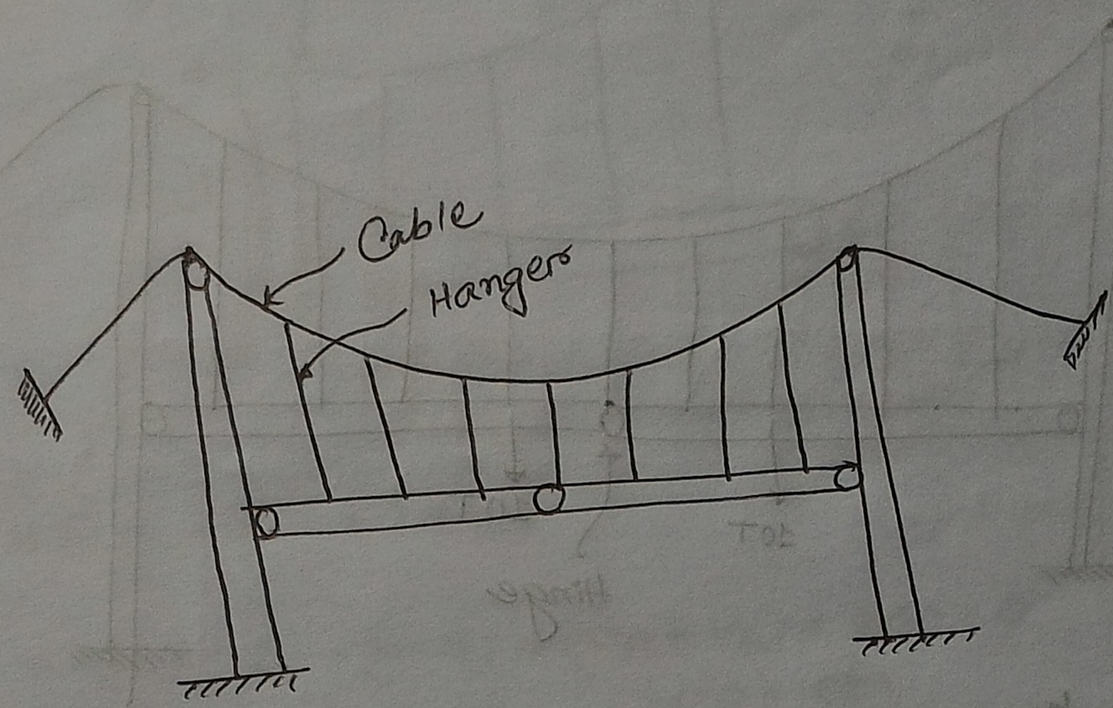
1st Lecture

Structural Analysis and Design

Date: 14.02.2015

Statistically Determinate Suspension Bridge

* REFERENE BOOKS :-
MORIS AND WILLBER



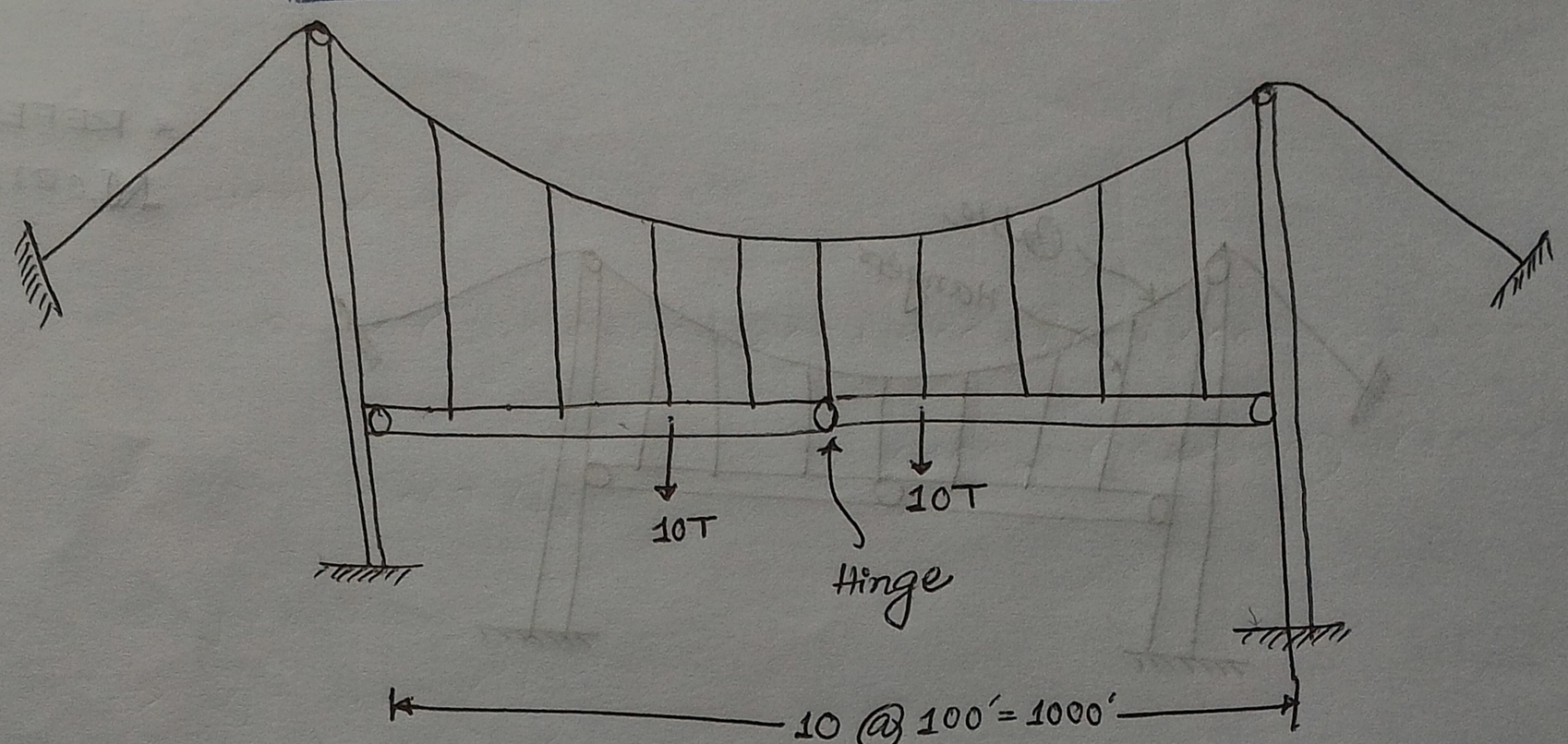
Elastic Theory of Suspension Bridge:-

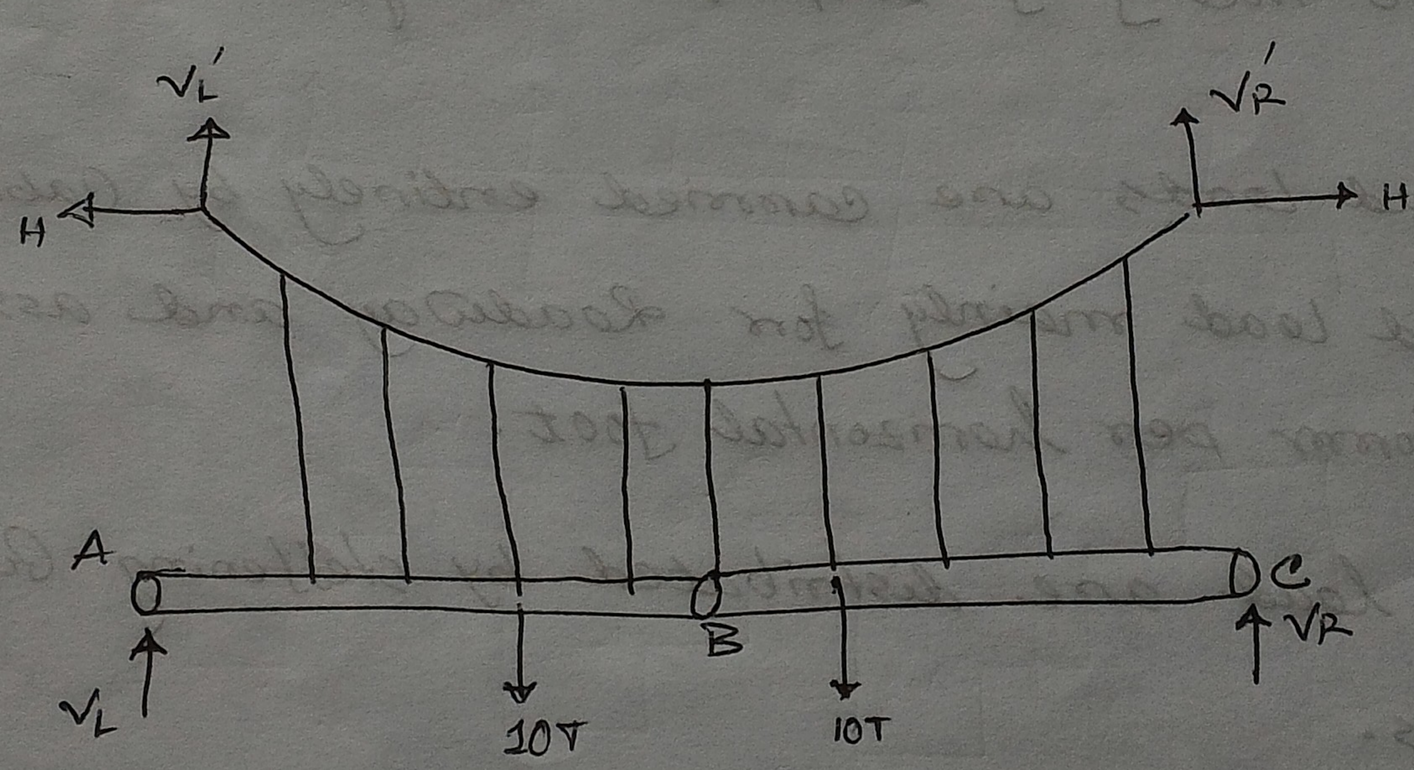
- Dead Loads are carried entirely by Cable
- Dead load mainly for Roadway and assumed uniform per horizontal foot.
- Live load are distributed by stiffening Girder or Truss.
- Total load is uniform per horizontal foot.
- Cable is parabolic.
- Hangers are equal in tension.

*** This is elastic theory of Suspension Bridge.

Problem:- (1)

Hanger force = ?
Bending moment Dia. of Girders



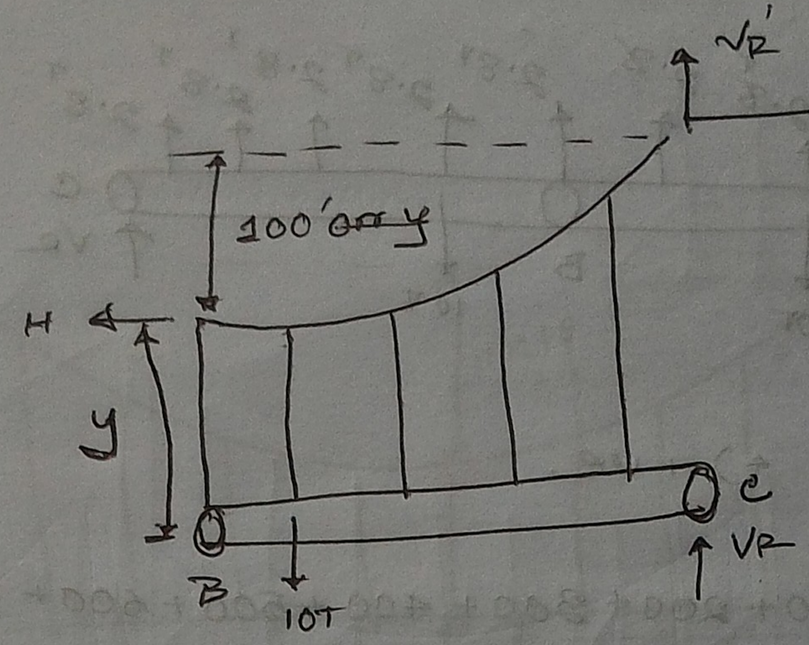


FREE BODY Dia. OF WHOLE STRUCTURE

Now, $\Sigma M @ A = 0$ ↻ +ve

$\Rightarrow -(V_R + V_R') \times 1000 + (10 \times 300) + (10 \times 600) = 0$

$\Rightarrow V_R + V_R' = 9^T$



FREE BODY DIA. OF RIGHT GIRDER

y
কিছু দেয়া না থাকলে y assume করে নিতে হবে BCE লাগবে না

$\sum M@B = 0 \quad \circlearrowleft +ve$

$\Rightarrow H\times(100+y) - (H\times y) - (V_R + V_R')\times 500 = 0$
$\qquad\qquad +(10\times 1000)$

$\Rightarrow 100H - (9\times 500) + 1000 = 0$

$\Rightarrow 100H = 3500$

$\therefore H = 35T$

From General Cable Theorem.

$$H = \frac{\omega L^2}{8h}$$

$$\Rightarrow \omega = \frac{H\times 8h}{L^2}$$

$$\Rightarrow \omega = \frac{35\times 8\times 100}{1000^2}$$

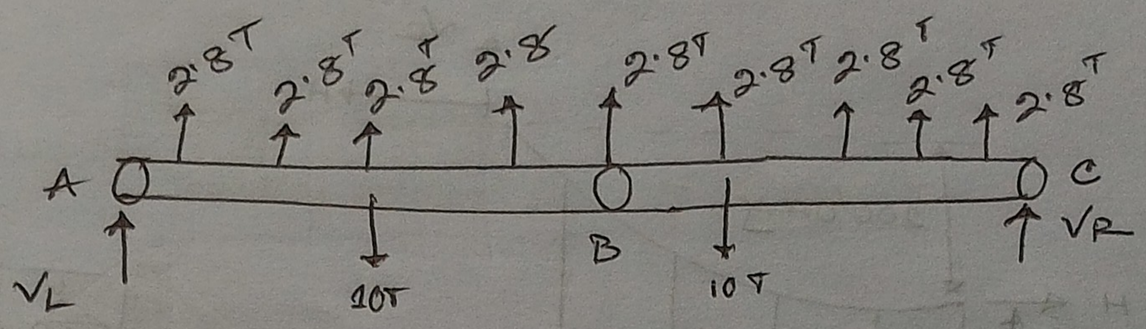
$\therefore \omega = 0.028$ Ton/ft

* Maximum Cable Tension, Length of Cable → Exam এ আসতে পারে।

$\therefore$ Hanger Force = $\omega \times$ spacings of hangers

$= 0.028\times 100$

$= 2.8T$



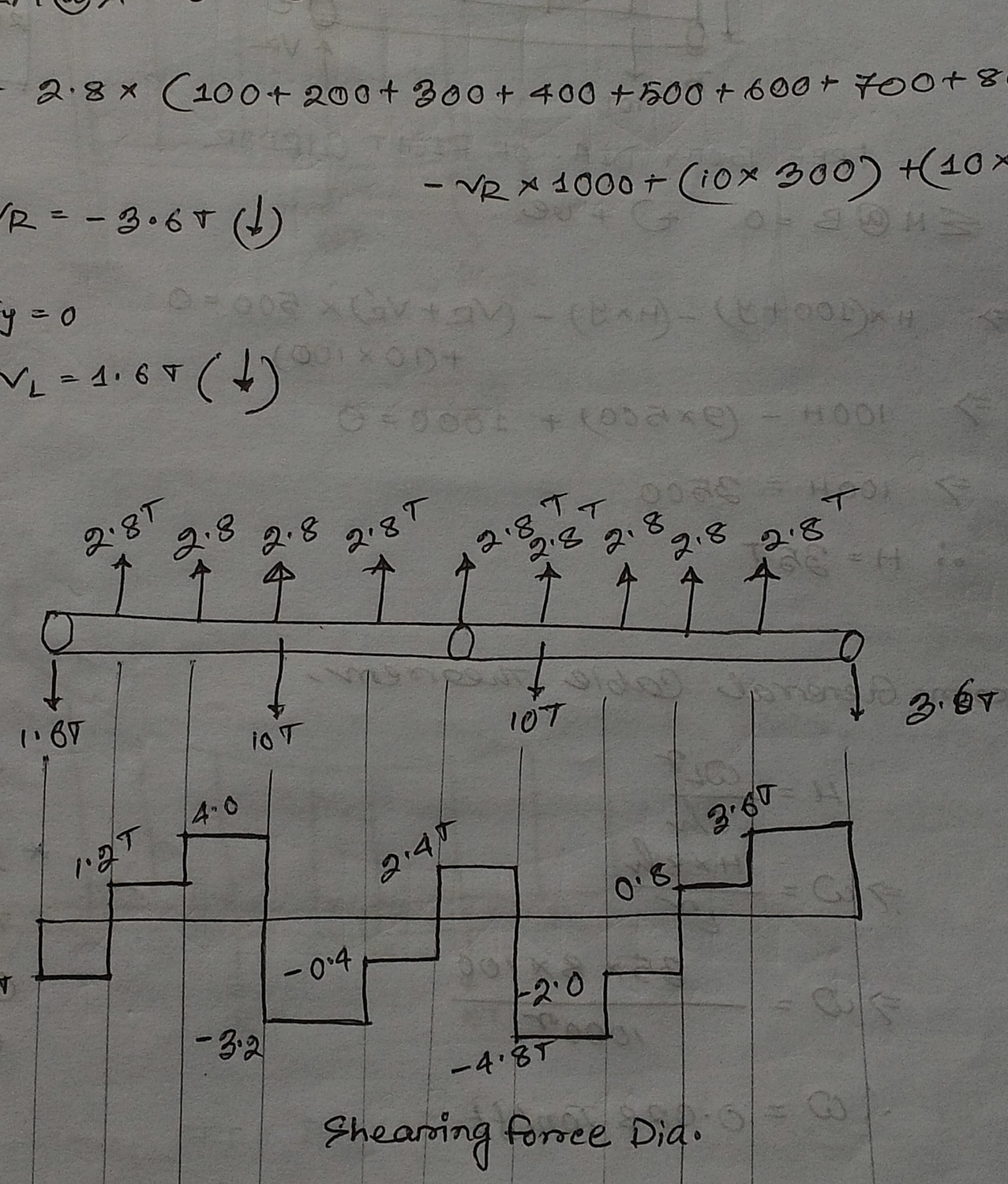
$\Sigma M @ A = 0 \quad \circlearrowleft +ve$

$\Rightarrow -2.8 \times (100+200+300+400+500+600+700+800+900) + -V_R \times 1000 + (10 \times 300) + (10 \times 600) = 0$

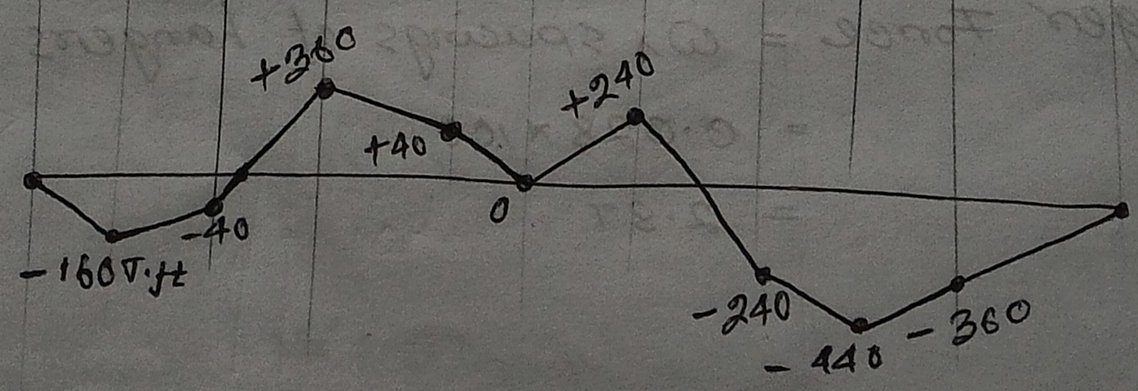
$\therefore V_R = -3.6T \ (\downarrow)$

$\Sigma F_y = 0$

$\Rightarrow V_L = 1.6T \ (\downarrow)$

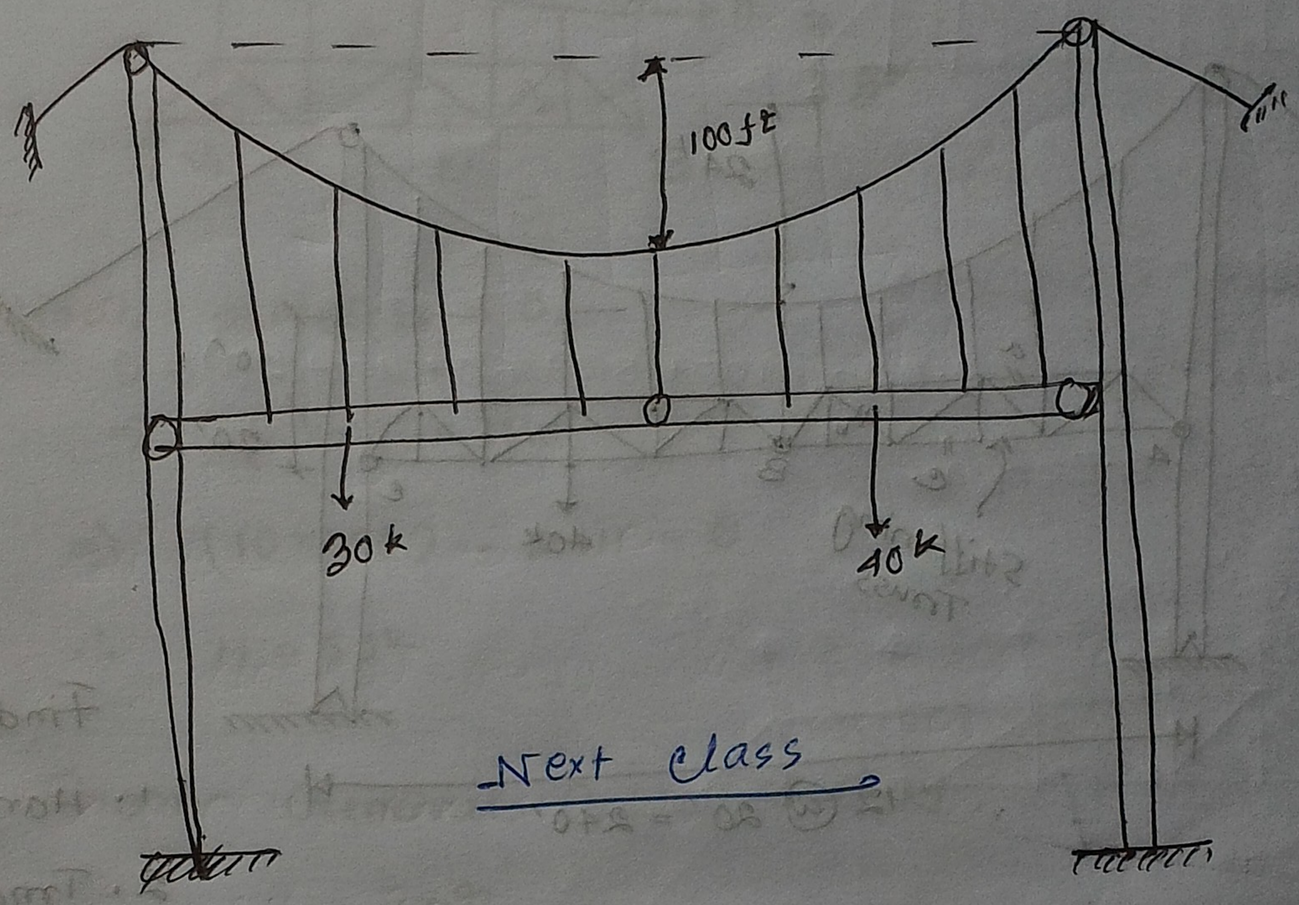


Shearing force Dia.



BENDING MOMENT DIAGRAM

ASSIGNMENT 1:-



Next class

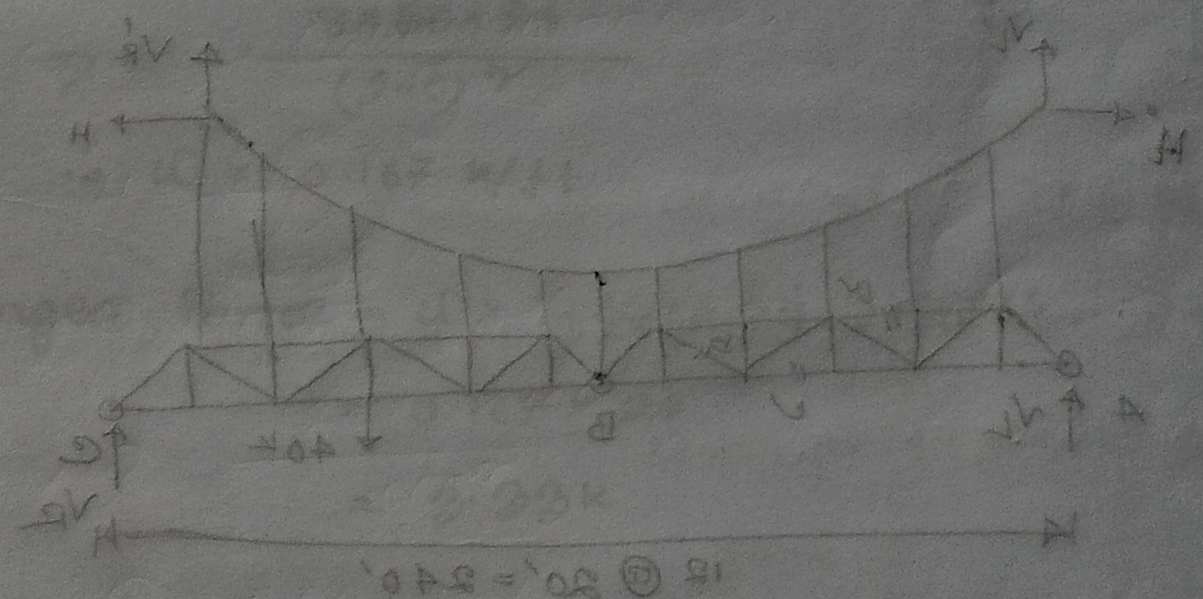
Determine:-

Hanger Force = ?

Shear force Dia. Girder

B.M.D. of Girder

Maximum Cable TENSION = ?

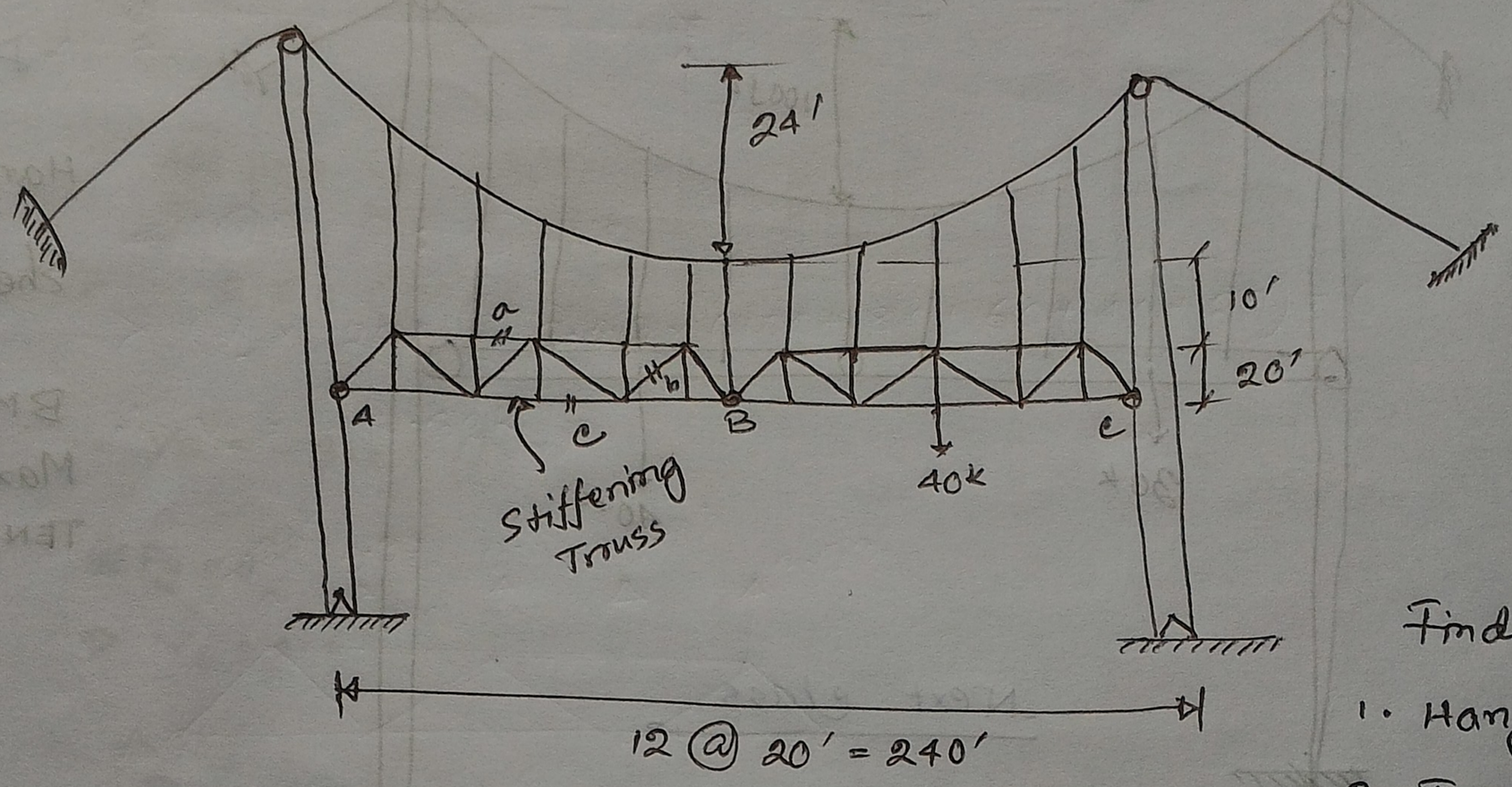


2ND LECTURE

Date: 28·02·2015

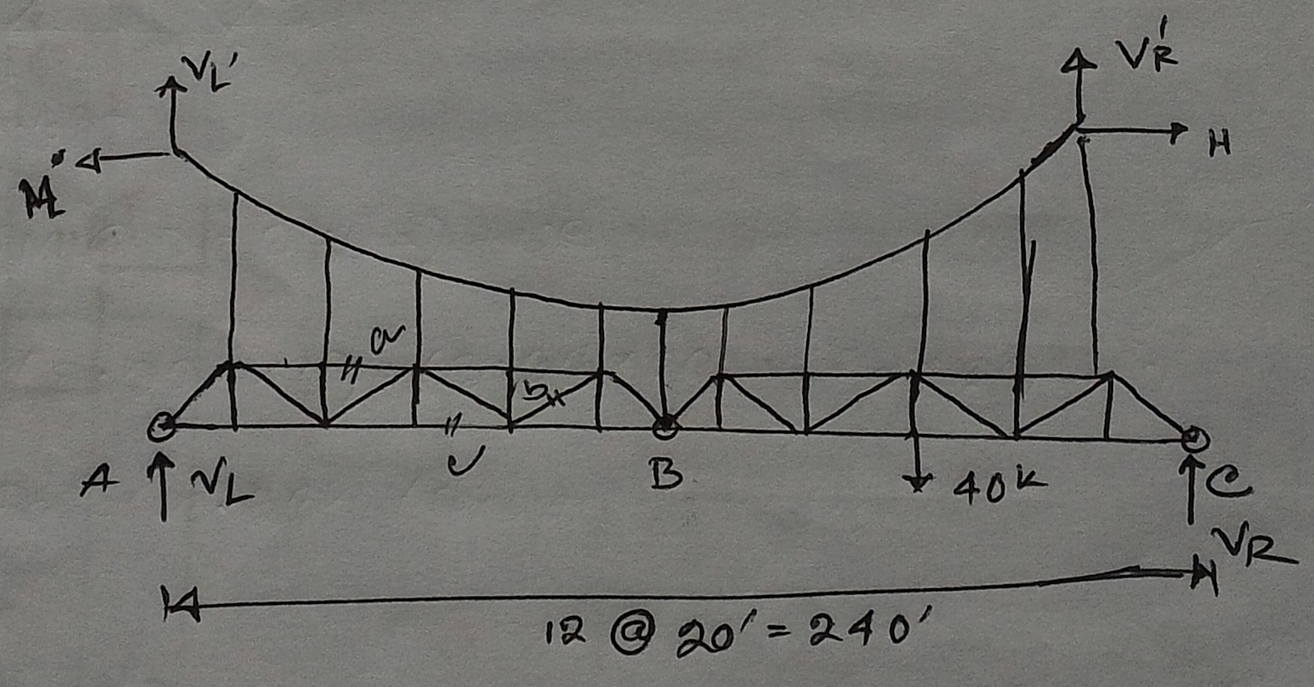
Statically Determinate Suspension Bridge

Problem 2:-



Find:

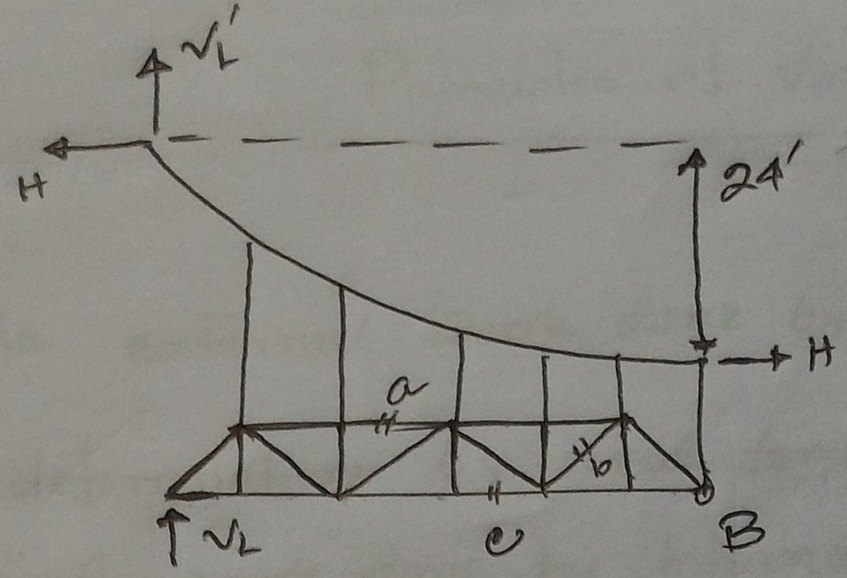
1. Hanger force
2. Tmax of cable
3. Some bar forces of truss. (a, b, c)



$$\Sigma M @ C = 0 \quad \circlearrowleft (+ve)$$

$$\Rightarrow \quad (V_L + V_L') \times 240 - (40 \times 60) = 0$$

$$\therefore \quad V_L + V_L' = 10k$$



Now, $\Sigma M @ B = 0$

$\Rightarrow (V_L + V_L') \times 120' - 24H = 0$

$\Rightarrow (10 \times 120') - 24H = 0$

$\therefore H = 50^k$

From General Cable Theory,

$$H = \frac{\omega L^2}{8h}$$

$$\Rightarrow \omega = \frac{8Hh}{L^2}$$

$$\Rightarrow \omega = \frac{8 \times 50 \times 24}{(240)^2}$$

$\therefore \omega = 0.167\ k/ft$

$\therefore$ Hanger Force = $\omega \times$ Spacing of hangers

$= 0.167 \times 20$

$= 3.33^k$

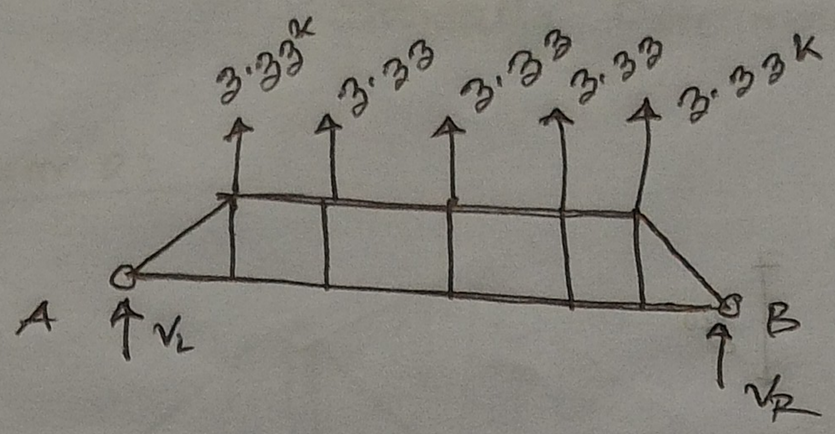
We know,

$$T_{max} = H[1 + 16\theta^2]^{\frac{1}{2}}$$

Here, $\theta = \frac{24}{240} = \frac{1}{10}$

$\therefore T_{max} = 50 \times [1 + 16 \times (\frac{1}{10})^2]$

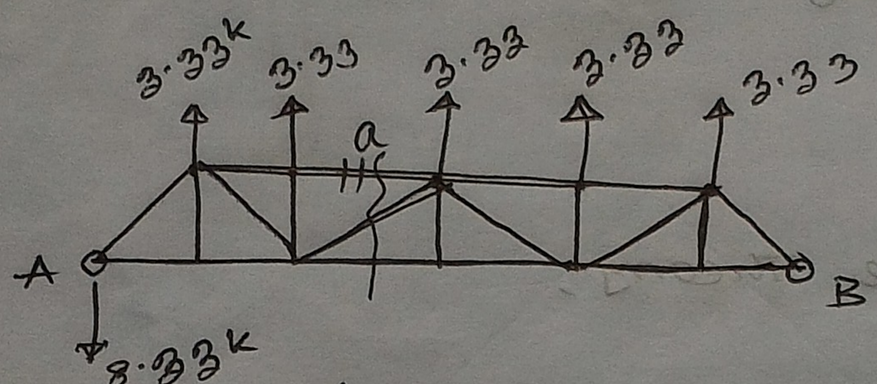
$= 53.85^k$

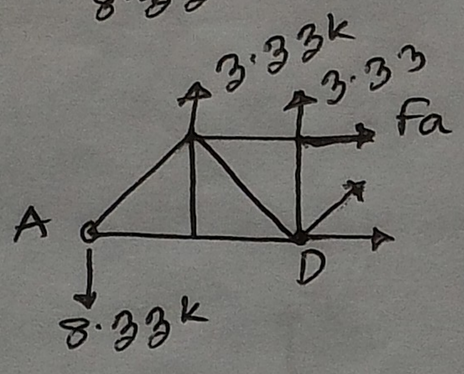


$\Sigma M @ B = 0$; ↺ +ve

$\Rightarrow (V_L \times 120') + 3.33 \times (100 + 80 + 60 + 40 + 20) = 0$

$\therefore V_L = -8.33k (\downarrow)$



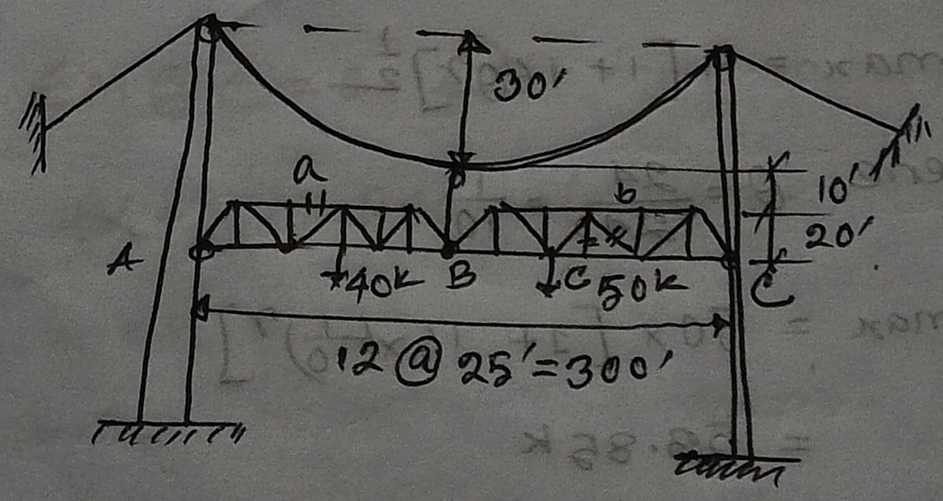


$\Sigma M @ D = 0$; ↻ +ve

$\Rightarrow -(8.33 \times 40) + (3.33 \times 20) + (Fa \times 20) = 0$

$\therefore Fa = 13.33k$ (Tension)

Assignment 2:-



Find:-

1. Hanger force
2. Max. Tension
3. a, b, c

3RD LECTURE

Date: 01-03-2015

Principles of Virtual Work (chapter 8)

The external work done by the external virtual Q-forces on deformation by real force, P is eaual to the internal virotuad work done by internal virtual Q stresses on the actual deformation.

$$W_s = W_d$$

$$W_s = \sum Q\delta$$

$$W_d = \int_0^L F_Q e_0 ds + \int_0^L \frac{M_Q M_f}{EI} ds$$

↳ Bending Effect

K = Curvature

for Truss structure,

$$W_d = \int_0^L f_Q e_0 ds$$

$$e_0 = \left(\frac{f_P}{EA} + \alpha_t t\right)$$

α_t = Thermal Expansion co-efficient

$$W_d = \sum \frac{F_Q F_P L}{AE} + \sum F_Q \alpha_t t L$$

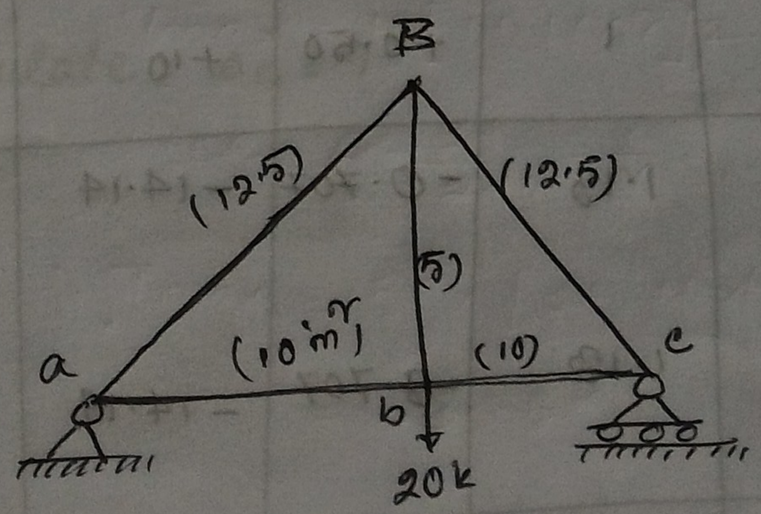
Chapter 8 এর অংকগুলো করতে হবে।

$W_s = \sum Q\delta$ → 1 দেয়া হয়

$W_s = W_d$

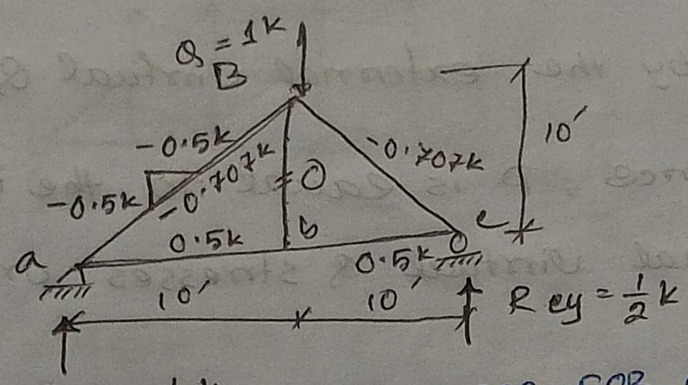
So, it's called Unid Load Method.

Example :-



Find Vertiele deflection at B. Given: E = 29000ksi Areas are shown in parenthesis.

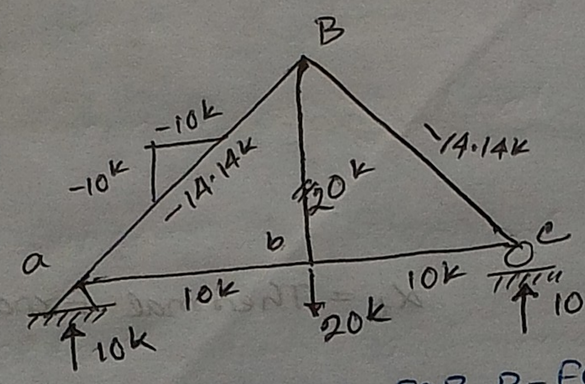
Step 1: Analyze for Q-force system



BAR FORCE FOR Q-FORCE SYSTEM

$$\text{Diagonal Force} = \sqrt{(-0.5)^2+(-0.5)^2}$$
$$= 0.707k$$

Step 2:



BAR FORCE FOR P-FORCE SYSTEM

Table
1ST → Horizontal
2nd → Diagonal
3RD → Vertical

Step 3: Tabular Form to shear, f_Q, f_P ------ etc.

	BAR	L (inch) ft	A (inch²)	L/A	f_Q (k)	f_P (k)	$\frac{f_Q f_P L}{A}$	t	$f_Q t L$
Horizontal	ab	10	10	1	+0.50	+10	5	—	—
	bc	10	10	1	+0.50	+10	5		
Diagonal	aB	14.14	12.5	1.13	-0.707	-14.14	+10	—	—
	~~Bc~~ cB	14.14	12.5	1.13	-0.707	-14.14	+10		
Vertical	~~Bb~~ bB	10	5	2	0	+20	0	—	—

$\sum f_Q f_P L/A = +30$

Using Principle of virtual work,

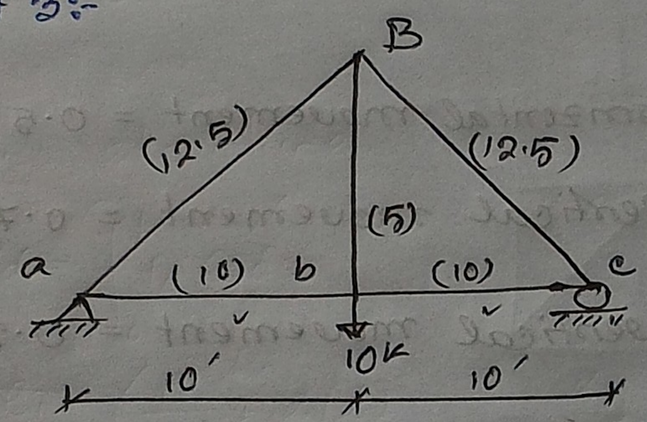
$$\sum Q\delta_B = \sum \frac{f_q f_{pL}}{AE} + \sum f_q \alpha t L \quad (\alpha t \to 0)$$

$$= \frac{30}{E}$$

$$= \frac{30}{29000}$$

$$= +0.00103 \text{ ft (Downward)} \quad \text{(Ans.)}$$

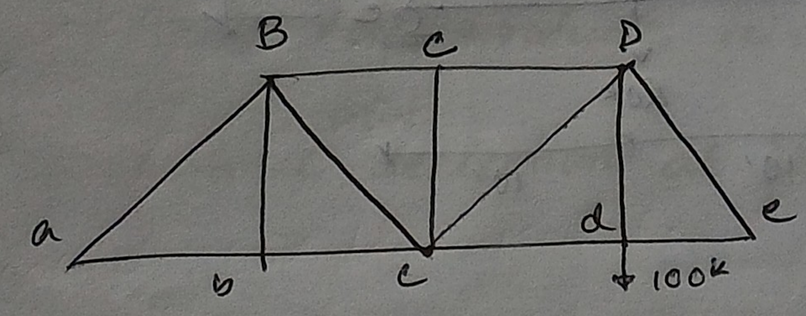
Assignment 3:-



Find vertical deflection at B
Given: E=29000ksi; areas
area are shown in parenthess

50°F decrease in Temp. observed in bottom chord members.

Assignment 4:- Solve example 8.1 with following data



50°F decrease in Temp. in Bottom chord only.

Calculate: $\Delta_B = ?$

4th Lecture

Structural Analysis and Design

Date: -03-2015

Truss with Support Movement

Principle of Virtual Work,

$$\sum Q\delta + W_R = \sum \frac{F_Q F_P L}{AE} + \sum F_Q \alpha_t t L$$

External Work for Reactions; ΔL for F_P; ΔL for temp. change; Virtual

Problem 2:-

Consider problem #1 with some loading.

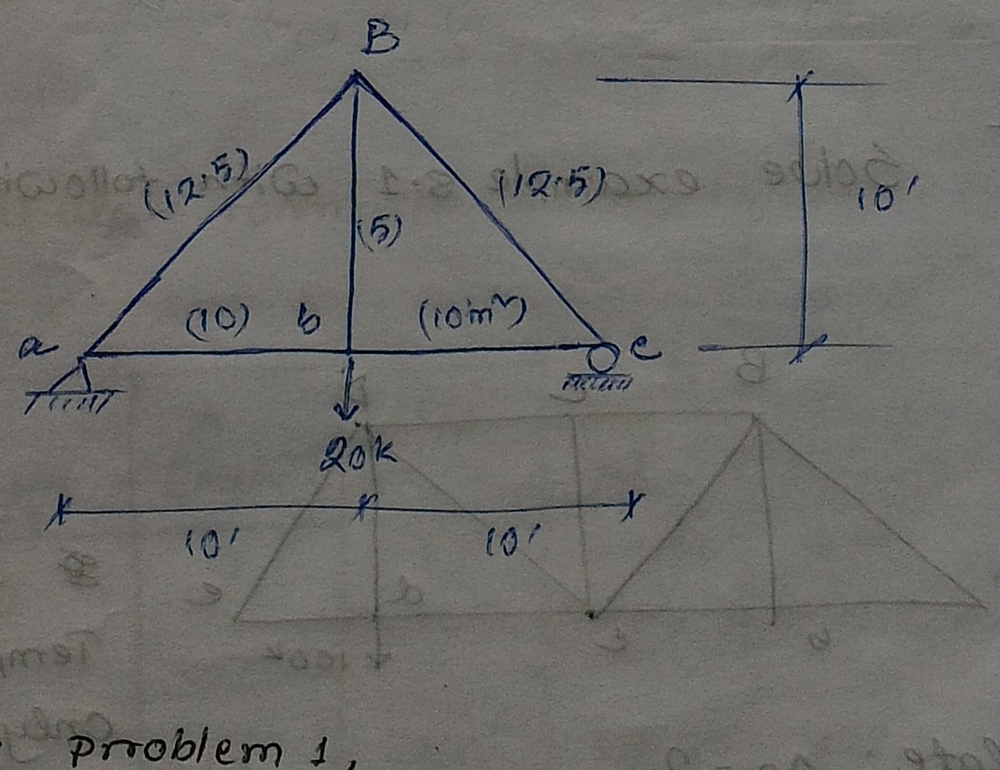
Also Given,

at support "a" horizontal movement = 0.5" (left)

at support "a" vertical movement = 0.75" (down)

at support "c" vertical movement = 0.3" (down)

Calculate, vertical movement at joint B.



From problem 1,

$$\sum \frac{F_Q F_P L}{AE} = \frac{32.6}{E}$$

From principle of virtual work,

$$\sum Q\delta + W_R = \sum \frac{F_Q F_P L}{AE} + \sum F_Q \alpha_t t L \;(=0)$$

$$\Rightarrow (1 \times \delta_B) + (R_{ax} \times \Delta_{ax}) + (R_{ay} \times \Delta_{ay}) + (R_{cy} \times \Delta_{cy}) = \sum F_Q F_P L/AE$$

From problem ①,

$R_{ax} = 0$

$R_{ay} = \frac{1}{2}k$

$R_{cy} = \frac{1}{2}k$

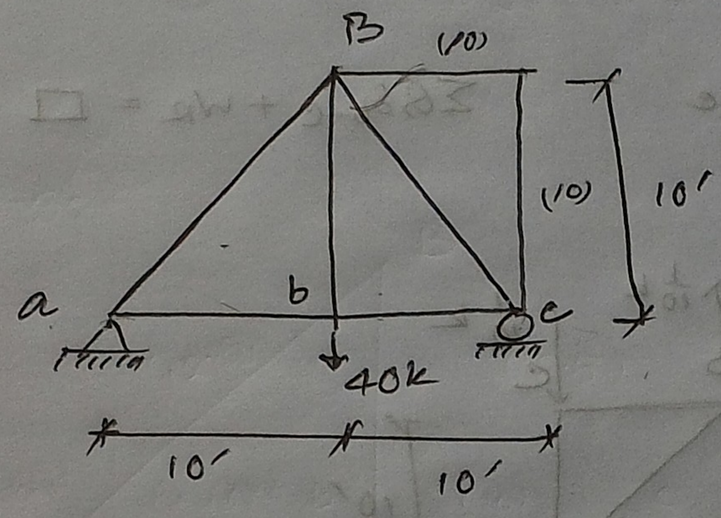
$$\Rightarrow (1 \times \delta_B) + \left(\frac{1}{2} \times \frac{0.750}{12}\right) + \left(\frac{1}{2} \times \frac{-0.150}{12}\right) = \frac{32.6}{E}$$

$$\Rightarrow \delta_B = 0.00112 + 0.04375$$

$$\Rightarrow \delta_B = 0.04487 \text{ ft}$$

$$\therefore \delta_B = 0.5384 \text{ inch} \quad \underline{\text{(Ans.)}}$$

Assignment 5:-



Given that,

at support "a" horizontal movement = 0.6" Right

at " "a" = vertical " = 0.7" down

at " "c" " " = 0.30" down

Also, a 50°F temparature rise in Bottom chord member.

Calculate, ~~vertical~~ horizontal deflection at joint B & C (top chord)

○ 3 Load cases:-

Case 1: 40k

Case 2: Supportmovement

Case 3: Temparature change

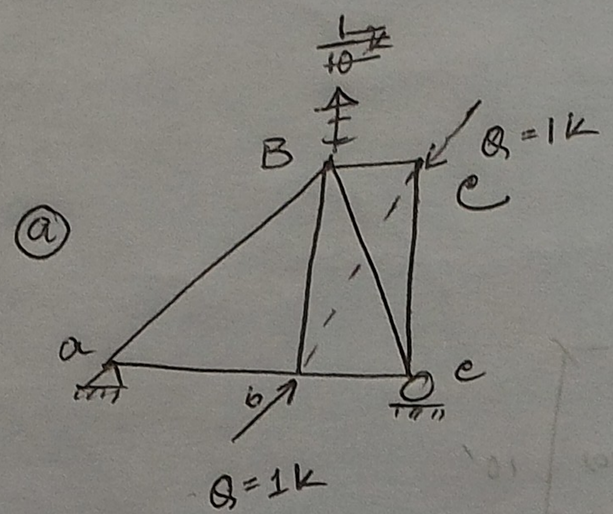
Vertical Deflection = (1 ↓)

Horizontal " = (2 ←)

ⓐ Relative movement of the joints

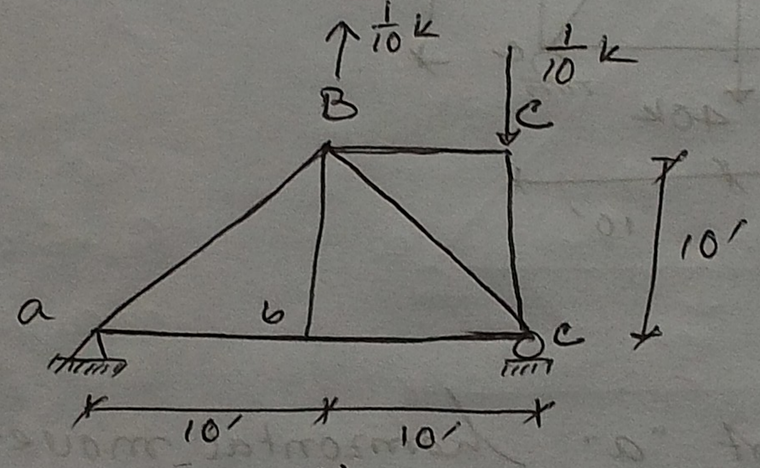
ⓑ Rotation of a bar

ⓐ



$$\sum Q\,\delta_{b-c} + W_R = \square$$

ⓑ



$$\sum Q \xrightarrow{(k\text{-}ft)} \times \theta_{BC} + W_R = \sum \frac{f_Q f_P L}{AE} + \sum f_Q \alpha_t t L$$

For Truss:

Example: 8.1, 8.2, 8.3, 8.4

Deflection, Rotation (slope) for Beam and Frames
By Virtual Work Method

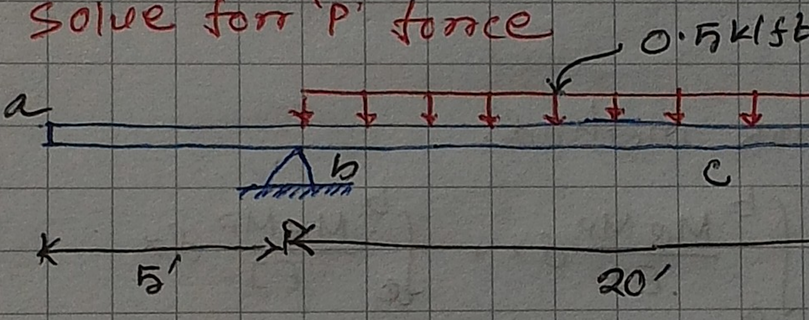
$$\sum Q\delta + WR = \sum F_Q F_P L/AE + \int \frac{M_Q M_P}{EI} ds + \sum F_Q \alpha_t t t$$

(WR: if support movement; $\alpha_t t t$: if temp. changes)

Beams will no axial force, no support movement, no temp. changes

$$\sum Q\delta = \int \frac{M_Q M_P}{EI} ds$$

Example 8-5: Solve for 'P' force

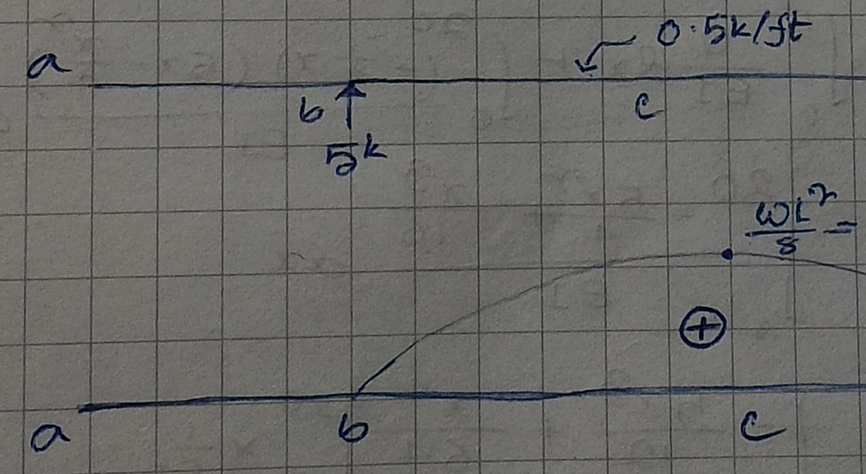


Given that,

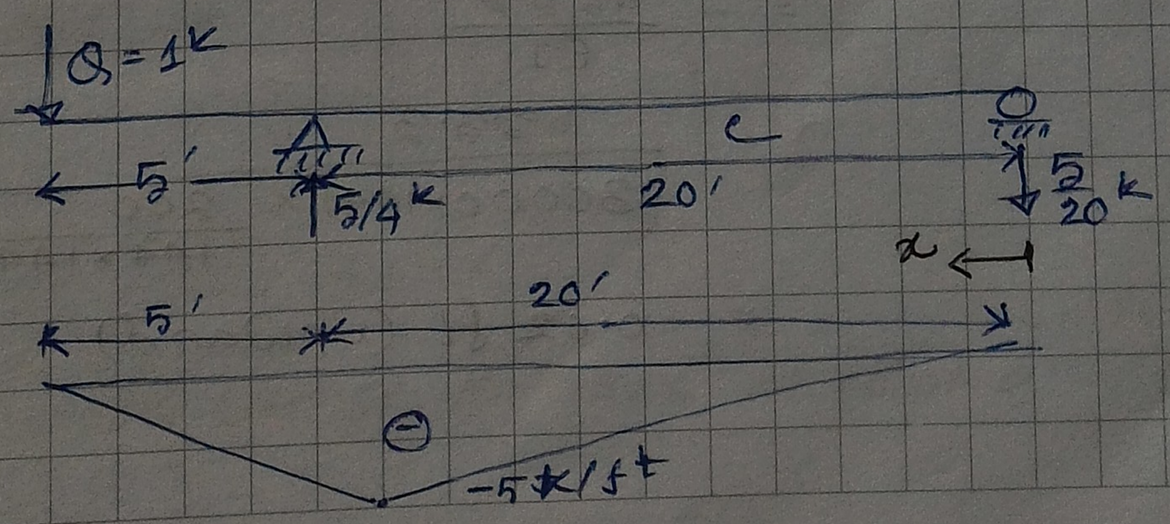
$E = 30000 ksi$

$I = 200 in^4$

Compute vertical deflection at 'a"



Solve for 'Q' force:



Victoria
41 SQUAREX 34 SQUARE

Assignment 2:-

segment ab ($0 < x \leq 5$)

$M_P = 0$

$M_Q = -1x$

segment (bed or dcb) → dcb ka equation ($0 < x \leq 20$)

$$M_P = 5x - 0.5x \times \frac{x}{2}$$

$$= 5x - \frac{x^2}{4}$$

$$M_Q = -\frac{1}{4}x$$

By virtual work method.

$$\Sigma Q \cdot \delta = \int_a^b \frac{M_Q M_P}{EI} dx + \int_b^b \frac{M_Q M_P}{EI} dx$$

$$\Rightarrow 1 \cdot \delta_a = \int_0^5 \frac{0}{EI} dx + \int_0^{20} \frac{(-\frac{1}{4}x)(5x - \frac{x^2}{4})}{EI} dx$$

$$= \int_0^{20} \frac{-\frac{5x^2}{4} + \frac{x^3}{16}}{EI} dx$$

$$= \left[-\frac{5x^3}{12} + \frac{x^4}{64} \right]_0^{20} \times \frac{1}{EI}$$

$$= \left(-\frac{5 \times 20^3}{12} + \frac{20^4}{64} \right) \times \frac{1}{EI}$$

$$= -\frac{833.3}{EI}$$

$$= -\frac{833.3}{(30000 \times 144) \times \frac{200}{144 \times 144}}$$

$$= -0.02 \text{ ft (upward)}$$

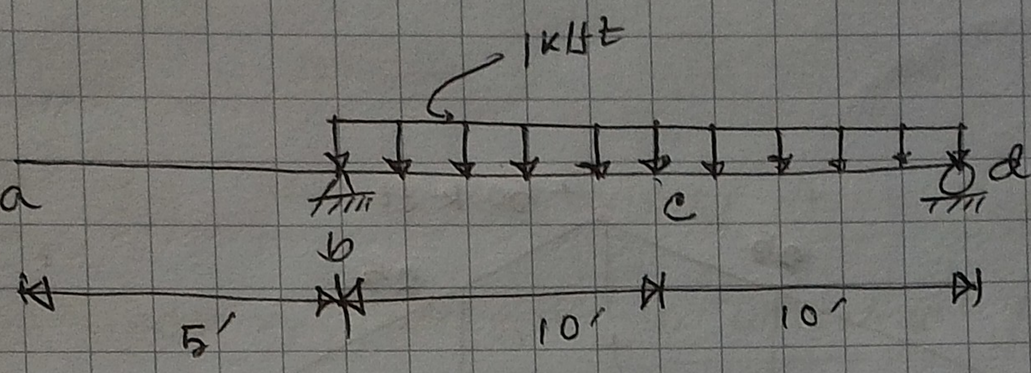
$E = 30000 \text{ ksi}$

$= 30000 \times 144 \text{ ksf}$

$I = 200 \text{ in}^4$

$= \frac{200}{(12)^4} \text{ ft}^4$

Assignment 6:-



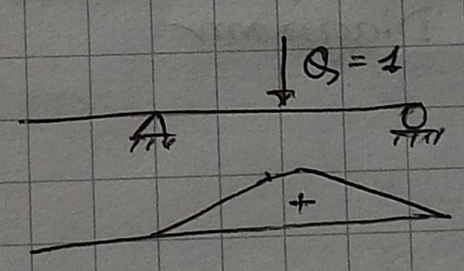
Given that, $E = 30000 ksi$

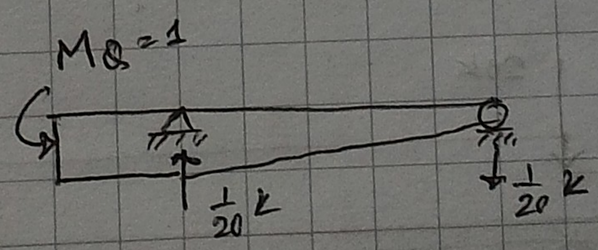
$I = 300 in^4$

Compute: (a) vertical defection at point "c"

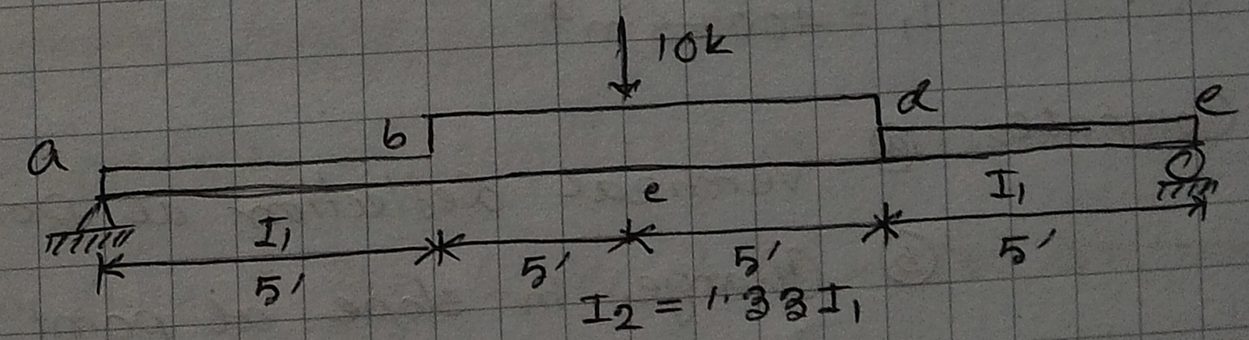
(b) Change in slope (rotation) at point "d"

↳ unit (radian)





Example 8.6:-



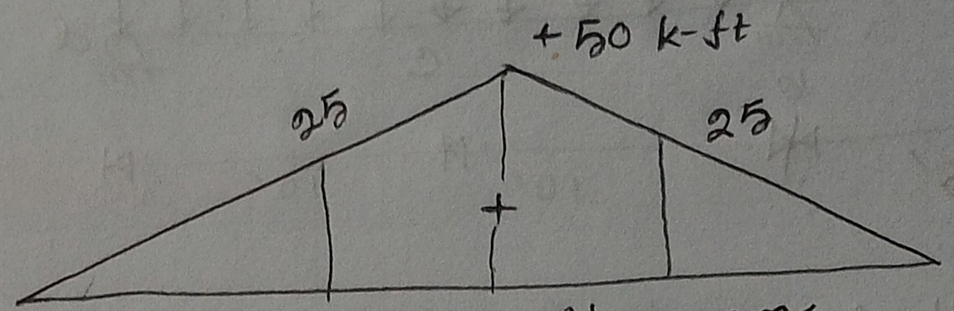
Given that, $E = 30000 ksi$

$I_1 = 150 in^4$

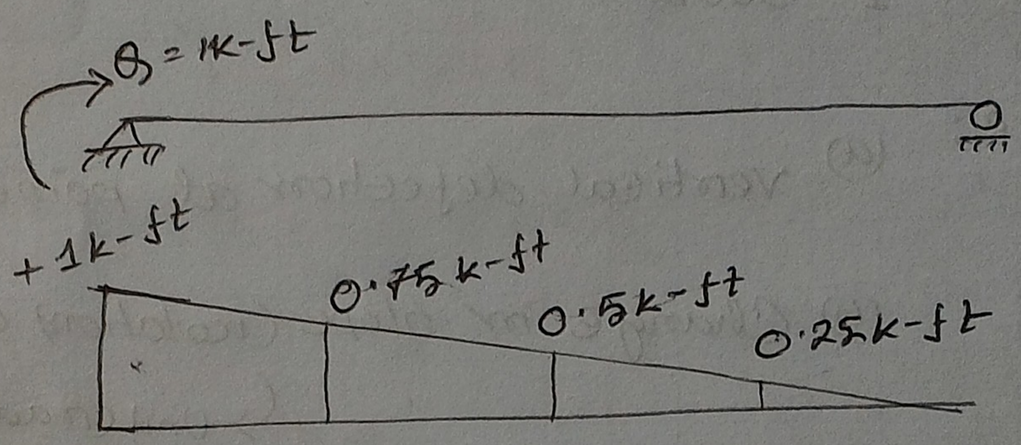
Calculate change in slope at point 'a'

Victoria

41 SQUAREX 34 SQUARE

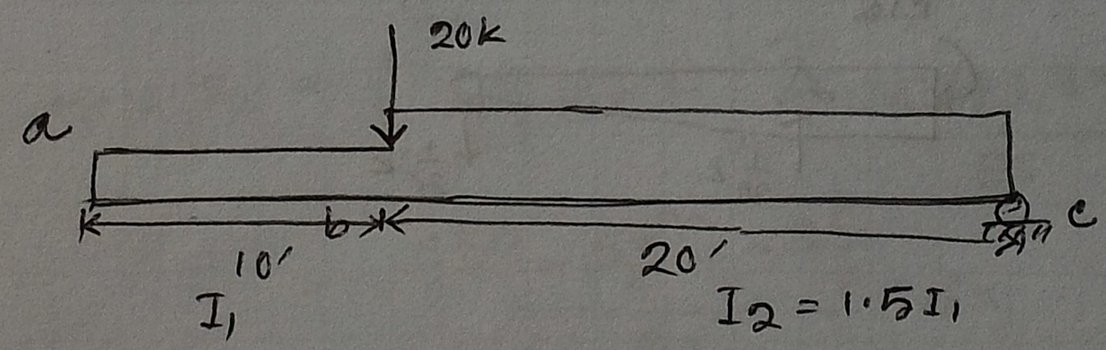


M-P diagram



M-θ Diagram

Assignment No.: 07



Given that, $E = 30,000$ ksi

$I_1 = 400$ ~~ks~~ in^4

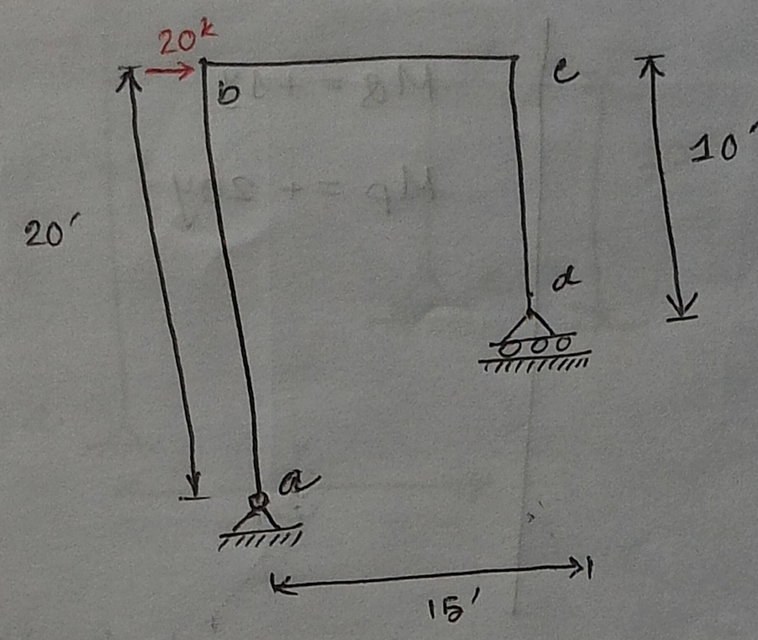
Compute, ⓐ Vertical deflection at point "b"

ⓑ Change in slope at point "c"

6th Lecture

Structural Design and Analysis (Frame)

Date: 21.03.2015



Given that,

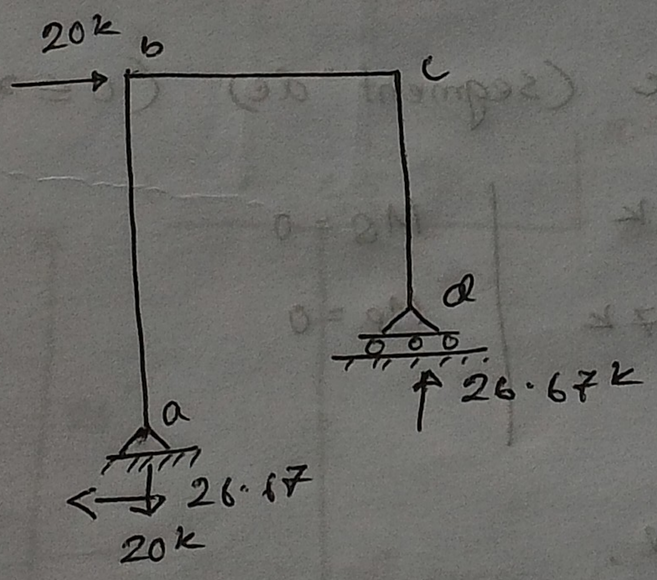
$E = 30,000\ ksi$

$A = 10\ in^2$

$I = 200\ in^4$

Find horizontal deflection at point "b".

Solve for 'p' force:



$\Sigma M @ a = 0$

$-(Rd \times 15) + (20 \times 20) = 0$

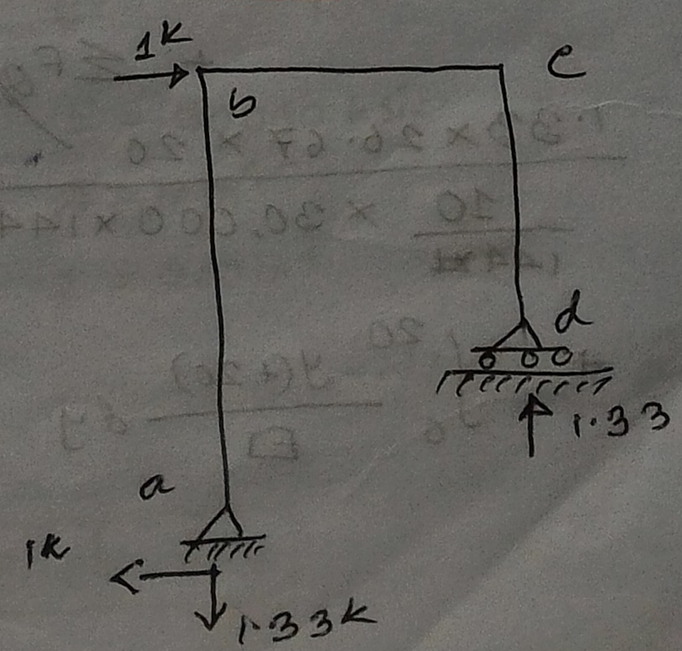
$\therefore Rd = 26.67k\ (\uparrow)$

$\Sigma fy = 0$

$\Rightarrow Ra + 26.67k = 0$

$\therefore Ra = -26.67k\ (\downarrow)$

Solve for "Q" force:



From a to b (segment "ab") ($0 \le x \le 20'$)

$F_Q = +1.33^k$

$F_P = +26.67^k$

$M_Q = +1y$

$M_P = +20y$

From c to b (segment "cb") ($0 \le x \le 15'$)

$f_Q = 0$

$f_P = 0$

$M_Q = +1.33x$

$M_P = +26.67x$

From d to c (segment "dc") ($0 \le x \le 10'$)

$f_Q = -1.33^k$

$f_P = -26.67^k$

$M_Q = 0$

$M_P = 0$

Cls test

Virtual Work Method

BEAM

FRAME

29-03-2015

By Virtual Method,

$$\sum Q \cdot \delta + \cancel{WK}^{0} = \frac{\sum F_Q F_P L}{AE} + \int \frac{M_Q M_P}{EI} ds$$

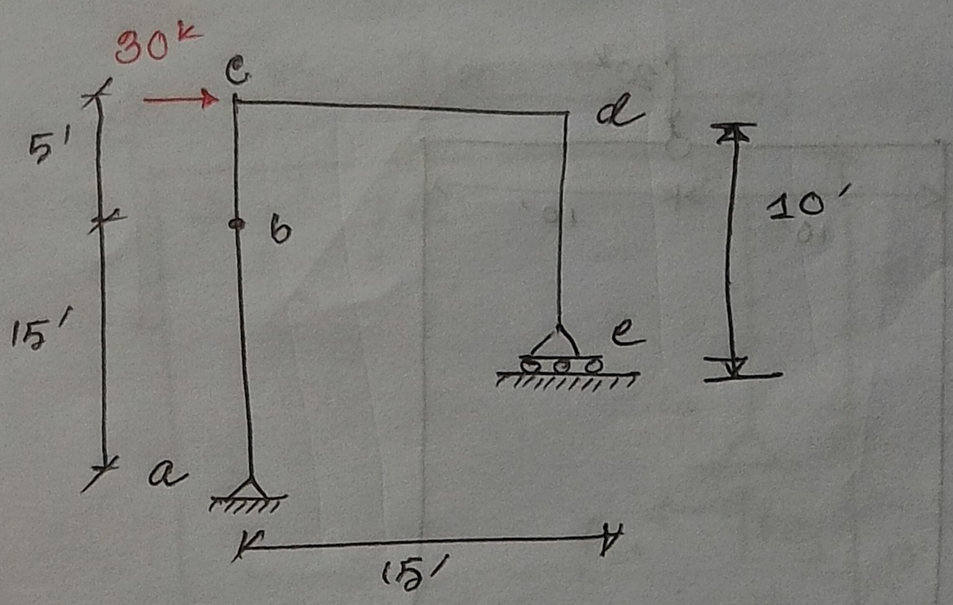
$$+ \cancel{\sum F_Q \alpha_t t L}^{0}$$

$$\Rightarrow 1^k \times \delta_b = \frac{1.33 \times 26.67 \times 20}{\frac{10}{144} \times 30,000 \times 144} + 0 + \frac{1.33 \times 26.67}{\frac{10}{144} \times 30,000 \times 144}$$

$$+ \int_0^{20} \frac{y(+20)}{EI} dy + \int_0^{15} \frac{1.33x \times 26.67x}{EI} dx$$

$\therefore \delta_b =$

Assignment NO.: 08



Given that, $E = 30,000$ ksi

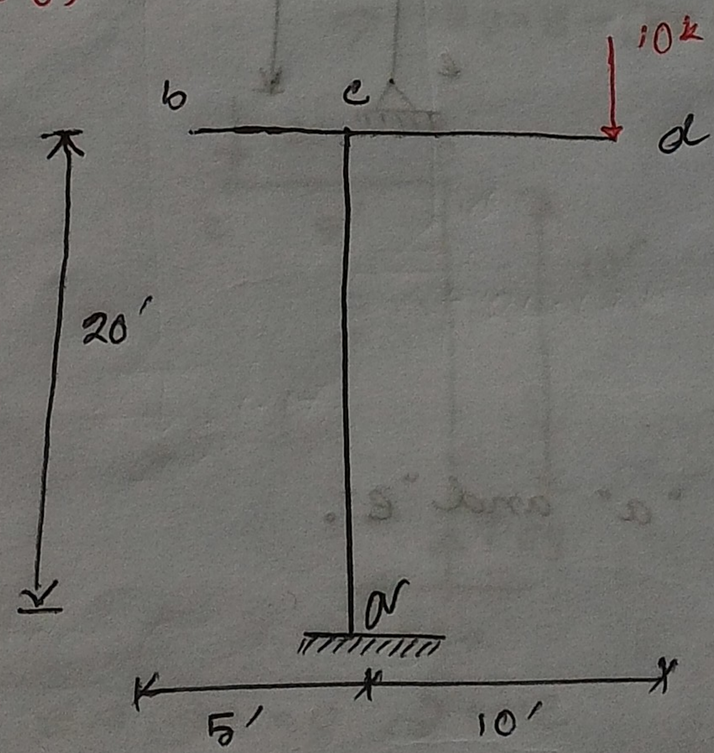
$A = 10\ in^2$

$I = 300\ in^4$

(a) Compute horizontal deflection at point "b".

(b) Compute change in slope at "a"

Assignment NO.: 09



Given that, $E = 30000$ ksi

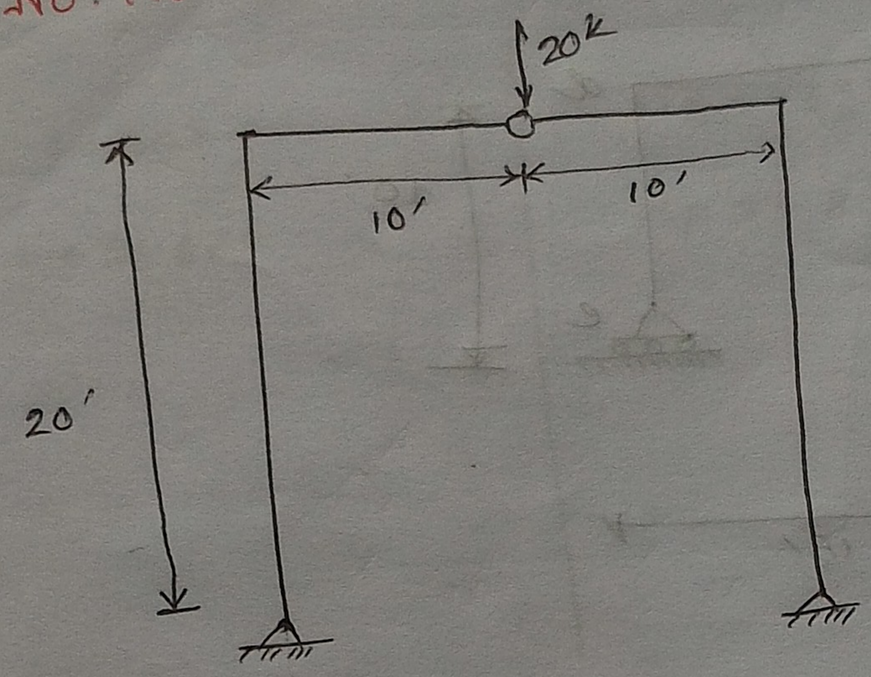
$A = 10\ in^2$

$I = 200\ in^4$

Compute vertical deflection at "b".

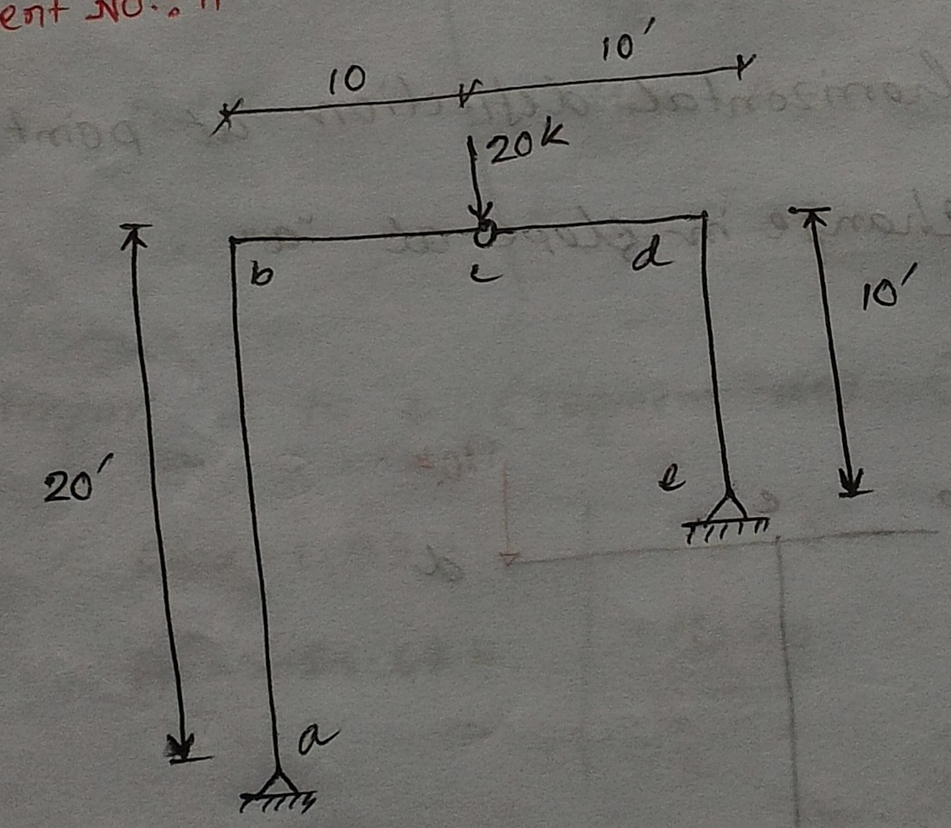
Example 8.6

Assignment NO. : 10



Find Reaction at a & e.

Assignment NO. : 11

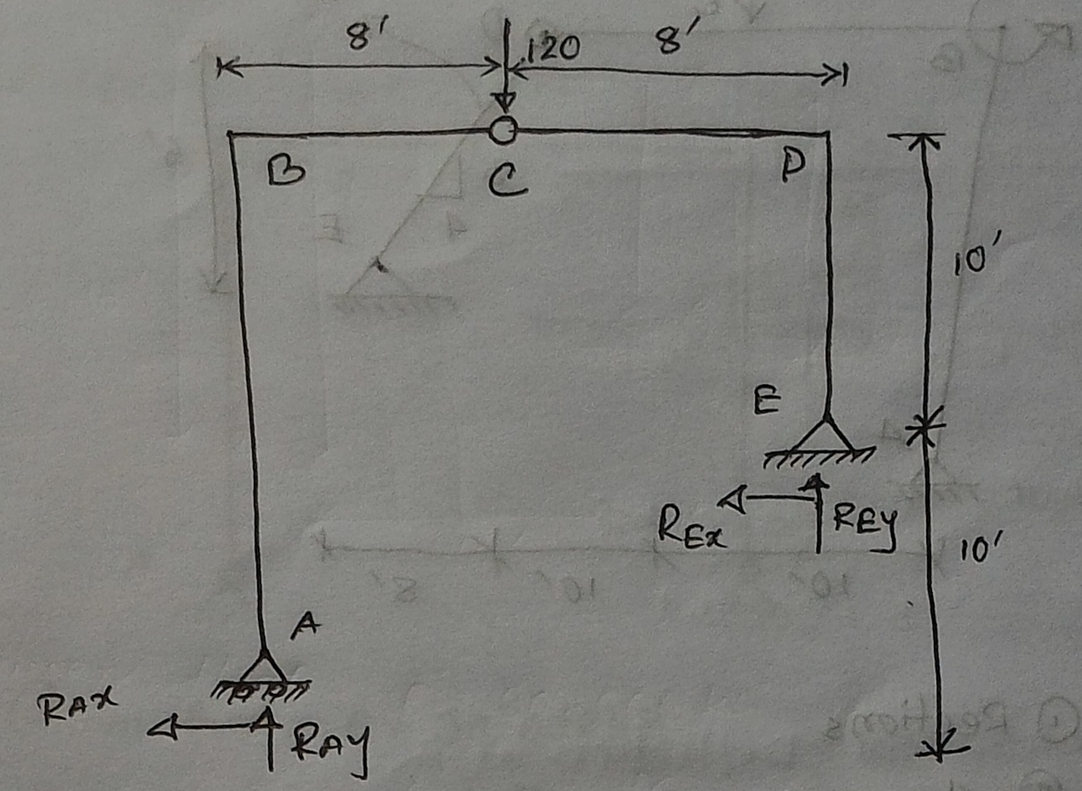


find Reactions at "a" and "e".

7TH LECTURE

Structural Analysis

Date: 22.03.2015



Question:- find Reaction s

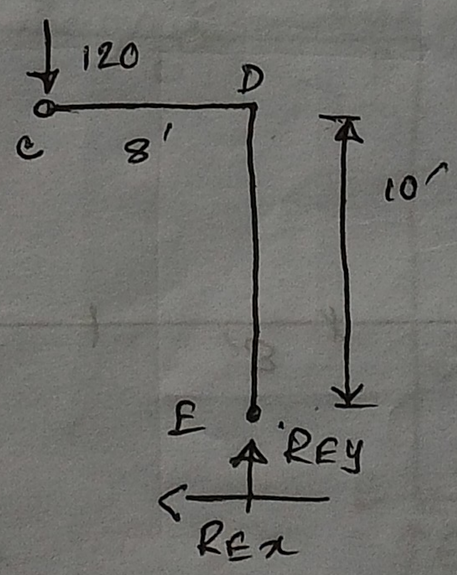
Draw SF Diagram

Draw BM Diagram

Whole structure,

$\Sigma M @ A = 0 : \circlearrowleft +ve$

$\Rightarrow 120 \times 8 - (R_{Ex} \times 10) - (R_{Ey} \times 18) = 0 \longrightarrow (1)$



$\Sigma M @ C = 0 \circlearrowleft +ve$

$\Rightarrow (R_{Ex} \times 10) - R_{Ey} \times 8 = 0 \longrightarrow (2)$

Now, (1) and (2), $960 - 24R_{Ey} = 0$

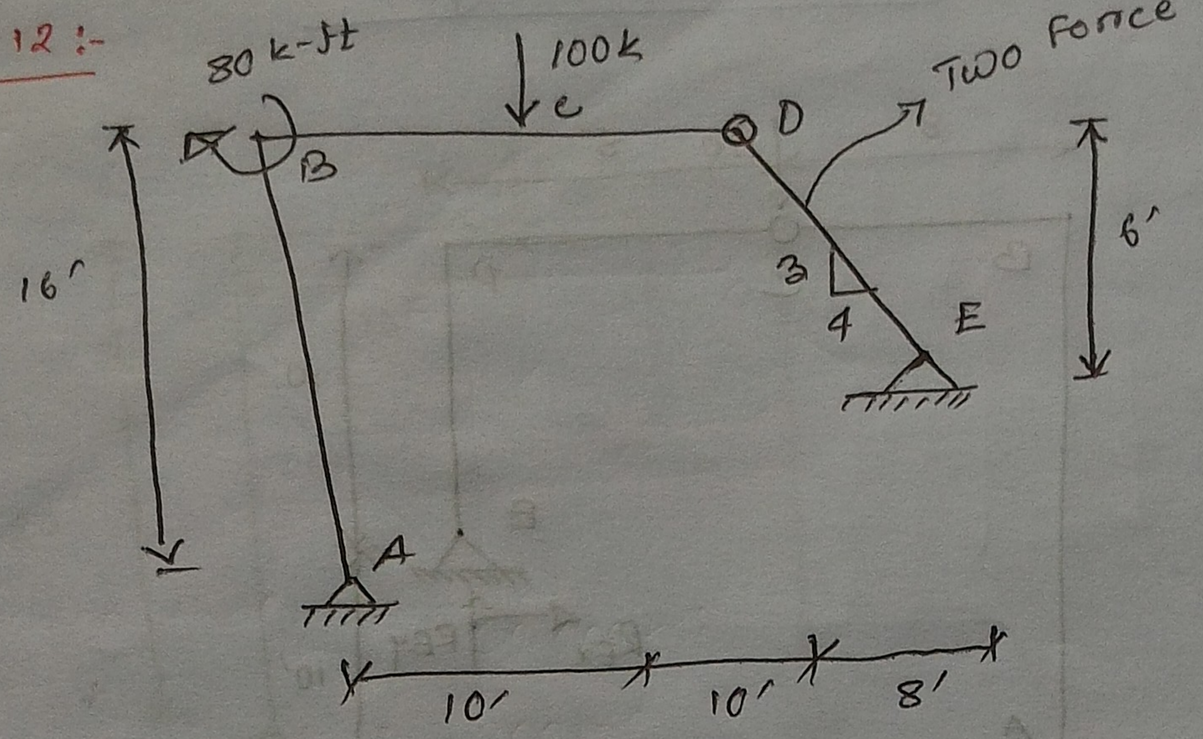
$\therefore R_{Ey} = 40^k (\uparrow)$

$R_{Ex} = 32^k (\leftarrow)$

$\Sigma F_y = 0 \Rightarrow R_{Ay} = 80^k (\uparrow)$

$\Sigma F_x = 0 \Rightarrow R_{Ax} = 32^k (\rightarrow)$

Assignment 12 :-

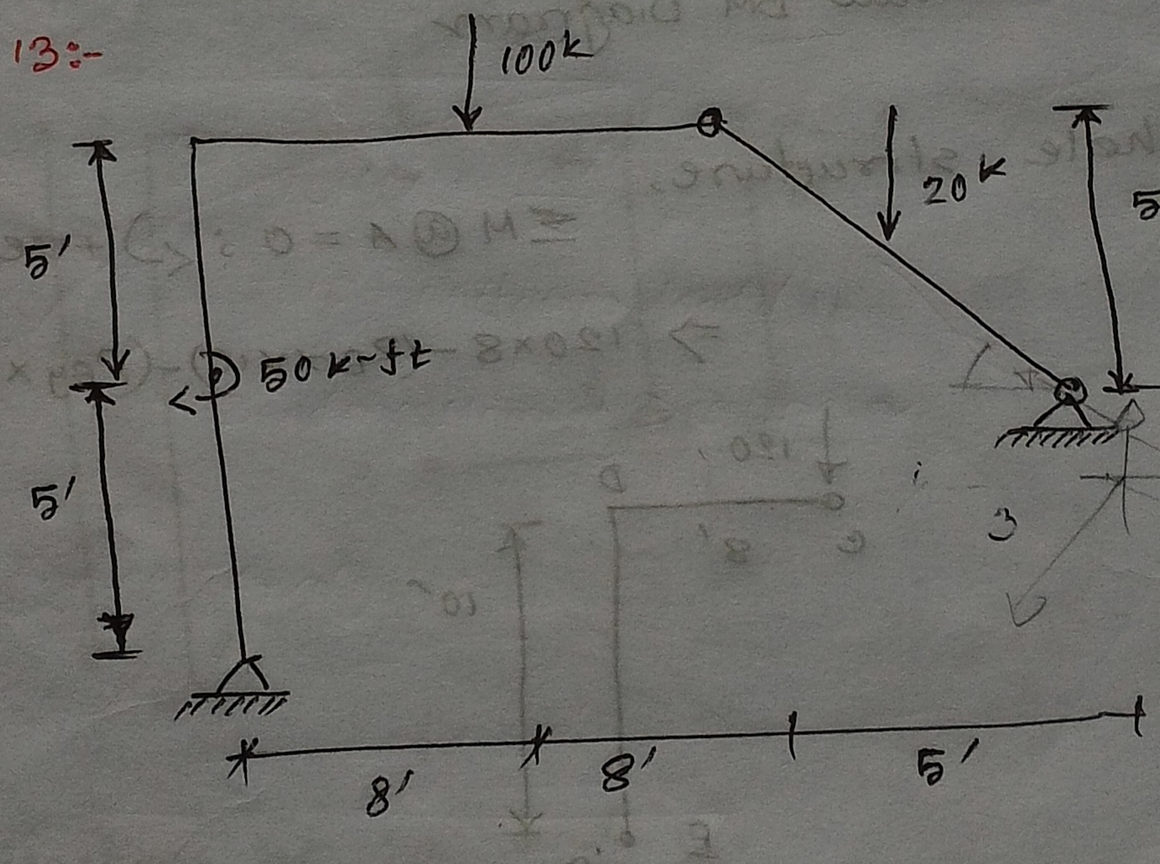


Find :- ① Rections

② Shear Force Dia.

③ Bending moment Dia.

Assignment 13:-



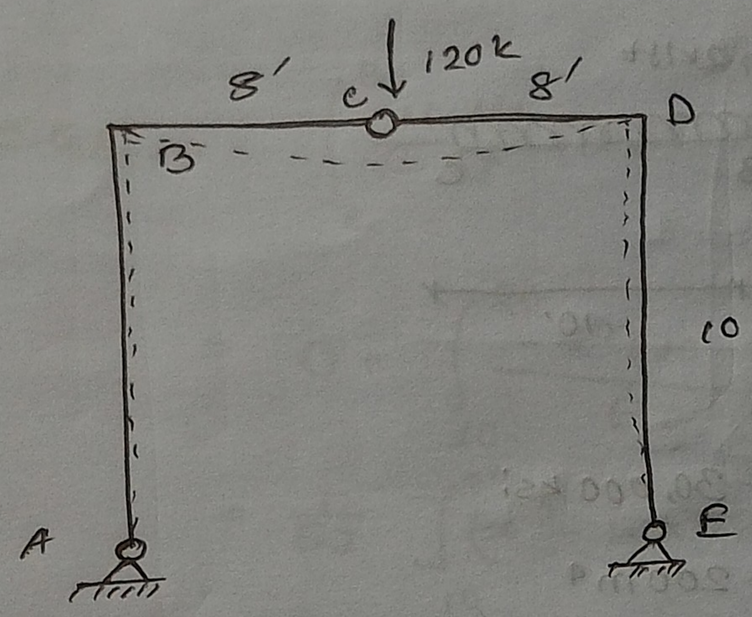
$+(R_{Ex} \times 5)$

$-(R_{ey} \times 21)$

$+(20 \times 18) +$

$(100 \times 8) + 50 = 0$

Example 8.6:-



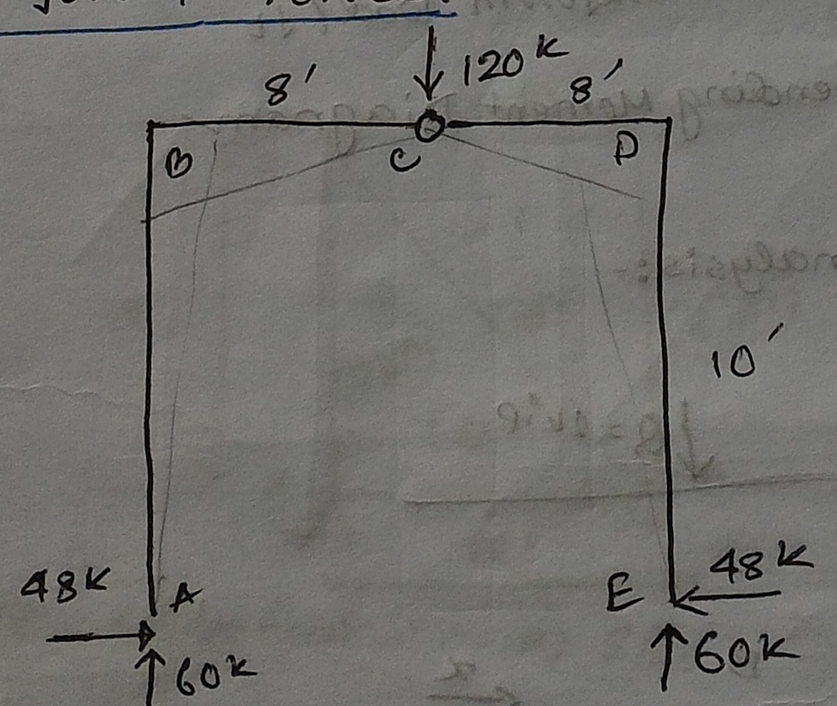
Given that, $E = 30,000 ksi$

$A = 20 in^2$

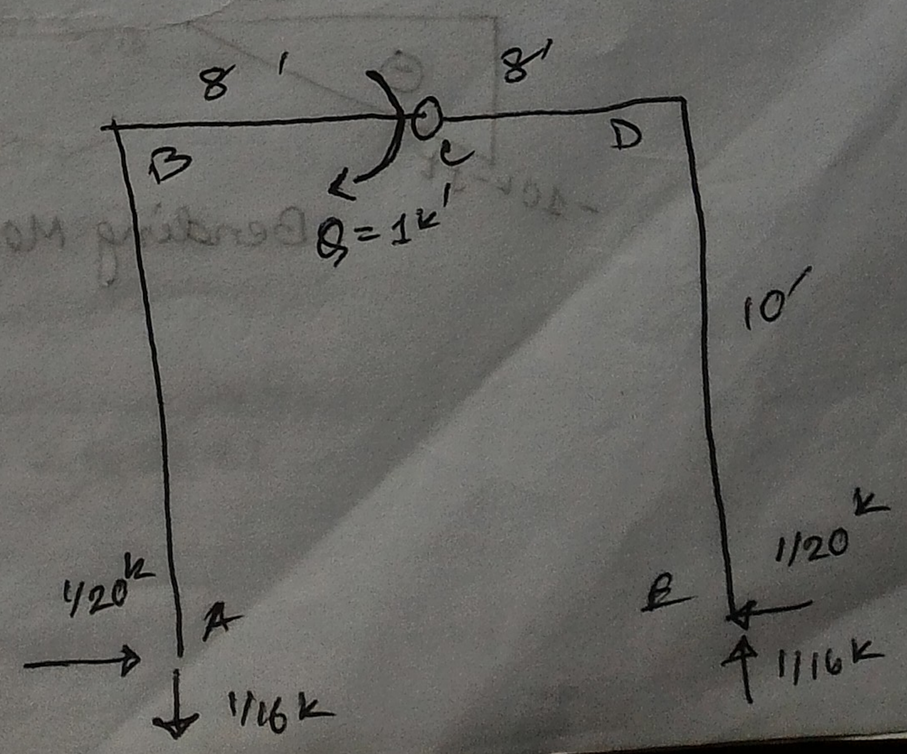
$I = 2500 in^4$

Compute Change in slope of cross-section of left side of the hinge "C".

Solve for "P" Force:-



Solve for "Q" Force:-

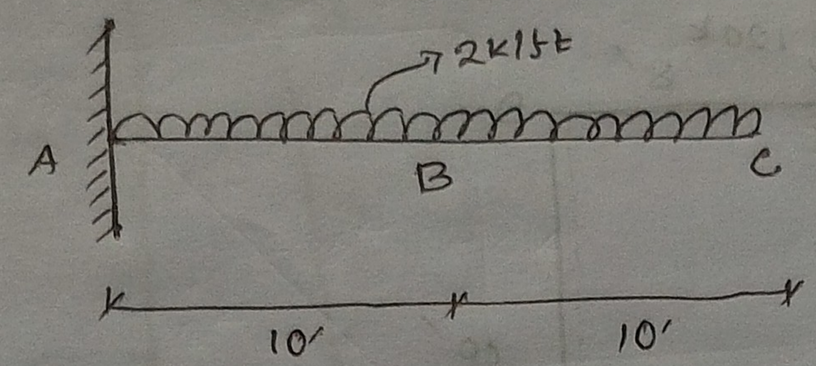


8TH Lecture

Structural Analysis and Design

Date: 28.03.15

Problem:-

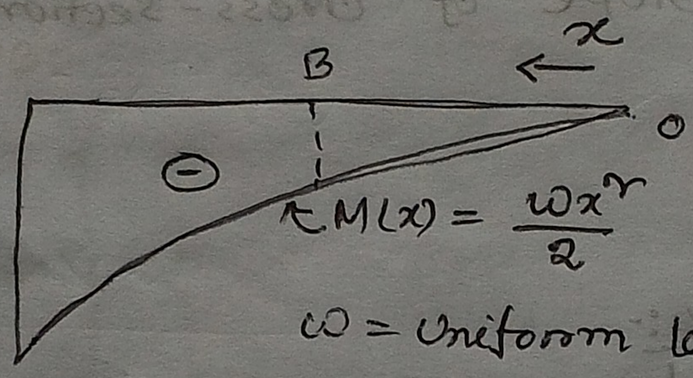


Given that, $E = 30,000$ ksi

$I = 200 in^4$

Compute vertical Deflection at B

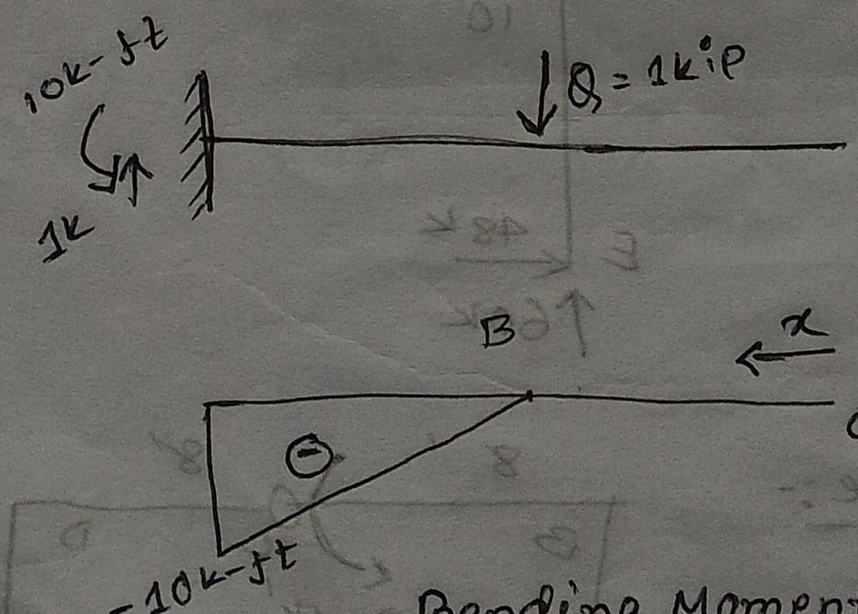
"P" Force Analysis:-



w = Uniform load / ft

Bending Moment Diagram

"Q" force Analysis:-



Bending Moment Dia.

By virtual Work Method:-

$$\Sigma Q\delta_{B-V} = \int_C^B \frac{M_P M_Q}{EI} dx + \int_B^A \frac{M_P M_Q}{EI} dx$$

From B to A

$M_Q = -1x + 10$

$(10 \le x \le 20)$

$M_P = -\frac{10x^2}{2}$

$= -\frac{2x x^2}{2}$

$= -x^2$

$= 0 + \int_{10}^{20} \frac{-x^2(10-x)}{EI} dx$

$= \frac{1}{EI} \int_{10}^{20} (x^3 - 10x^2) dx$

$= \frac{1}{EI} \times \left[\frac{x^4}{4} - \frac{10x^3}{3}\right]_{10}^{20}$

$=$

Home work:-

0 to 10 (C to B)

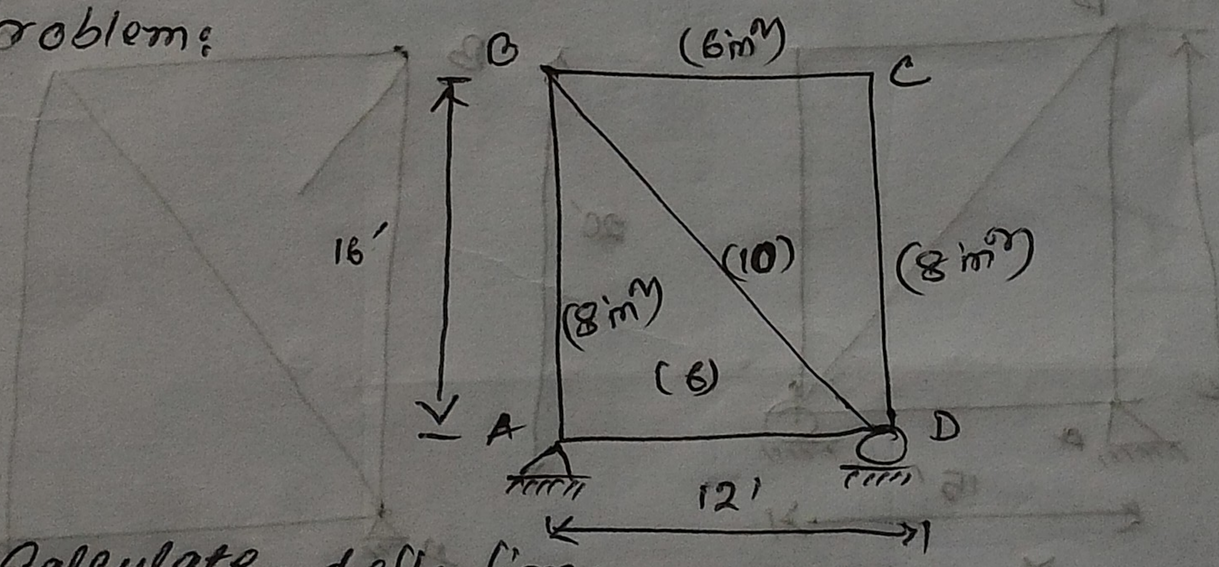
0 to 10 (B to A)

$\int_0^{10} \quad + \int_0^{10}$

Special Problem for TRUSS:-

Truss with Lack of Fit or fabrication Defects:

Problem:



Calculate deflection : a) δ_{HB}

If member BD is b) δ_{VB}

fabricated 1" larger than

Specified.

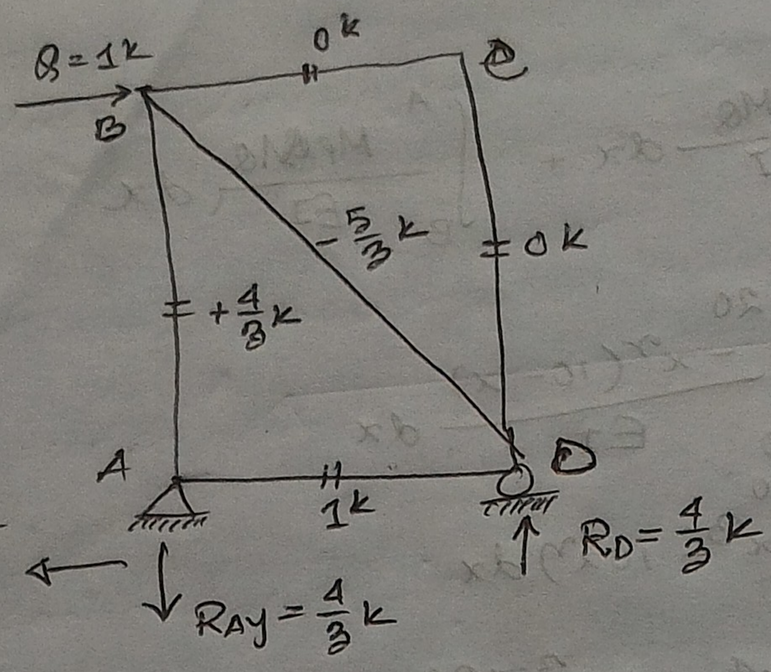
By V.W. method,

$$\Sigma Q\delta_{HD} = \Sigma \frac{F_Q F_P L}{AE} + \cancel{\Sigma F_Q \alpha t L}^{\to 0}$$

$= \Sigma F_Q \Delta L$

Intak
Intake Itre main
Treat
Dis

Q force Analysis:-

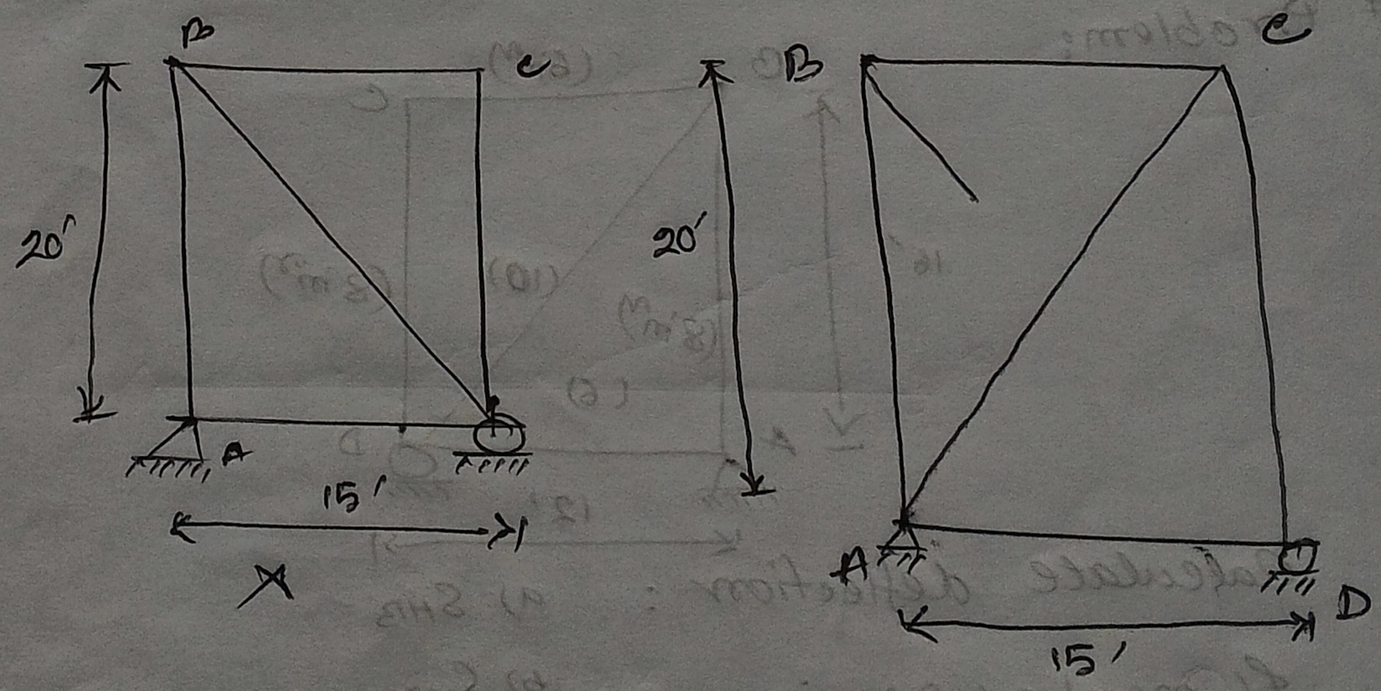


By V.W. Method:-

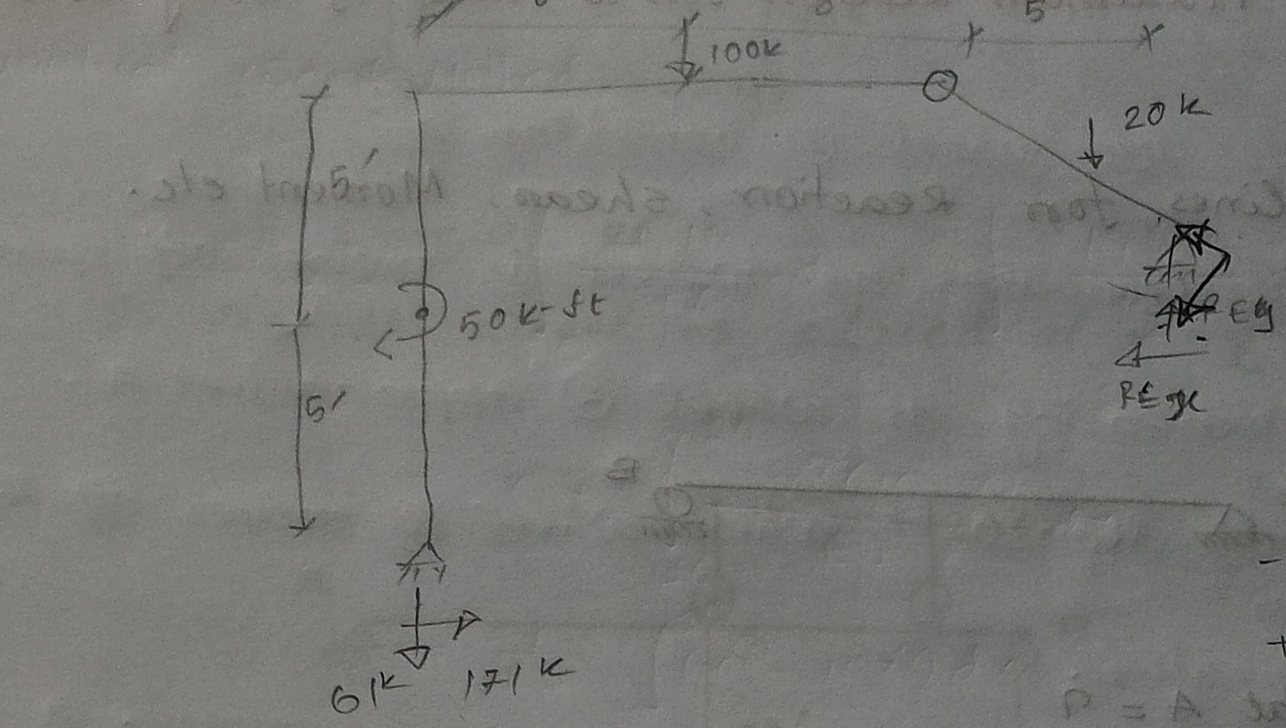
$$1^k \cdot \delta_{HB} = \left(-\frac{5}{3}\right) \times \left(\frac{1}{12}\right)$$

$$\therefore \delta_{HB} = -\frac{5}{36} ft \ (\leftarrow)$$

Assignment NO.: 15



Calculate: Deflection at B (δ_{HB}, δ_{VB})
if member 'AC' is fabricated 2" shorter and member CD is fabricated 1" larger than the specified.



$$-(REy \times 21) - (REx \times 5)$$

$$+50 + (100 \times 8) + (20 \times 18.5)$$

$$= 0$$

$$21REy + 5REx = 1220$$

$$+ (REx \times 5)$$

$$-(REy \times 5) = 0 + (20 \times 2.5)$$

~~REx~~

$$REy - REx = 10$$

$$REy = \frac{1270}{7} = 181^{k}$$

$$REx = \frac{1200}{7} = 171^{k}$$

=

9TH Lecture

Date: 12.04.15

Maximum Reaction for a series of Moving Loads

Influence lines for Reaction, shear, Moment etc.



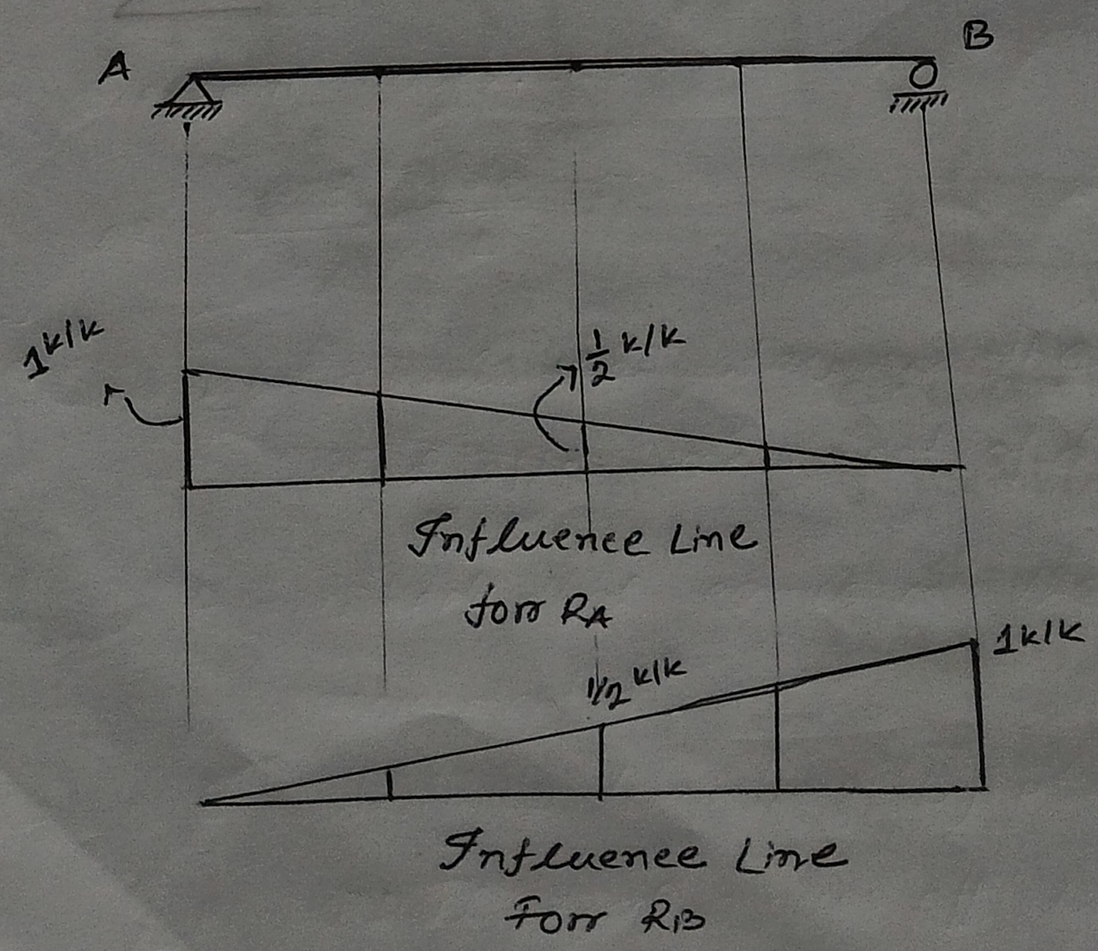
- Reaction at A = ?
  for an unit load that moves from B to A.

Unit load (1k) at $x = \frac{L}{4}$ (from "B"), $R_A = \frac{1}{4}k$

Unit load (1k) at $x = \frac{L}{2}$, $R_A = \frac{1}{2}k$

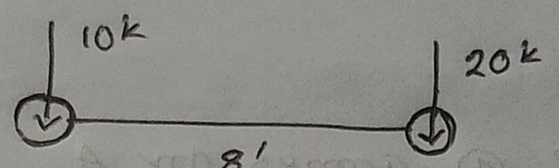
Unit load (1k) at $x = \frac{3L}{4}$, $R_A = \frac{3}{4}k$

Unit Load (1k) at $x = L$, $R_A = 1k$



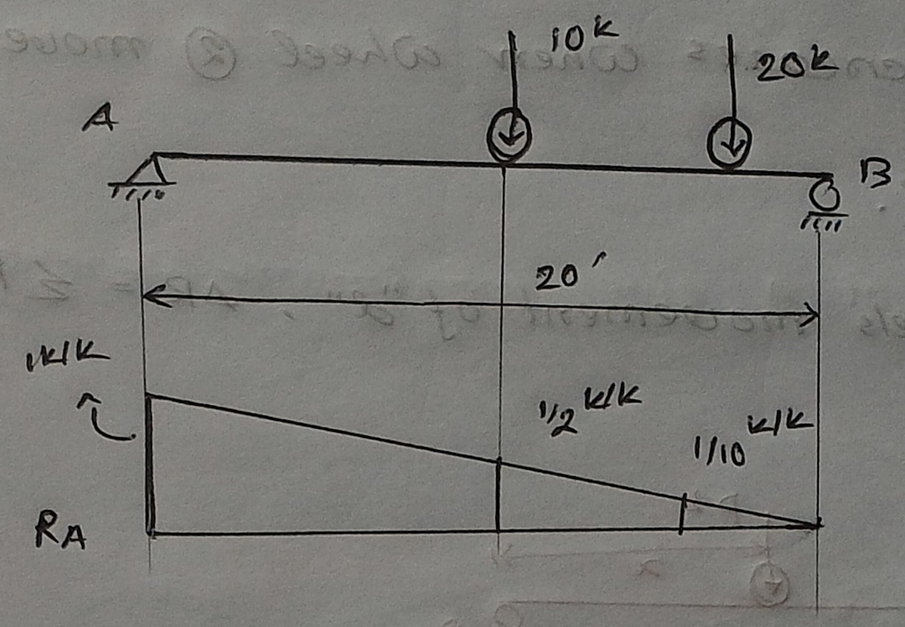
- চলো wheel load এমনে একটি Axial load হয়।
- Series means more than one load.

Problem:-



Simple span of 20'

If the 1st wheel is placed at $x = \frac{L}{2}$, R_A = ?



$\therefore R_A = (\frac{1}{2} \times 10) + (20 \times \frac{1}{10})$

$= 5 + 2$

$= 7k$

For Maximum Reaction R_A, Place wheel ① at A

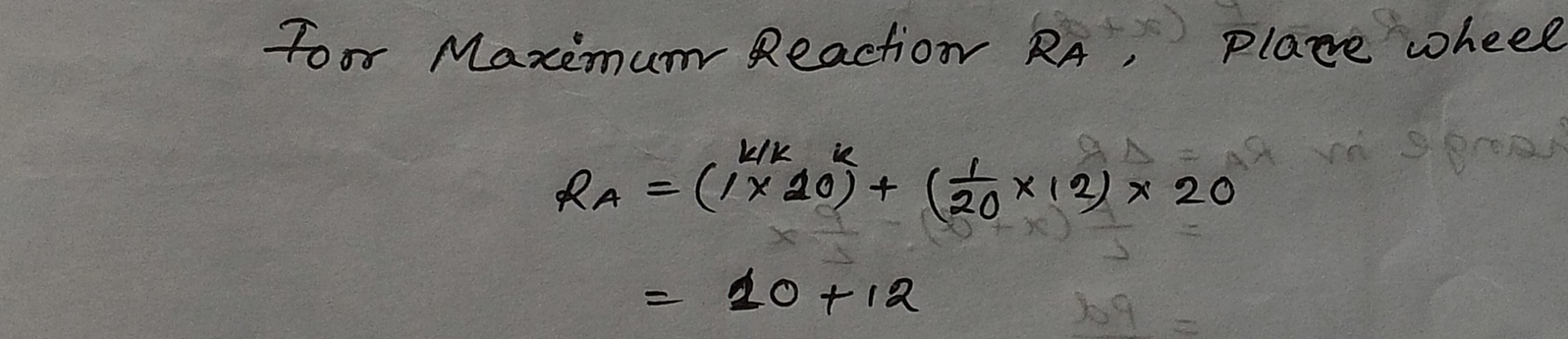
$R_A = (1^{k/k} \times 20^{k}) + (\frac{1}{20} \times 12) \times 20$

$= 20 + 12$

$= 22k$

Position of wheels to produce Maximum Reaction

Article: 160
Book: Shedd & Vowter



IL For R_A
When Locomotive moves from Right.

Observations :-

① R_A increases till wheel ① comes on A

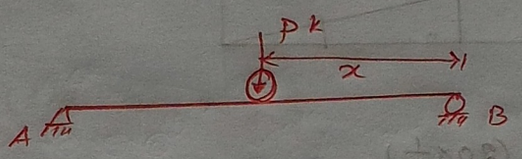
② R_A suddenly decreases as wheel ① moves off span.

③ R_A starts increasing as wheel ② approaches A.

④ R_A suddenly decreases when wheel ② moves off the span.

⑤ Cycle is repeated.

"n" no.s of wheels movement of "d", $\Delta R = \Sigma P \cdot d \cdot \frac{1}{L}$



$R_A = \frac{P}{L} x$

If wheel (P) moves "d" distance towards A

$R_A = \frac{P}{L}(x+d)$

∴ Change in $R_A = \Delta R$

$= \frac{P}{L}(x+d) - \frac{P}{L}x$

$= \frac{Pd}{L}$

For General cases.....

$\Delta R = \frac{\Sigma P d_1}{L} + \frac{P'e}{L} - P_1$

Here, ΣP = wheels that stay on the span before and after movement of d_1

P' = wheel that comes on the span during movement "d".

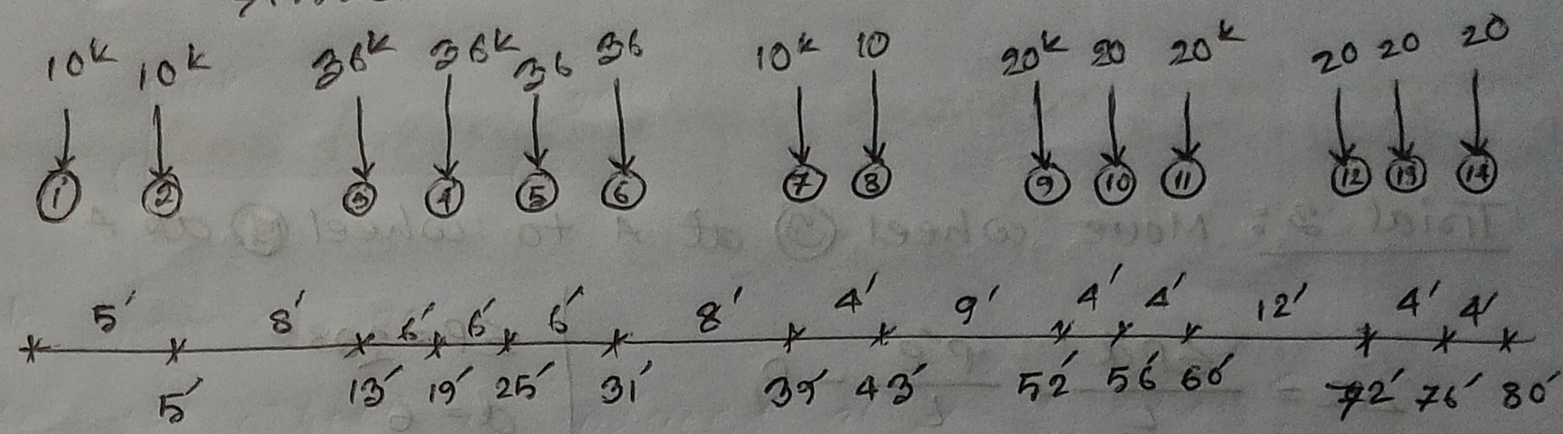
e = distance travelling by P'

P_1 = Wheel that moves off the span.

10TH LECTURE

Structural Analysis and Design

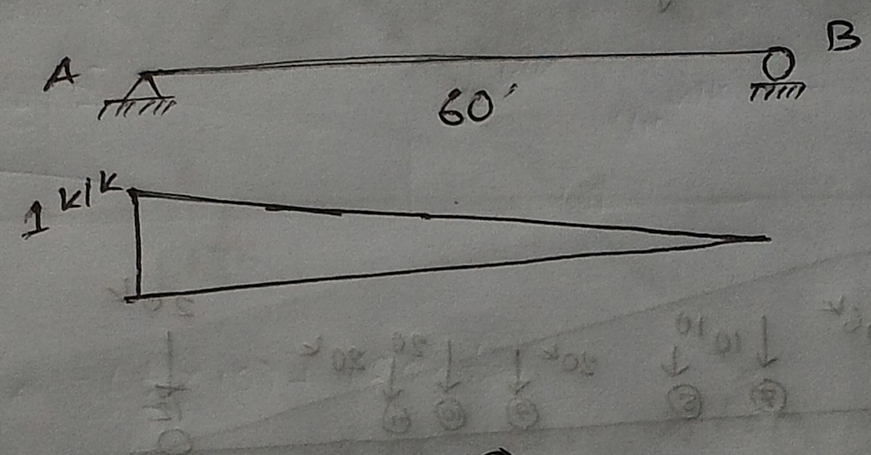
Problem:-



Steam Locomotive

Find Maximum Reaction for simple span of 60'

Solution:-



Trial 1: Move wheel ① at A to wheel ② at A

$$\Delta R = \frac{\Sigma Pd}{L} + \frac{P'e}{L} - P_1$$

$$= \frac{234 \times 10}{60} + 0 - 10$$

$$= 9.5^k \ (+ve)$$

ΣP = wheels that stay on span before and after movement

= wheel ② to ⑪

$= 234^k$

$d = 5'$

$P' = 0$, e = NO Need

P_1 = wheel ① $= 10^k$

Trial 2: Move wheel ② at A to wheel ③ at A

$$\Delta R = \frac{\Sigma Pd}{L} + \frac{P'e}{L} - P_1$$

$$= \frac{224 \times 8}{60} + \frac{20 \times 1}{60} - 10$$

$$= 20.2^k \ (+ve)$$

ΣP = wheel ③ to ⑪

$= 224$

$P' = 20^k$

$e = 1'$

$P_1 = 10^k$

$d = 8$

Trial 3: Move wheel ③ at A to wheel ⑨ at A

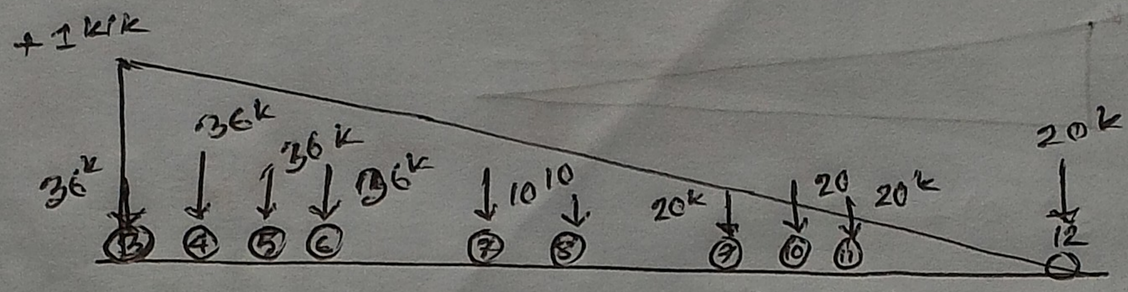
$$\Delta R = \frac{\Sigma P d}{L} + \frac{P' e}{L} - P_1$$

$$= \frac{208 \times 6}{60} + \frac{20 \times 3}{60} - 36$$

$$= -14.2^k \text{ (-ve)}$$

$\Sigma P = 208^k$
$d = 6'$
$P' = 20^k$
$e = 3'$
$P_1 = 36^k$

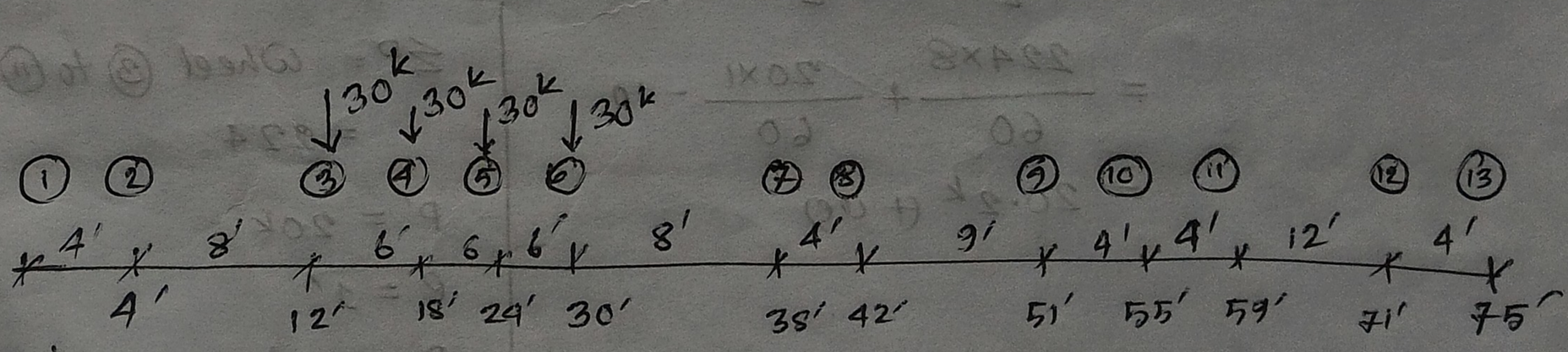
Hence, Wheel ② at A gives maximum Reaction.



Maximum Reaction, $R_A = \frac{1}{60}[60' \times 36^k + 54' \times 36^k + 48' \times 36^k + 42' \times 36^k + 34' \times 10^k + 30' \times 10^k + 21' \times 20^k + 17' \times 20^k + 13' \times 20^k + 1' \times 20^k]$

$= 150.4^k$

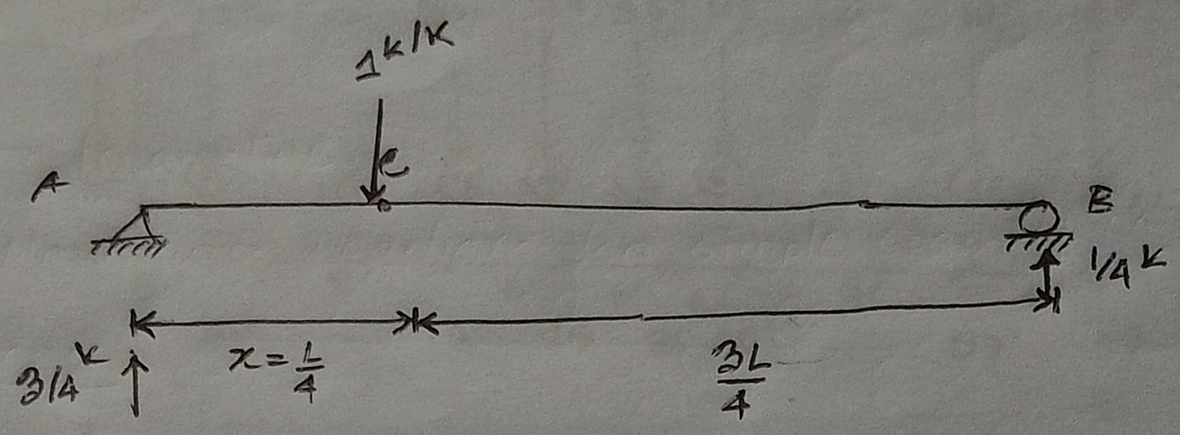
Assignment NO.: 16



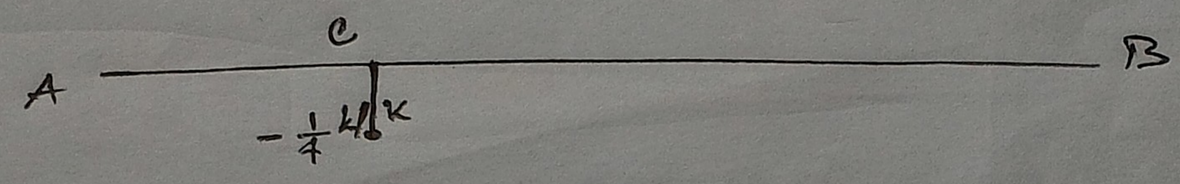
Simple
Span = 70'

o Draw Influence line for shear at quarters point from left

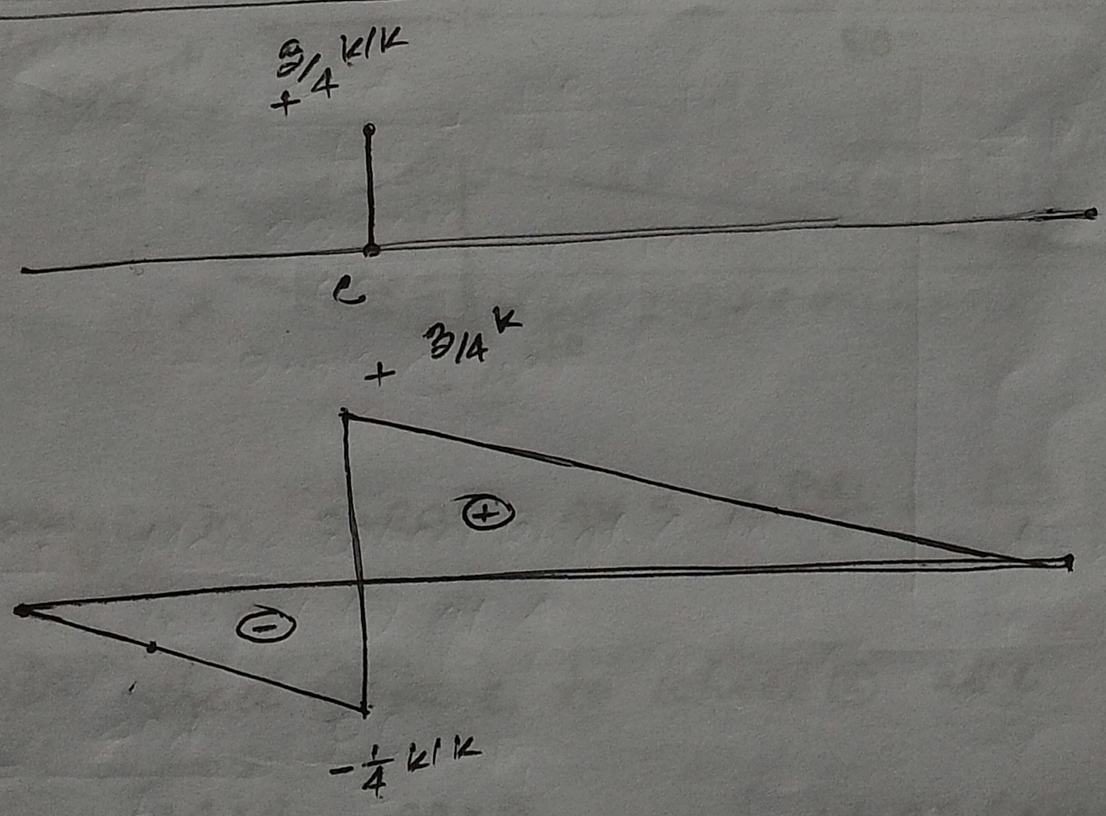
($x = \frac{L}{4}$ from left)



When unit load 1k just before C (C^-)



When unit load 1k just after C (C^+)



Article: 62A64

Position of wheel for Maximum shear at a section

Change in shear, $\Delta V = \sum \frac{Pd_1}{L} + \frac{P'e'}{L} - P_1 + \frac{P_2 e'}{L}$

Where, $\sum P$ = Loads that stay on span throughout the movement

d_1 = distance travelled by $\sum P$

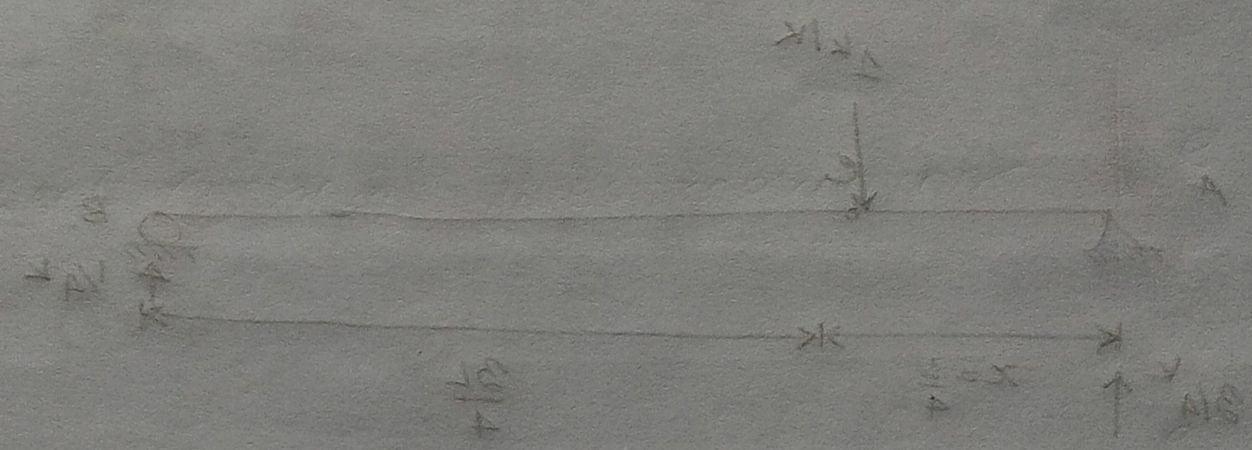
P' = Load that comes on the span during movement

e = Distance travelled by P' on the span

P_1 = Load that crossed "c" to the left.

P_2 = Loads that move off the span

e' = distance travelled by P_2 before moving off the span.

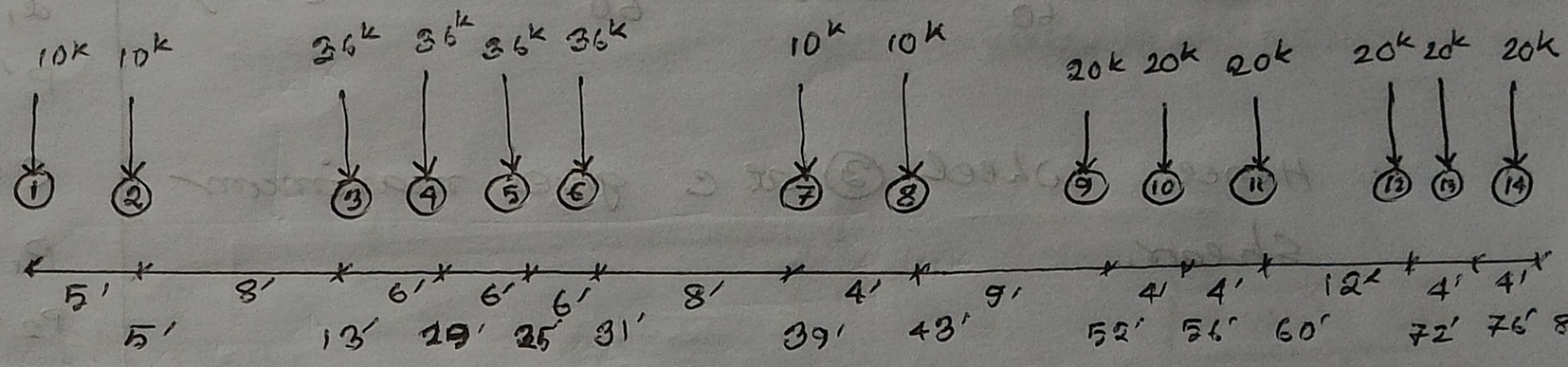


11TH LECTURE

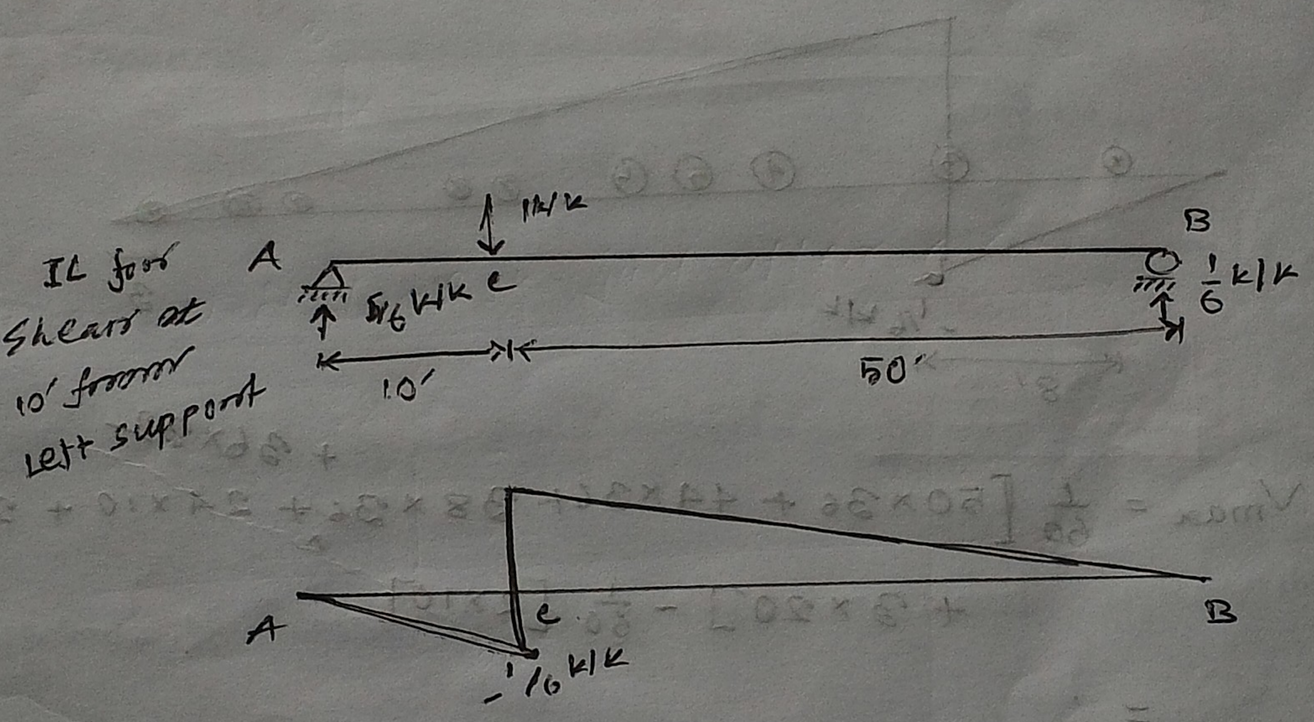
Date: 25.04.2015

Structural Analysis and Design

Example:



Find Maximum shear at a distance of 10' from left support for simple Beam of 60'



Change in shear, $\Delta V = \Sigma \frac{Pd_1}{L} + \frac{P'e}{L} - P_1 + \frac{P_2 e'}{L}$

Trial ①: Wheel ① at c to wheel ② at c

$\Delta V = \frac{184 \times 5}{60} + \frac{20 \times 3}{60} - 10 + 0 = +6.33$ (+ve)

Trial ②: Wheel ② at c to wheel ③ at c

$\Delta V = \frac{194 \times 8}{60} + \frac{(20 \times 7) + (20 \times 3)}{60} - 10 + \frac{10 \times 5}{60}$

$= 20.03$ (+ve)

e = 7' for wheel ⑩ and 3' for wheel ⑪ [$e_1 = 7', e_2 = 7'$]

e' = 5'

ΣP = wheel ① to wheel ⑧

= 184k

$d_1 = 5'$

P' = wheel ⑨ = 20k

e = 3'

P_1 = wheel ① = 10k

$P_2 = 0$

ΣP = wheel ② to wheel ⑨

= 194k

$d_1 = 8'$

P_1 = wheel ② = 10k

P_2 = wheel ① = 10k

P' = wheel ⑩ = 20k
wheel ⑪ = 20k

Trial ③ : Wheel ⑤ to wheel ④ at c

$$\Delta V = \frac{224 \times 6}{60} - 0 - 36 + \frac{10 \times 2}{60} = -13.26 \text{ (-ve)}$$

Hence, wheel ③ at c gives maximum shear.

ΣP = Wheel ③ to ⑪
= 224k

$d_1 = 6'$

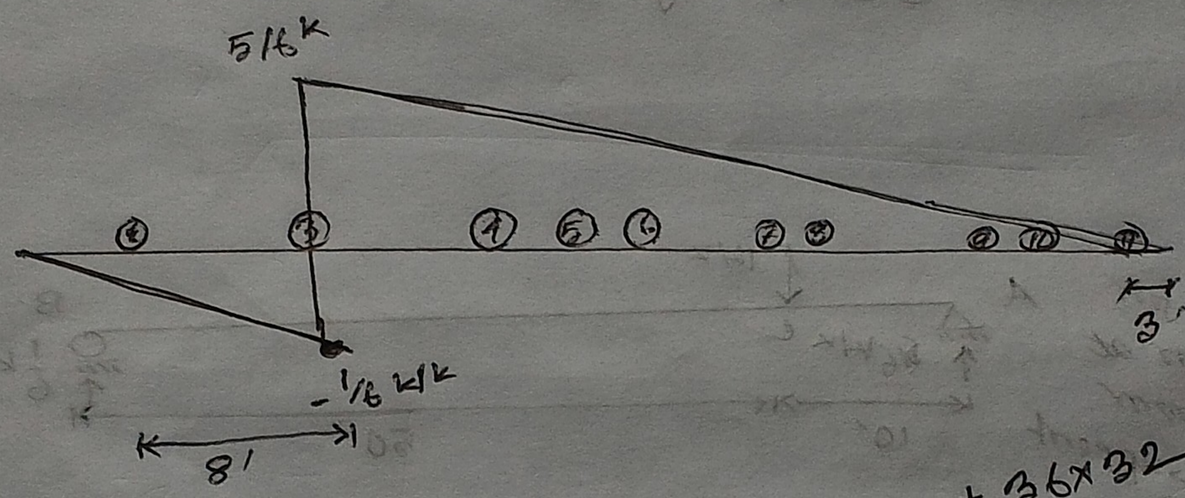
$P' = 0$

$e =$

P_1 = Wheel ③ = 36k

P_2 = Wheel ② = 10k

$e' = 2$

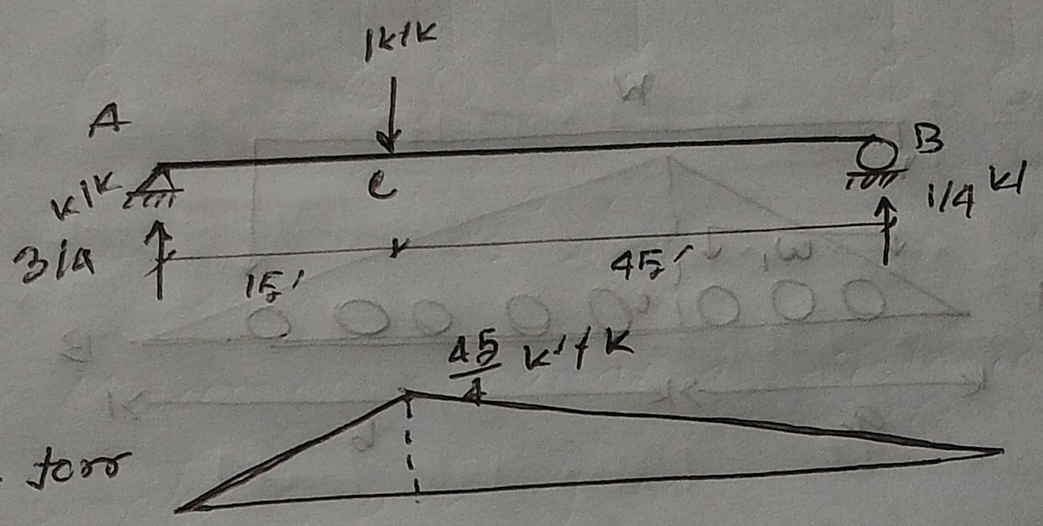


$$V_{max} = \frac{1}{60}[50 \times 36 + 44 \times 36 + 38 \times 36 + 36 \times 32 + 24 \times 10 + 20 \times 10 + 11 \times 20 + 7 \times 20 + 3 \times 20] - \frac{1}{60}[2 \times 10]$$

$$= '$$

Assignment NO 17: find V_{max} at quarter point from left support of 60' span (15')

Draw IL at quarter point at 60' span



M at 15' from
Left support

Article 65

নিজে পড়ে নিতে হবে

$$\frac{W}{L} = \frac{M_v}{S}$$

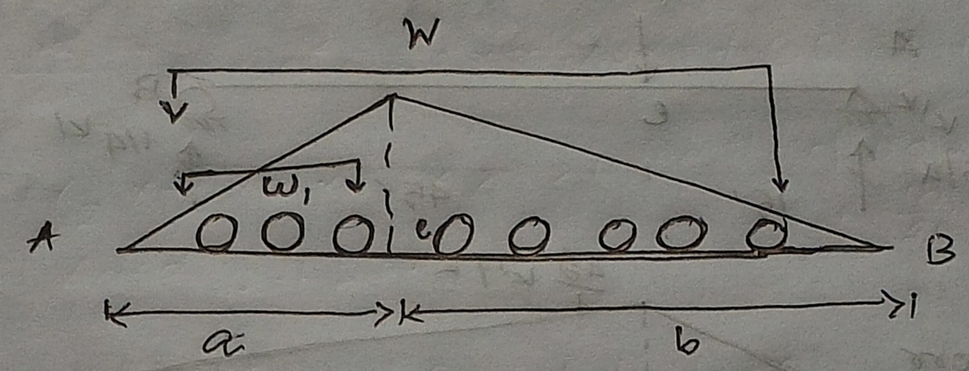
12TH Lecture

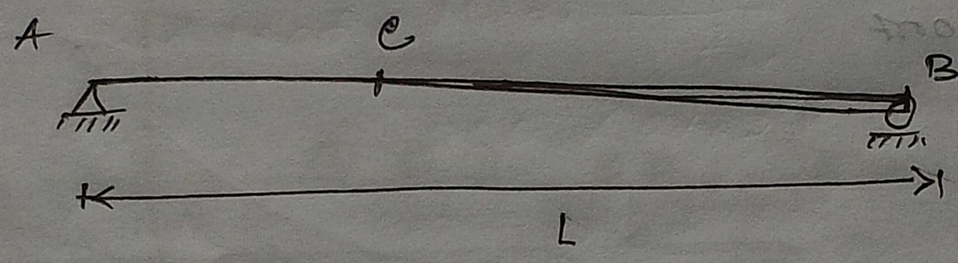
Structural Analysis and Design

Date : 26.04.2015

Article 65:- Position of wheel for maximum Moment at a section of a beam/chord stress in truss.

Criterion:

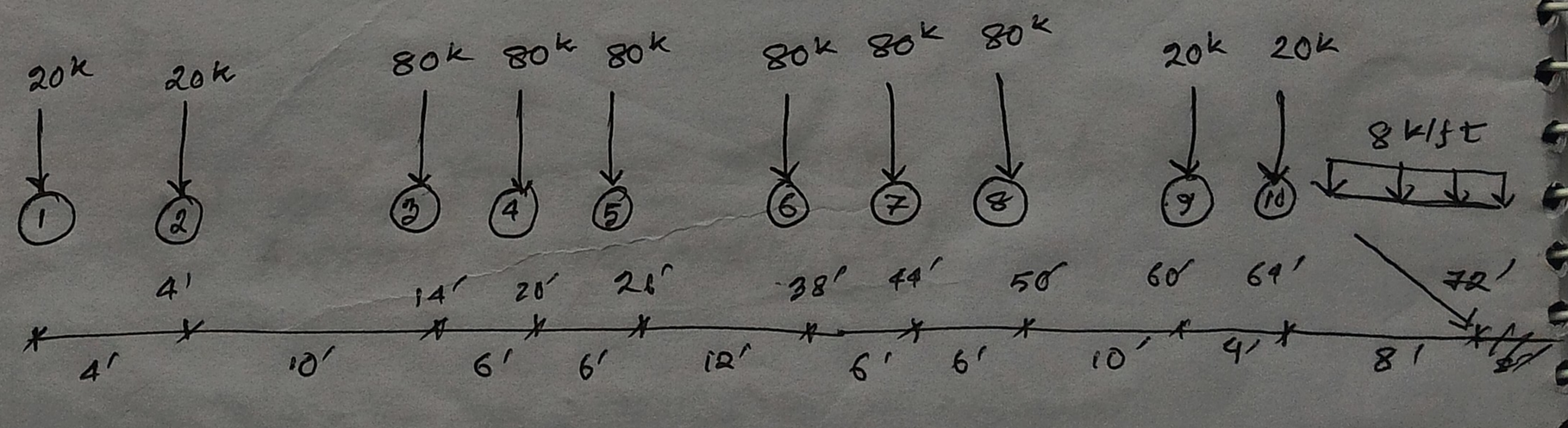




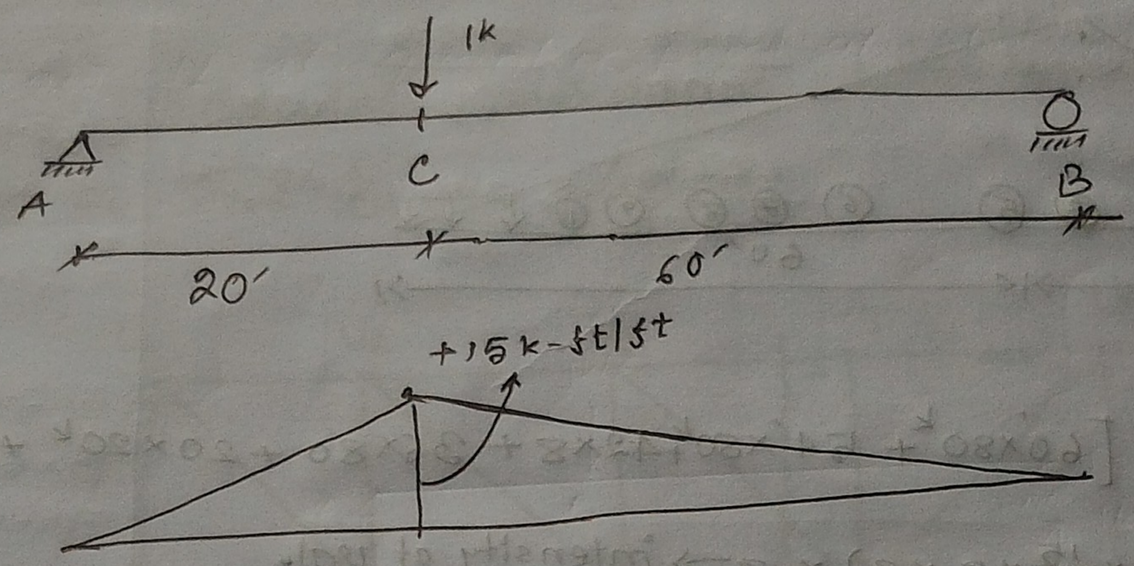
$$\frac{w_1}{a} = \frac{W}{L}$$

Average load on left of a section = Average load on span

Example:



Due to the axial load shown, calculate maximum moment at the quarter point of a span of 80 ft.



If diagram at quarter point

Trial 1:- Wheel 2 (Just Left of C and just right of C)
(2nd) (1st)

Just Right to C

$\frac{W}{L} = \frac{540}{80} = 6.75 > \frac{W_1}{a} = \frac{20}{20} = 1$

Just Left to C

$W/L = \frac{560}{80} > \frac{W_1}{a} = \frac{40}{20} = 2$

Remarks	Wheel on span, W	Wheel on the left of c, W_1
Criteria is not satisfied.	540k	20k
	560k	40k

Trial 2: Wheel 3

→ Just Right to C $\frac{W}{L} = \frac{576}{80} > \frac{W_1}{a} = \frac{40}{20}$

→ Just Left to C $\frac{W}{L} = \frac{576}{80} > \frac{W_1}{a} = \frac{120}{20}$

Wheel on span, W	Wheel on Left of c, W_1
576k	40k
576k	120k

Remarks: Criteria is not satisfied.

Tria 3: Wheel 4

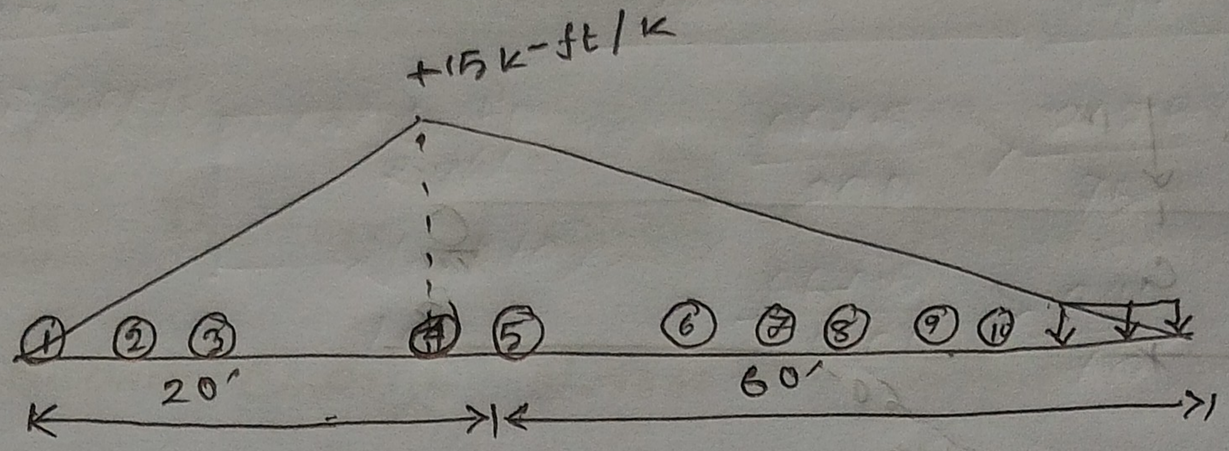
→ Just to Right $\frac{W}{L} = \frac{624}{80} > \frac{W_1}{a} = \frac{120}{20}$

→ Just to Left $\frac{W}{L} = \frac{604}{80} < \frac{W_1}{a} = \frac{180}{20}$

624k	120k
604k	180k

Remark: Criteria is satisfied.

Hence, Arli ④ at c gives maximum moment.



$$M_{max} = \frac{15}{60}\left[60' \times 80^k + 54' \times 80^k + 42 \times 8 + 36 \times 80 + 20 \times 20^k + 16 \times 20\right]$$

$$+\left(\frac{1}{2} \times \frac{15}{60} \times 8 \times 8\right] \times 8 \rightarrow \text{intensity of vol.}$$

Area of IL Dia.

$$+ \frac{15}{20} \times [\cancel{20}' \times 20^k + 14' \times 80^k]$$

$= 5584$ k-ft [For Axle Load]

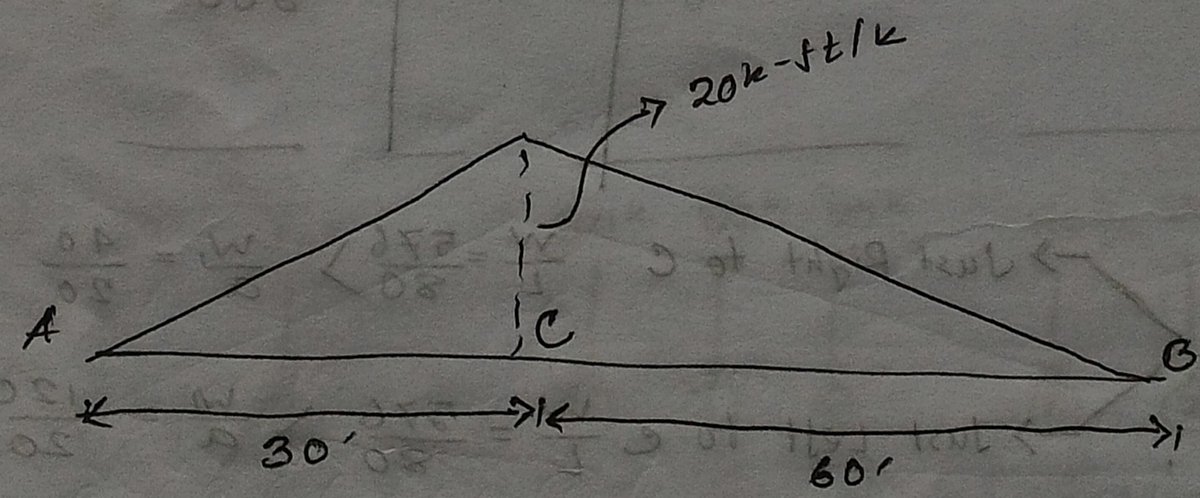
for wheel Load, $M_{max} = \frac{5584}{2}$

$= 2792$ k-ft

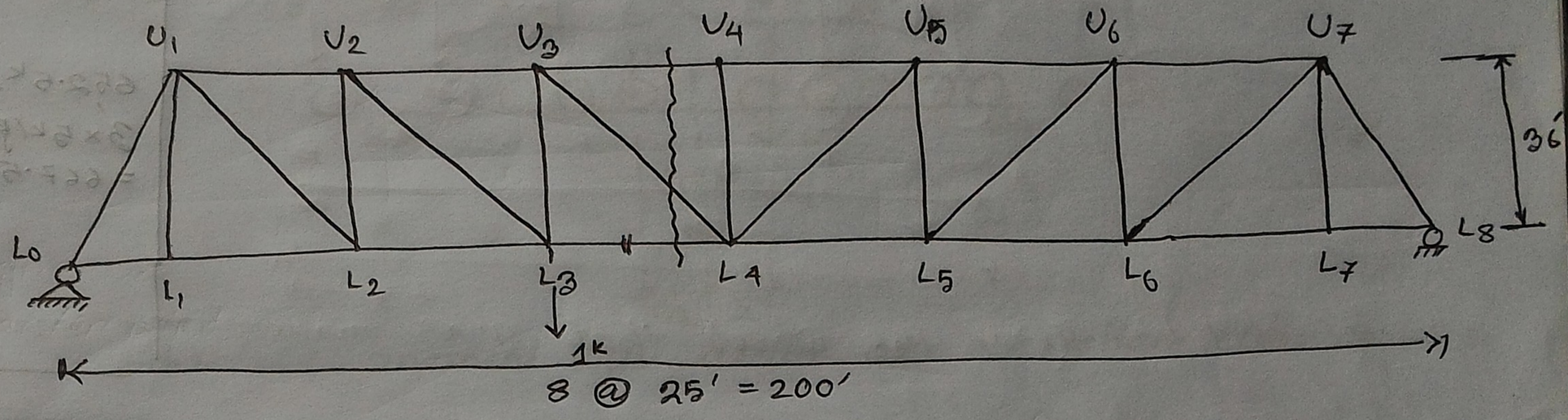
Assignment:

At 90' span in one-third point, find Maximum Moment.

Loading is same.

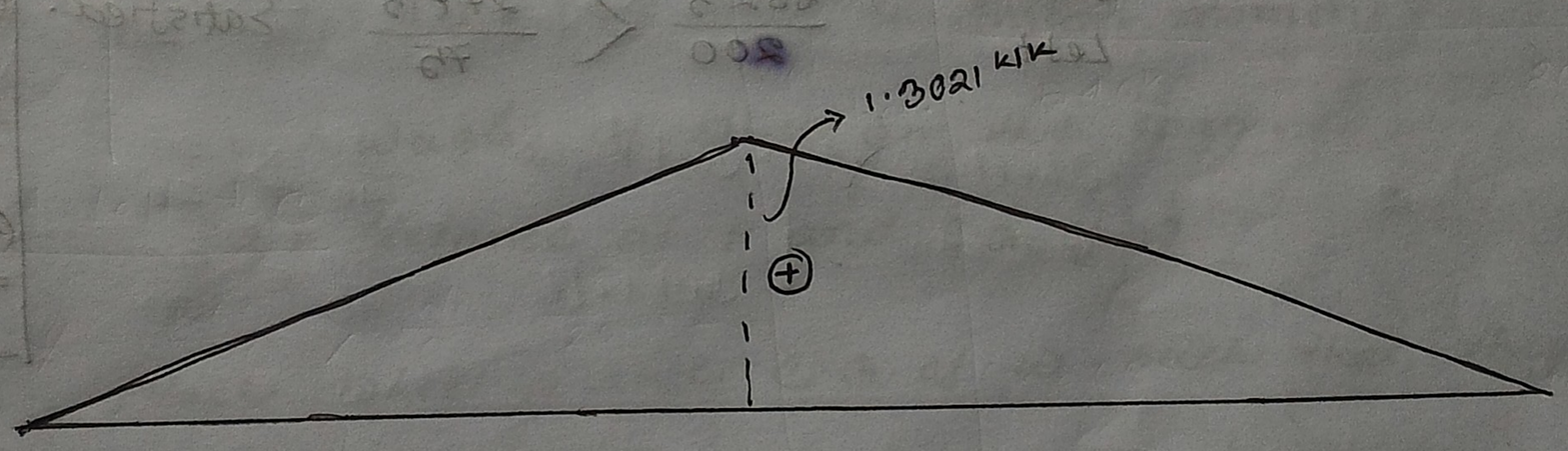


Example: Calculate maximum chord stress in member L_3 and L_4 due to the load shown.

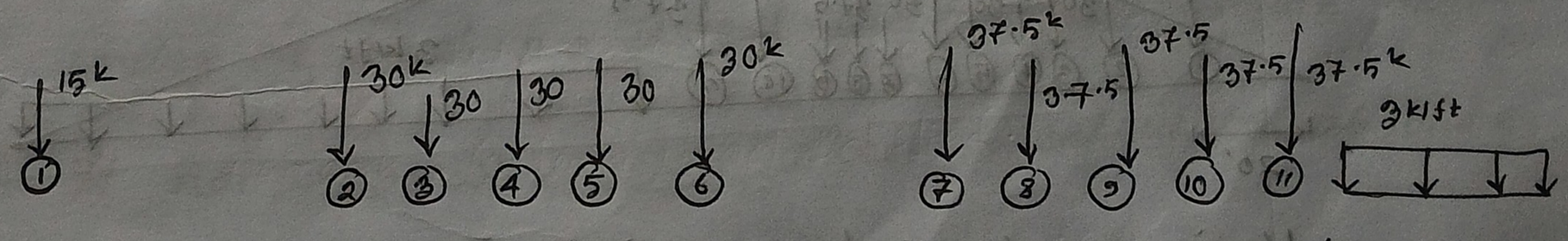


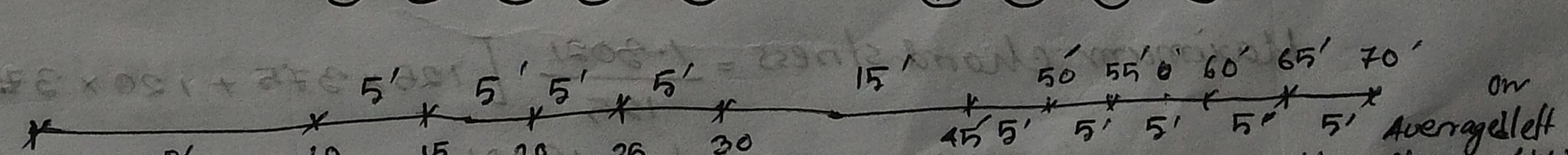
O যে Point এ Moment নিলে সেই point এ Maximum পাওয়া যায়।

If 1k load at L_3, $F_{L_3L_4} = \frac{518 \times 75}{36} = 1.3021$ k/k



IL for L_3L_4.





Trial 1: Wheel 7

→ Just to Right

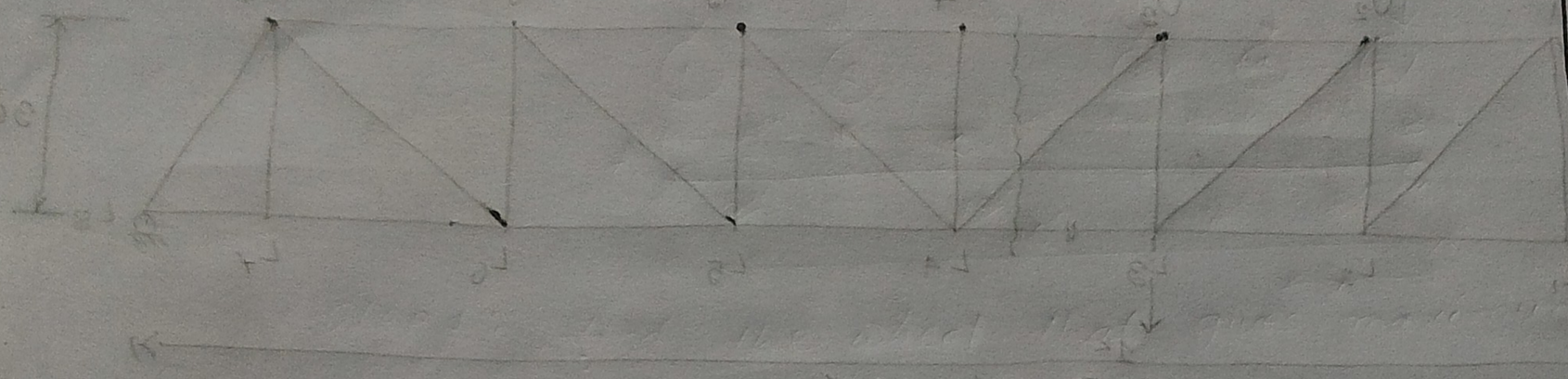
→ Just to Left

	Average on span $\frac{W}{L}$	Average load on left of span $(\frac{W_1}{d})$	W	W_1	Remarks
Just to Right	$\frac{652.5}{200}$ >	$\frac{165}{75}$	$W_{10 \text{ to } 11}$ +100 Unit = 652.5 k	$W_{1 \text{ to } 6}$ = 165 k	
Just to Left	$\frac{652.5}{200}$ >	$\frac{202.5}{75}$	$W_{10 \text{ to } 11}$ +100 U = 652.5 k	$W_{1 \text{ to } 7}$ = 202.5 k	

Criteria Not Satisfied.

Trial No	Wheel No.	Average on the span	Average on the Left	Results
Trial 2	Wheels → Just to Right	$\frac{667.5}{200} > \frac{202.5}{75}$		Not Satisfied
	→ Just to Left	$\frac{667.5}{200} > \frac{240}{75}$		

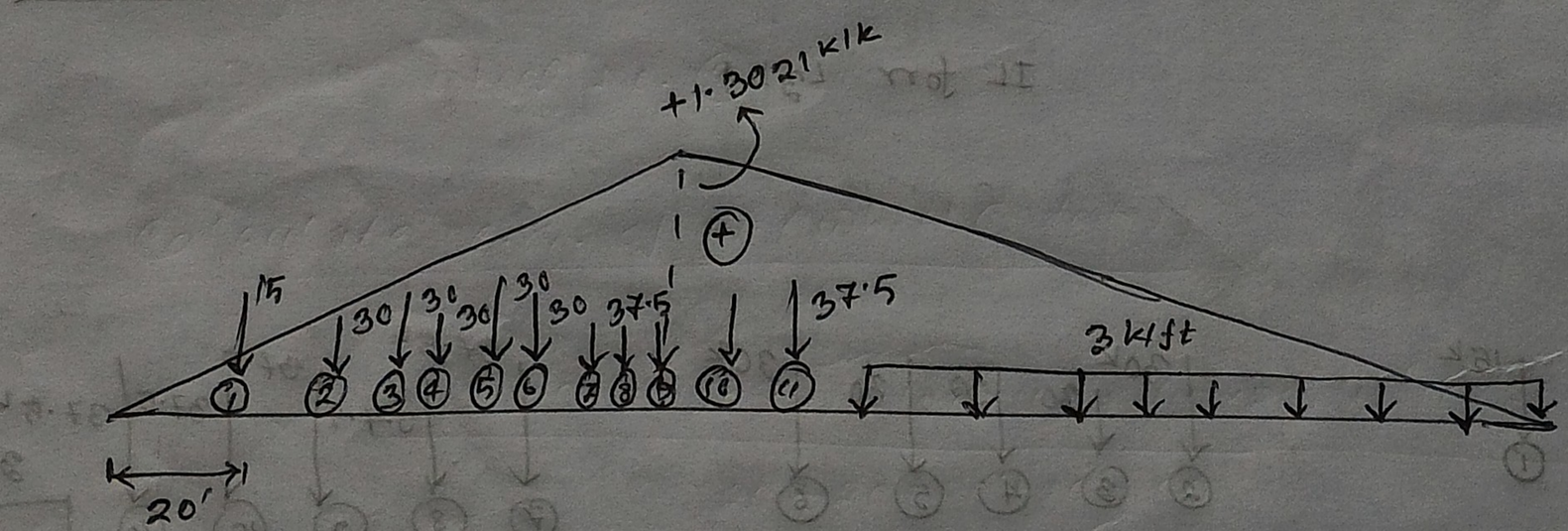
W	W_1
652.5 + (3'×5k) = 667.5'	Wheel ① to ⑧ = 202.5k
652.5k + 3×5k/ft = 667.5k	Wheel ① to ⑧ = 240k



Trial 3 — wheel ⑨ → Just to Right: $\frac{682.5}{200} > \frac{240}{75}$ — Criteria is Satisfied.

→ Just to Left: $\frac{682.5}{200} < \frac{277.5}{75}$

W	W_1
667.5 + (3'×5k/l) = 682.5k	Wheel ① to ⑧ = 240k
667.5k + (3×5k/l) = 682.5k	Wheel ① to ⑨ = 277.5k



Maximum chord stress $= \frac{1.3021}{125}[125\times375 + 120\times375 + 115\times37.5]$

$+ \frac{1}{2}\times\frac{1.3021}{125}\times110\times110\times3^{k/ft} +$

$\frac{1.3021}{75}[70\times37.5 + 65\times37.5 + 50\times30 + 45\times30 +$

$40\times30 + 35\times30 + 30\times30 + 20\times15]$

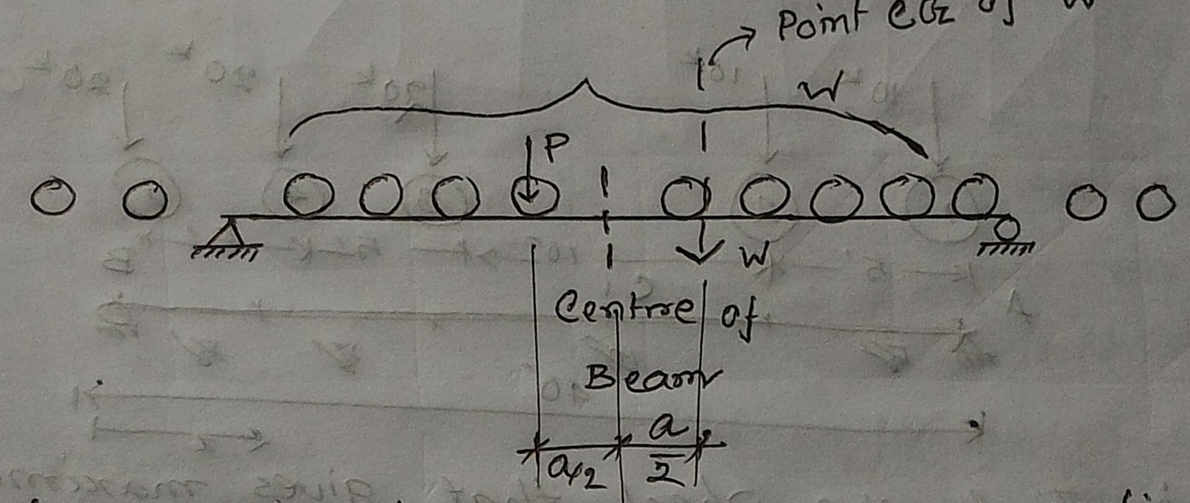
$= 526.96^{k}\ (+)$ (Ans.)

Structural Analysis and Design

Date: 09-05-15

Art. 67

Greatest Moment / Absolute Moment



Absolute moment will occur at a section close to mid-section.

Procedure:-

① Find what wheel (P) produce maximum moment.

② W = Weight of wheel on the span.

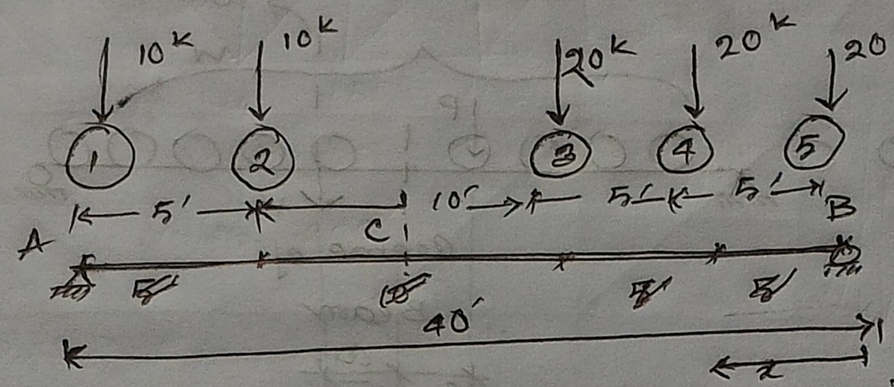
a = distance of P and C.G. of W.

Place wheel P and C.G. of W such that they are equidistance from center line of the beam.

③ Check that criterion for maximum moment is satisfied under the wheels P and calculate max/absolute moment.

④ If not, try with other wheel & calculate absolute moment.

Example: Calculate maximum or greatest moment for a span of 40'. wheel loads are shown:-



Step 1: Find the wheel that gives maximum moment

Trial No	position of wheel		$\frac{W}{L}$	$\frac{W_1}{a}$	Remarks
1	wheel ② at mid span	Just Right	$\frac{60}{40}$	$\frac{10}{20}$	Criteria is not satisfied
		Just Left	$\frac{80}{40}$	$\frac{20}{20}$	
2	wheel ③ at midspan	Just Right	$\frac{80}{40} > \frac{20}{20}$		Criteria is satisfied.
		Just Left	$\frac{80}{40} = \frac{40}{20}$		

$\therefore$ P = wheel No. ③

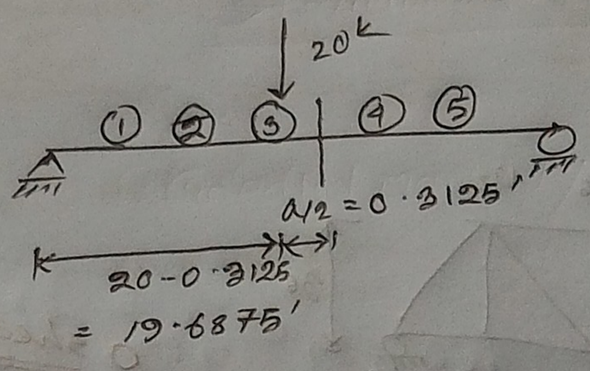
Calculate C.G. of W (wheel ① to 5)

$$\bar{x} = \frac{(20\times0) + (20\times5) + (20\times10) + (10\times20) + (10\times25)}{20+20+20+10+10}$$

$$= 9.375'$$

$\therefore a = 10 - 9.375 = 0.625'$

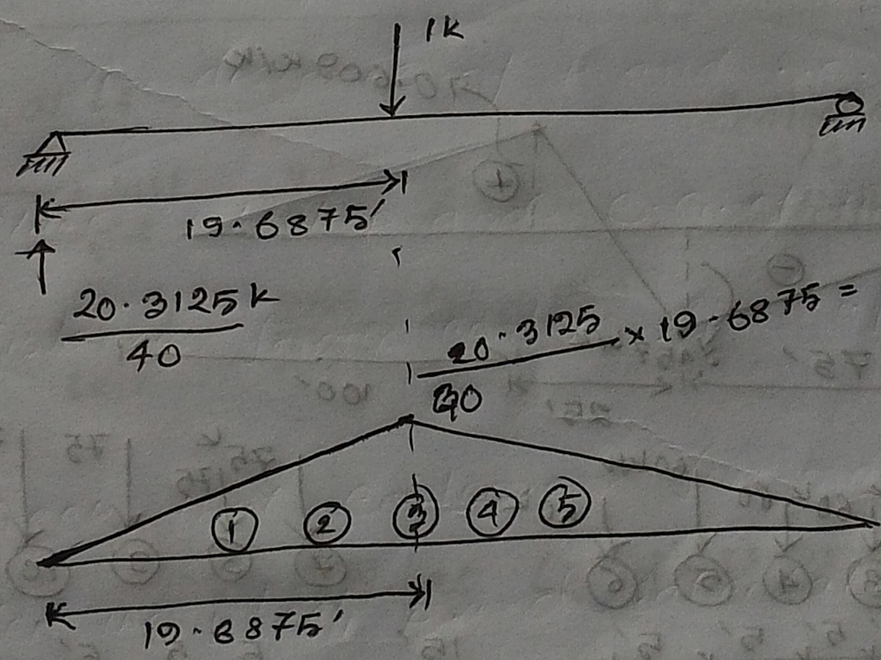
$\therefore \frac{a}{2} = 0.3125'$



Step 2: Where the Criteria under "P" (Maximum moment occurs at distance 19.6875' from left support)

Trial No.	Position of Wheel		$\frac{W}{L}$		$\frac{W}{a}$	Remarks
1	Wheel ③ at 19.6875' from Left	Just Right	$\frac{80}{40}$	>	$\frac{20^k}{19.6875'}$	Criteria is satisfied.
		Just Left	$\frac{80}{40}$	<	$\frac{40}{19.6875}$	

Absolute Moment:



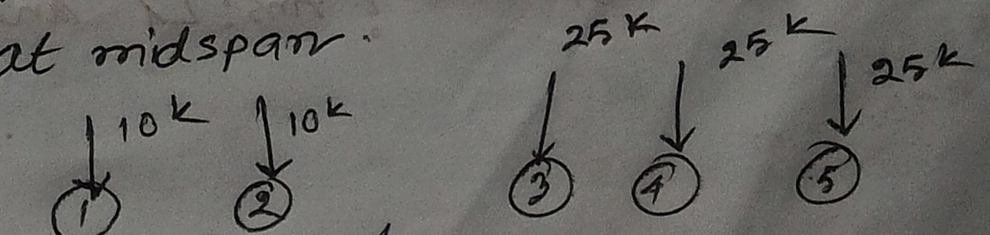
$$\text{Absolute moment} = \frac{10}{20.3125}\left[20.3125 \times 20 + 15.3125 \times 20 + 10.3125 \times 20\right]$$

$$+ \frac{10}{19.6875}\left[9.6875 \times 10 + 4.6875 \times 10\right]$$

$$= 525.3 \text{ k-ft}$$

Homework: Poove that, maximum moment does not occur at midspan.

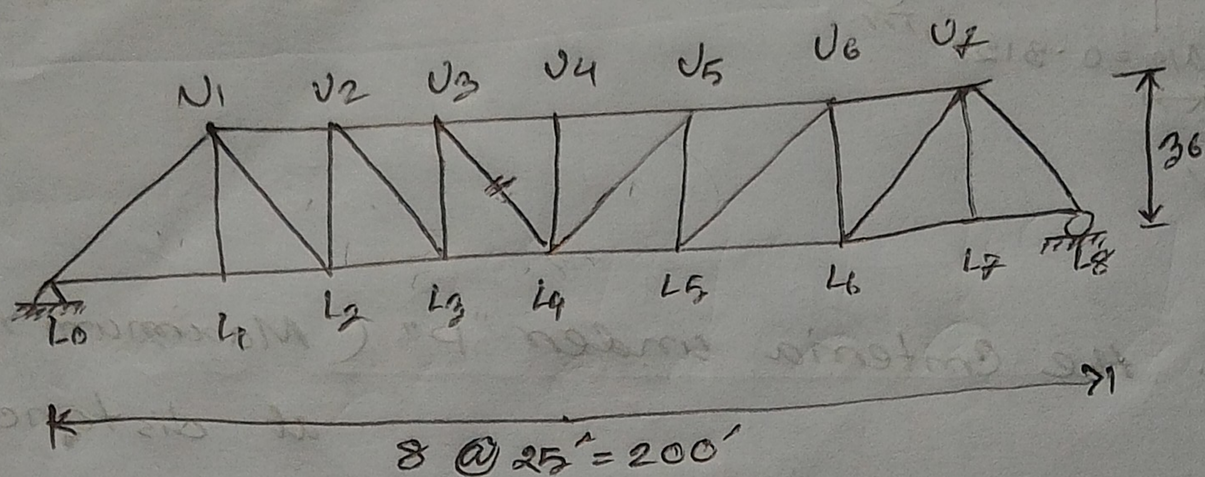
Assignment 19:



Calculate, max. moment.

Article 69

Maximum Web stress in Truss



Web = Diagonal members

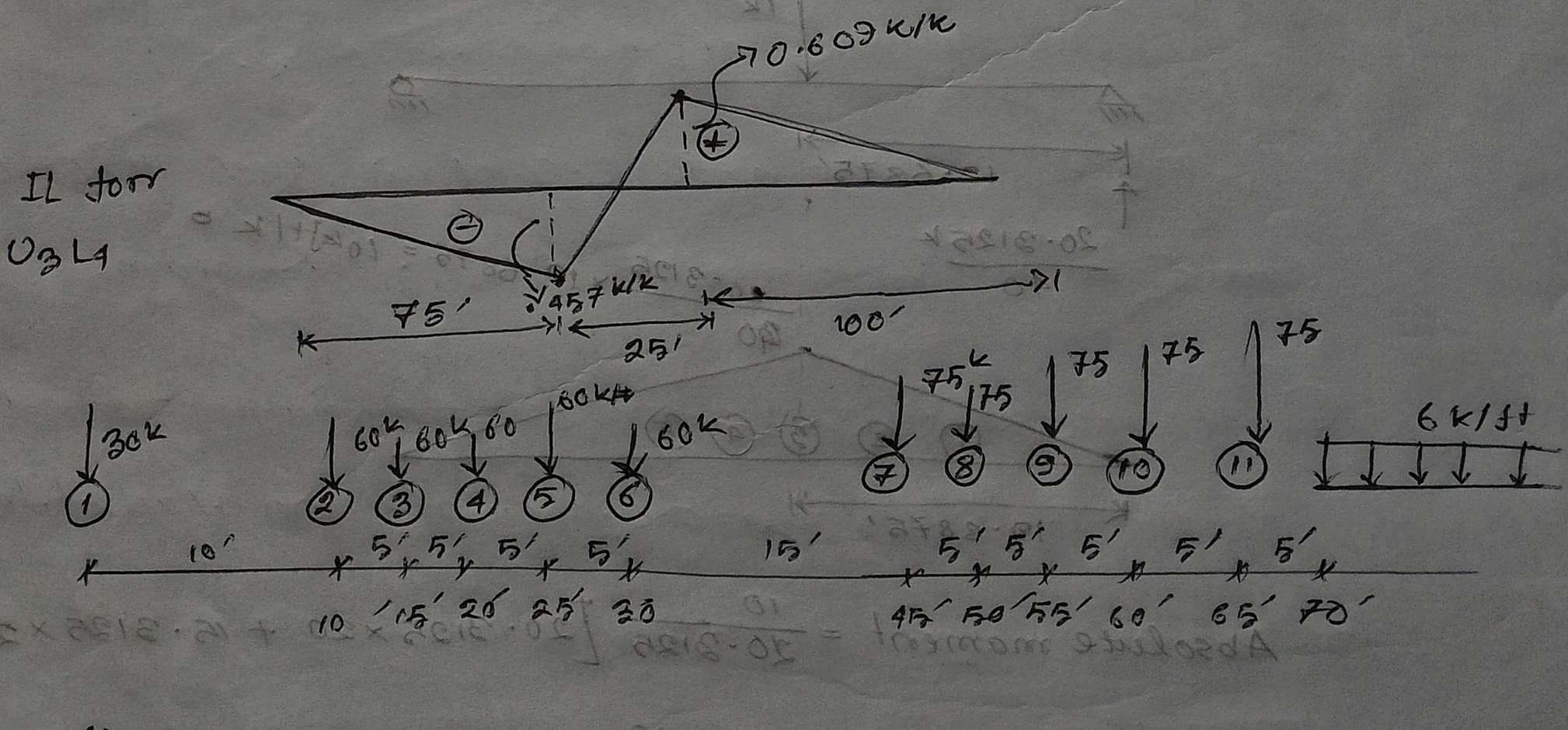
Criterion : $\frac{W}{L} = \frac{W_1}{P}$

W = Weight of wheel on span
P = Length of pannel

} Average load on span = Average load on pannel.

Question:- Calculate maximum stress in web of 4th pannel.

Web : U_3L_4



Since + area of IL Diagram is more than - area of IL Diagram, we will move wheel from Right to Left.

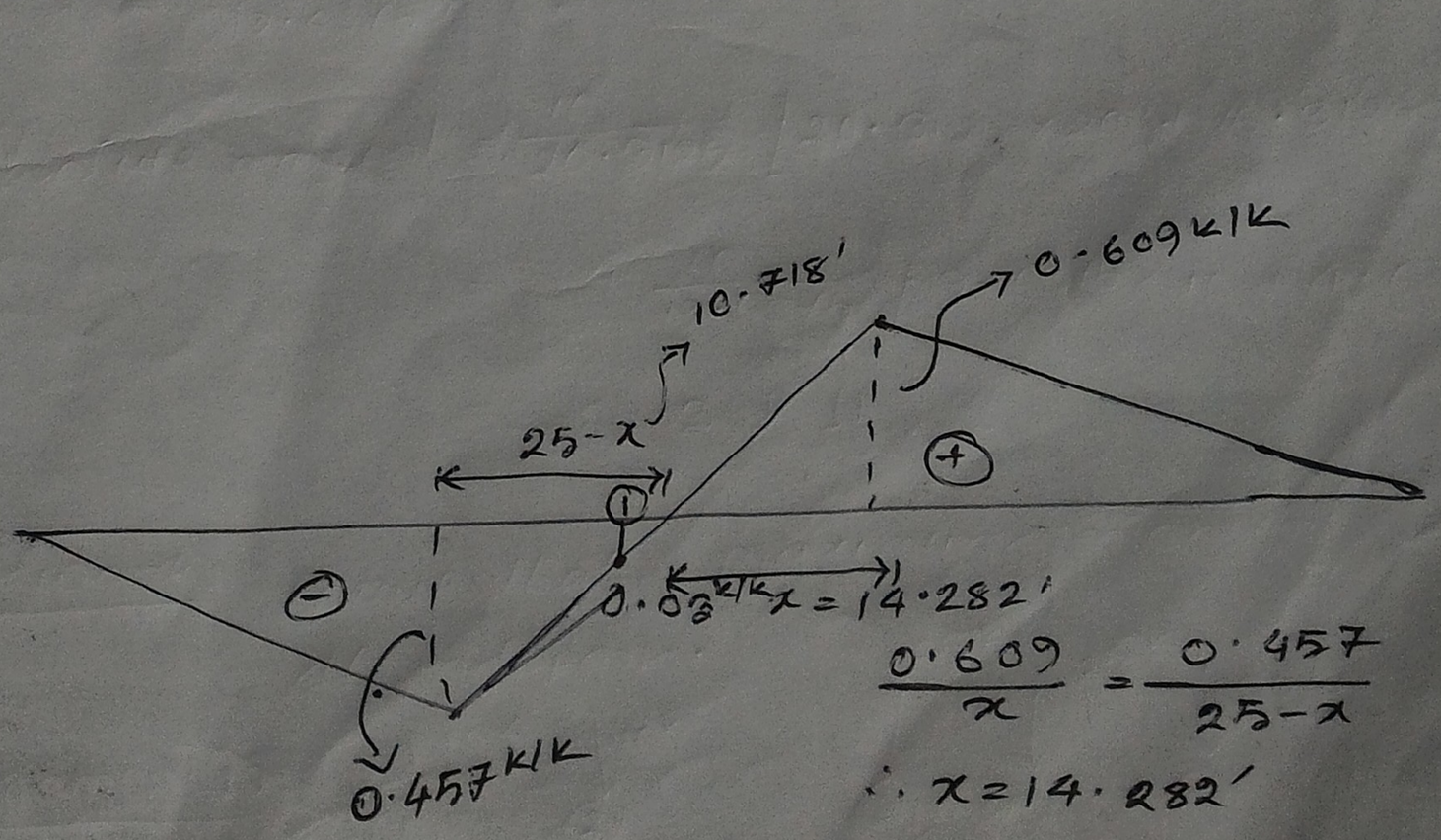
Q What is the control Point? Ans: L4 and why?

Shedd:-

Problem 221

Trial No.	Position of wheel	$\frac{W}{L}$	$\frac{W_1}{P}$	Remarks	Calculation
1	Wheel ① at L_4 → just Right $\frac{885}{200} > \frac{0}{25}$ → just Left $\frac{885}{200} > \frac{30}{25}$			Not Satisfied	W = wheel ① to wheel ⑪ = 885 k $W_1 = 0$ L = 200' P = 25' W_1 = 30 k
2	wheel ② at L_4 → just Right $\frac{885}{200} > \frac{30}{25}$ → just Left $\frac{885}{200} > \frac{90}{25}$			No Satisfied	W = 885 L = 200 W_1 = 30 P = 25 W_1 = 90
3	wheel ③ at L_4 → just Right $\frac{975}{200} > \frac{90}{25}$ → Just Left $\frac{975}{200} < \frac{150}{25}$			Criterion is Satisfied	W = 975 k L = 200 W_1 = 90 k W = 975 k W_1 = wheel ① to = 150 k

Hence, wheel ③ at L_4 gives maximum stress.



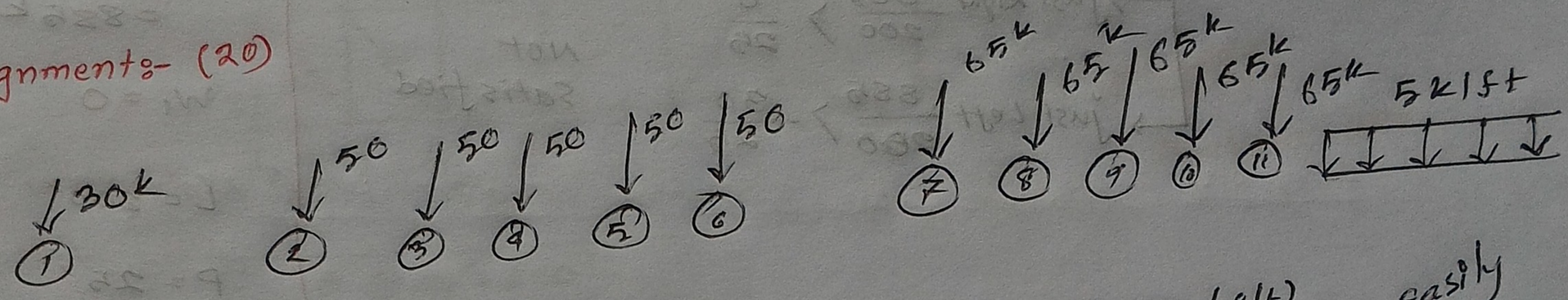
$\frac{0.609}{x} = \frac{0.457}{25-x}$

$\therefore x = 14.282'$

Ans :- 33267 for for Axial load and 164.03 for wheel load.

23-05-2015 → Class test

Assignments- (20)



Find Maximum stress at 5th pannel (from Left)
↳ To solve easily

