (30 + x \quad) =$

$\Delta x = 1$, $S = 1/16$

$\Delta V_{1-2} = -10x1 + \frac{1}{16} x 1 (10 + 30 + 30$

$=$





Max +ve SF

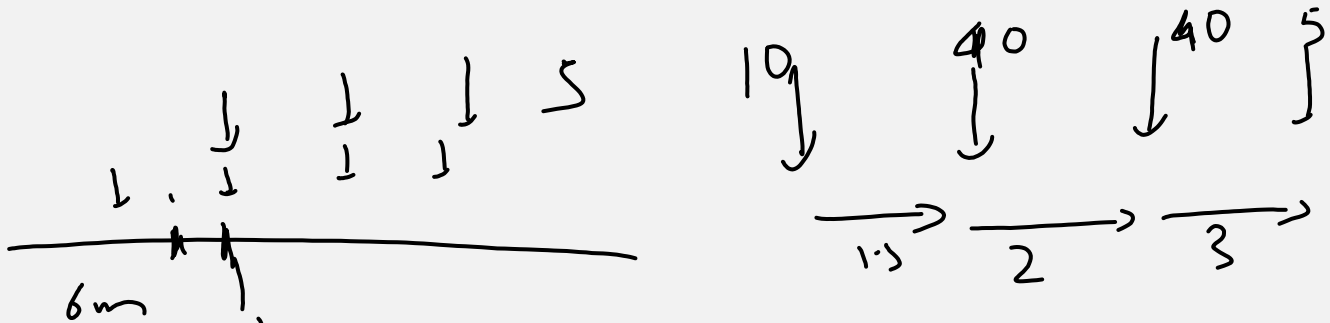
$\Delta n = 1.5$, $S = \frac{1}{16}$

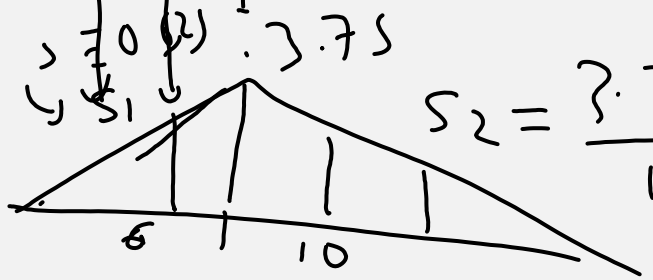
$\Delta V_{1-2} = -10 \times 1 + 2.5 \times 1/10 \times (35 + 10 + 30)$

$+ 1.5 \times 1/16 \times (10) = -2.03$

$\Delta n = 2$

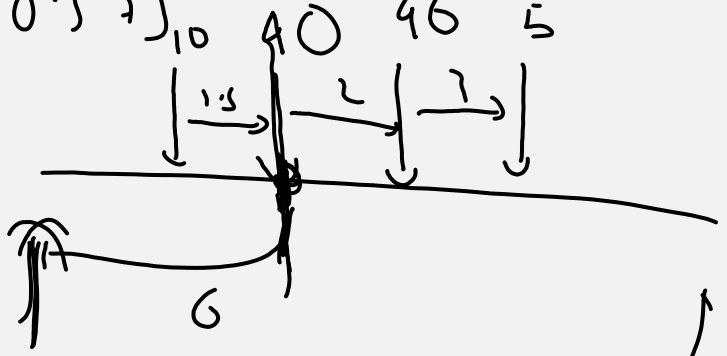
$\Delta_{2-3} = -35 \times 1 + 2 \times 1/16 \times (10+30) + 2 \times 1/16 \times (10+35)$





$$S_2 = \frac{3.75}{10} = 0.375$$

$$\Delta x = 1.5$$

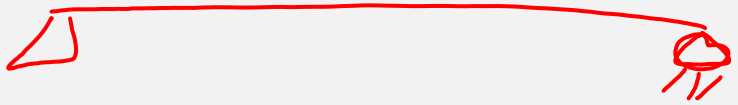


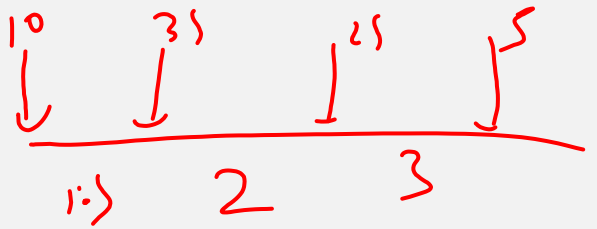
$$\Delta M_{1-2} = -\left(1.5 \times 0.625 \times 10\right) + 1.5 \times 0.375 \times \left(40 + 40 + 5\right)$$

$$= 38.43$$

$$\Delta M_{2-3} = \sum_{\Delta x=2} -\left(2 \times 0.625 \times (10+40) + (40+40) \times 0.375 \times 2\right)$$

$$= -78.5$$





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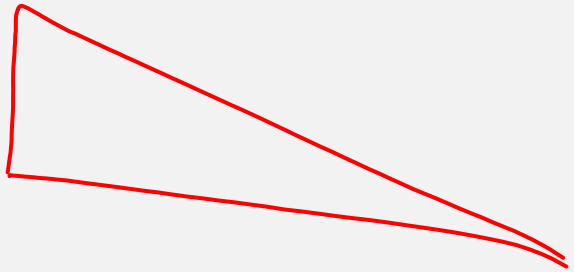
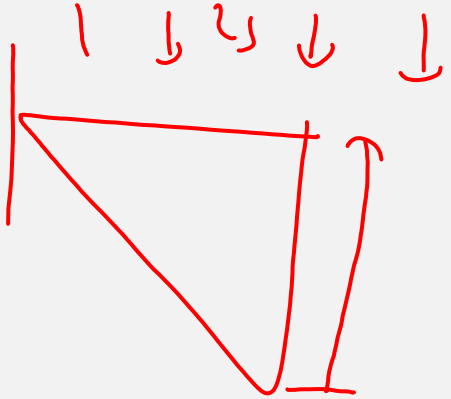
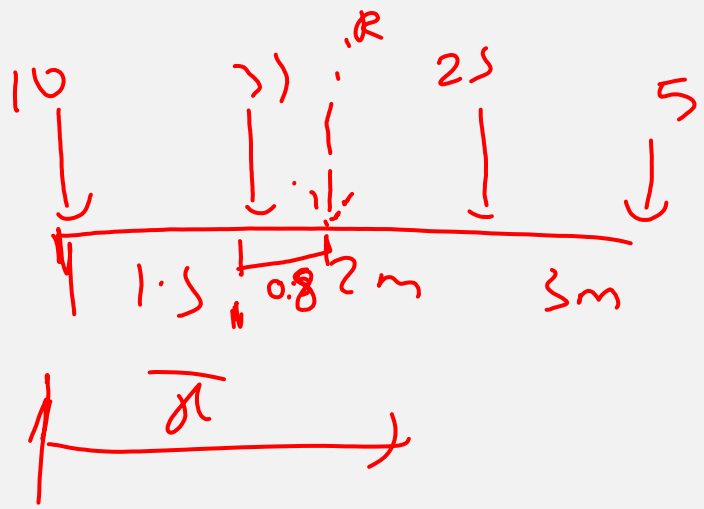
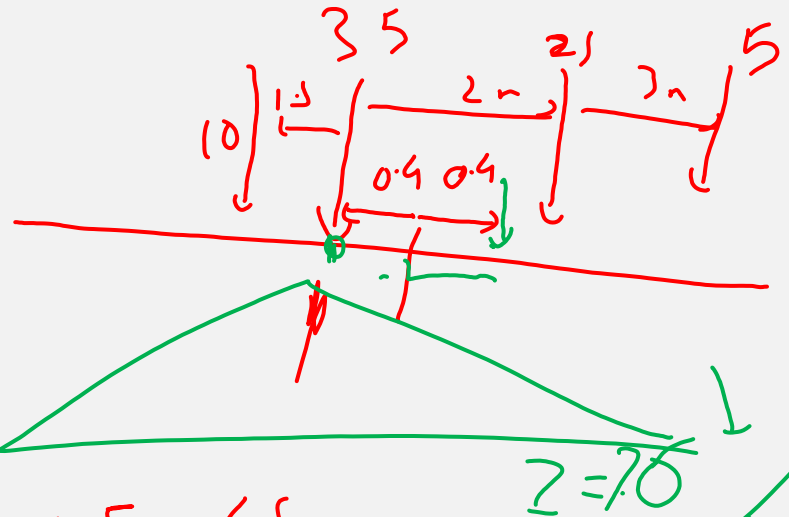


SF max +ve | abs max SF



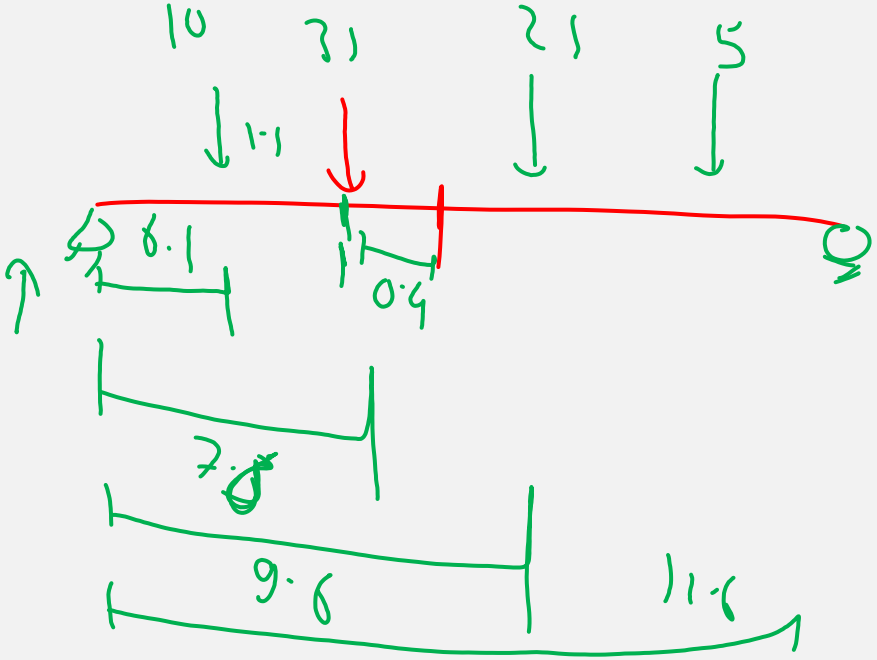
SF max -ve | abs min SF





$$\bar{x} = \frac{10\times 0 + 35\times 1.5 + 25\times 3.5 + 5\times 6.5}{10+35+21+5}$$

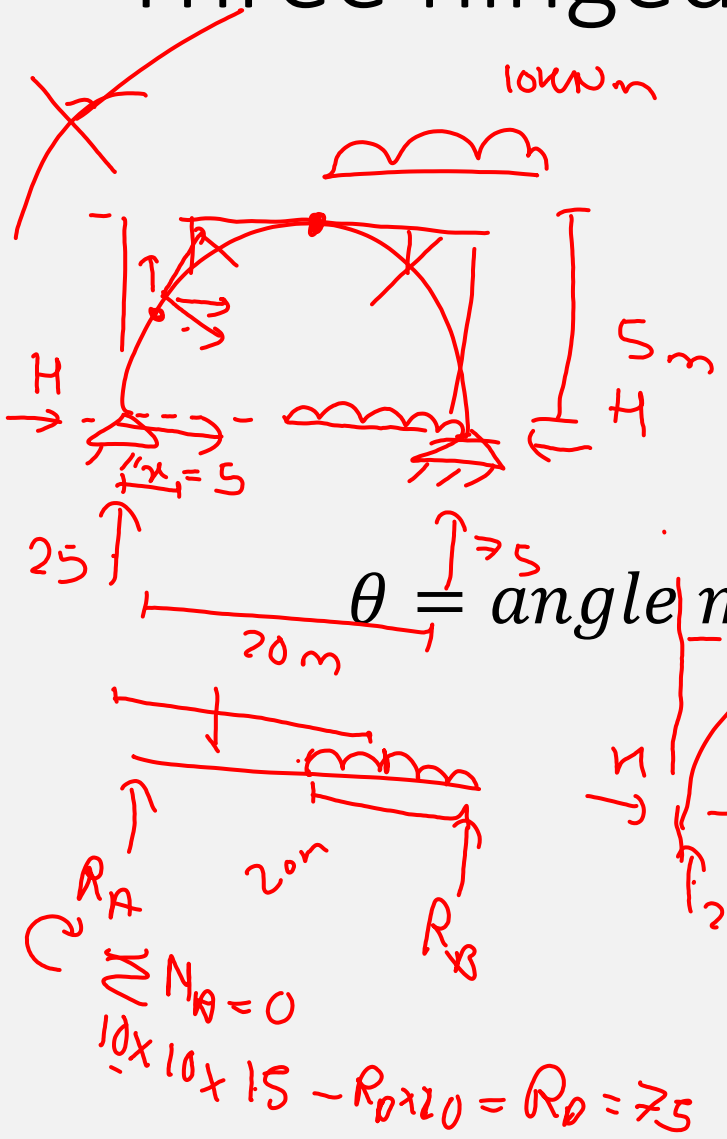
$$= 2.3$$



ILD for continuous beam

R_B ILD

Three hinged circular arches.

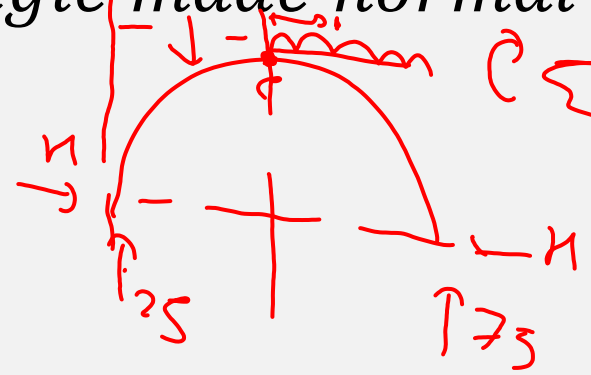


$$R = \frac{l^2}{8h} + \frac{h}{2}$$

$$x = \frac{l}{2} - Rsin\theta$$

$$y = h - R(1 - cos\theta)$$

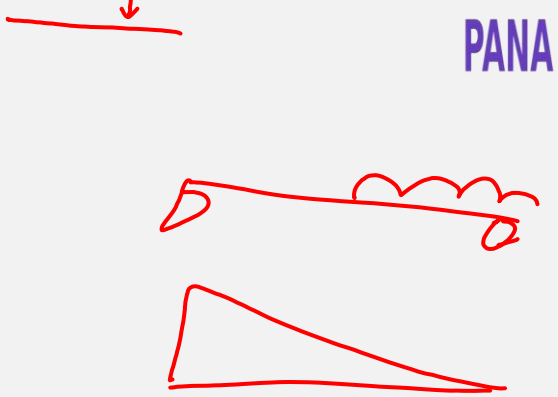
$\theta = angle\ made\ normal\ from\ point\ with\ vertical$



$\sum M_C = 0$

$+25 \times 10 - H \times 5 = 0$

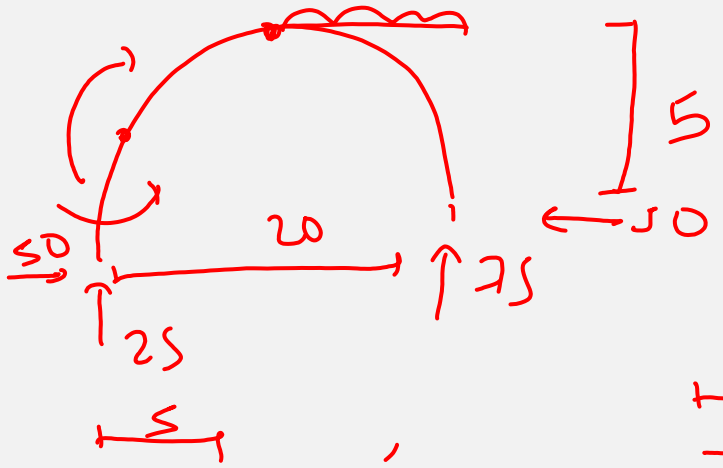
$H = 50$

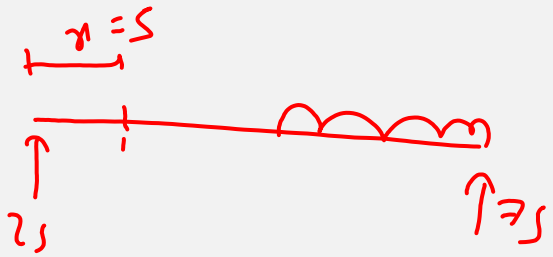


$\sum M_{RC} = 0$

$-75 \times 10 + H \times 5 + 10 \times 10 \times 5 = 0$

$H = 50$





$V_n = 25$

$H_n = 50$

$$y = \frac{4h_x(l-x)}{l^2} = 3.75_m$$

$$\tan\theta = \frac{4h(l-2x)}{l^2} =$$

$\theta = 26.57^0$

Beam Moment $= 25 \times 5$
$= 125\ kN_m$

~~Hom~~ Horizontal Moment (H-moment) $= H_{xy}$
$= 50 \times 3.75 = 187.5\ kN_m$

BM = Beam Moment $= H_y$
$= -62.5\ kN_m$

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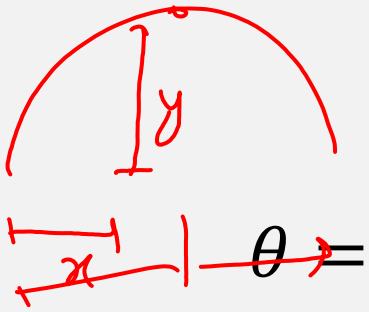
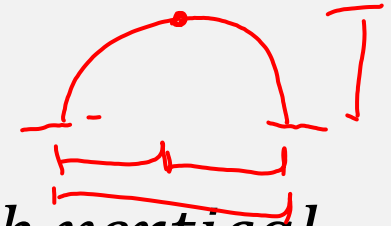
Three hinged parabolic arches.

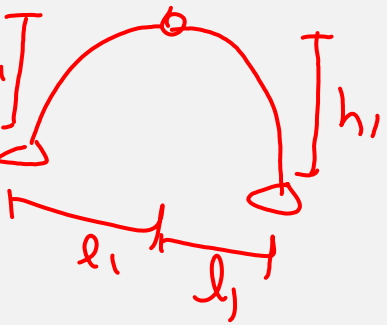


$$y = \frac{4h(l-x)x}{l^2}$$



θ = angle made normal from point with verticdl

$$\theta = tan\theta = \frac{dy}{dx} = \frac{4h(L-2x)}{l^2}$$

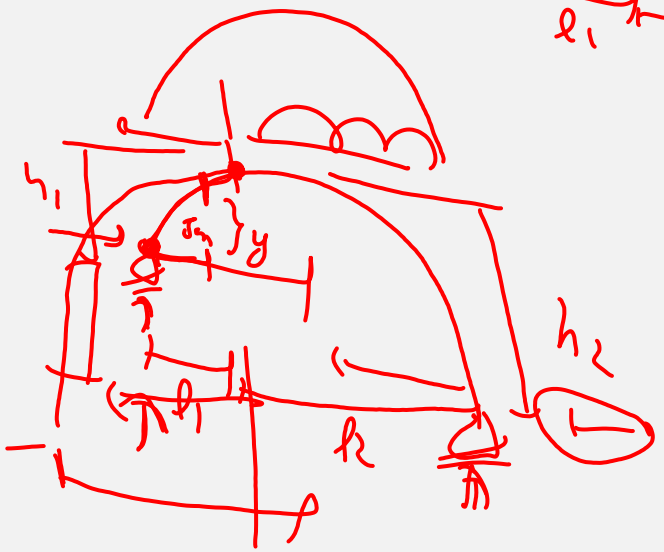


For support at different level $l_1 = l_2 \sqrt{\frac{h_1}{h_2}}$

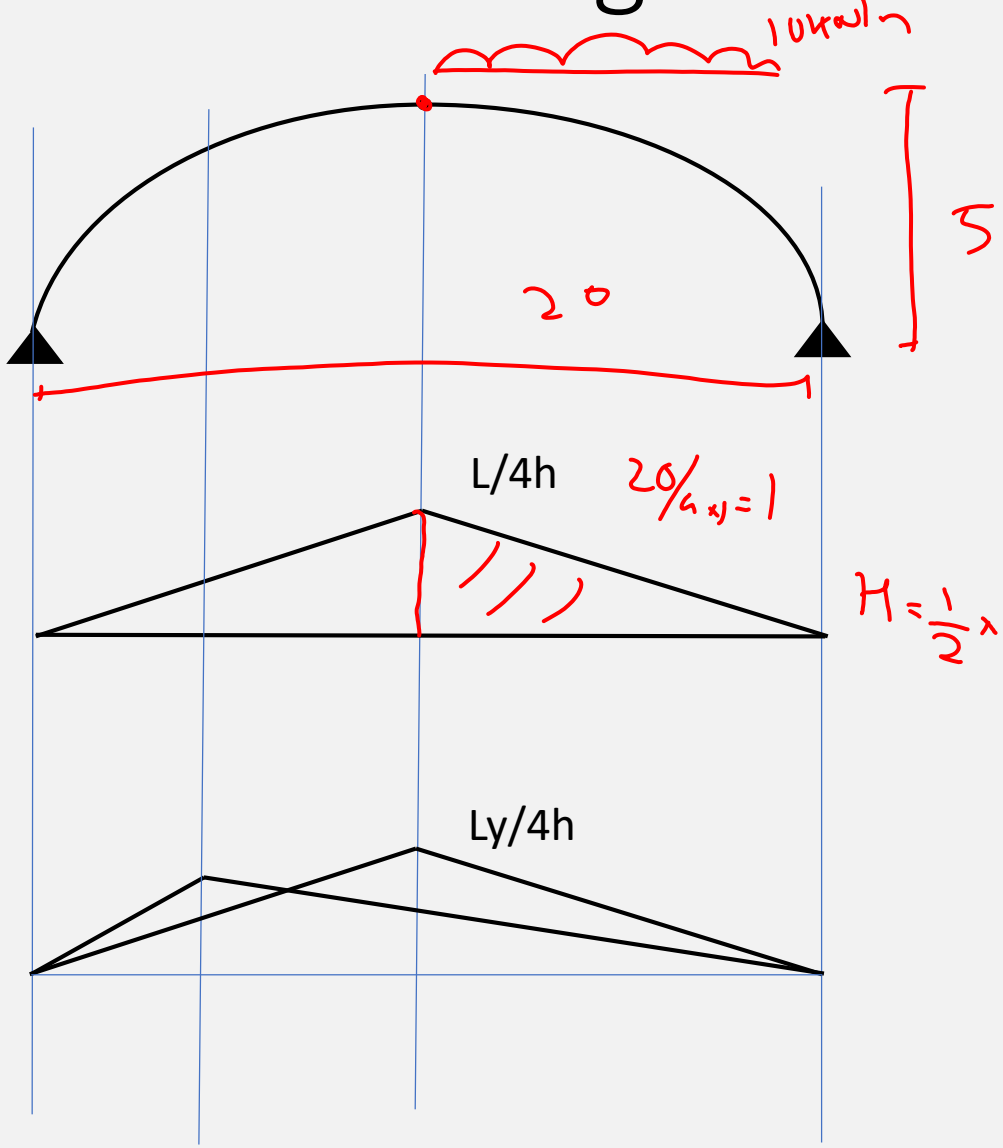
$l = l_1 + l_2$

$$\frac{l_1}{\sqrt{h_1}} = \frac{l_2}{\sqrt{h_2}}$$

$$l_1 = \frac{l\sqrt{h_1}}{\sqrt{h_1} + \sqrt{h_2}}$$



ILD Three hinged arc

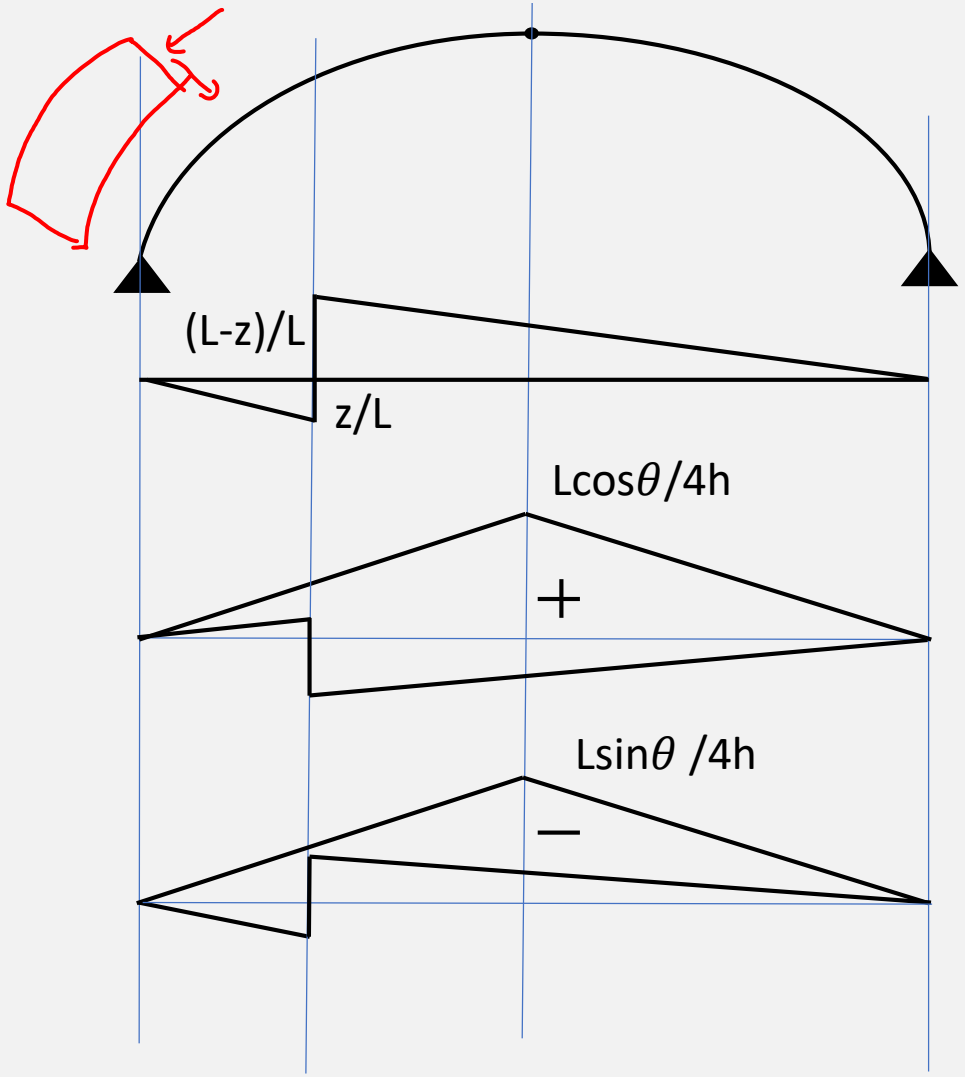


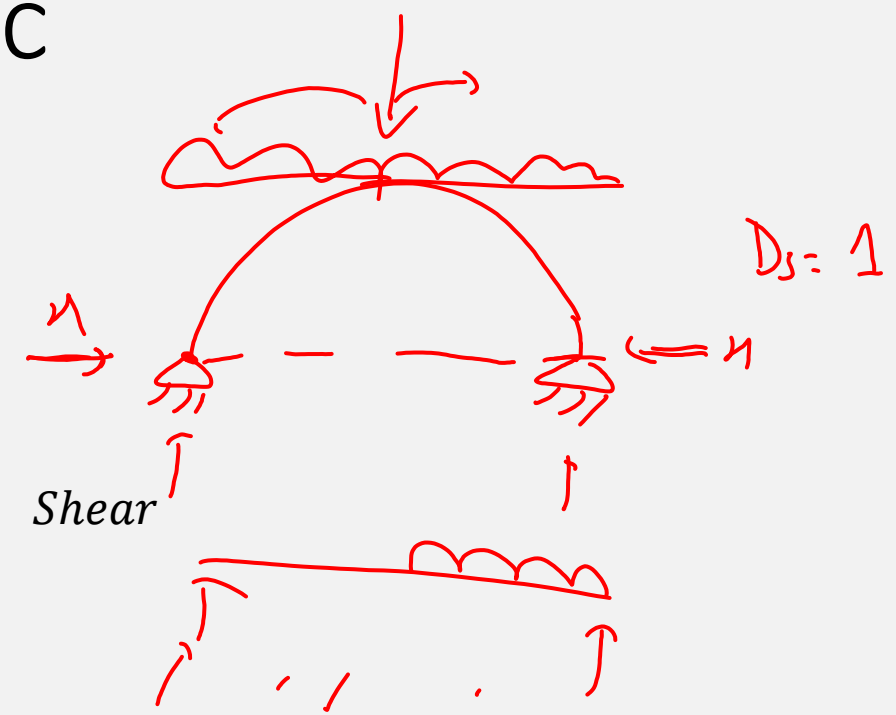
$H = \frac{1}{2} \times 10 \times 1 \times 10 = 50$

Horizontal reaction (H)

M=Beam moment-Hy

ILD Three hinged arc





$N = V\sin\theta + H\cos\theta$ *Normal Shear*

$Q = V\cos\theta - H\sin\theta$ *Radial Shear*

Two hinged parabolic arches.

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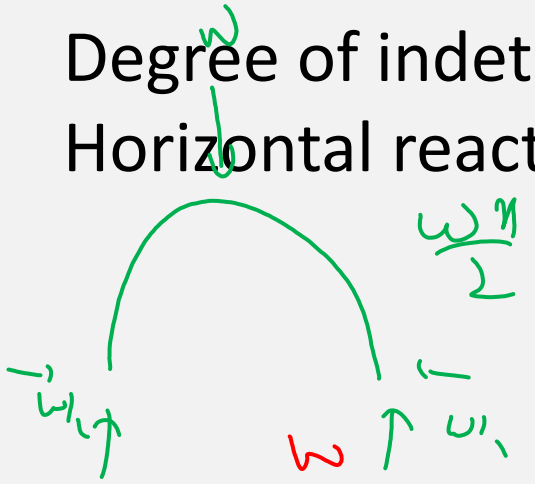
Degree of indeterminacy :1

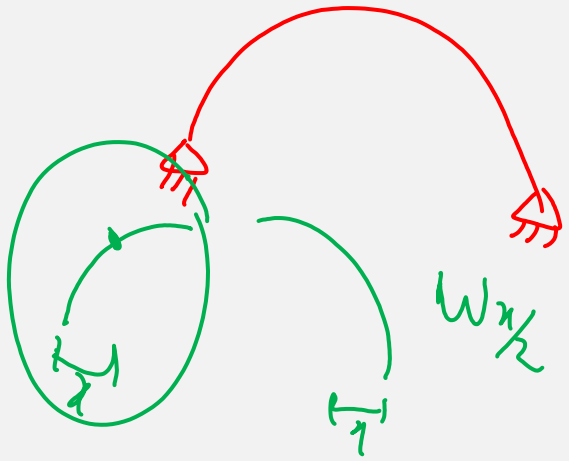
Horizontal reaction as redundant.



$$H = \frac{\int \frac{My\,ds}{EI} + L\alpha T}{\int \frac{y^2\,ds}{EI} + \frac{L}{AE} + k}$$

load → temperate → support settlement → rib shortening

For point load (W) at crown,



$$H = \frac{25}{128}\frac{WL}{h}$$

$$H = \frac{\int_0^{L/2} \frac{W_x}{2}\frac{4hx(L-x)}{L^2}\,dx + (\quad)}{\int \left(\frac{4hx(L-x)}{L^2}\right)^2 dx + (\quad)}$$

Two hinged parabolic arches.

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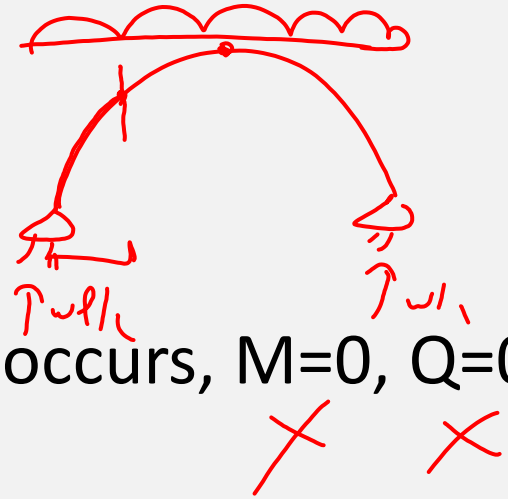
For UDL entire span,

3 hinged arch

$$H = \frac{wL^2}{8h}$$



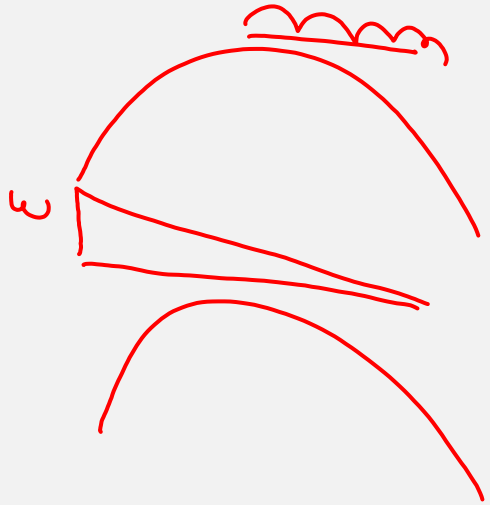
For udl on whole span, only normal thrust occurs, M=0, Q=0;

For UDL half span,

$$H = \frac{wL^2}{16h}$$

For UVL entire span,

$$H = \frac{wL^2}{16h}$$

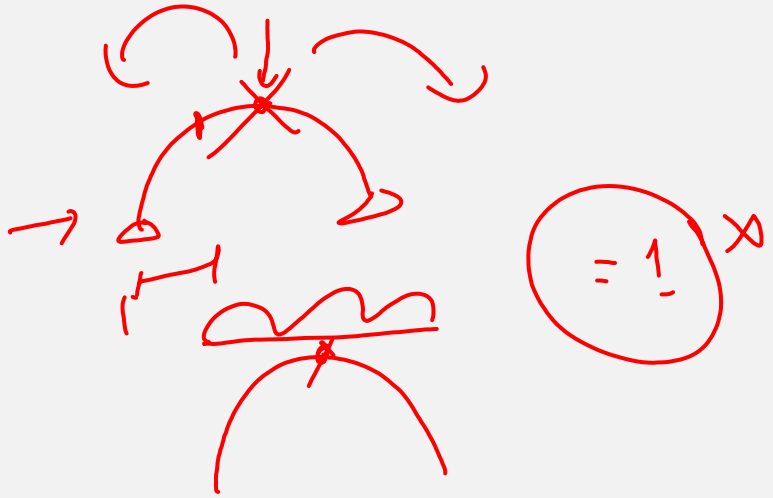


Two hinged semicircular arches. (R - radius)

PANA ACADEMY

For point load (W) at crown,

$$H = \frac{W}{\pi}$$



For UDL entire span,

$$H = \frac{4}{3}\frac{wR}{\pi}$$

For UDL half span,

$$H = \frac{2}{3}\frac{wR}{\pi}$$

$$R = \frac{l^2}{8h} + h/2$$

For UVL entire span,

$$H = \frac{2}{3}\frac{wR}{\pi}$$

Two hinged semicircular arches.

PANA ACADEMY

The locus of the reaction of a two hinged semi-circular arch is a **straight line** whereas the locus of the reaction of a two-hinged parabolic arch is a **parabolic curve**.

MCQs

Ordinate of ild is dependent on

a. Load
b. Location of load
c. Direction of load
d. Independent of load

PANA ACADEMY

MCQs

Two hinged symmetric parabolic arch subjected to UDL over entire span is subjected to

a. Radial shear only

b. Normal thrust only

c. Normal thrust and bending moment

d. Normal thrust, bending moment and radial shear

MCQs

PANA ACADEMY

Maximum bending moment on a simply supported beam of length 8m subjected to 1KN/m load over entire span is:

a. 4.5 KNm

b. 6 KNm

c. 8 KNm

d. 16 KNm

MCQs

PANA ACADEMY

Maximum bending moment on a simply supported beam of length 8m subjected to 1KN/m load over 4m is:

a. 4.5 KNm

b. 6 KNm

c. 8 KNm

d. 16 KNm

MCQs

PANA ACADEMY

Maximum bending moment at a section 2m from left support on a simply supported beam of length 8m subjected to 1KN/m load over 4m is:

a. 4.5 KNm

b. 6 KNm

c. 8 KNm

d. 16 KNm

MCQs

PANA ACADEMY

Horizontal thrust when udl of 1KN/m covers left half span of symmetric three hinged parabolic arc, with rise 5m, span 20 m

a. 1 KN

b. 5 KN

c. 10 KN

d. 15 KN

PANA ACADEMY

Thank YOU !!!