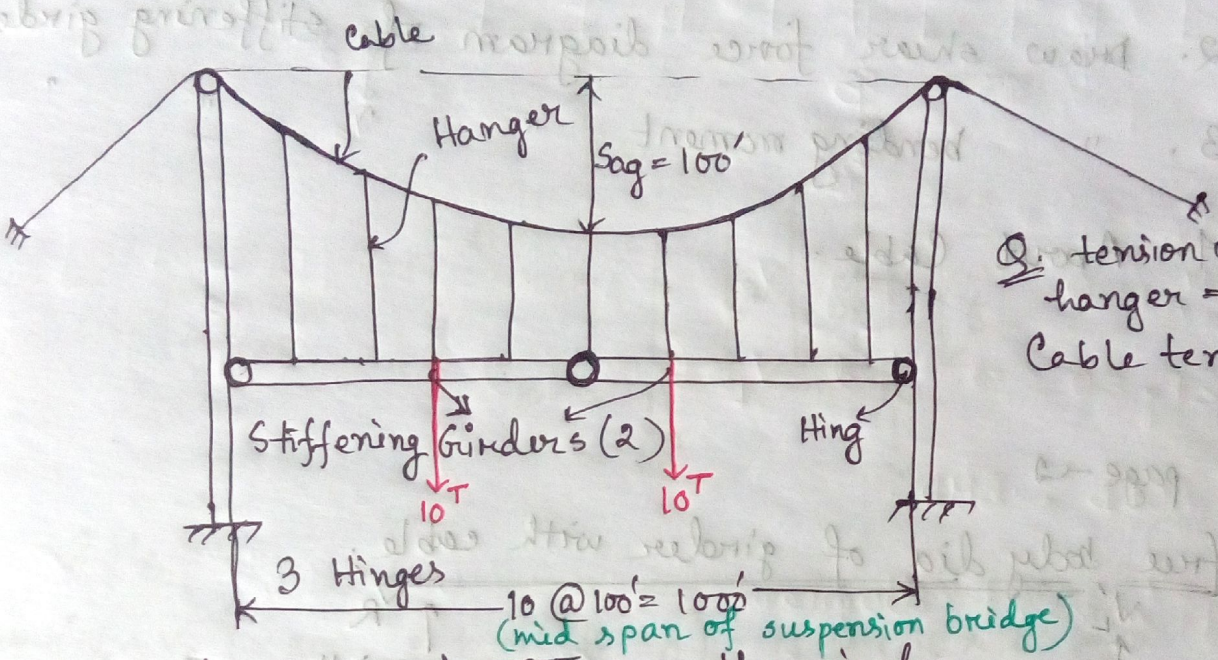
29.8.2015

CE-311

Suspension Bridge



Q. tension of hanger = ?
Cable tension = ?

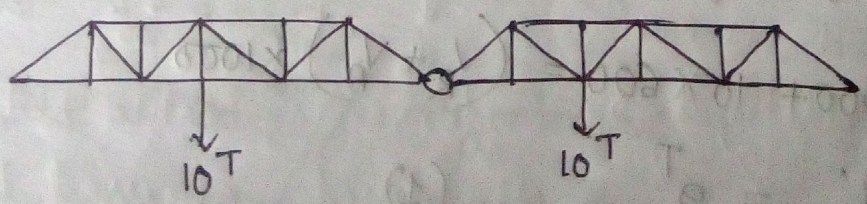
* Vehicle movement করছে over the girder.

* Cable + hanger ⇒ only tension

> W × spacing of the hanger = hanger force

⇒ Finally SFD, BMD of the Girders.

* Stiffening girders may be replaced by two stiffening trusses.



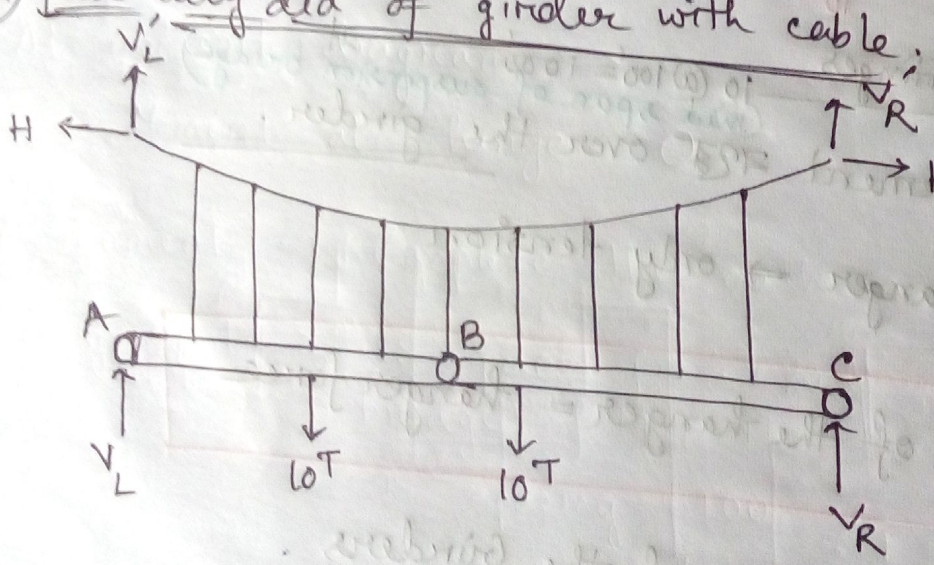
Determine —

for girder

1. Hanger force = ?
2. Draw shear force diagram of stiffering girder
3. " bending moment " " " "
4. About Cable.

New page →

(*) Free body dia of girder with cable:



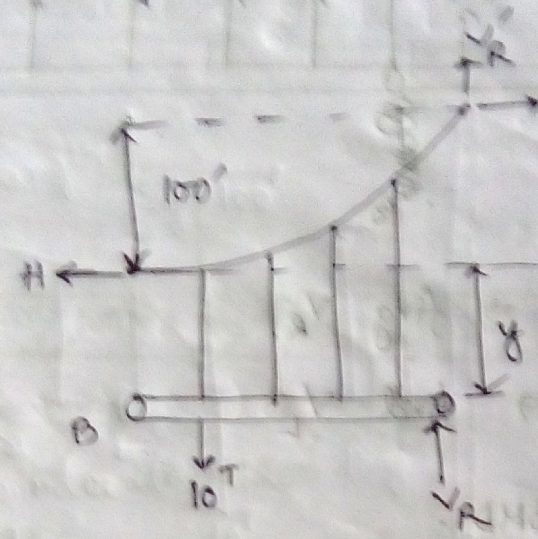
(Free body dia. of girder and cable)
whole structure

$\Sigma M_A = 0$ ↴

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

$\Rightarrow V_R + V_R' = 9^T$ . . . . (1)

* lowest point - ১ vertical component of cable tension আছে ।
only hor. component.



$\Sigma M_B = 0$ ↻+

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

$\Rightarrow -1500 + H \times (100+y) - Hy + 1000 = 0$

$\Rightarrow -3500 + 100H + Hy - Hy = 0$

$\Rightarrow 100H = 3500$

$\therefore H = 35^T$

According to GCT →

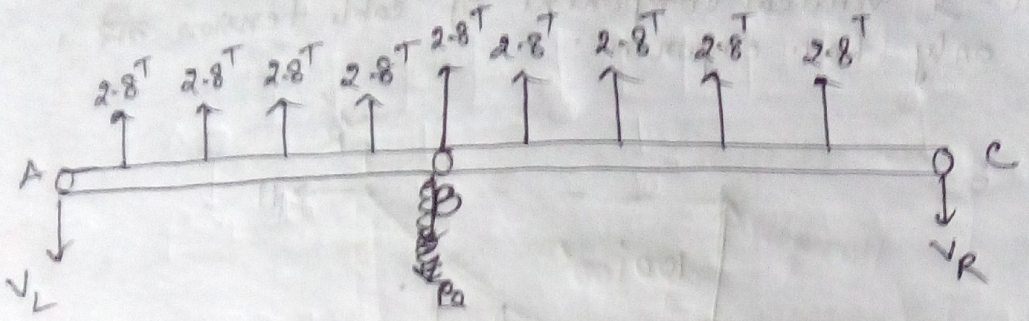
$$\text{Sag, } h = \frac{WL^2}{8H}$$

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

$\Rightarrow W = 0.028^{Ton}$ / horizontal foot.

∴ Hanger force = W × spacing of hanger

$= 0.028 \times 100 = 2.8^{Ton}$.



$\Sigma M_A = 0 \Rightarrow$ fing V_R.

then $\Sigma F_y = 0 \Rightarrow$ find V_L

Then SFD, BMD.

At moment diagram $\Rightarrow$

Moment at hinge = 0.

Assignment $\Rightarrow$ 1. Complete the math in class note.

Assignments $\rightarrow$ 2. 8 spaces of a mid span suspension bridge ~~of~~ bet^n the hangers.

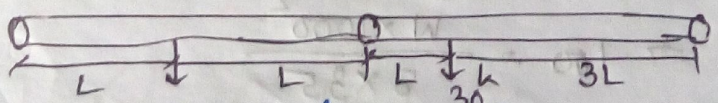
spacing = 100′, L = 800′

sag = 75′

Load = middle of the first girder = 50^k

B point থেকে quarter point - 1 = 30^k.

আগের math-এর মতই সব বের করব।



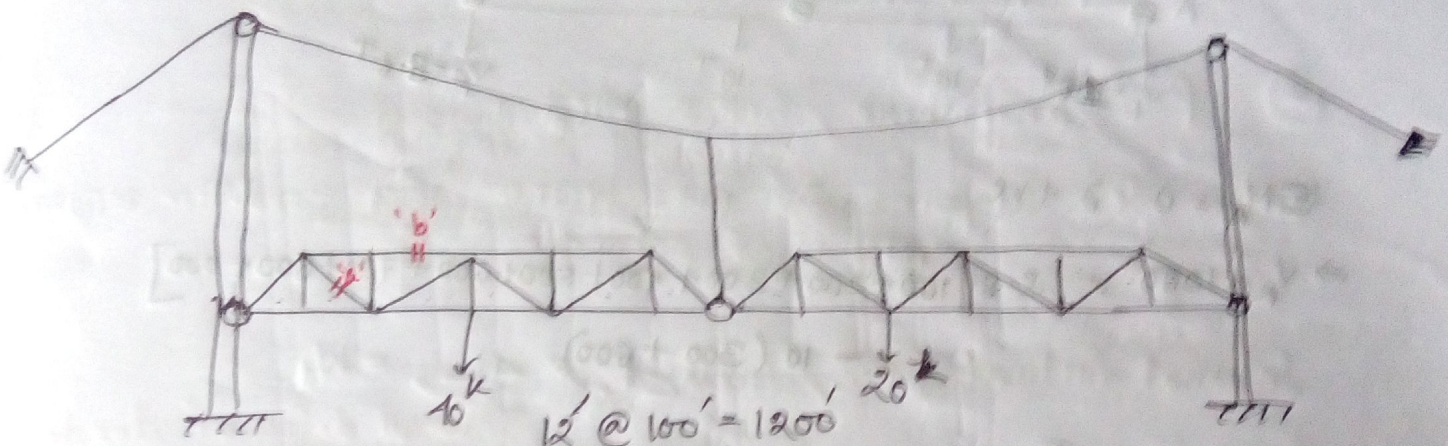
Hanger force = ?

Additional $\rightarrow$ Max^m tension of cable = T_{max} = ?

Unstressed, stressed length = ?

Stretch of the cable = ?

2. 12 spaces.

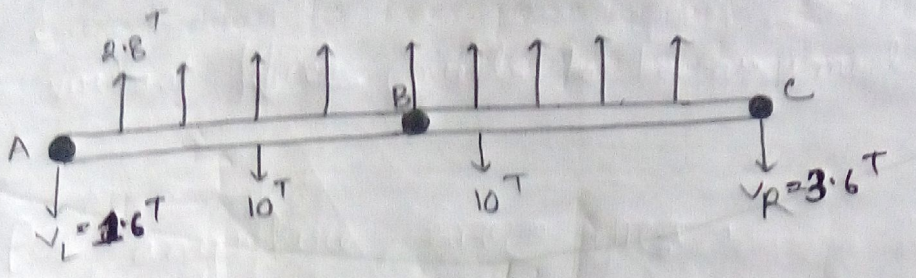


Hanger force = ?

two member forces = ?

'a', 'b' = ?

Home Work

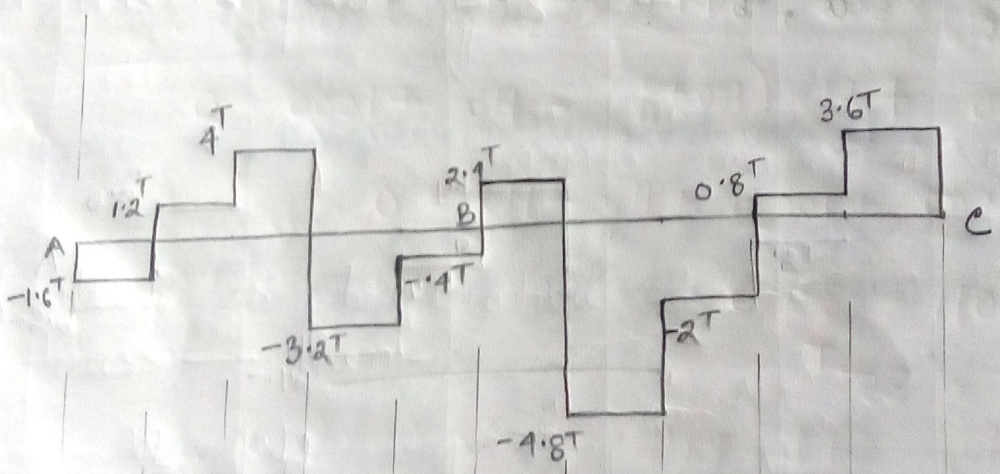


$\Sigma M_A = 0$ ↻ +ve

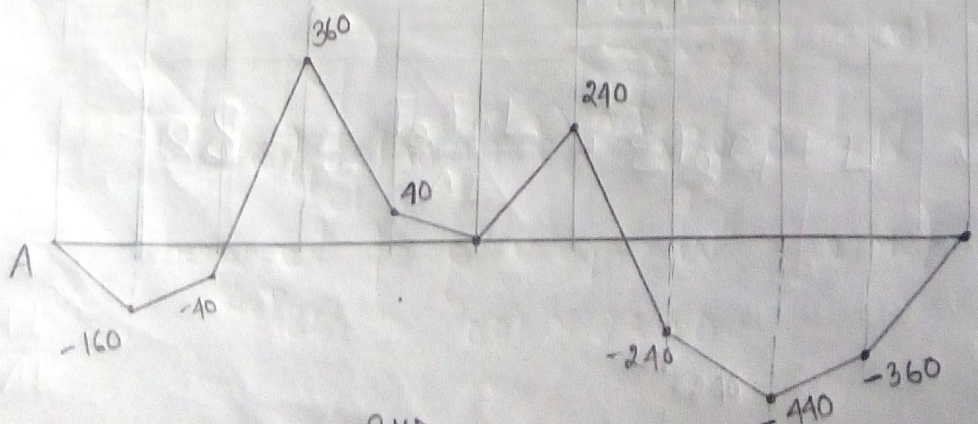
$\Rightarrow V_R \times 1000 = 2.8[100+200+300+400+500+600+700+800+900] - 10(300+600)$

$\Rightarrow V_R = 3.6^T$

$\Sigma F_y = 0$ ↑ +ve $\rightarrow V_L = 2.8 \times 9 - 20 - 3.6 = 1.6^T$



SFD



BMD

30·8·2015

Assignment-3

Spacing 50'

L = 600'

Truss Height = 40'

First force is = 40^k (same place-2)

2nd force = same

Deflection of Truss, Beam & Frame by Virtual Work Method

(Chapter-8)

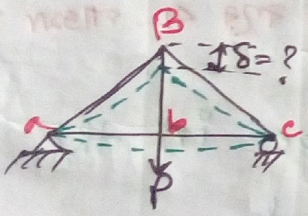


Fig-1

⇒ According to virtual work method

Principle ⇒ Actual virtual work done by virtual force is equal to internal virtual work done by virtual stresses.

$\therefore W_s = W_d$.

but for our case, W_s = external work

W_s = Force × deflection

W_d = internal work

W_d = Force × deformation.

Force = virtual force

deflection/deformation = for real force.

stress

always area নিয়ে কাজ করা যাও লাগতে পারে।

Q. Here, top chord deflection in fig (i) $\Rightarrow$, $\delta = ?$

P = given force i.e actual/Real force acting on structure

Q = virtual force (needs to be assumed)

(*) P = anywhere থাকতে পারে।

But, Q = যে point-এ ব্রের করতে হবে condition অনুযায়ী সেখানে load হবে।

Internal virtual force/stress $\Sigma F_Q \times \underbrace{\Delta L}_{\text{Internal deformation due to real force}} = W_d$.

and $W_s = Q\delta$

$\therefore$ For truss, $\boxed{Q\delta = \Sigma F_Q \times \Delta L}$ ←

Σ তে যতগুলো member আছে সবগুলোর $F_Q \Delta L$ বের করে যোগ করতে হবে।

- If there is temperature change in the member of truss — then —

$W_s = W_d$

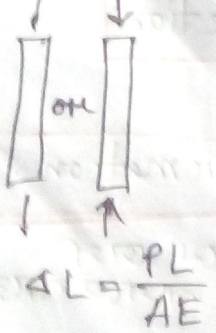
$\Rightarrow Q\delta = \Sigma F_Q \Delta L + \Sigma F_Q \alpha_t t L$ → Length.

(α_t ← coefficient of thermal expansion; t ← Temp. change)

+ for increase

− " decrease

Truss member



$\therefore \Delta L = \frac{PL}{AE}$

$\Rightarrow \boxed{Q\delta = \Sigma \frac{F_Q F_P L}{AE} + \Sigma F_Q \alpha_t t L}$ ←

যে member-এর temp. change নাই তা zero.

(*) We assume, $Q = 1$ (1^k unit force) or ($1^{k\cdot ft}$ unit moment.)

⇓

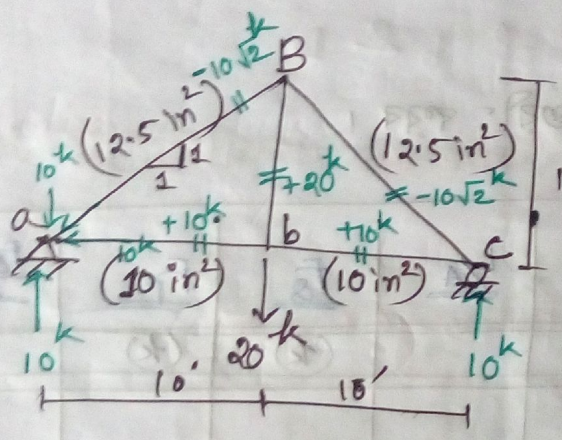
হিসাব করতে সুবিধা

- If $Q = 1$

  then, $\delta = \int \dots\dots$

* lower part - যে joint ⇒ lower case letters
* upper " " " ⇒ upper case letters.

Example



Area shown in parentheses.

$E = 29000$ ksi

Find vertical deflection at

Sol^n

(1) Analyse the structure for P or real Load —

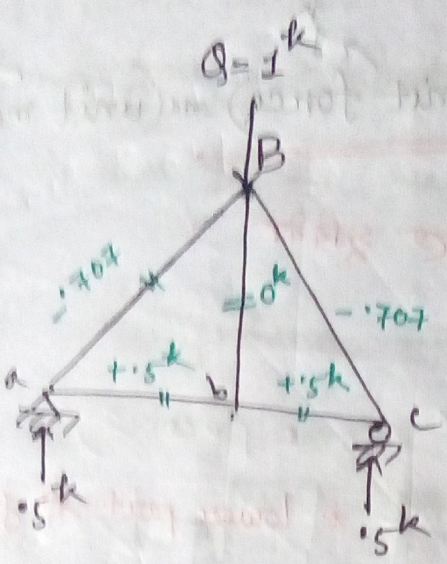
$F_{Bb} = +20^k$ (by joint analysis of b).

Analysis of 'P' force

P = 20 tension So, F_{aB} = compression - যে যেদিকে।

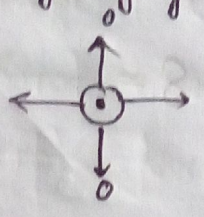
- All the member forces are F_p.

(2) Analyse the structure for Q force.



As B point-এ vertical deflection চাইছে।

analysing joint b →



E -এর জন্য Table তৈরী করব।

Bar	Length (ft)	Area (in²)	L/A	F_Q (k)	F_{PL} (k)	$F_Q F_{PL}$ / A	t °F	$F_Q tL$
Horiz. ab								
bc								
Vert. aB								
cB								
Diag. Bb								
							$E = +32.6$	$E = 0$

↓ no temp change given

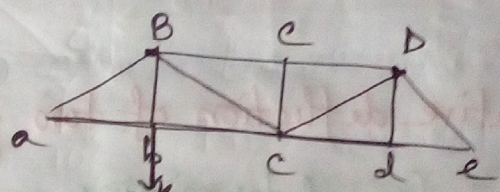
Applying principle of V.W →

$$\sum \delta_V = \sum \frac{F_Q F_P L}{A} + \sum F_Q \alpha t L^0$$

$$\Rightarrow 1^k \cdot \delta_{BV} = + \frac{32.6}{29000}$$

$$\therefore \delta_{BV} = +0.00112' \text{ (downward)}$$

Assigment – 4. Exp 8.1 ⇒ changed load = 80^k instead of 100^k



Find hor. deflection at point "D"

temp. change + load साथ में

" – 5. Exp 8.2 ⇒ changed load = 80^k instead of 100^k

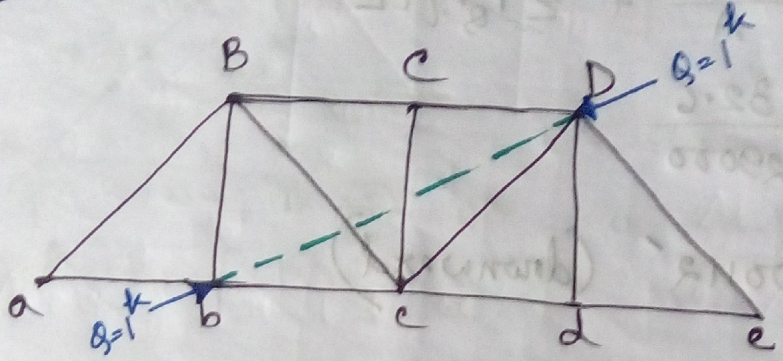
temp. change 40° F decrease in diagonals only.

Find ver. deflection at "E" (top chord)

12.09.15

* Fig - 8.10 vv. imp

Ex - 8.3 & 8.4



Relative deflection of b & D

↓

this means b & D কাছে আসবে নাকি দূরে সরে যাবে??

Relative deflection of two joints — (Ex-8.4)

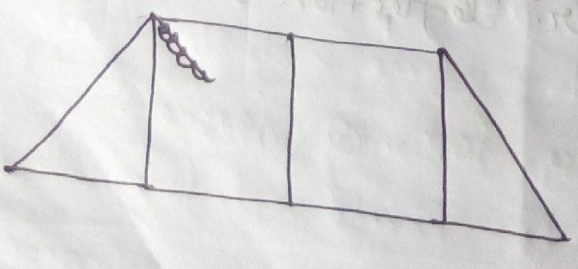
for determining,

if δ_{bD} = +ve ⇒ কাছাকাছি আসবে
δ_{bD} = -ve ⇒ দূরে সরে যাবে

} (Ex-8.4)

Assignment - 6

load same, dimension different. Find relative deflection of joints Bd. (Bar arrangement & load same as book)



15'

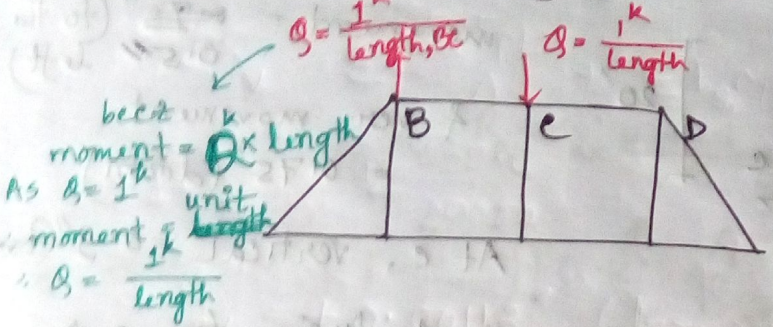
Only height different.

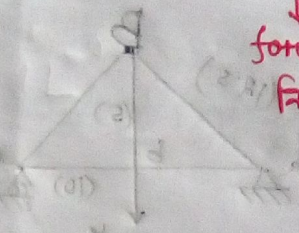
Rotation of a member/bar :- (Ex-8.5)

bar O° থাকে না কিভাবে downward/upward হবে?

↓

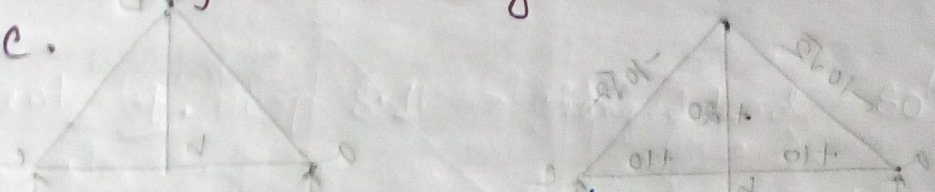
for this unit moment নিতে হবে ঐ bar-এর দুটো end point-এ.





Assignment-7

All other info same as assignment 6. Find rotation of bar BC.



Effect of support movement/settlement :-

↓

ফ্রেম এমন Building-এর joint displace হয়।

Principal of virtual work—

$$W_S + W_R = W_d$$

Here, W_R = work done by virtual support reaction on real support movement due to real load

↓

virtual ও force থেকে থেকে

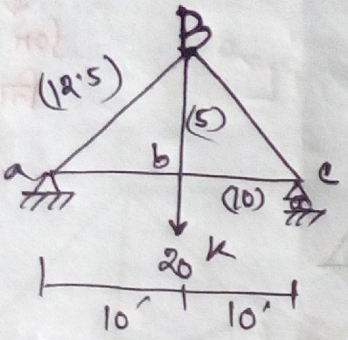
$W_R = \sum$ support reaction × deflection

↓

(উল্টা আকার)

⇒ কোন support এর movement না থাকলে অথবা $W_R = 0$.

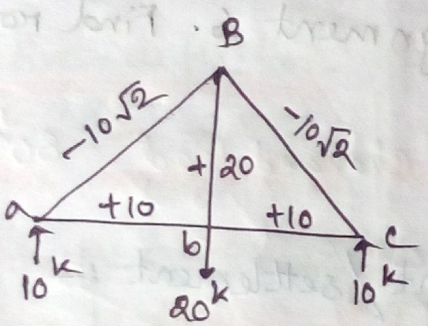
Example Compute vertical deflection of joint B. Given, E = ___ at support 'a' hor. movement = ~~0.75~~ 0.5" (to the left)



& ver. movement = 0.75" (down)

At c, vertical = 0.3" (down)

1) Analysing for P force



2) Analysis for Q force

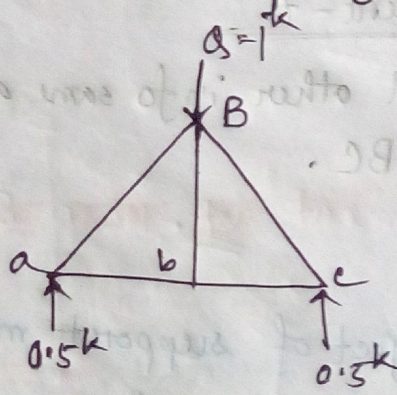


Table (from previous example)

			$\Sigma F_Q F_P L/A$	$\Sigma F_Q t L$
			$\Sigma = 82.6$	$\Sigma = 0$

Apply principle of V.W →

$$W_s + W_R = W_d$$

$$\Rightarrow 9\delta_{BV} + R_{Ay}\Delta_{Ay} + R_{ax}\Delta_{ax} + R_{cy}\Delta_{cy} = \Sigma F_Q F_P \frac{L}{AE} + \Sigma F_Q \alpha_t t L$$

$$\Rightarrow 9\delta_{BV} + \left(0.5 \times \left(-\frac{.75}{12}\right) + 0 + .5 \times \left(-\frac{.3}{12}\right)\right) = \frac{32.6}{29 \times 10^3} + 0$$

-ve bcz settlement বলতে force এর opposite-এ

$$\Rightarrow \delta_{BV} = 0.524$$

$$\Rightarrow \delta_{BV} = 0.00112' + 0.04375'$$

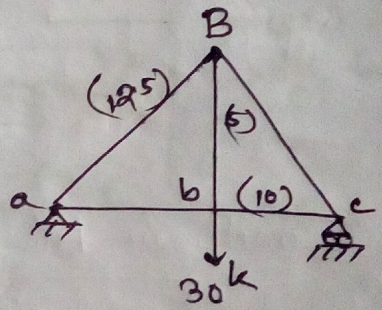
$$\Rightarrow \delta_{BV} = 0.04485' \; 0.04487'$$

Assignment-8

Compute hor. deflection of joint B.

Support movement

for a hor. = 0.6" (right)
" a ver. = 0.8" (down)
" c ver. = 0.5" (down)



Assignment-9

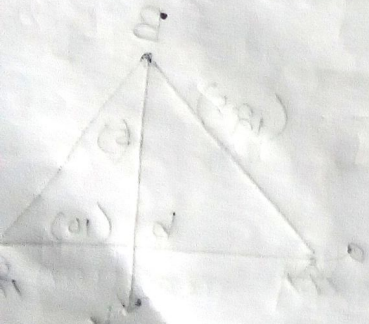
~~loading~~ Fig as given for assgnmt-7, no external loading. dimension same asgnmt-7.

Support movement

for a. hor. = 0.6" (right)
" a ver. = 0.8" (down)
" e ver. = 0.4" (down)

Determine ver. Δ hor. deflection at 'C' (top chord).

Class test → next class (upto Assignment-9)



03·9·2015

* Deflection of beams & frames by virtual Method –

$$\Sigma Q\delta = \underbrace{\int \frac{M_Q M_P}{EI}dx}_{①} + \underbrace{\Sigma F_Q F_P L/AE}_{②} + \underbrace{\Sigma F_Q \alpha_t t L}_{③}$$

① → Bending moment effect.
② → Axial force effect
③ → Temp. effect.

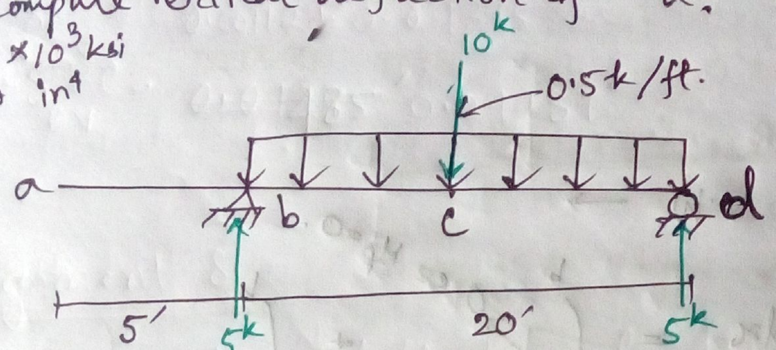
Imp [2 & 3 এ integration form-এ নেই আছে। But uniform বলে Σ দিয়েছি। যদি এগুলো non-uniform হয় তাহলে ∫ form-এ নিতে হবে। Similarly Moment ও যদি uniform হয় তাহলে Σ form-এ নিতে পারি/যায়।]

Exp-8.5

Compute vertical deflection of "a".

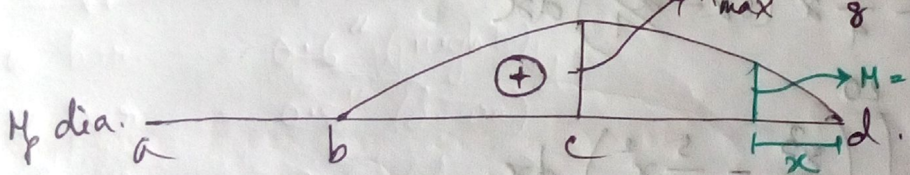
$E = 30\times10^3$ ksi

$I = 200$ in^4



* এখানে no axial force. So, ② will be zero.

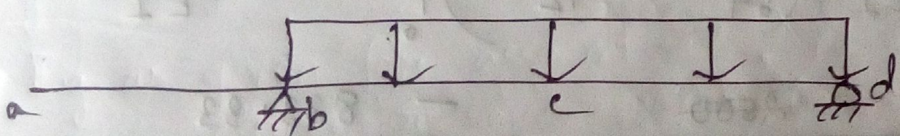
P-force analysis.



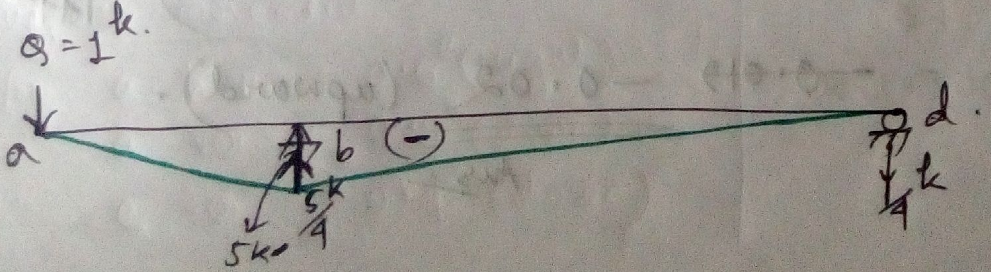
$M_{max} = \frac{wL^2}{8} = 0.5\times\frac{20^2}{8}$

$M = 5x - 0.5\frac{x^2}{2}$

Q-force analysis



⇓



Expression for M_Q and M_P)

Segment ab ($0 < x \leq 5'$)

$M_Q = -1x$

$M_P = 0$

Segment db : ($0 < x \leq 20'$)

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

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

Using Principle of V.W →

$$\Sigma Q \delta_{av} = \int \frac{M_Q M_P}{EI} dx = \int_a^b \to 0 \text{ as } M_P = 0. + \int_d^b$$

$Q = 1^k$.

$$\Rightarrow \delta_{av} = \frac{1}{EI} \int_0^{20} -\frac{1}{4}x\left(5x - \frac{x^2}{4}\right) dx$$

$$= \frac{1}{EI} \int_0^{20} \left(\frac{x^3}{16} - \frac{5}{4}x^2\right) dx$$

$$= \frac{1}{EI} \left(\frac{1}{64}x^4 - \frac{5}{12}x^3\right)\Big|_0^{20} = -\frac{833.33}{EI}$$

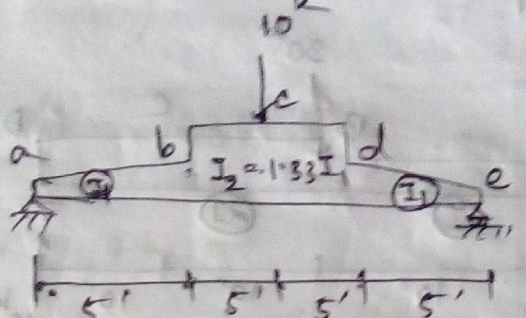
$$= -\frac{2500}{30 \times 10^3 \times 3 \times 200} = -\frac{833.33}{(30000 \times 144) \times \frac{200}{144^2}}$$

$$= -0.019 \quad -0.02 \text{ (upward)}.$$

Ans:

Ex-8.6

4 টি segment



$E = 30000$ ksi

$I_1 = 150$

Calculate change in slope at point "a".

Q will be = 1 unit moment.

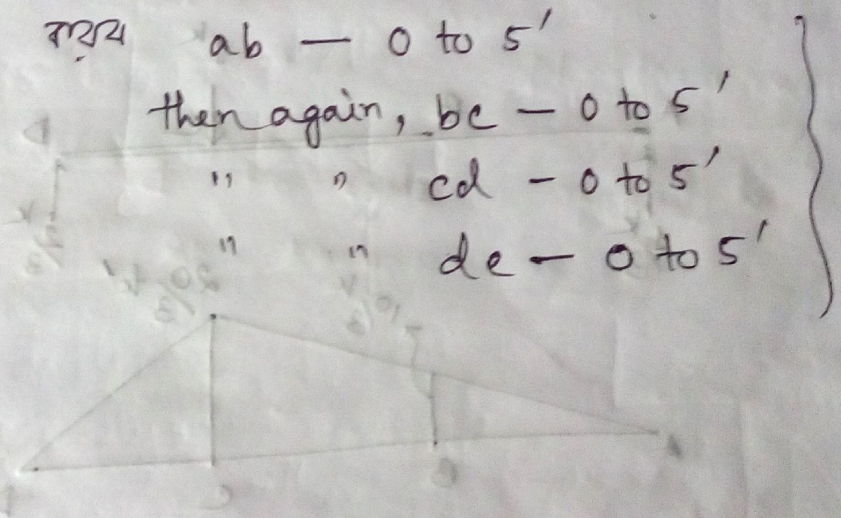
বইতে যেভাবে আছে 0 – 5', 5'–10' - - -

But আমরা নিব ab — 0 to 5'

then again, bc — 0 to 5'

" " cd — 0 to 5'

" " de — 0 to 5'

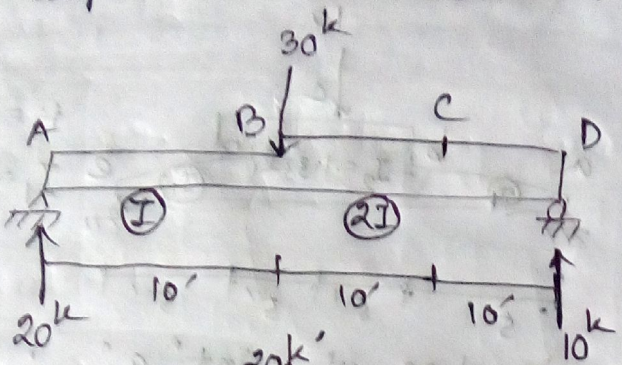


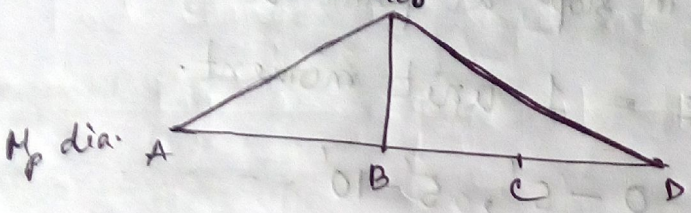
04.10.15

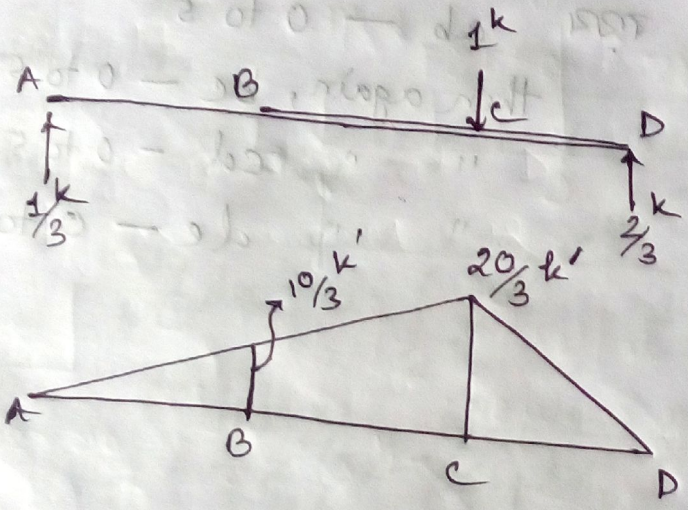
Problem-1 Compute vertical deflection at "c". Given,

$I = 200\ in^4$

$E = 30000\ ksi$







Ans: No of segments = ? ⇒ depends on moment diagram, Inertia etc.

Segment AB $(0 \leq x \leq 10)$:

$$M_Q = \frac{1}{3}x \quad , \quad M_p = 20x$$

Segment Be $(0 < x \leq 10')$:

$$M_Q = \frac{10}{3} + \frac{x}{3}$$

$$M_p = 200 - 10x$$

Segment DC ($0 < x \leq 10'$):

$$M_Q = \frac{2}{3}x \; ; \quad M_P = 10x$$

Using Principle of V.W →

$$\Sigma Q\delta = \int \frac{M_P M_Q}{EI}\,dx + \Sigma \frac{F_P F_Q L}{AE}\,(\to 0) + \Sigma F_Q \alpha \Delta t L\,(\to 0)$$

$$\Sigma Q\delta = \frac{1}{EI}\int_A^B 20x \cdot \frac{1}{3}x\,dx + \frac{1}{EI_2}\left\{\int_B^C \left(\frac{10+x}{3}\right)(200-10x)\,dx + \right.$$

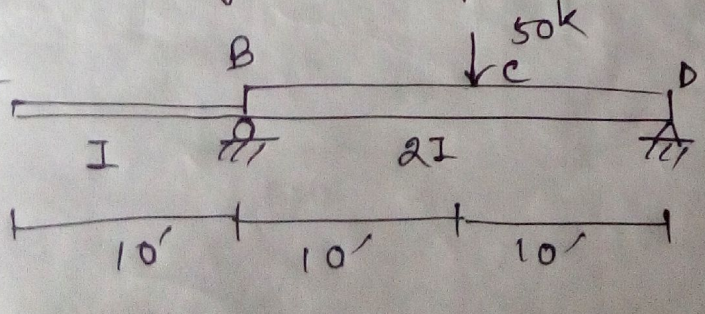
$$\Rightarrow \delta = 6944/EI$$

$$\therefore \delta = 0.166 \quad (\downarrow \text{ downward})$$

Assignment-11:

Find change in slope at "A" (for class figure)

Fig for ass-12



$E = 30 \times 10^3$ ksi

$I = 300$ in^4

Assignment - 12

Find ver. deflection at "A". Same fig. as previous page.

Assignment - 13

Find change in slope at "A".

Fig as assgnmnt - 12

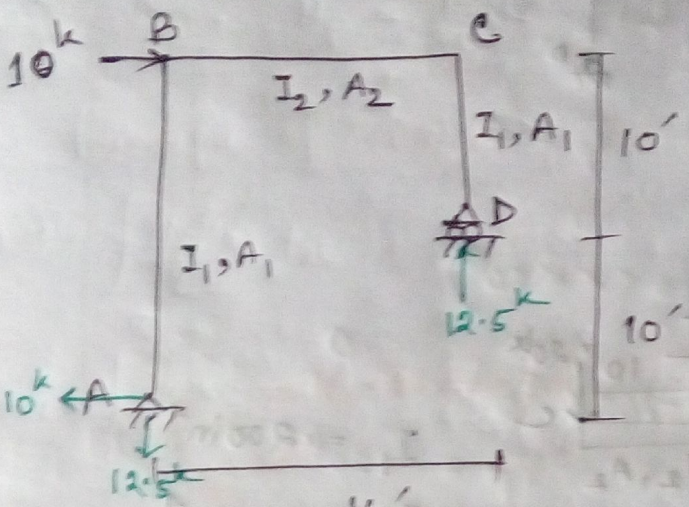
Assignment - 14

Find change in slope at "D"

Fig as assngmnt - 12

Frame

Problem-1



Compute hor. deflect^n at "B".

Given.

$I_1 = 300 in^4$

$I_2 = 200 in^4$

$E = 30 \times 10^3 ksi$

$A_1 = A_2 = 10 in^2$

Ans: a) $0.938'(\rightarrow)$ b) $0.9395'(\rightarrow)$

Two cases

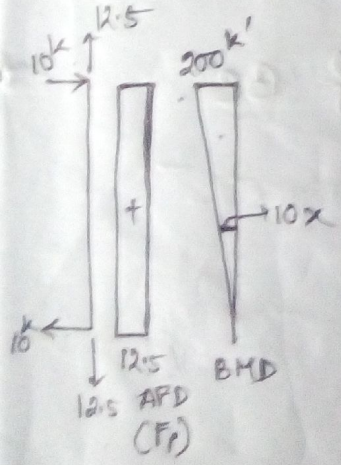
(a) Neglect Axial force effect

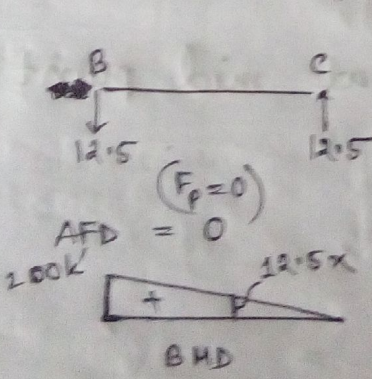
(b) include all effects.

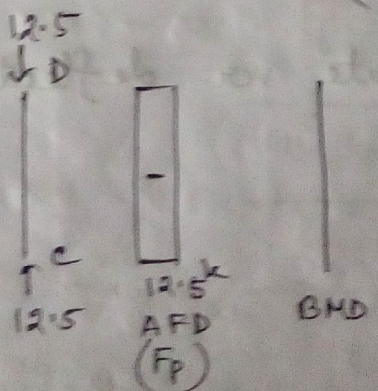
* (এখানে 10^k BC member-এ add হচ্ছে না কেন BC/CD member hor. load নিতে পারছে না। নিচ্ছে only AB. ⇓ So 10^k hor. load AB calculat^n-এ আসছে।)

$\Sigma M_A = 0 \; \curvearrowleft + \Rightarrow 10 \times 20 - R_{D_y} \times 16 = 0$

$\Rightarrow R_{D_y} = \frac{200}{16} = 12.5^k (\uparrow)$

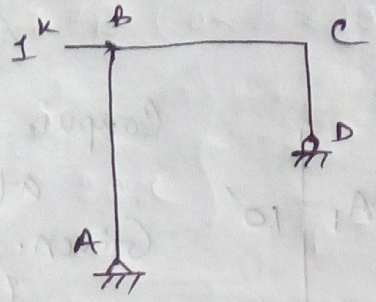




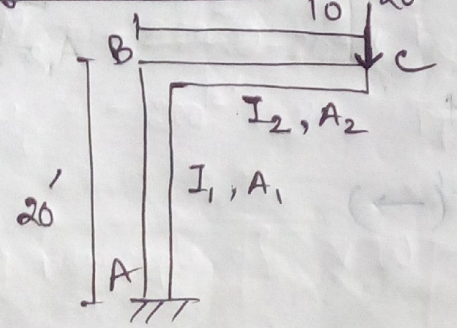


← Eye direct^n

* Complete the calculat^{n} for virtual load –



Assignment – 15



$I_1 = 200 \text{ in}^4$

$I_2 = 150 \text{ in}^4$

$A_1 = 15 \text{ in}^2$

$A_2 = 10 \text{ in}^2$

$E = 30 \times 10^3 \text{ ksi}$

Compute hor. deflect^{n} at "B".

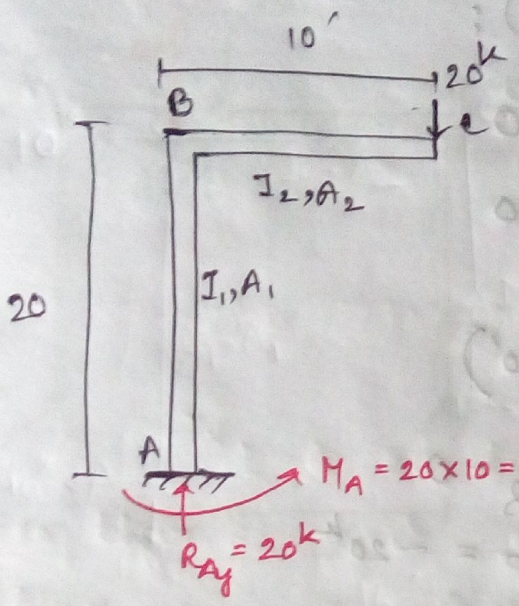
Assignment-16 ; change in slope at "C".

Ass – 17

Compute ver. deflect^{n} at mid point of BC.

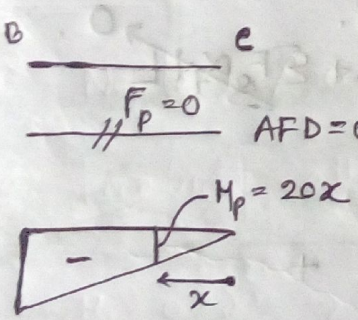
Assignment-15

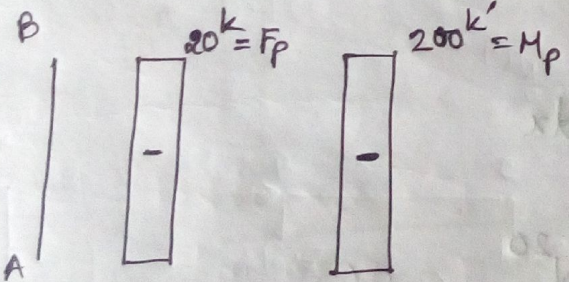
10.10.15



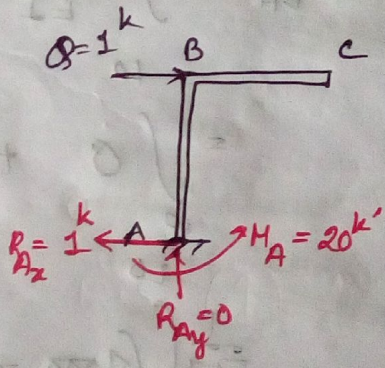
Find Hor. deflection at "B"

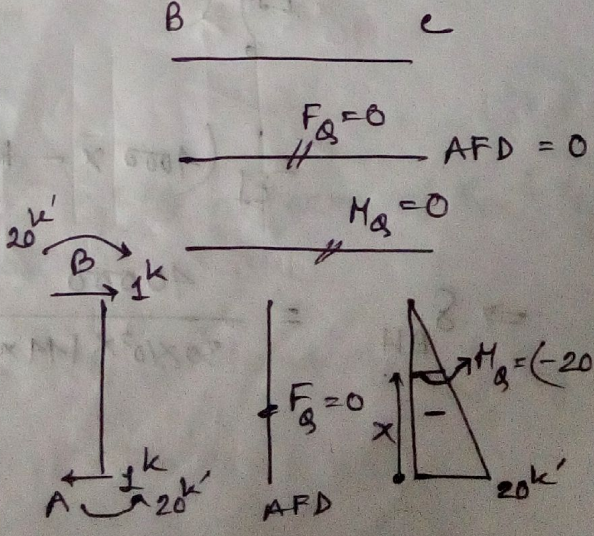
P-force Analysis





Q-force Analysis

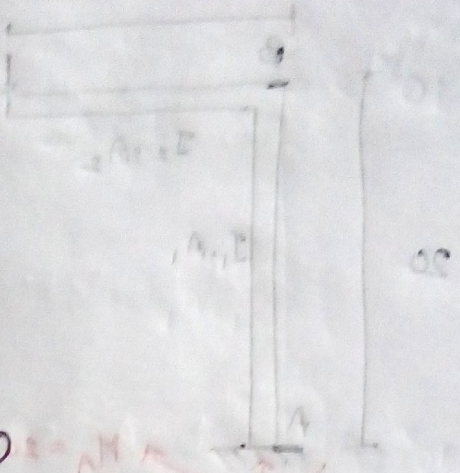




Segment CB $(0 < x \leq 10')$:

$M_Q = 0$ $\quad F_Q = 0$

$M_P = 20x$ $\quad F_P = 0$



Segment AB $(0 < x \leq 20')$

$M_Q = -200 - 20 + x$ $\quad F_Q = 0$

$M_P = -200^{k'}$ $\quad F_P = -20^{k}$

Using Principle of V.W. $\longrightarrow$

$$\Sigma Q\delta_{BH} = \int \frac{M_Q M_P}{EI} dx + \Sigma F_Q F_P \frac{L}{AE} + \Sigma F_Q \alpha_t t L$$

$$= \int_0^{10} 0 + \int_0^{20} 200(20-x)dx + \cdots$$

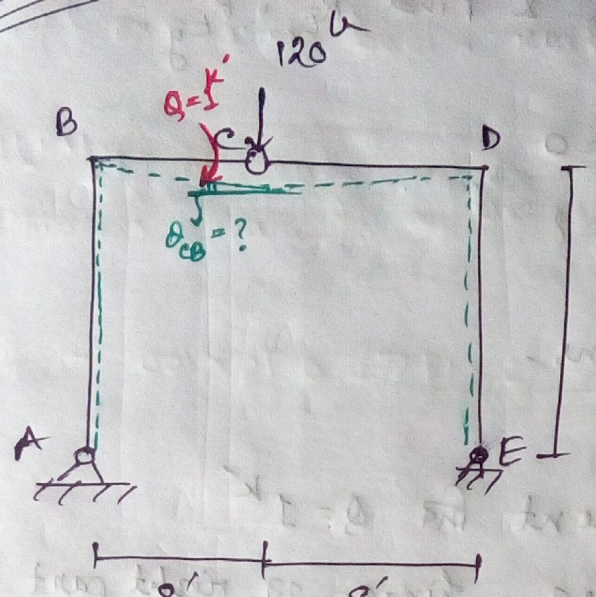
$$= \frac{1}{EI}\int_0^{20} (4000 - 200x)\,dx$$

$$= \frac{1}{EI}\left(4000x - 100x^2\right)\Big|_0^{20} = \frac{1}{EI}\left(4000\times 20 - 100\times 20^2\right)$$

$$\Rightarrow \delta_{BH} = \frac{40000}{30\times 10^3 \times 144 \times \frac{200}{144^2}} = \underline{0.96'}$$

Ans.

Example 8.7



$E = 30 \times 10^3$ ksi

$A = 20\ in^2$

$I = 2500\ in^4$

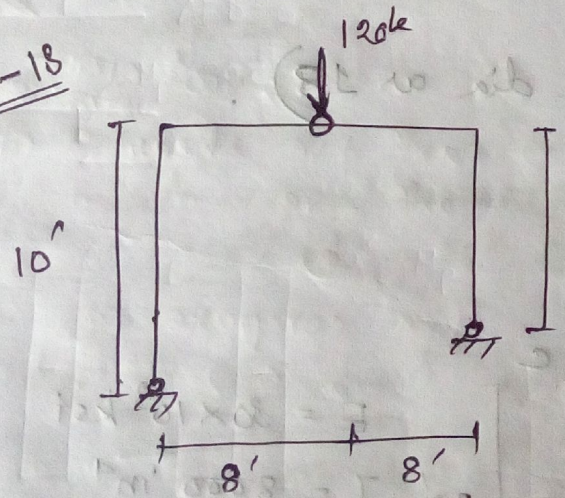
Compute change in slope for the cross-section on ~~depth~~ Left of hinge.

left বলতে AB না, BC part বোঝায়

⇓

unit moment দিব C - এ বামে C⁻ left of hinge বলা হচ্ছে

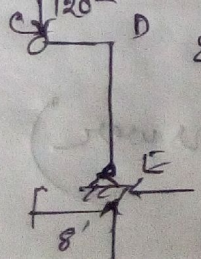
Assgn-18



Compute change in slope for the cross section on left of hinge.

Whole structure $\Sigma M_A = 0$ ⇒ Eq^n (1) in terms of R_{Ex} & R_{Ey}.

Hinge - এ বামে কাটব।



ΣM @ C = 0 ⇒ Eq^n (2) in terms of R_{Ex} & R_{Ey}.

Solve eq^n (1) & (2) & Find R_{E_x}, R_{E_y}.

$\left\{ \begin{array}{l} \Sigma F_x = 0 \\ R_{Ax} = ? \end{array} \right.$, $\left\{ \begin{array}{l} \Sigma F_y = 0 \\ R_{Ay} = ? \end{array} \right.$

Next diagrams.

⇓

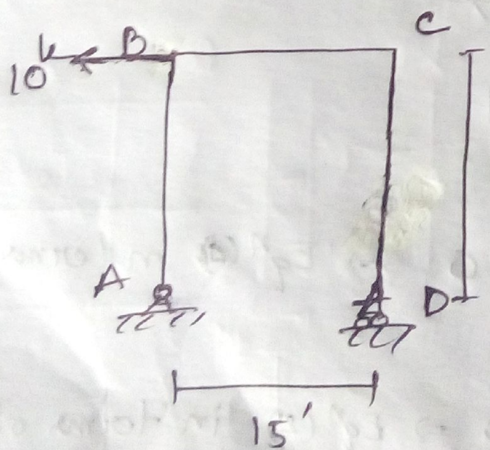
Then moment দিব $Q = 1^k$

In this case hinge-এর right part দিব না, left part দিব। CE right part-এ moment নাই।

Assgn-19

$\delta_{BH} = ?$ (Same dia as 18).

Assgn-20



$E = 30 \times 10^3$ ksi

$I = 8000$ in^4

$A = 20$ in^2

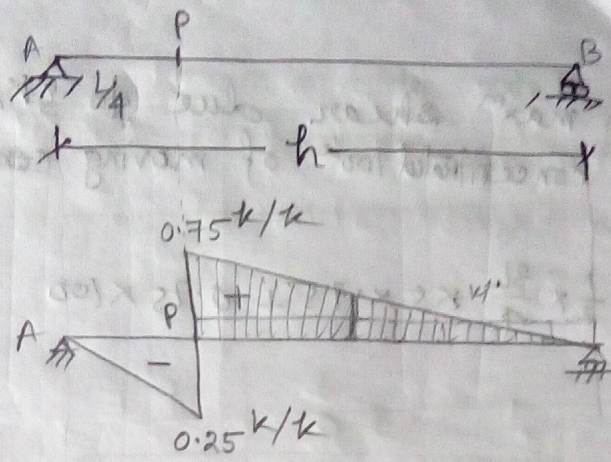
Find δ_{BH}, δ_{CH}, θ_B, θ_C

Chapter-8

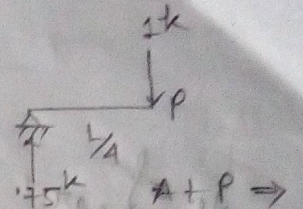
(See Ex-ercise Problem with Answer)

11.10.15

• 1^k ⇒ moving unit load.



I Line for shear at quarter point from left support.



Q.(1) What is the maximum at quarter point due to moving 100k load of a wheel?

⇓

$= 0.75 \times 100^k = 75^k$.

↓

becz max^m is told.

⇓

max^m −ve shear বলতে

$.25^{k/k} \times 100^k = 25^k$ হবে.

Q.(2) What is the max^m shear at quarter point due to uniform moving load of $5^{k/ft}$. ?

⇓

load টি কোথায় place বসাতে হবে।

⇓

As uniform load, area of the IL dia. × Intensity of UDL

∴ Max^m shear $= \frac{1}{2} \times 3/4 \times 0.75^{k/k} \times 5^{k/'} = ?$ (+ve shear)

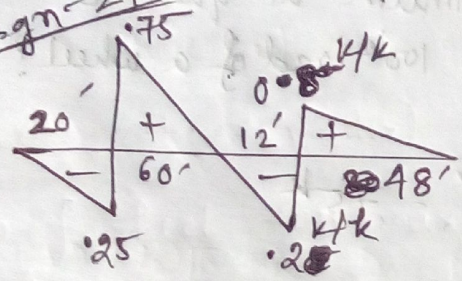
for max^m – ve shear, load place করব for AP.

Q(3) What is the max^m shear due to 5K/' UDL & concentrated 100^k of moving ~~concentrated~~ load.

$\therefore$ Max^m shear $= \frac{1}{2} \times \frac{3L}{4} \times 5 \times .75 + 0.25 \times 100 = \dots$ (+ve)

Example of IL for shear

Assgn-2



similar for -ve.

যেটা বড় আসবে 100^k বসাব

100^k যেকোন এক পাশে বসাতে পারব

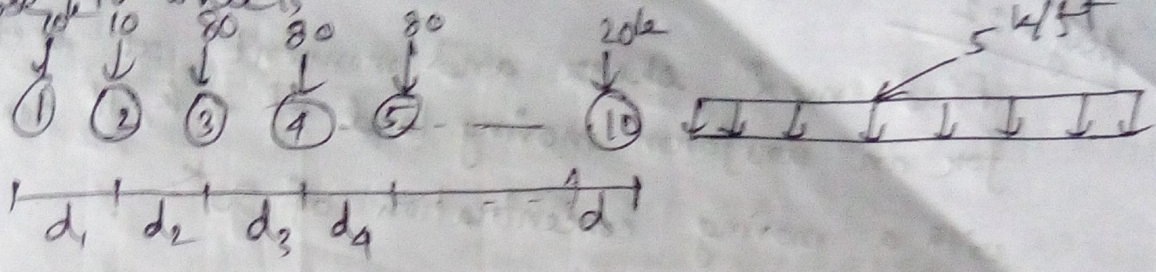
Q. (3) for this case ⇒ max^m +ve shear ও বের করব
max^m –ve " " " "

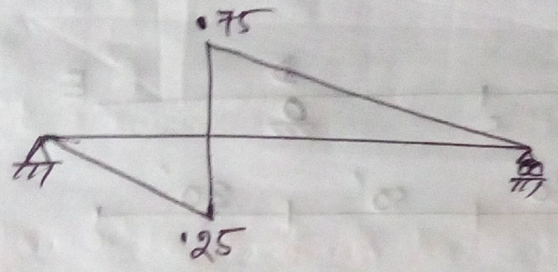
⇓

Then compare করে বলব কোনটা max^m ?

Assign Problem-2

Suppose 10 wheels





Trial 1

upto 7 ⇒ shear = wheel load × coordinate

from 8 to 10 ⇒ 0.

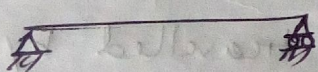
Trial 2 : ৫০৪২৩ আগামুর পেনফলাৱা load

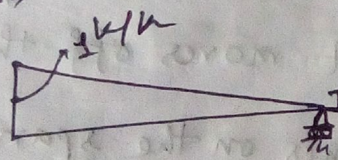
⇓

But it is very troublesome.

\# **best way** ⇒ which wheel will give you max^m shear at quarter point?

Q. What is the max^m reaction at left support for this load of problem (2).



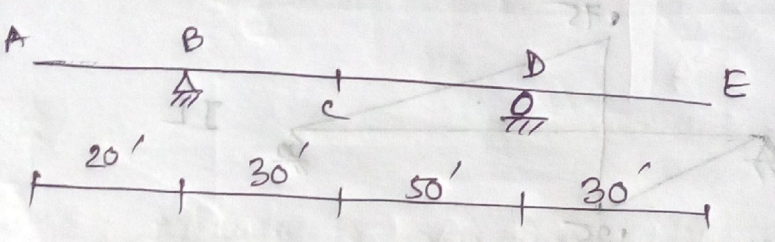


IL for left support reaction.

18.10.2015

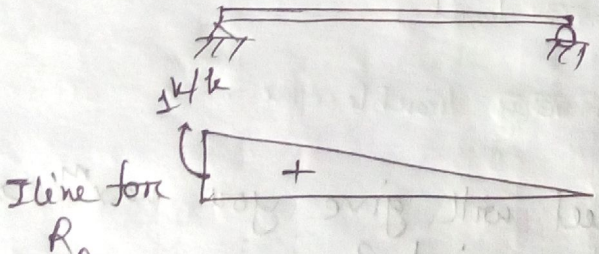
Asg # 22

Find max^m shear and moment at section C for an uniform moving load of 7 k/ft combined with a moving concentration of 90^k.



Art # 60 (Shedd Vowter)

- Position of wheel for max^m reaction of a simple beam :—



Due to a movement d_1 for a locomotive with series of loads,

Change in reaction

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

where, ΣP = loads that stay on the span before & after ~~moment~~ movement

d_1 = distance travelled by ΣP

P_1 = load that moves off the span

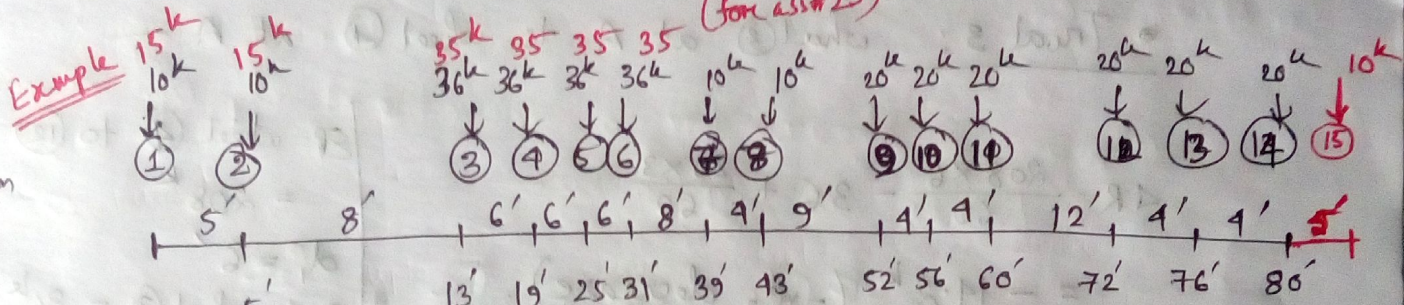
P' = load that comes on the span

e = distance travelled by P' on the span.

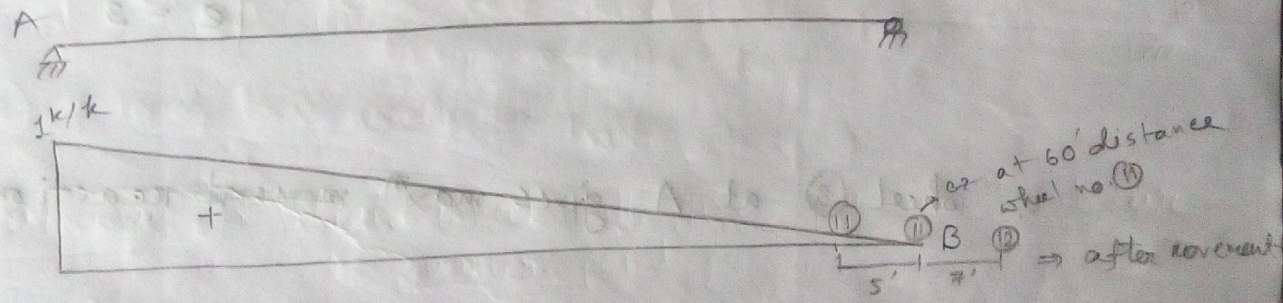
- Procedure :—

1. Place wheel (1) at A
2. Move wheel until wheel (2) at A and calculate ΔR.
3. If ΔR = −ve, then wheel (1) at A give max^m reaction.
4. If ΔR = +ve, move wheel (3) at A and calculate ΔR and repeat until ΔR = −ve.

Example (for assi#23)



Find max^m react^n for a simple span beam of 60'



- Trial no 1 :— wheel ① at A to wheel ② at A :—

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

$$= \frac{234 \times 5}{60} - 10 + 0 = 9.5^k \text{ (+ve, increase)}$$

ΣP = wheel ② to wheel ⑪ = 234^k

$d_1 = 5'$

P_1 = wheel ① = 10^k

$P' = 0$

• Trial 2 : wheel ② at A to wheel ③ at A —

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

$$= 20.2^k \text{ (+ve, increase)}$$

ΣP = wheel ② to wheel ⑪

$= 224^k$

$d_1 = 8'$

P_1 = wheel ② $= 10^k$

P' = wheel ⑫ $= 20^k$

$e = 1'$

• Trial 3 : wheel ③ at A to wheel ④ at A —

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

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

ΣP = wheel ④ to ⑫

$= 208^k$

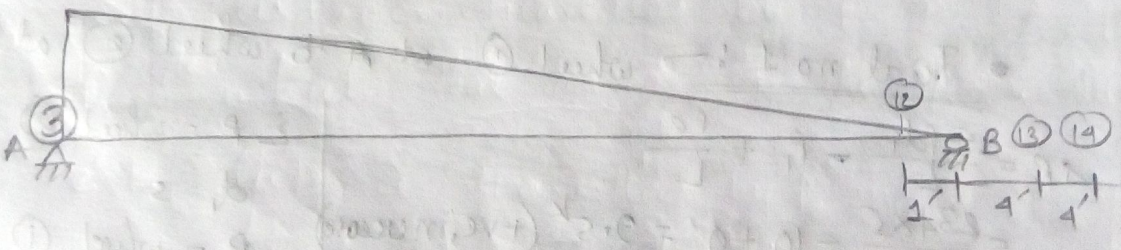
$d_1 = 6'$

P_1 = wheel ③ $= 36^k$

P' = wheel ⑫ $= 20^k$

$e = 3'$

∴ wheel ③ at A gives max^m ~~moment~~ reaction. Hence,



$$\therefore \text{Max}^{m} \text{ reaction} = \frac{1}{60}\left[60 \times 36^{k} + 54 \times 36^{k} + \cdots + 1 \times 20^{k}\right]$$

$$= 150.4^{k}$$

Assgn #23

Find max^{m} reaction of a simple beam of 70' span.

(Previous figure)

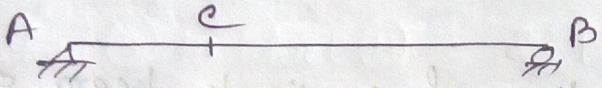
CT ⇒ Sunday (Assgn II to today's class)

31·10·15

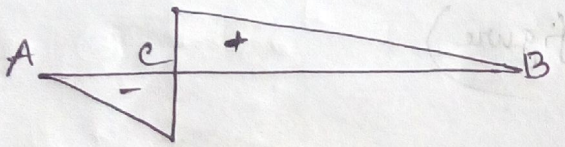
Art 62 & 64

Position of wheel to produce max^m shear at a section.

যে side টা বড় সেদিকে পিছে movement হবে।



IL diagram for shear at C



Change in shear for a movement d_1 of a series Loads is given by—

$$\Delta V = \frac{\Sigma P d_1}{L} - P_1 + \frac{P' e}{L} + \frac{P_2 e'}{L}$$

where, ΣP = wheel load that stay on the span before and after movement

P_1 = the wheel that crossed point C (section C)

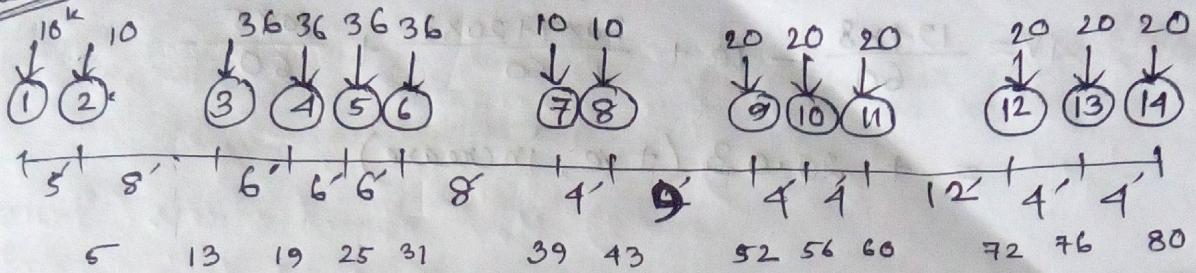
P' = wheel that comes on the span during movement

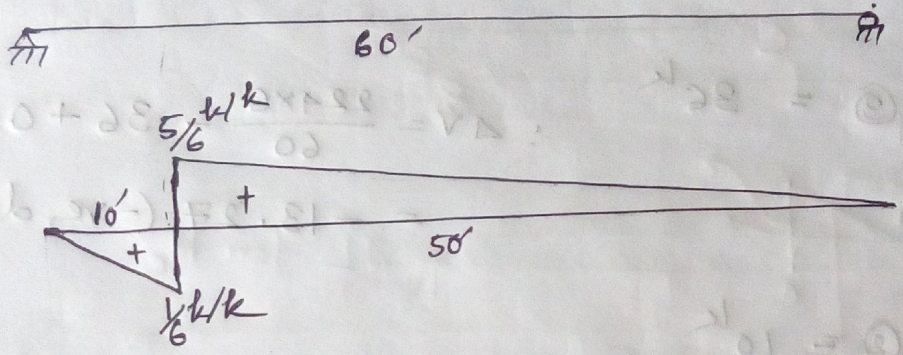
e = distance travelled by P' on the span

P_2 = wheel that moves off the span during movement.

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

Example-1





Find max^m shear at distance 10' from left support of a 60' simple span

Trial-1 wheel ① at C to wheel ② at C.

ΣP = wheel ② to wheel ⑧ = 184^k

$d_1 = 5'$

P_1 = wheel ① = 10^k

P' = wheel ⑨ = 20^k

$e = 3'$

$P_2 = 0$

$e' = 0$

$$\Delta V = \frac{\Sigma P d_1}{L} - P_1 + \frac{P' e}{L} + \frac{P_2 e'}{L}$$

$$= \frac{184 \times 5}{60} - 10 + \frac{20 \times 3}{60}$$

$$= +6.33^k \text{ (+ve, increasing)}$$

Trial-2 wheel ② at C to wheel ③ at C

ΣP = wheel ② to wheel ⑨ = 194^k

$d_1 = 8'$

P_1 = wheel ②

P_2 = wheel ① = 10^k

$e' = 5'$

P' = ~~wheel ⑩ &~~ wheel ⑫ = ~~20^k + 20^k~~ wheel ⑩ = 20^k

e = ~~7' + 3'~~ 7' for wheel ⑩, 3' for wheel ⑪.

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

$$= +20.03 \text{ (+ve, increase)}$$

Trial-3

ΣP = wheel ③ to wheel ⑪ = 224^k

$d_1 = 6'$

P_1 = wheel ③ = 36^k

$P' = 0$

$e = 0$

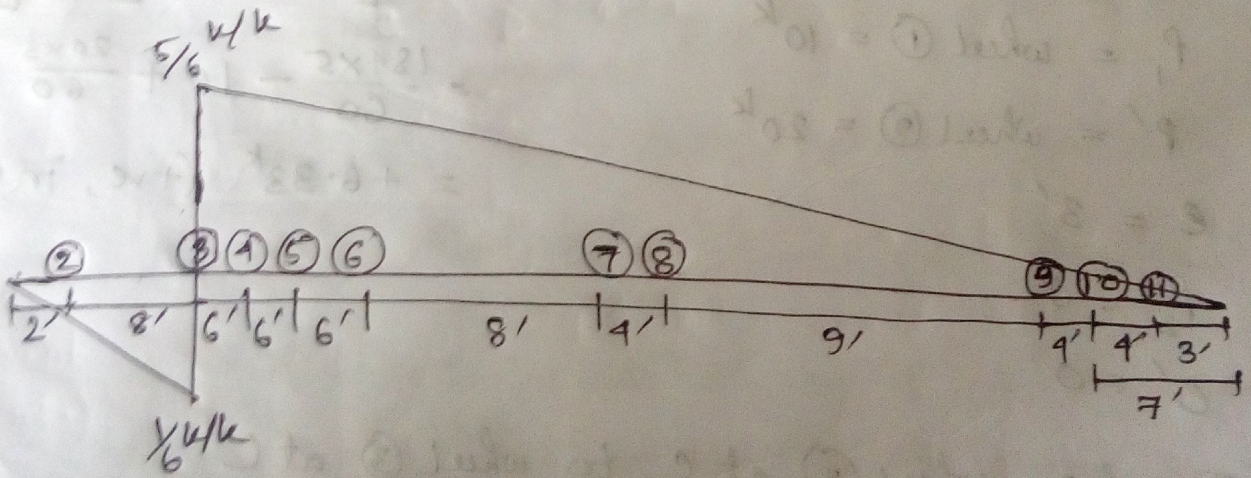
P_2 = wheel ② = 10^k

$e' = 2'$

$$\therefore \Delta V = \frac{224\times 6}{60} - 36 + 0 + \frac{10\times 2}{60}$$

$$= -13.27 \text{ (-ve, decrease)}$$

∴ wheel ③ at C gives the max^m shear.

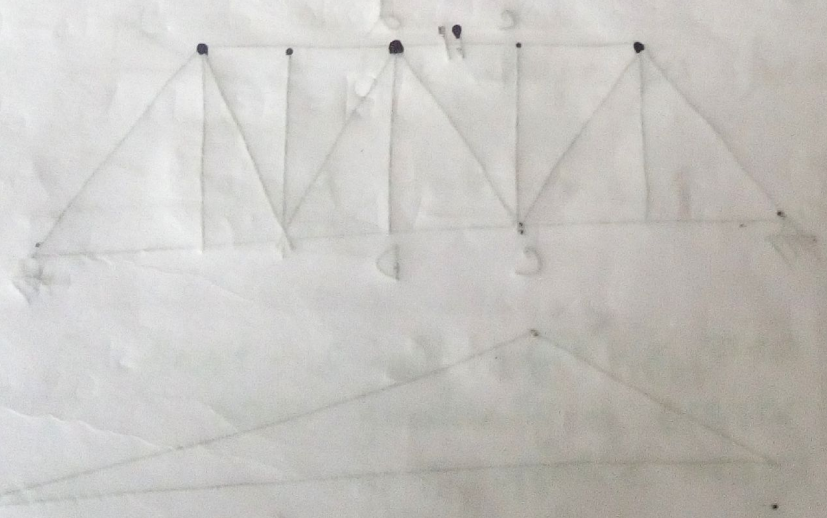


$$\therefore \text{Max}^m \text{ shear} = +\frac{5/6}{50}\left[50\times 36 + 44\times 36 + 38\times 36 + \cdots + 7\times 20 + 3\times 20\right] - \frac{1/6}{10}\left[2\times 10 + 3\times 20\right]$$

$$= \underline{112.4^k}$$

Assgn-24

Span = 80' Max^{m} shear at quarter point. Loading same as before.

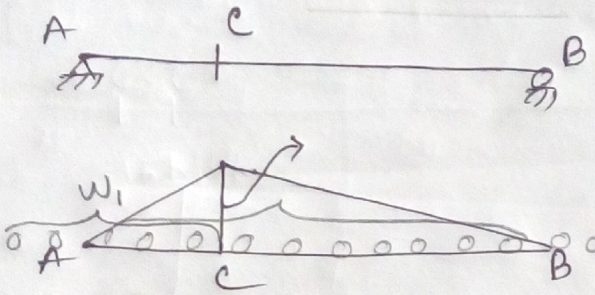


01.11.15

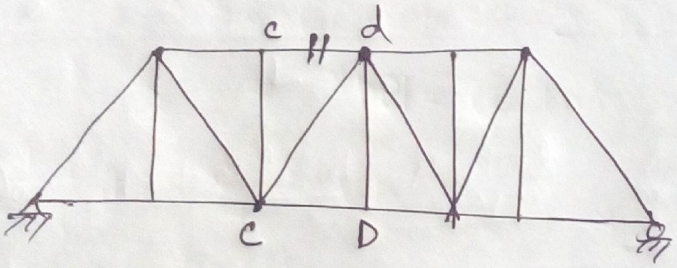
Art 65

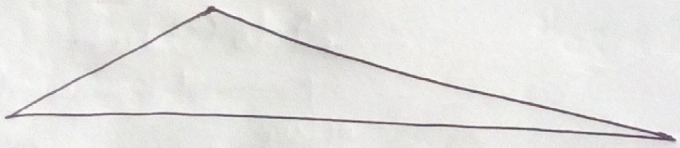
Position of wheel for 1) maximum moment at a section (Beam)

2) Max^m chord stress (Truss)
(max^m chord force member)



IL for M_C





IL for member cd

(cz এই cd ⇐ chord মেম্বার bottom chord → C point → moment নিলে force পাব।)

⇓

Top & bottom chord → almost same

⇓

symmetric truss, so, half side বললেই হবে

⇓

(load left support থেকে দূরত্ব হবে right support পর্যন্ত থাকবে।)

Assignment 25 I line force ⇒

① top chord members
② bottom " "
③ diagonal " "
④ verticle " "

• Criterion for maximum moment at a section —

$$\frac{W}{L} = \frac{W_1}{a}$$

এটার diff করবে যে C-এর বামে/ডানে বসাবে।

W = wheels on the span

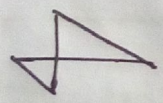
W_1 = wheels at the left side of the ~~span~~ control point

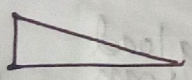
L = total span

a = span of the left of the section.

∴ Avg load on the span = avg load of the left of the section

This criterion are valid for only this shape of IL dia

Similarly,  ⇒ this shape is fixed for shear

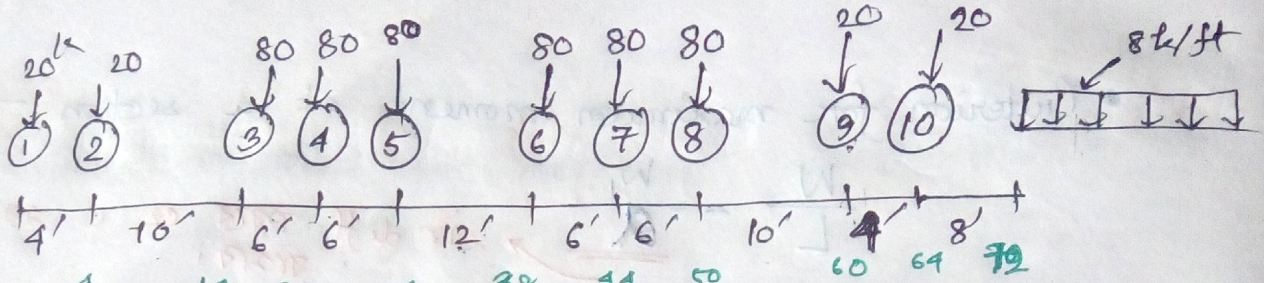
&  ⇒ " " " " " reactions.

Prob-120

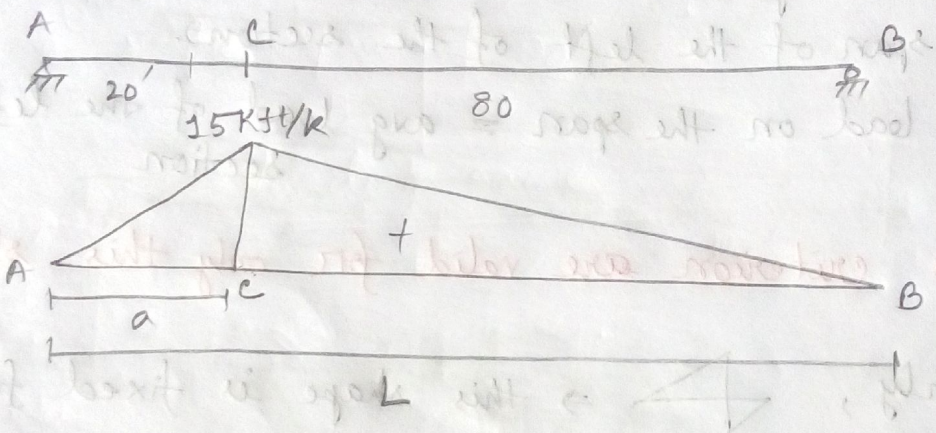
(*) first - এ just right - এ বসাবে then ~~slowly~~ left - এ বসাবে gradually ⇒ যেভাবে right - এ and left > or < opposite ভাবে যে স্থান stop.

⇓

stop - এর পর যে wheel control point - এ ছোঁয় সে load দিবে তা Max^m moment.



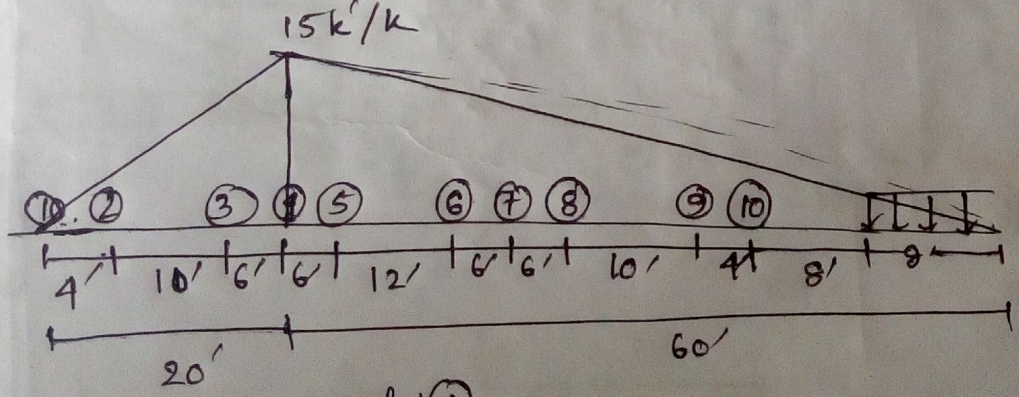
Dul to the Axle load shown, Find max^m moment at quarter point of a simple span of 80'.



Trial No.	Position of wheel	Avg load on span	Avg load on left of sect^n	Remark	Calculation.
I	wheel ② at C				
	just to right	$\frac{540}{60}$	$\frac{20}{20}$	Criterion not satisfied	W = ① to ⑤ W = ① to ⑥ W = ① & ②
	just to left	$\frac{560}{60}$	$\frac{40}{20}$		

Trial No	Position of wheel	Avg. load on the span	Avg load on the left	Remark	Calculation
2	wheel ④ — right	$\frac{624}{80}$	$>$ $\frac{120}{20}$	satisfied	W = ① to ⑩ + 8×8 = 624 W_1 = ①, ②, ③ = 120
	wheel ④ — left	$\frac{604}{80}$	$<$ $\frac{180}{20}$		W = ② to ⑩ + 8×8 = 604 W_1 = ② to ④ = 180
2	wheel ③ — right	$\frac{576}{80}$	$>$ $\frac{40}{20}$	Not sat	W = ① to ⑩ + 8×2 = 576 W_1 = ① & ② = 40 k
	wheel ③ — left	$\frac{576}{80}$	$>$ $\frac{120}{20}$		W = ① to ⑩ + 8×2 = 576 W_1 = ①, ②, ③ = 120

Hence wheel ④ at c (quarter point) give maximum moment for Axle load.



$$\therefore \text{Max}^m M \text{ for Axle load} = \frac{15}{60}\Big[60\times 80 + 54\times 80 + 42\times 80 + \cdots + \cdots \times 20\Big] + \Big[\Big(\tfrac{1}{2}\times 8\times \tfrac{15}{60}\times 8\Big)\times 8 \text{ k/ft}\Big] + \frac{15}{20}\Big[14\times 80 + 4\times 20\Big]$$

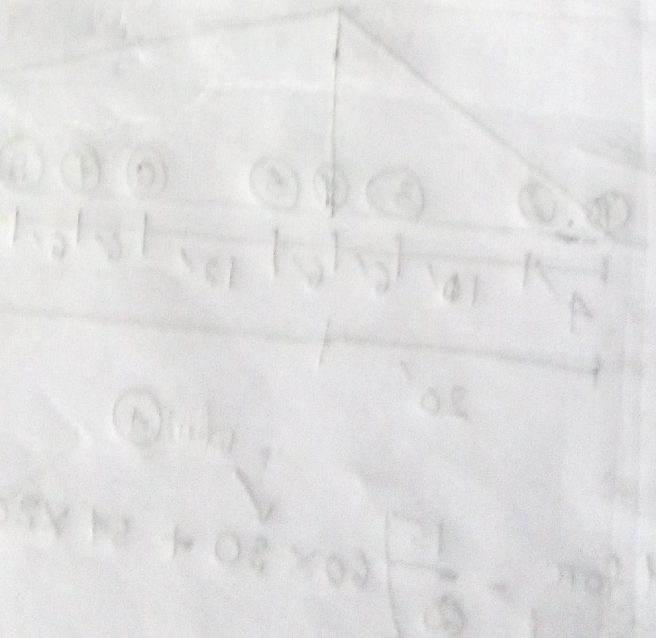
(wheel ④ at the first term; wheel ⑩ at the last term; wheel ③ at the last term; the bracketed area is the area of the IL dia of that portion of UDL.)

$$= 5584 \text{ k-ft}$$

∴ Max^m moment for wheel load = $\frac{5581}{2}$ = 2792 kft.

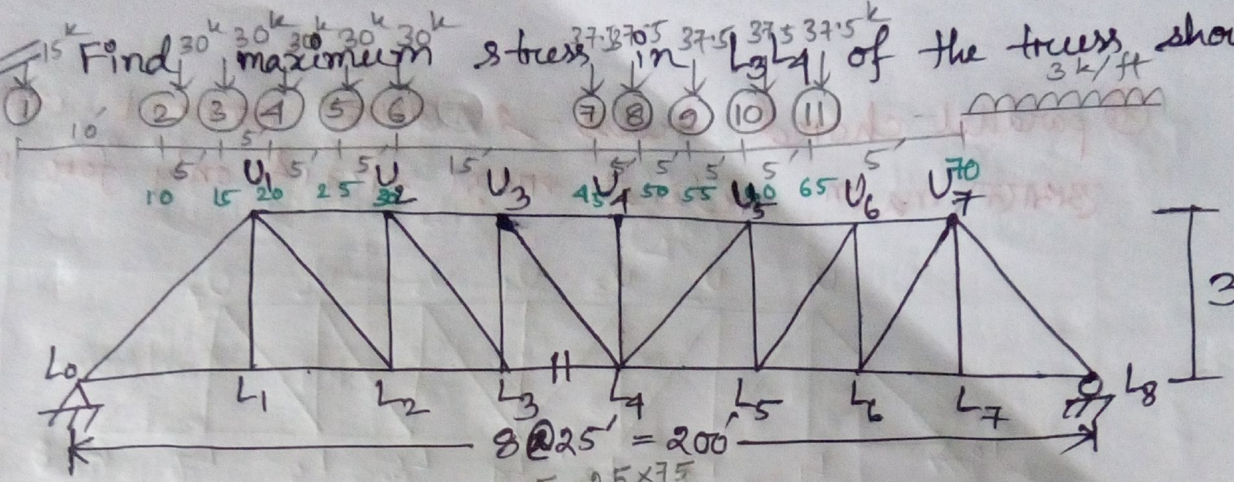
Assgn-2.6

Find max^m moment at ~~quarter~~ one third point of a simple span of 90' if loading same

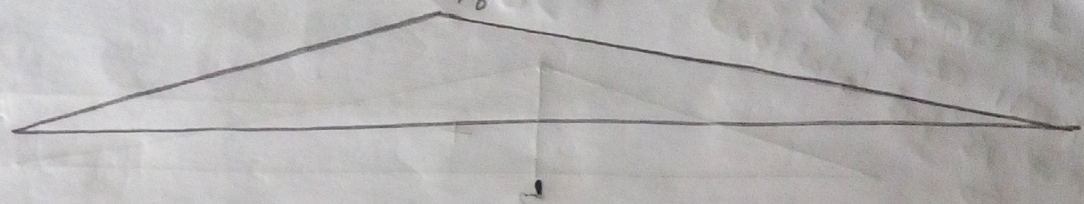


Problem # 221

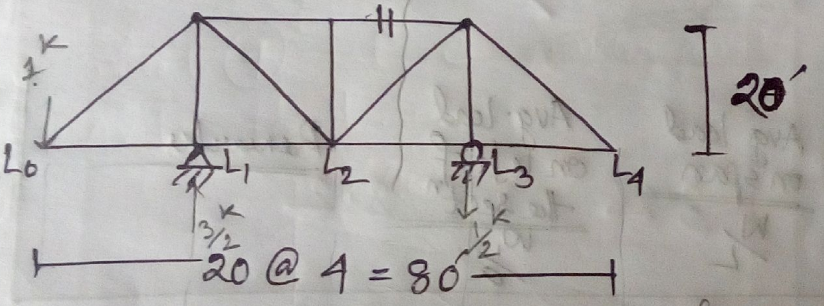
Find maximum stress in L_3L_4 of the truss shown.



$\frac{5}{8} \times 25 \times 75$



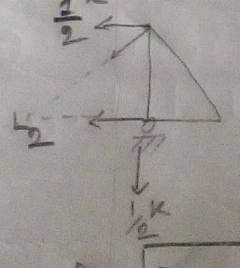
Assignment-27



Draw IL dia for U_2U_3 and L_1L_2 and U_1L_2

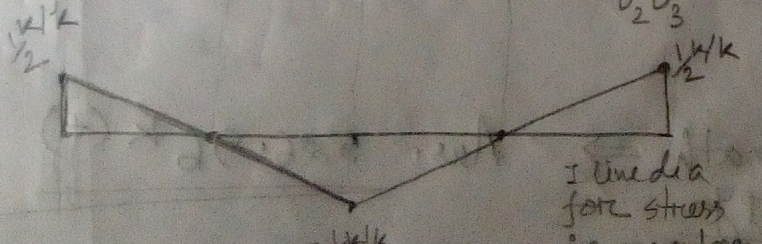
only member এর মানে stress/ bar force এর জন্য cz এখানে moment / shear নাই

(*) first এ 1^k L_0 এ then gradually L_1, L_2, L_3, ... এ বসাব।



$\Sigma H_{L_2} = 0 \Rightarrow$ $F_{U_2U_3} \times 20 - \frac{1}{2} \times 20 = 0$ —— (1)

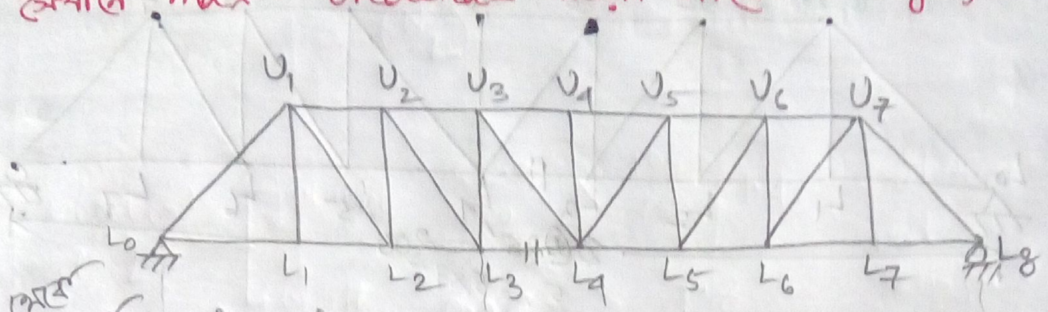
$\Rightarrow F_{U_2U_3} = \frac{1}{2}$ (+)



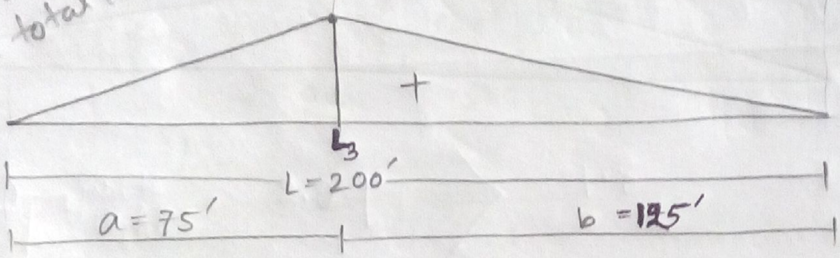
I line dia for stress in member U_2U_3

(*) force বের করে then first এ 1^k যেখানে বসালাম ওখানেই বসাব

※ parallel chord truss → এখানে moment বেশি হবে সেখানে max^m ordinate পাওয়া যাবে। & only for || members.



※ এখানে 1 থেকে start করলে অনেক time লাগবে। cz left → total span ই 75' but total load length 70' 50 load গুলোকে মোটামুটি middle-এ আনতে হবে for max^m.



* যেদিক থেকে move করালে load বেশি আনতে পারব ওদিক থেকে move করাব। for this problem B থেকে move করাব।

alwz $a \leq b$ ⇒ most imp.

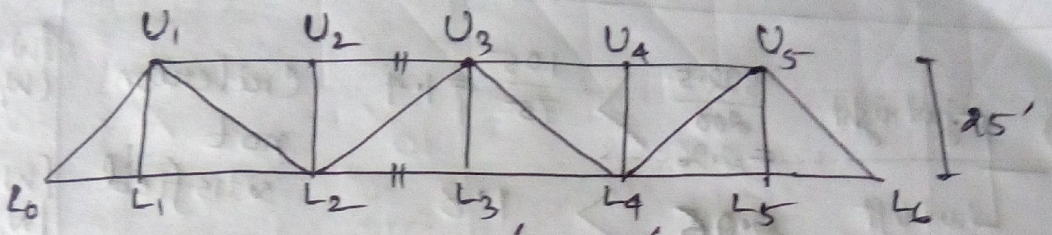
Trial No

No	Position of wheel	Avg load on span W/L	Avg. load on left of the sect^n W_1/a	Remarks
1	wheel ⑤ at L_3	[		

W = wheel ① to wheel ⑪ + 80' of UDL =

Complete the math in CW copy ⇒ Ans. 526.96^k (+)

Assignment-28



6 @ 20' = 120'

Find max^m stress in member-

a) U_2U_3

b) L_2L_3

Loading (same as before)

$\Sigma M_{U_3} = 0$

$\rightarrow \frac{85}{8} \times 75 = F_{L_3L_4} \times 36$

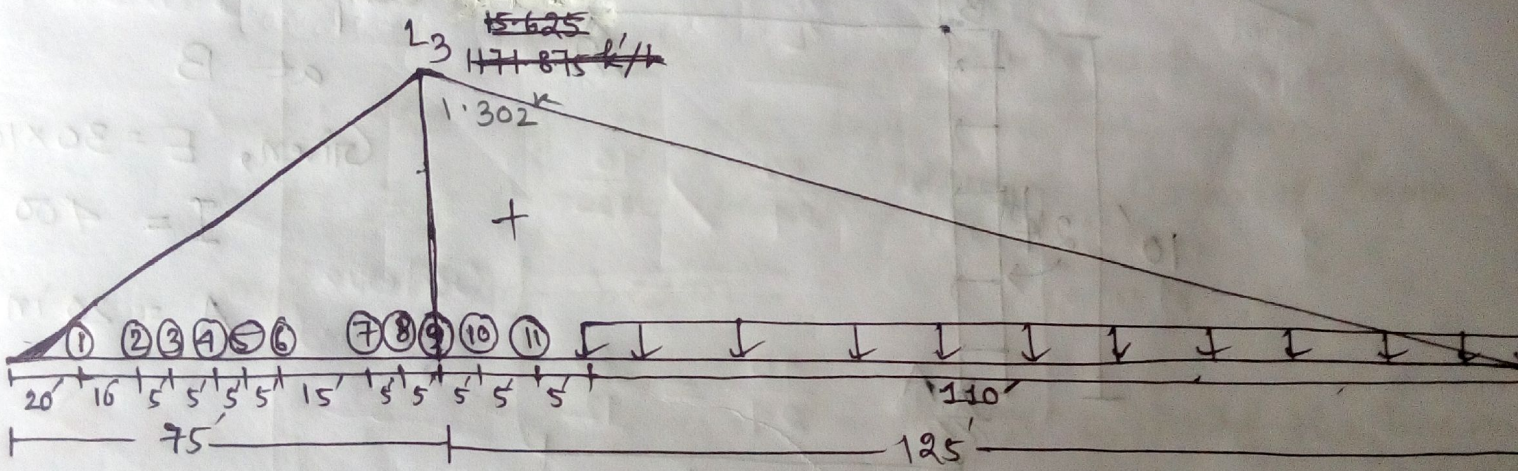
$\Rightarrow F_{L_3L_4} = 1.302^{k}$

352.5

Trial No	Position of wheel	Avg load on span (W/L)	Avg load on left of the seat (W_1/a)	Remarks	Calculation
1	wheel ⑤ at L_3 — just right	$\frac{592.5}{200} = 2.96$	$> \frac{105}{75} = 1.4$	Criterion not satisfied	W = wheel ① to ⑪ + 3 × 80 = 592.5 W_1 = ① to ④ = 105
	just left	2.96	> 1.8		W = ① to ⑪ + 3 × 80 = 592.5 W_1 = ① to ⑤ = 135
2	wheel ⑥ at L_3 — just to right	3.04	> 1.8		W = ① to ⑪ + 3 × 85 = 607.5 W_1 = ① to ⑤ = 135
	just to left	3.04	> 2.2		W = ① to ⑪ + 3 × 85 = 607.5 W_1 = ① to ⑥ = 165
3	wheel ⑦ at L_3 — just to right	3.26	> 2.2		W = ① to ⑪ + 3 × 100 = 652.5 W_1 = ① to ⑥ = 165
	just to left	3.26	> 2.7		W = ⑥ to ⑪ + 3 × 100 = 652.5 W_1 = ① to ⑦ = 202.5
4	wheel ⑧ at L_3 — just to right	3.3	> 2.7		W = ① to ⑪ + 3 × 105 = 667.5 W_1 = ① to ⑦ = 202.5
	just to left	3.3	> 3.2		W = 667.5 W_1 = ① to ⑧ = 240

Trial No	Position of wheel	Avg load on span $\frac{W}{L}$		Avg load on left of the sect^n $\frac{W_1}{a}$	Remarks	Calculation
5	wheel ⑨ at L_3 — just to right	3.4	>	3.2		W = ① to ⑪ + 110 = 682.5 W_1 = ① to ⑧ = 210
	just to left	3.4	<	3.7		W = 682.5 W_1 = ① to ⑨ = 277

∴ wheel ⑨ at L_3 gives max^m moment.



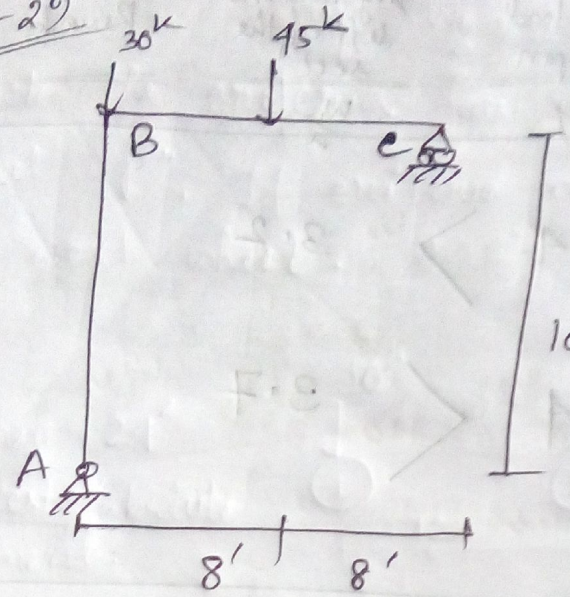
Max^m bar force moment = $\frac{171.875}{125}$ [1.302 (125 × 37.5 + 120 × 37.5 + 115 × 37.5)] + $\left(\frac{1}{2} \times \frac{171.875}{125} \times 110 \times 110\right) \times 3$

+ $\frac{171.875}{75}$ [1.302 (70 × 37.5 + 65 × 37.5 + 50 × 30 + 45 × 30 + 40 × 30 + 35 × 30 + 30 × + 20 × 15)]

= 252773.44 + 1101.56 + 1636 + 90.75 + 94.69

= 5737.56 k 526.92 k (+)

Assignment-29



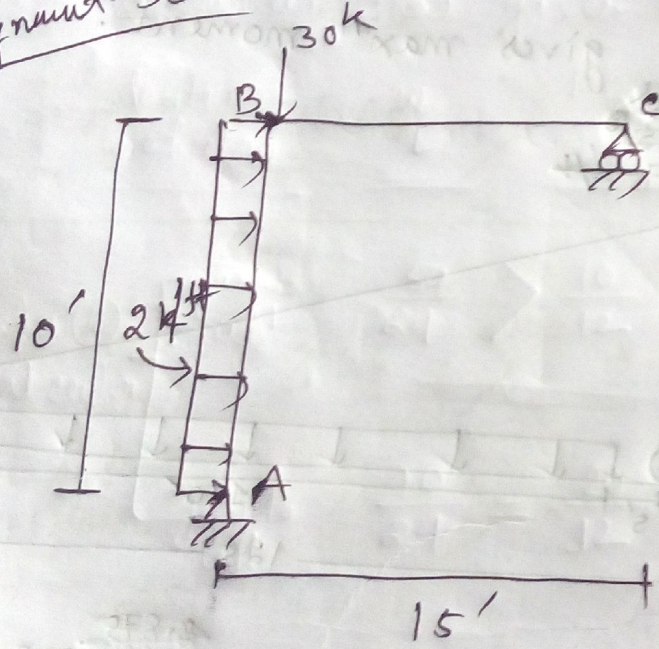
Compute rotation at C

Given, $E = 30,000$ ksi

$I = 400\ in^4$

$A = 20\ in^2$

Assignment-30



Compute hor. deflection at B

Given, $E = 30 \times 10^3$ ksi

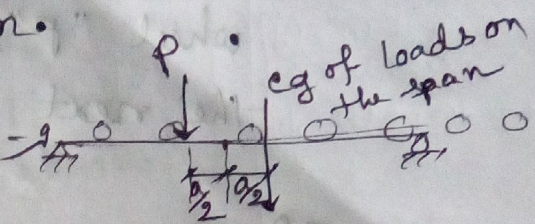
$I = 400\ in^4$

$A = 20\ in^2$

14.11.15

Art # 67 : Greatest Moment or Absolute Moment —

• কোথায় সর্বোচ্চ নির্দিষ্ট নয়, but কোথায় the point/section is unknown.



• তাহলে আমি যেই beam - এ middle - এ BM max^m. But practically exact middle - এ হয় না

⇓

So first - এ identify which load on middle point gives max^m moment, P ??

⇓

Then P should be changed in such a way that the cg of the loads on the span and ~~dist~~ P will be at equal distance from mid point of beam.

(*) P = The wheel that gives max^m moment at center of the beam (mid sect^n)

a = distance bet^n P and cg of the loads on the span.

(*) Procedure —

1. Find the wheel that gives max^m moment at midspan
2. Place this wheel and c.G. of the loads on the span such that they are equidistant from the center line (mid sect^n)

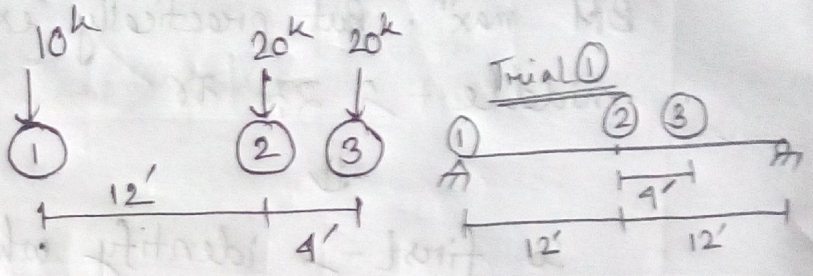
$\frac{W}{L} > \frac{W_1}{a}$ and $\frac{W}{L} < \frac{W_1}{a}$ → a is same as before.

3. Check the criteria for max^m moment under wheel "p". If criteria not OK then try with the next wheel.

Prob #130

Span = 24′

Find greatest / absolute moment.



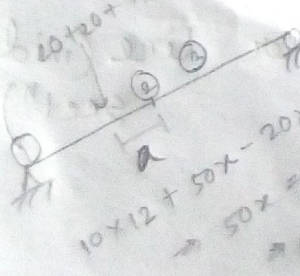
Sol^n :

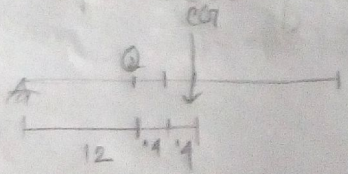
① Find the wheel that gives max^m moment at mid-span.

Trial No.	Position of wheel	$\frac{W}{L}$	$\frac{W_1}{a}$	Remarks	Calculation
1	wheel ② at center, just to right	$\frac{50}{24}$	$> \frac{10}{12}$	Criteria Satisfied	
	just to left	$\frac{40}{24}$	$= \frac{20}{12}$		

∴ p = wheel ②

(*) এখানে $\frac{W}{L}$ এর মান probability ② & ③ i.e. mid point এর right এ বেশি। So we will move P to the left. Then ① will be out of the span.



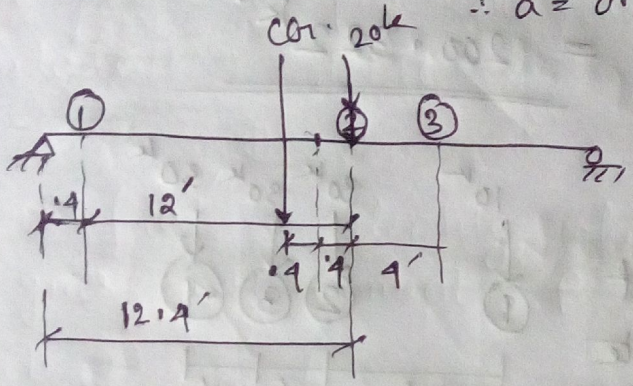


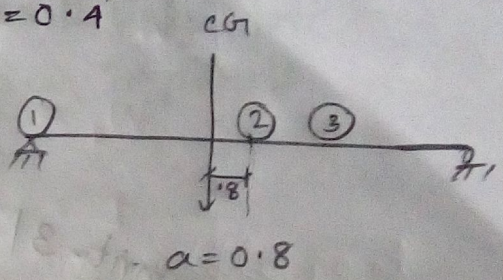
2. Locate cg of loads on the span.

From wheel ③

$$X = \frac{20\times0 + 20\times4 + 10\times16}{20+20+10} = 4.8 \text{ ft.}$$

$\therefore a = 0.8'$ and $a/2 = 0.4'$



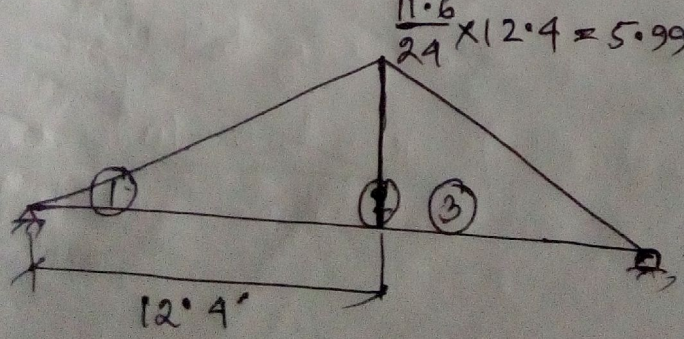


$a = 0.8$

3. $\frac{W}{L} = \frac{50}{24}$

For W_1/a

	W/L	W_1/a	Remarks
wheel ② at 12.4' from the left support; just to right	$\frac{50}{24}$	$\frac{10}{12.4}$	criteria under wheel ② satisfied
just to left	$\frac{50}{24}$	$\frac{30}{12.4}$	



$\therefore$ Greatest moment $= \frac{5.993}{11.6}\left[11.6 \times 20 + 7.6 \times 20\right]$

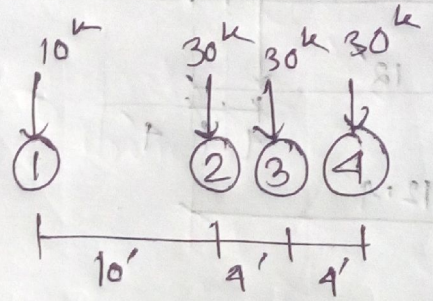
$+ \frac{5.993}{12.4}(10 \times .4)$

$= 200.322^{k'}$

Assignment-3|

Span = 40 ft

Find greatest / absolute moment.

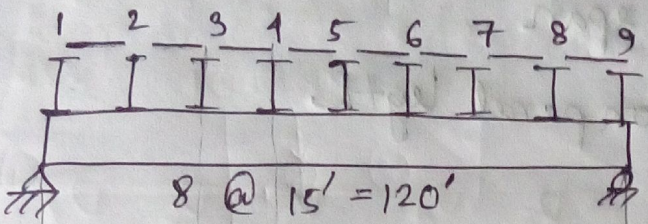


15.11.15

• Art 69

1. Panel shear in Span with floor beams —
2. Max^m Web / Diagonal stress in Truss

(1)



Span with floor beams

Draw I lines for shear in panels 4-5, 2-3,

I line for shear in 3rd panel

V_{3-4}

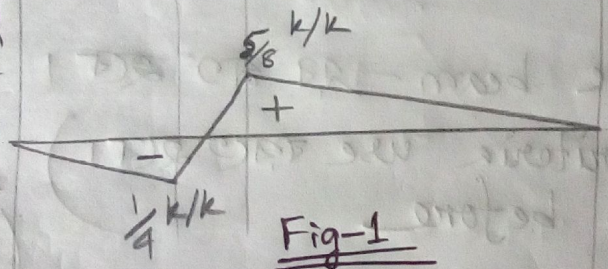
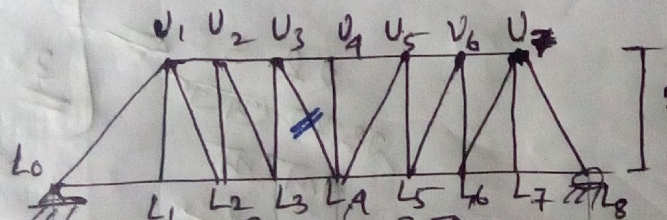


Fig-1

1^k 3 no ∧ वरून left reaction 1/4 k

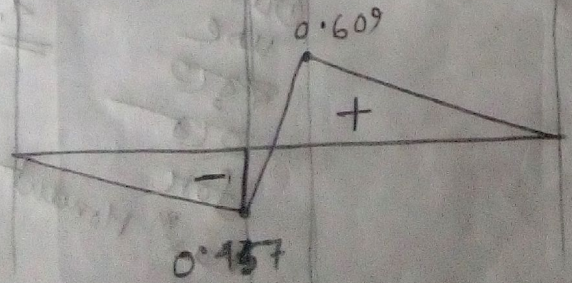
& 1^k 4 no ∧ वरून left reaction is 5/8 k

(2)



Draw I lines for U_2L_3, U_1L_2

⇒ for U_3L_4 ⇒ section → left part & $\Sigma V = 0$



1^k load at L_3

Reactⁿ = 5/8 k

$\Sigma V = 0 \Rightarrow \frac{5}{8}\uparrow - 1\downarrow + F_{U_3L_4} = 0$

$\Rightarrow F_{U_3L_4} = \frac{3/8}{36} \times \sqrt{36^2+25^2}$

$= -0.457$ k/k

1^k load at L_4

$F_{U_3L_4} = .609$ (+) (tension)

- Criteria for max^m panel shear/web stress — (floor beam) (truss)

$$\frac{W}{L} = \frac{W_1}{P}$$ ⇒ just to the right & just " " left

W = loads in span

W_1 = loads on panel length

L = Span

P = panel length.

- At panel point 4 ⇒ Max^m moment = ?

⇓

Moment shape beam — এর মত হবে।

(So ↗ criteria use করতে হবে। as before)

1. Beam Moment
2. Floor Beam reaction in span in floor beam
3. Panel point moment in girder with floor beam
4. Truss chord member

2 & 3. এখান থেকে বলতে same criteria use করতে হবে for Max^m Moment

Problem

Find max^m panel shear in 3rd panel of the span with floor beams (in previous fig-1)

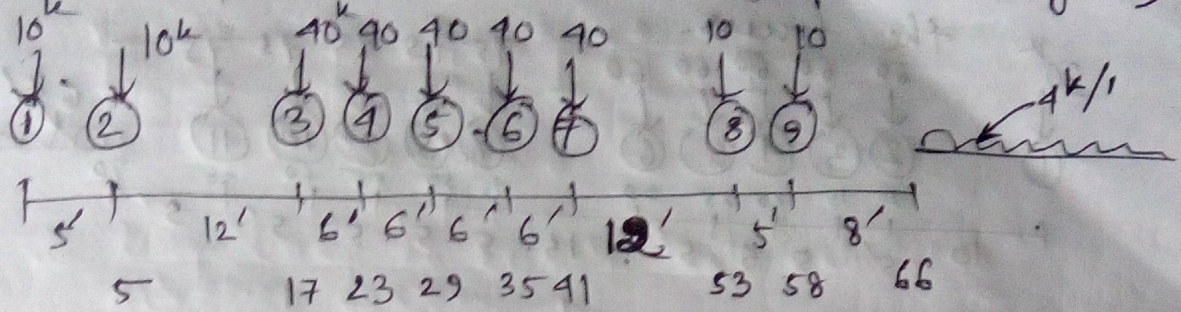
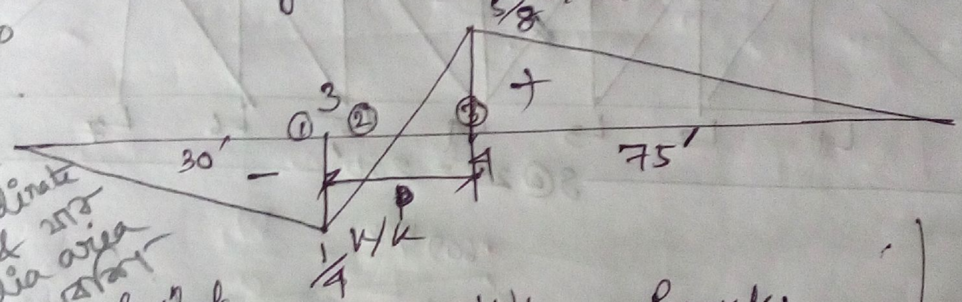


Fig of beam

For this ⇒ Control Point = 4



$\frac{\frac{5}{8}}{\frac{5}{8}+\frac{1}{4}} \times 15 = 10.71'$

$15 - x = 4.29$

& move right to left

load ধরে start করতে হবে ordinate বড় & dia area বড়

Trial No	Posn of wheel	$\frac{W}{L}$		$\frac{W_1}{P}$	Remarks
1	wheel ① at 4 — right	$\frac{276}{120}$	>	$\frac{0}{15}$	
	left	$\frac{276}{120}$	>	$\frac{10}{15}$	

Calculation

W = ① to ⑨ + 4 × 9 = 276^k

$W_1 = 0$

$W = 276^k$

W_1 = ① = 10^k

(*) wheel ③ at 4 gives max^m shear = 122.35 − 3.09 = 119.26^k

Ans: Max^m Panel shear = 119.26^k

Assignment-32

Same loading, 10 @ 15 = 150'

Max^m Panel shear in 5th panel.

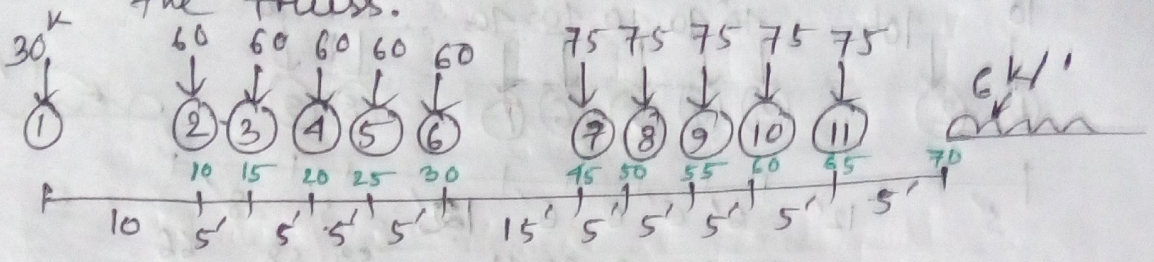
111.08 +
122.35

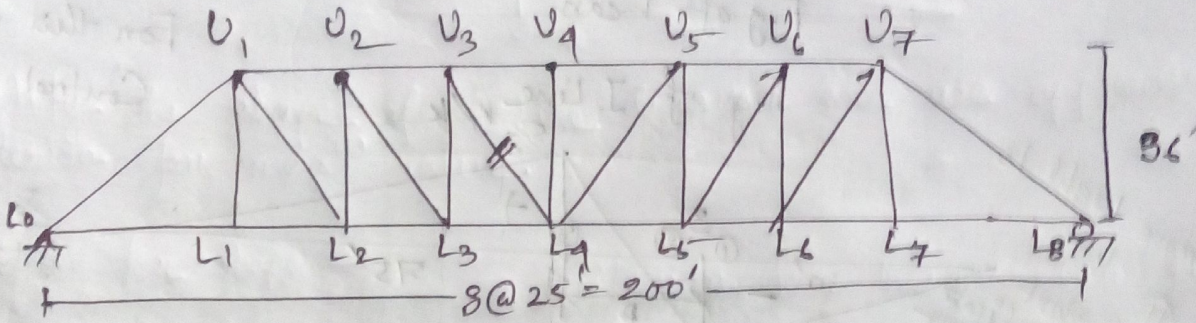
⑤ 38'   ③ 26'
344^k
240^k
50'   2.93   5.8

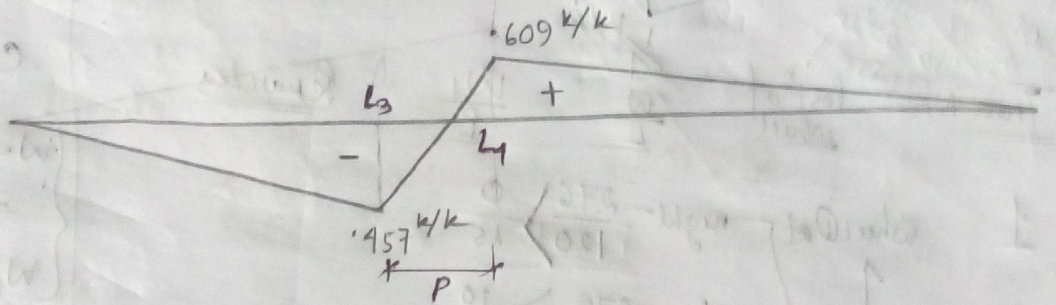
21·11·15

Problem-22

Find ① Max^m tension and ② Max^m Compression in U_3L_4 of the truss.







* For max^m tension, load will start to move through tension dia

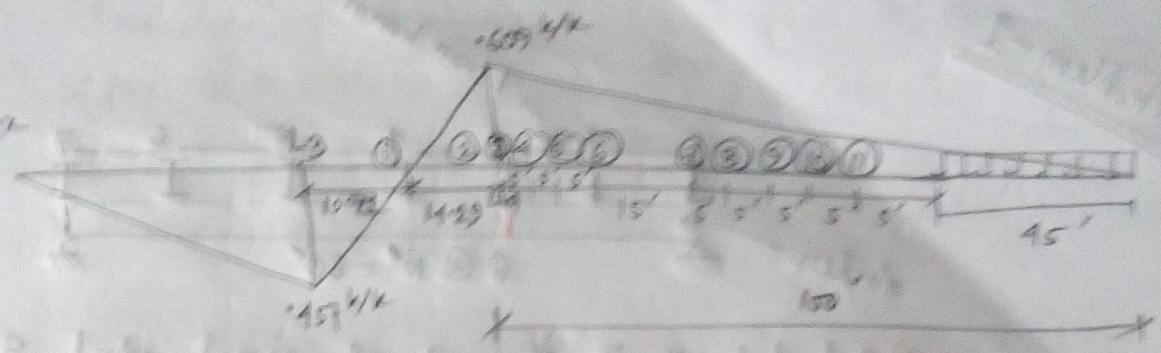
Trial No	Position of wheel	$\frac{W}{L}$	$\frac{W_1}{P}$	Remark
1	wheel ① at L_4	Right $\frac{885}{200} >$	$\frac{0}{25}$	Criteria not satisfied
		Left $\frac{885}{200} >$	$\frac{30}{25}$	
2				
3	wheel ③ at L_4	Right $\frac{975}{200} >$	$\frac{90}{25}$	Satisfied
		Left $\frac{975}{200} <$	$\frac{150}{25}$	

Calculation

$W = ① \text{ to } ⑪ + 30 \times 6 = 885'$

$W_1 = 0$

$W = 885'$, $W_1 = 30^k$ (wheel ①)



$$\therefore \text{Max}^m \text{ tension} = \frac{.609}{100}\left[60\times100 + 93\times60 + 90\times60 + \cdots + 50\times75\right]$$

$$+\left(\frac{1}{2}\times45\times\frac{.609}{100}\times45\right)\times6^{k/'} + \frac{.609}{14.29}\left[60\times9.29\right]$$

$$-\frac{.457}{10.71}\times30\times.71$$

$$= 332.07^k \text{ for axle load}$$

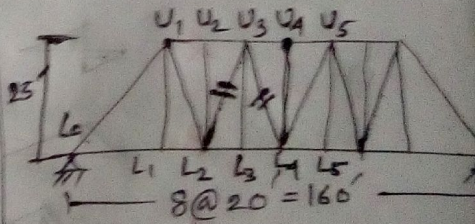
$$= \frac{332.07}{2} \text{ for wheel load}$$

② → Include in class note

Max^m Comp $= 195^k$ for axle load

& $\frac{195^k}{2}$ " wheel "

Assignment - 33



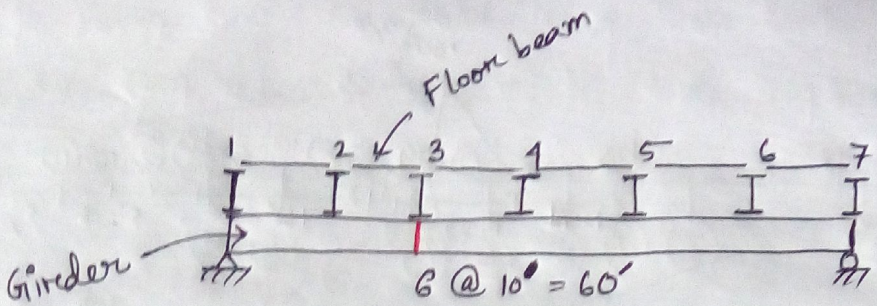
① Max^m Comp U_3L_4

② Max^m Ten. in L_2U_3.

CT
29.11.15 ⇒ 1 to Assignment 33

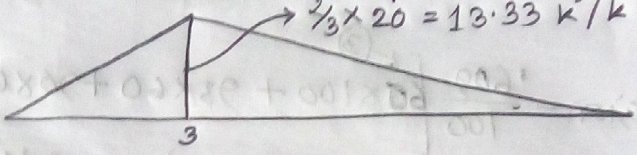
28.11.15

Problem-1



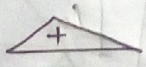
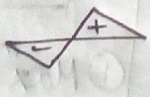
a) Calculate Max^m Moment at panel point 3.

① Draw I.Line diagram



② Identify the shape of I Line diagram and use approximate criterion for max^m value.

Criteria for shapes —

1. 
2. 
3. 
4. 

So criterion for this problem is—

$$\frac{W}{L} = \frac{W_1}{a}$$

b) Calculate max^m floor beam reaction at "3"

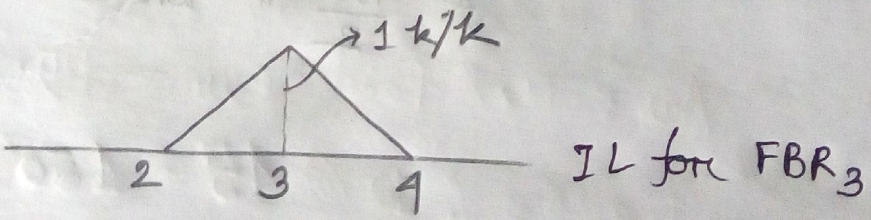


Fig-1

c) Calculate Max^m stress in U_3L_3

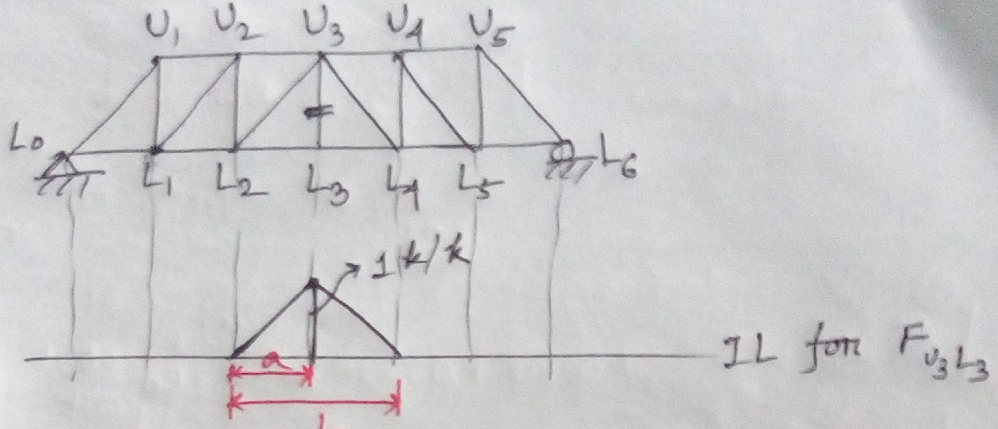
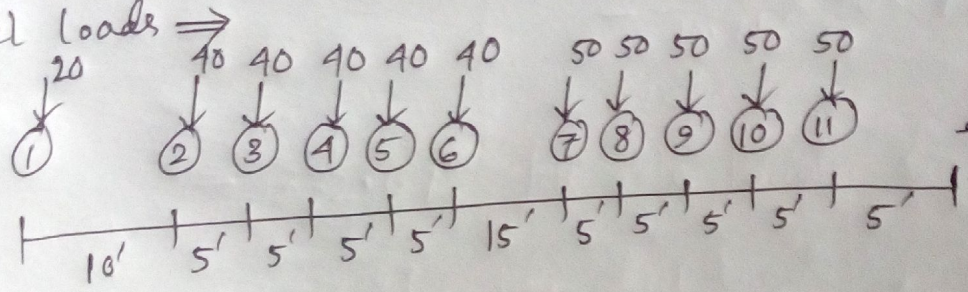
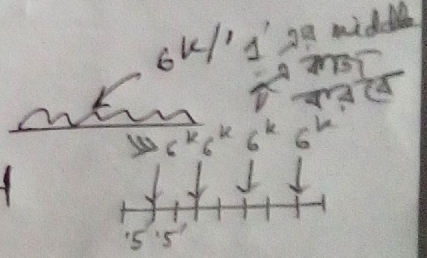


Fig-2

So criteria will be same $\Rightarrow \frac{W}{L} = \frac{W_1}{a}$

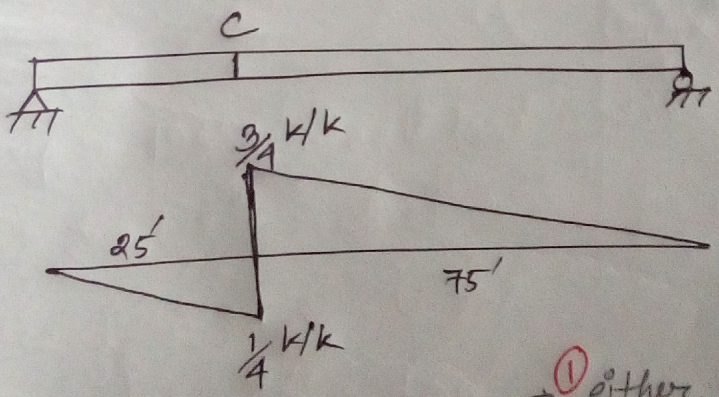
Wheel loads $\Rightarrow$





Assgn-34

Q-2 Calculate max^m shear at ~~dis~~ quarter point of 100' simple span ~~of floor beam with girder~~



for UDL

$$\Delta V = \frac{\Sigma Pd}{L} - P_1 + \frac{P'e}{L} + \frac{P_2 e'}{L}$$

$\Rightarrow$ ① either প্রতিটা 6k, 1' এর middle এ থাকা অবস্থায় বসিয়ে হিসাব করব।

② Suppose 6' UDL travel করল So total load = 36k acts at 3' (middle)

$\Downarrow$

i.e. 3' $\Leftarrow$ So actually এর total 36k load এটা travel করল