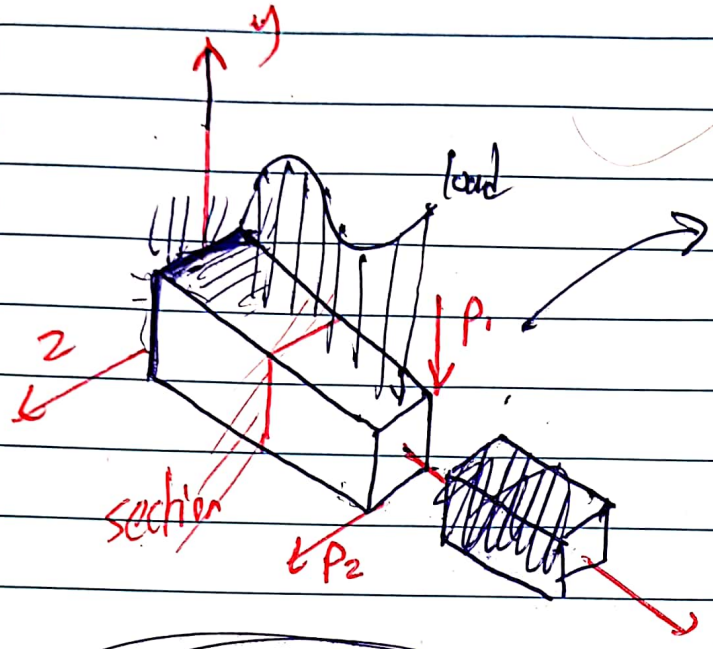
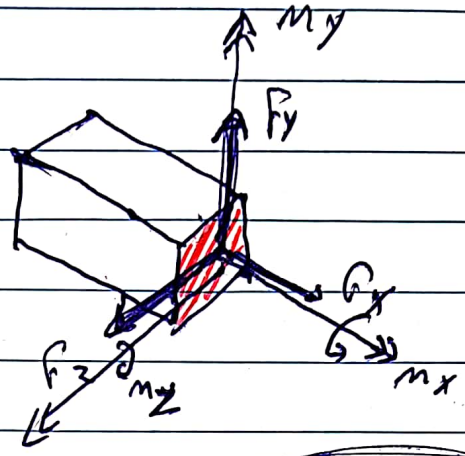
Internal Forces





F_x = normal Force (N)
axial force

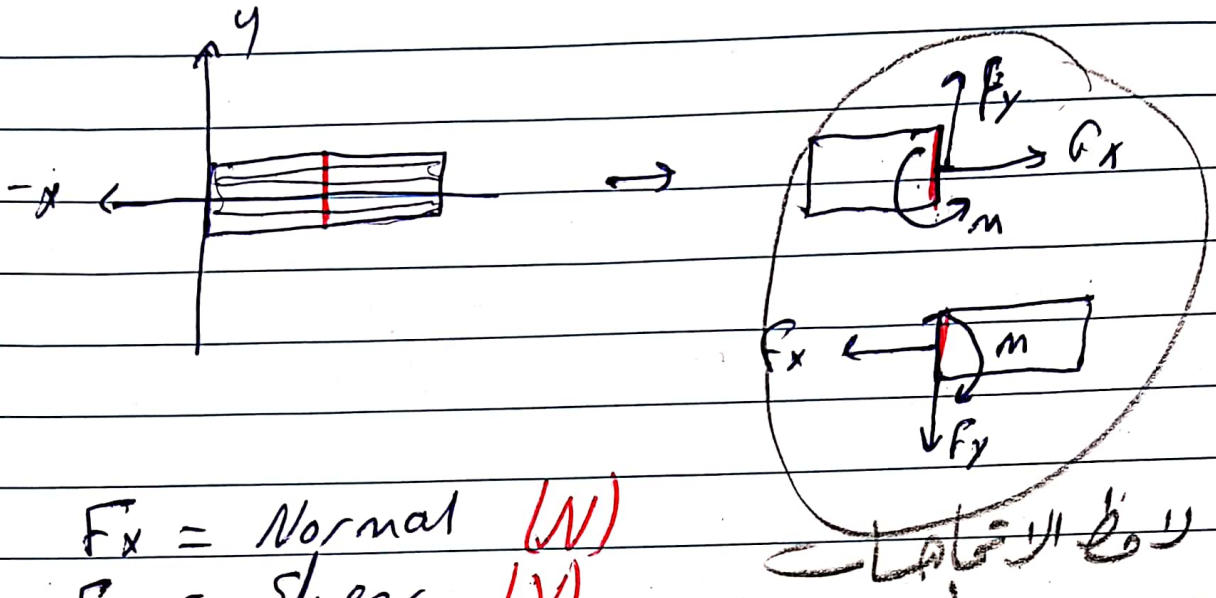
F_z, F_y } shear force on the plane of section not axial (V)

M_x = twisting moment (T)

M_z, M_y } Bending moment (M)

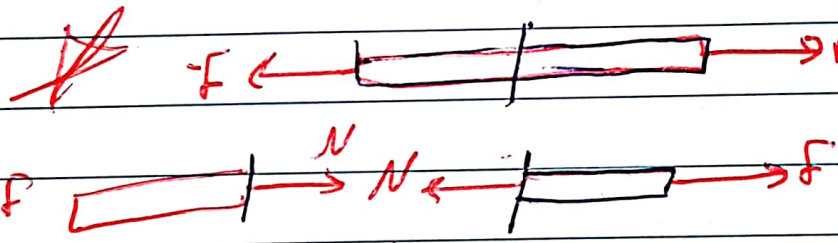
The Internal Forces in 3D

internal forces in 2D



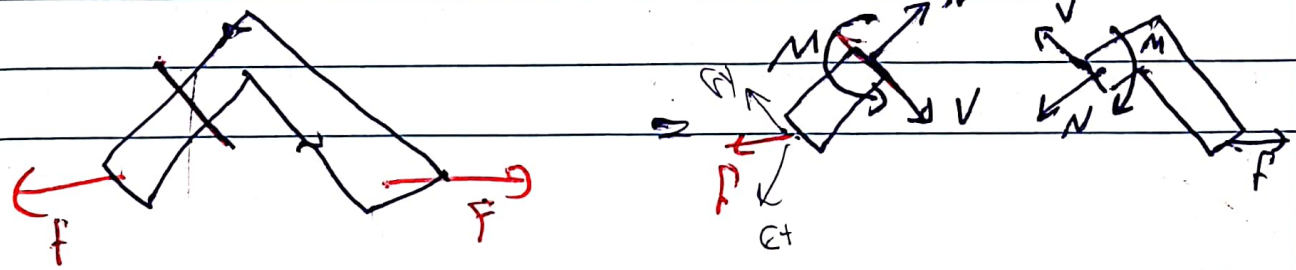
F_x = Normal (N)
F_y = Shear (V)
M = Bending moment (M)

لازم الاتجاهات

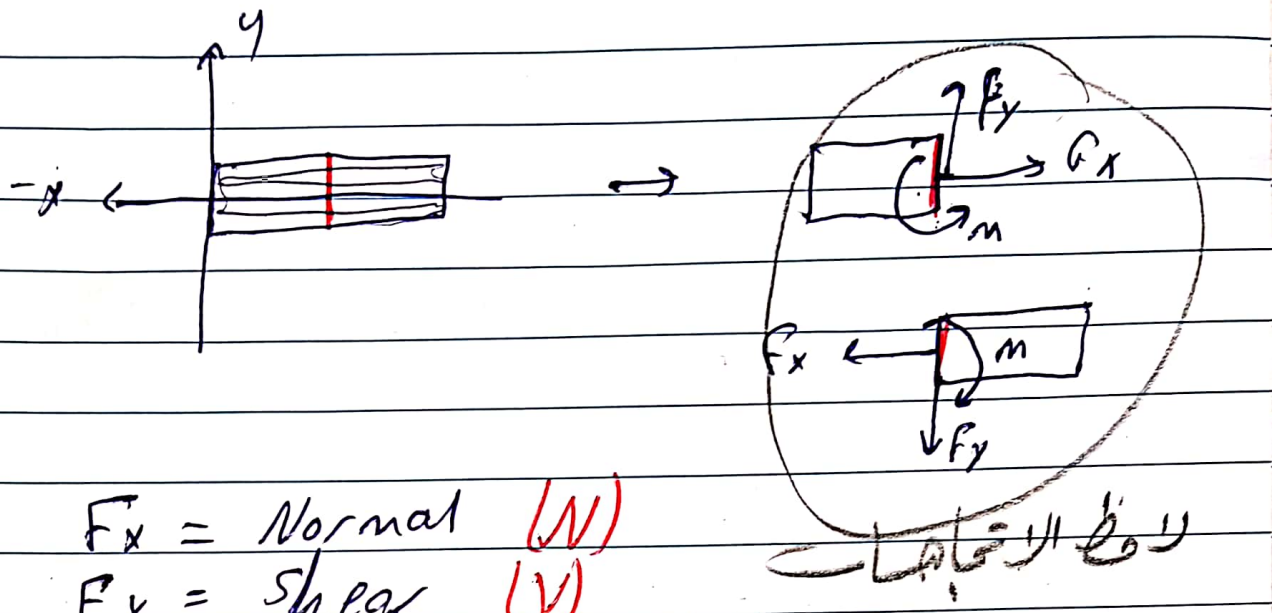


|N| = |F| for any stright 2-force member

if the 2-force member is not straight then you need to have (N) & (V) & (M) not only (N)



internal forces in 2D

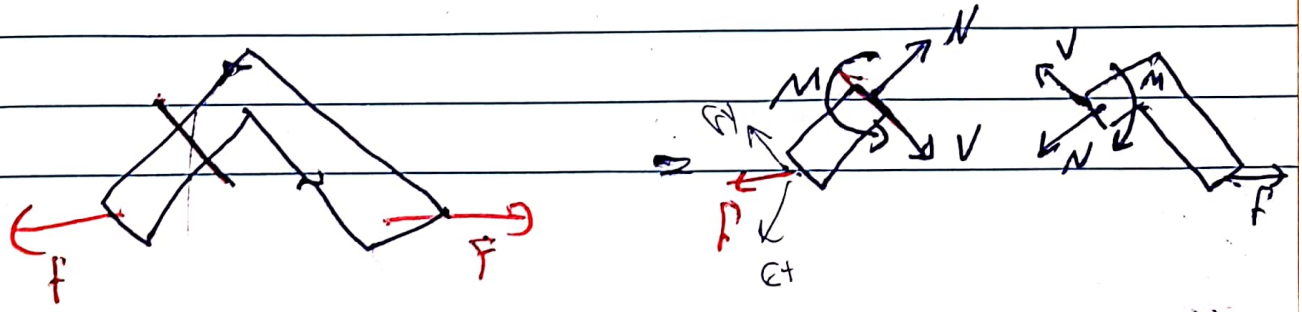


لاحظ الاتجاهات

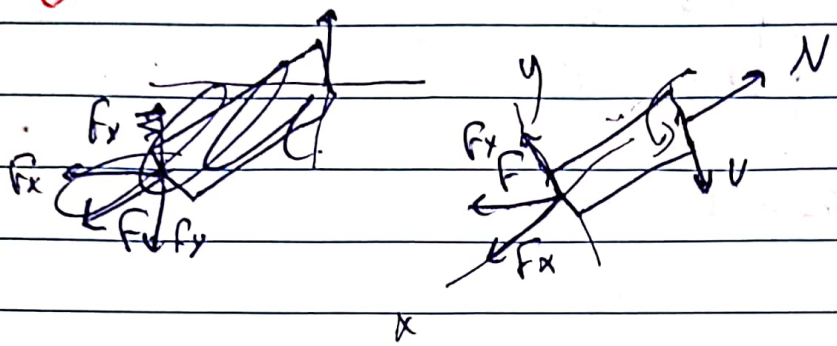
F_x = Normal (N)
F_y = Shear (V)
M = Bending moment (M)

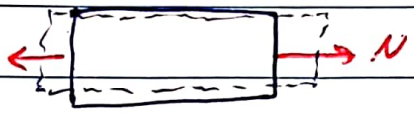
|N| = |F| for any stright 2-force member

if the 2-force member is not straight then you need to have (V) & (N) & (M) not only (N)

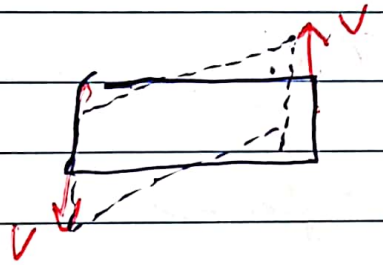


you can change (x / y) axes directions as you want

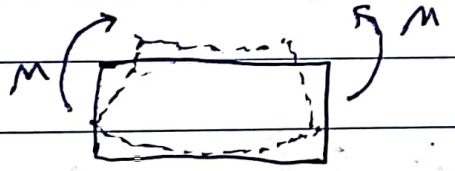




التشوه الناتج عن Normal
تطويل الجسم



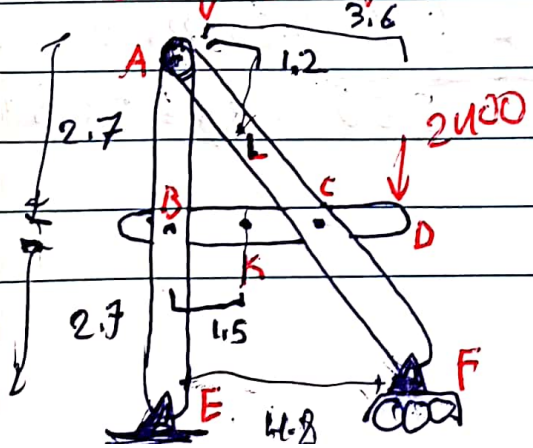
التشوه الناتج عن shear
قص



bending moment deformations

internal forces = forces + moment
$\vec{V} + \vec{N} + \vec{M}$

Sample 7.1



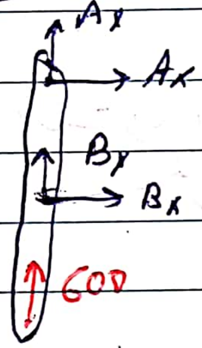
Find the internal Forces (a) in member ACF. at point j and (b) in member BCD at k

solution

Find reactions : $E_x = 0$, $E_y = 600 \uparrow$, $F_y = 1800 \uparrow$ ✓

we got 3 members each with 2 unknowns

ABE



$\Sigma F_x = 0 \rightarrow A_x = -B_x$

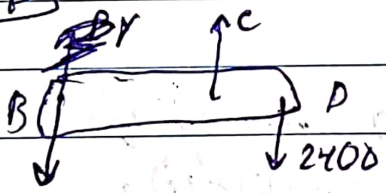
$\Sigma M_A = 0 \Rightarrow B_x = 0$ ✓

$A_x = B_x = 0$

$A_y + B_y = -600 \uparrow$

BD

تنساش تقلب الاتجاهات تحت
شوية (3)



C is upward because this is 3 force member 2 forces are parallel the third is parallel

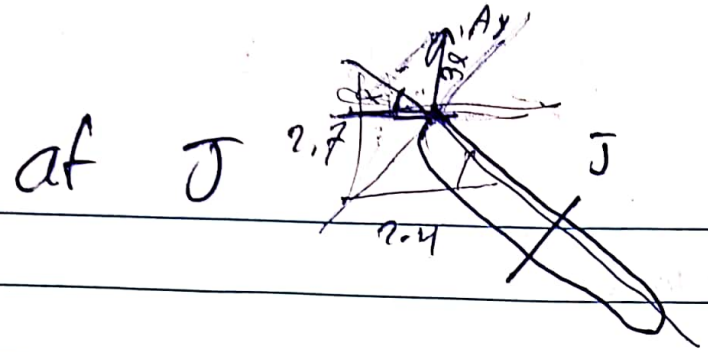
$2400 + B_y = C_y$

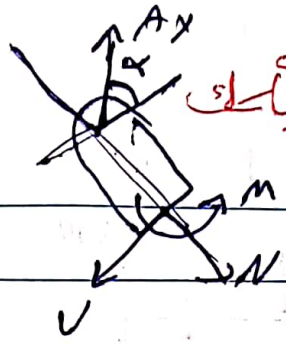
$\Sigma M_C = 0 \rightarrow B_y = ?$

$2400 * \left(3.6 - \frac{4.8}{2}\right) = B * 2.4$

$B_y = 1200$ $C_y = 3600$

$A_y = -1800$





انتبه الاتجاهات اهم حاجة بالسؤال

$$A_y * \cos\alpha = V$$

$$-1800 * \frac{2.4}{\sqrt{2.4^2+2.7^2}} = 1196\ N = V$$

$$A_y * \sin\alpha = N$$

$$1800 * \frac{2.7}{\sqrt{2.4^2+2.7^2}} = 1345 = N$$

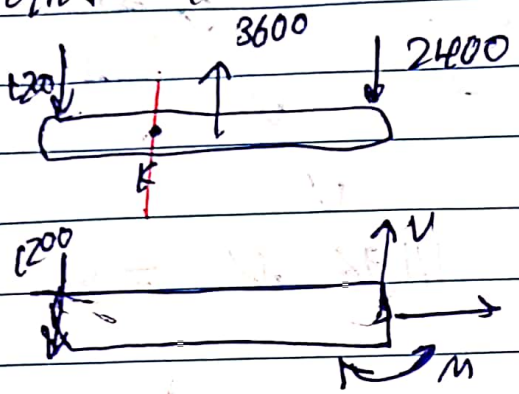
$M_{net}=0 \rightarrow \Sigma M_O = 0$ نأخذ عند النقاط المراد حساب BM عندها وذلك لأننا قد نحتاج قيم N / V

$$A_x * 1.2M + M = 0$$

$$M = +2160\ N.M$$

- عند القاطع نأخذ بعشة عودي
- قبل القاطع لازم نوجد الكريا تشة على القطعة
- عند العمل على اقد القاطع القطعة الأخرى تعطي نفس الاشوية بعكس الاتجاه

Point C



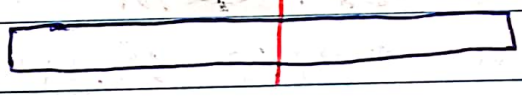
$+1200 = V \;/\; F = 0 \;/\; M = 1200 \times 1.5$

$= -1800\ N.m$

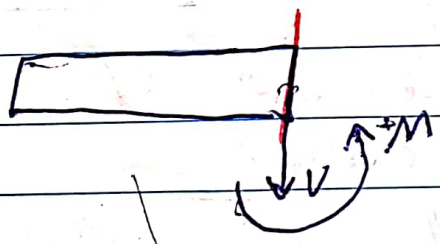
Beams

Positive sign conversion

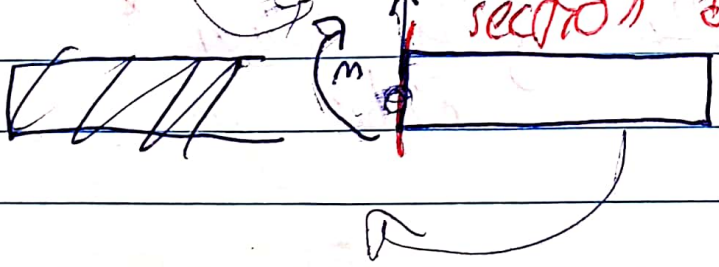
section



section on the right [V ↓] [M ↺]

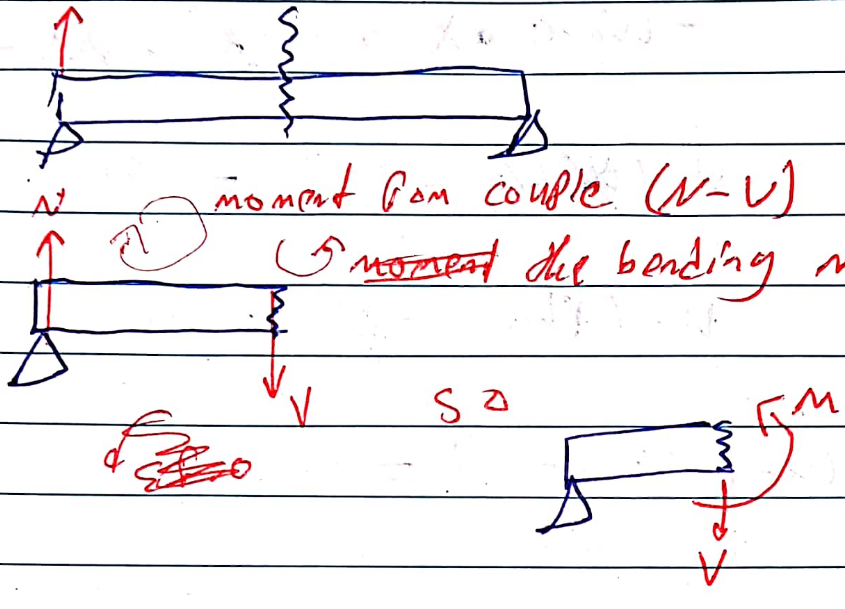


section on the left

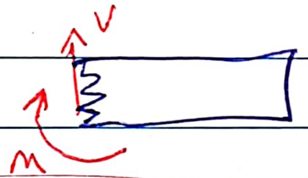


Positive sign للأشكال

لا فقط طريقة حل بدونه فقط

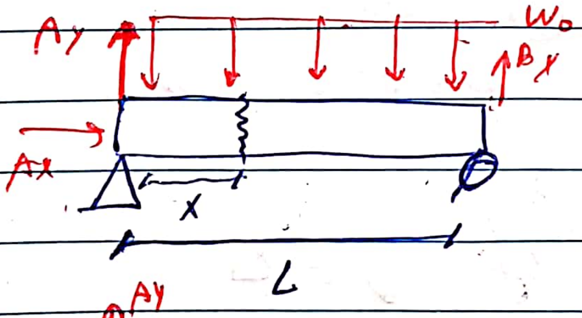


and the opposite of the other part

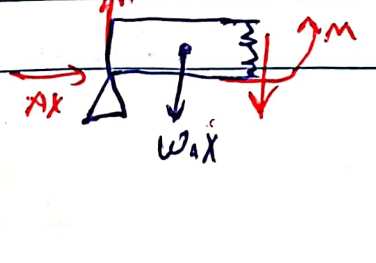


اذا كانت ~~?~~ (M) or (V) سالبة
اذن هي عكس positive s.c

نستخدم الـ equivalent force الخاصة بالوزن الموزع
فقط لايجاد الـ reactions ثم لا ~~?~~ نعتبرها كذلك
مرة أخرى لانه الـ internal forces تتأثر بتوزيع القوى

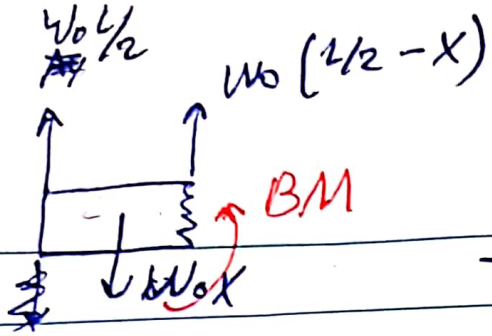


$A_x = 0$ $\quad A_y = B_y = \frac{w_0 L}{2}$



$\Sigma F_y = 0 \rightarrow \frac{w_0 L}{2} - w_0 x - V = 0$

$V = w_0\left(\frac{L}{2} - x\right)$



$\Sigma M_{section} = 0$

$$-w_0 L/2 \cdot x + \frac{w_0 x^2}{2} + M = 0$$

$$w_0\left(L/2 - \frac{x^2}{2}\right) = M$$

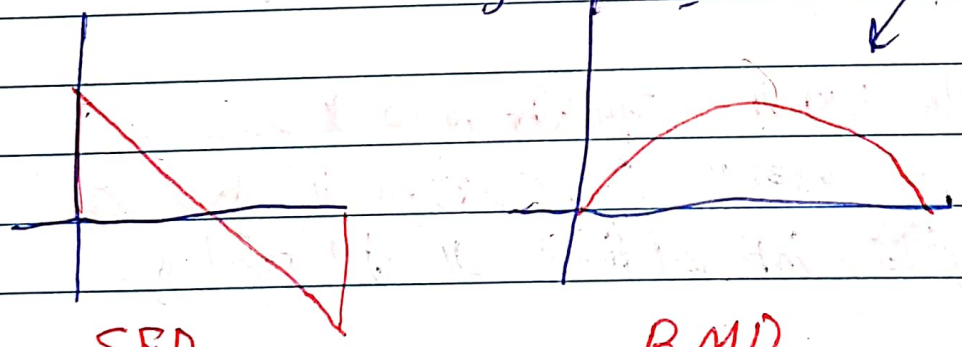
$$w_0\left(L/2 - \frac{x^2}{2}\right) = M$$

$$\frac{dM}{dx} = w_0(L/2 - x) = V$$

$$\frac{dM}{dx} = V \quad / \quad \frac{dV}{dx} = w_0(-1)$$

$$\frac{dV}{dx} = -w_0$$

دوماً نبدأ بـ 0 وننتهي بـ آخر



SFD
shear force diagram

BMD
Bending moment diagram

Min / Max moment at $V = 0$

$\frac{dM}{dx} = 0$ always if the diagram is differentiable

always they ask for max shear / moment

that means max ever negative or positive

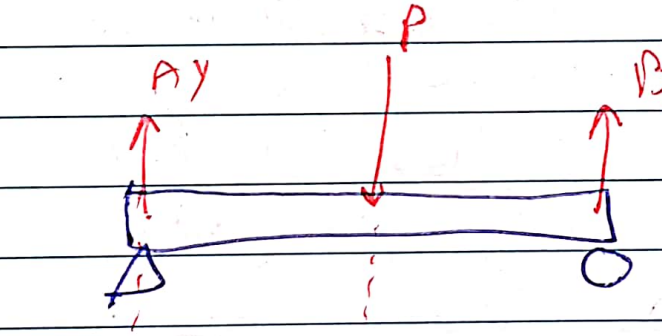
$|V|_{max}$ / $|M|_{max}$ abs. value

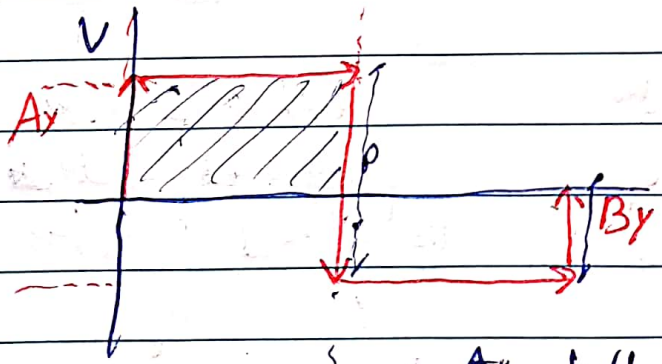
V_{max} يتأثر بسبب الـ shear عند الأطراف

M_{max} " " الـ moment في المنتصف

For complicated loads we need to draw the diagrams

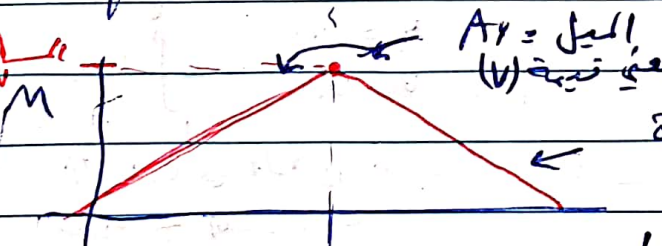
for not destributed forces ! (consentrated)





لازم نرجع للصفر

طالما خط ثابت إزاي المومنت خط مائل



المومنت عند أي نقطة (x') = المساحة تحت منحنى (V) من x=0 → x'

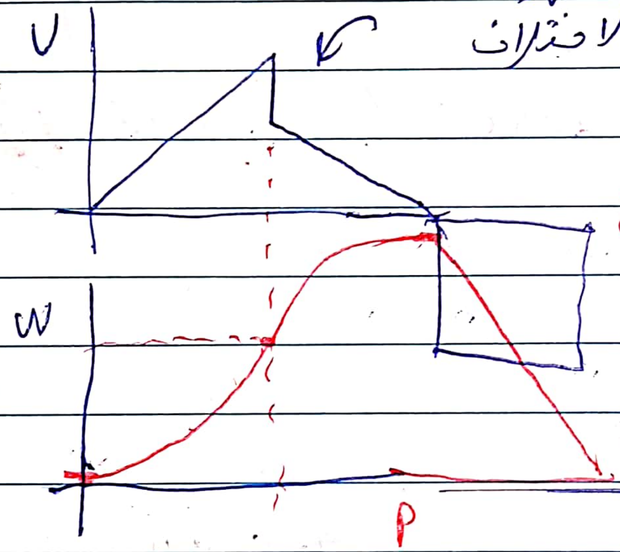
~~رسم المومنت دايا~~

* slope of moment diagrame = (V) at this point

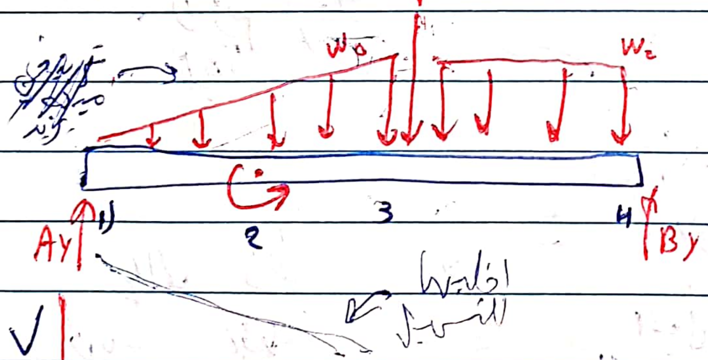
* moment value = Area under V diagram
  only for beams with no consentrated moments

* Moment change between two points = Area under (V) diagram between the two points
  for consentrated moments

مكان الانقطاعات

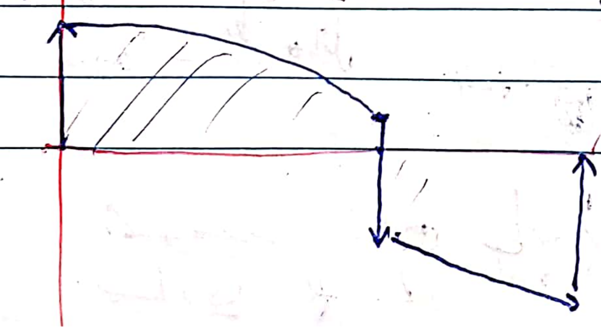


عندما الـ shear علاقة خطية المومنت تربيعية لان هنا الميل والقيمة النهائية.



بين (1) و (2) اللود فقط مستقيم بتزايد !

$V_{12} = -\int_1^2 load$



$V_1 = A_y$

$V_2 - V_1 = -\int_1^2 load$

= الزيادة في الشير سالب المساحة

الميل متزايد لكنه لانها اننا نضرب بسالب لذلك هو متناقص

شرح رسمة الـ shear عند (1) نرفع مقدار الـ (consentrated force) للأعلى

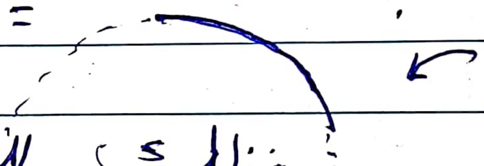
عند (2) لا يوجد اختلاف

بين (1) و(3) نتذكر انه $V_{13} = -\int_{1}^{3} w\,dx$

اي انه $V_3 - V_1 = -$ (المساحة)

كما اننا لتسهيل الرسم نقلب الـ w بالاتجاه لنعرف كيف نرسم الـ shear

$w \rightarrow$  $\Rightarrow -w =$ 

$V \rightarrow -\int w\,dx = \int -w\,dx =$ 

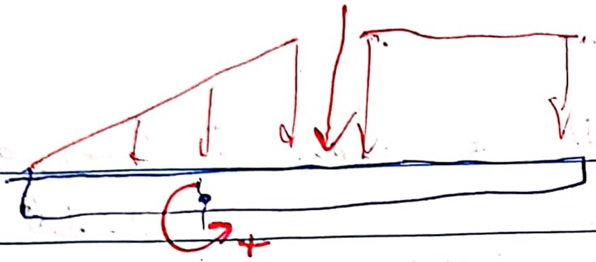
وذلك للتأكد من الميل والرسم نأخذ المقدار من المساحة

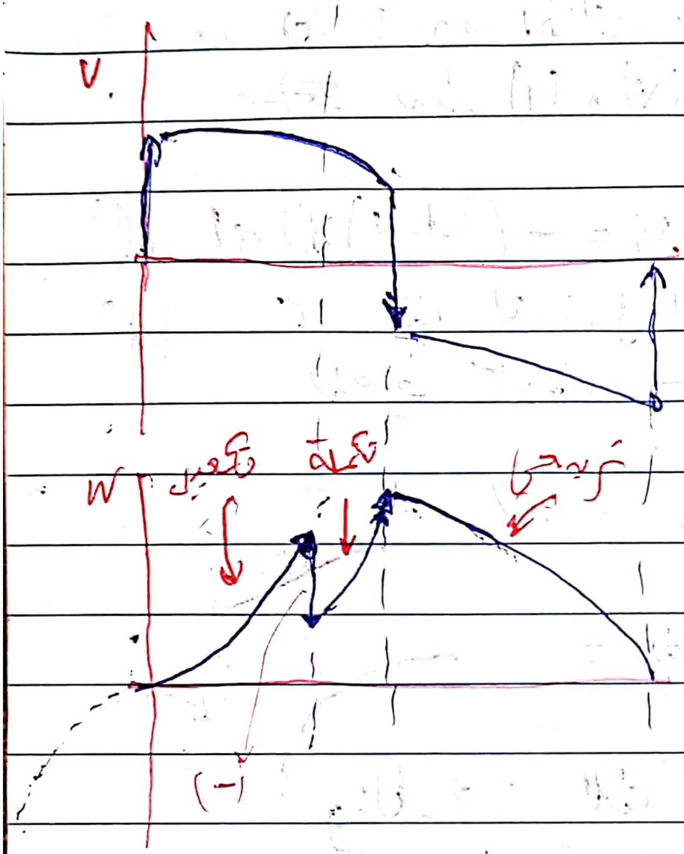
عند النقطة (3) ننزل بمقدار الـ (consentrated force) وننزل مع اتجاهها

بين النقطة (3) و(4) يزداد الـ shear بمقدار سالب المساحة والميل = مقدار الـ ~~…~~ الـ load بالسالب

عند النقطة (4) نرفع مقدار الـ cons. force

ويجب انه يعود للصفر





when there is a cons moment the bending moment is in the oposit direction

ماذا لو طلب

المومنت عند (٧)

I) المساحة تحت منحنى (V) من (١) إلى (٢)

II) نطرح المنزول في الـ moment عند النقطة (٢)

III) نجمع المساحة بين (٢) و(٣)

(يعني المساحة كاملة

consentrated ال +)

(1) $\Delta V_{ac} = V_c - V_a = -A_{(x=c \to A)}$ in load diag

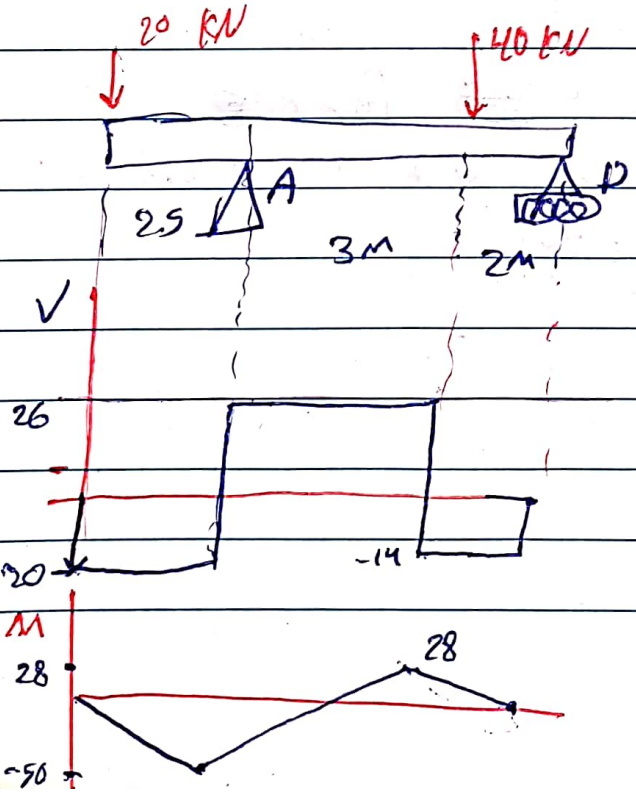
(2) $M_c - M_a = A_{(v)}$

(3) slope $M\big|_{x=a}$ = $V_{(a)}$

(4) slop $V\big|_{x=a} = -$ load (a)

Contra Flexure :- (Inflection Points)
Points wher bending moment is zero on it or change the sign changes from (-) to (+)

sample : drow bending moment / shear



reactions

$40 \times 3 - 20 \times 2.5 = D_y \times 5$

$D_y = \frac{70\,kN}{5}$

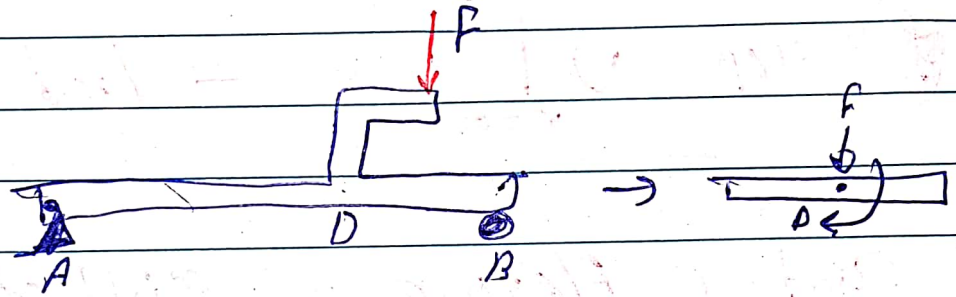
$D_y = 14\ kN$

$A_y = 46$

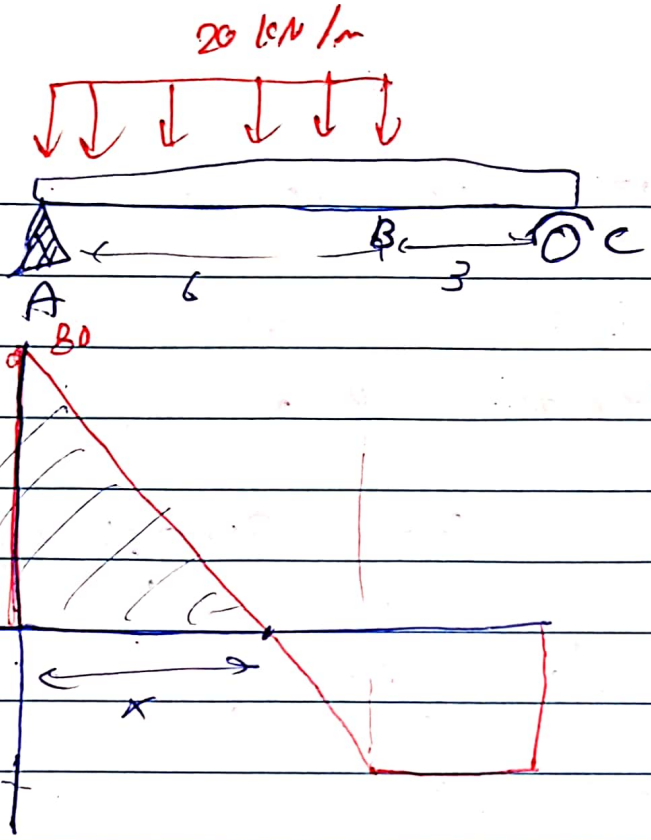
$M_{max} = |-50| = 50$

$V_{max} = 26$

Consentrated moment can't be treated as free vector unless to find reactions but for internal forces we should treat it in it's place



for this force on that beam we should ~~transform~~ move it to the support at point D with its consentrated couble at (D) because we are looking for the forces in beam AB so each force should be acting on a point of that beam.



Find the

M_{max}

V_{max}

$A_y = 120 * 3 = C * 9$

$C = 40$

$A = 80$

$V_{max} = 80$ ✓

$M_{max} = ?$

when $V = 0$

$\frac{x}{80} = \frac{6}{120}$ نحل لـ

$x = 4 \leftarrow$

او السيل

-20 =

من 0 لـ 80

$-80 = -20 * x$

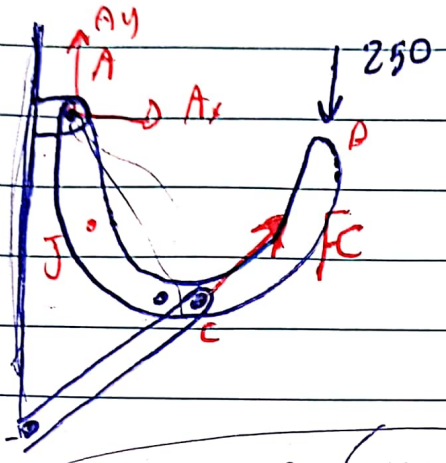
$x = 4$

at $x = 4$ the max moment

and $M_{max} = 160$ N.m

Home work 7

7.11

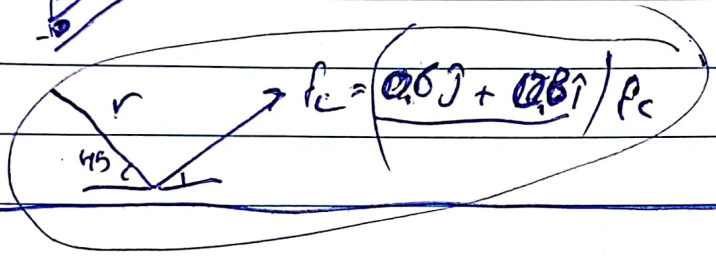


reactions :-

~~$\Sigma F_x = 0$~~ $M_A = 0$

$280 * 320 = 0.6 f_c * 160 + 0.8 * 160 f_c$

$89600 = 160 f_c (0.8 + 0.6)$



$f_c = (0.6\,\hat{j} + 0.8\,\hat{i})\, F_c$ ✓

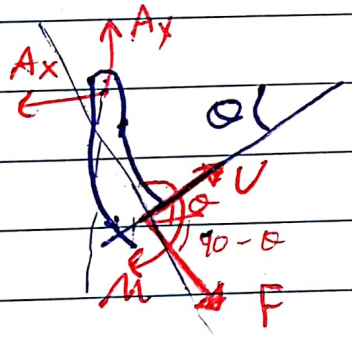
$F_c = 400$

$\Sigma F_x = 0 \rightarrow A_x + 320 = 0$

$A_x = -320 \uparrow N$ ✓

$\Sigma F_y = 0 \rightarrow -280 + A_y + 0.6 * 400 = 0$

$\rightarrow A_y = 40\ N \uparrow$ ✓



$\Sigma F_x = 0$

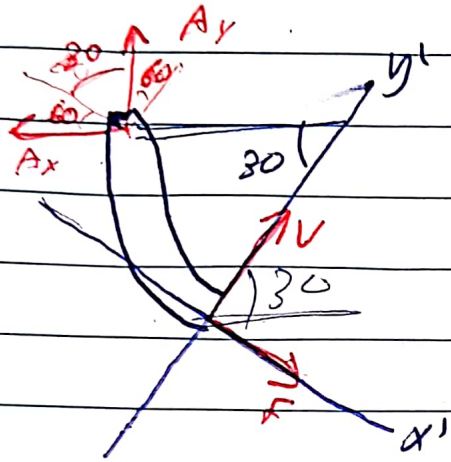
$F \cos(90 - \theta) + V \cos\theta = A_x$ ✓

$\Sigma M_J = 0$

$-A_y * (160 - 160 \cos\theta) + A_x * 80 - M = 0$

$M = 24.7\ N/M$ ✓ clock wise

الآن نعدل المحور الديكارتي 60° ليصبح y' مائل بزاوية 0 عند x



$$\Sigma f_{y'} = 0$$

$$V + A_y \cos 60 - A_x \sin 60 = 0$$

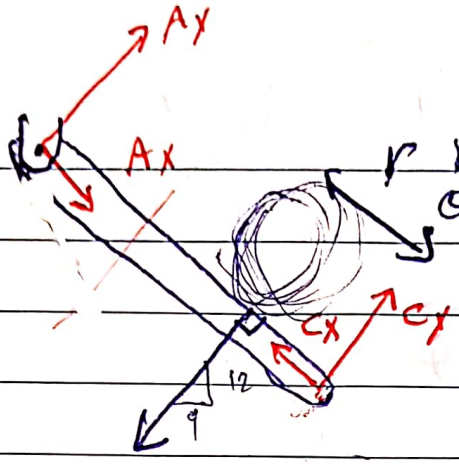
$$V = 257.13 \ N \angle 30$$

$$\Sigma f_{x'} = 0 \rightarrow F - A_x \cos 60 - A_y \cos 30$$

$$F = 194.6 \ N \quad \theta = -60$$

$$M = 24.7 \ N.m \ \circlearrowleft$$

17

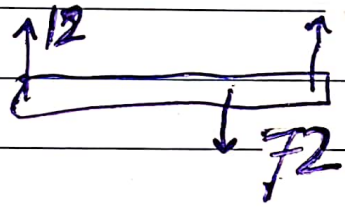


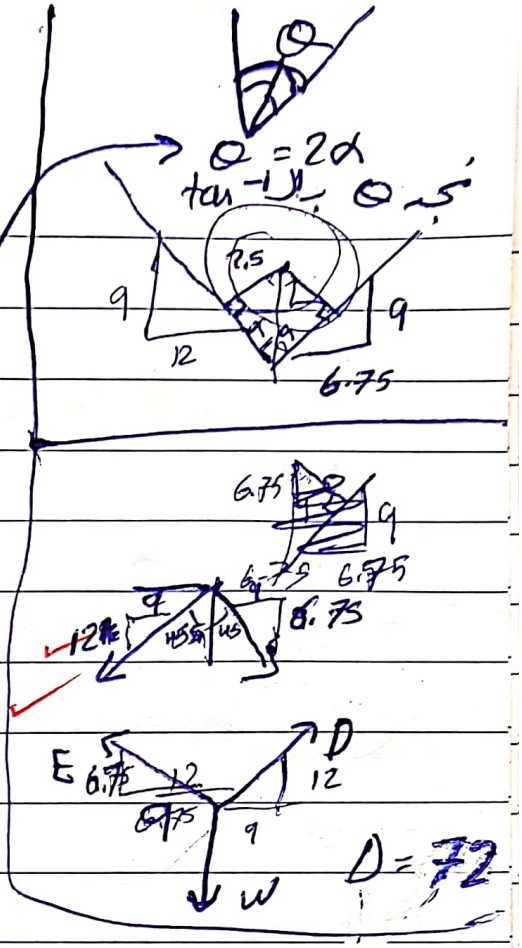
r because $\theta = 90$

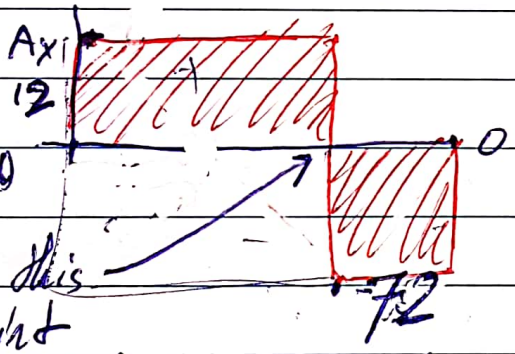
D 10 * 9 Ib

$M_A = 0 \rightarrow Ay = 12$

$\Sigma F_y = 0 \rightarrow Cy = 60$







at this Point M is the greatest

$\frac{dM_x}{dx} = V$

when $V = 0$ then $M =$ [illegible]

At Point D Moment = 12 x

= 12 * 12.5

Moment max =

150 Ib . in

at Point D

ادوا يا حمار

تعجل

مرى بوكى

لقاطها ودنة

الوزنة

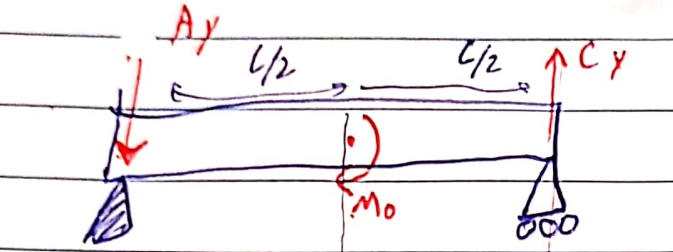
بأمر يا التمة

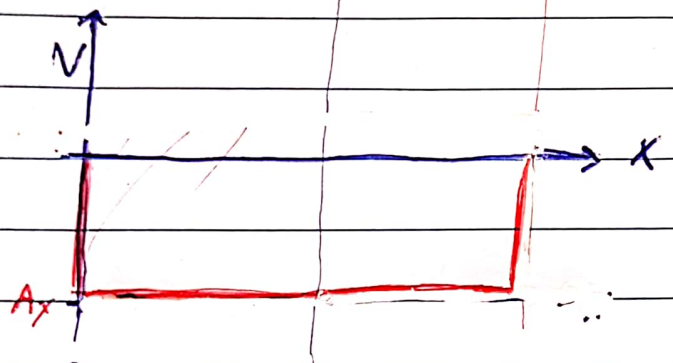
P.33

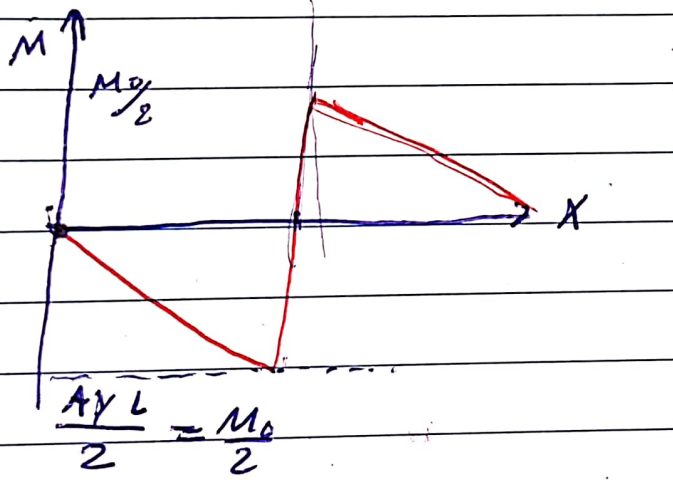
$A_y = -C_y$

$M_o = -A_y * L$

couple



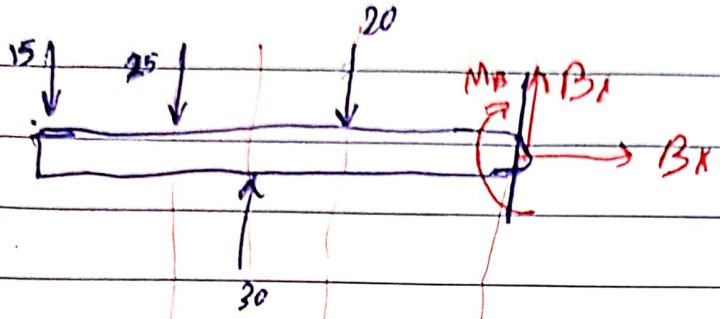




V_{max} at all Period between A&C

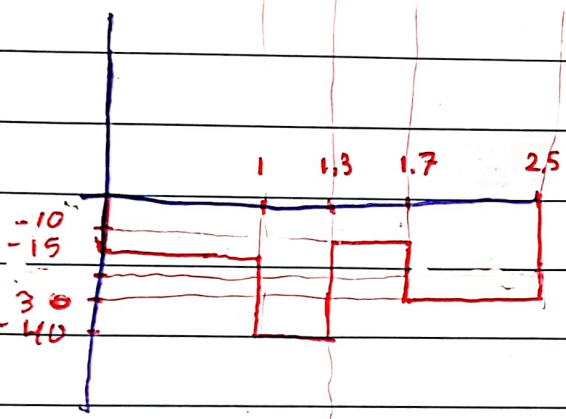
$V_{max} = -|A_y| = -K_x l$

$M_{max} = M_o/2$ at Point B



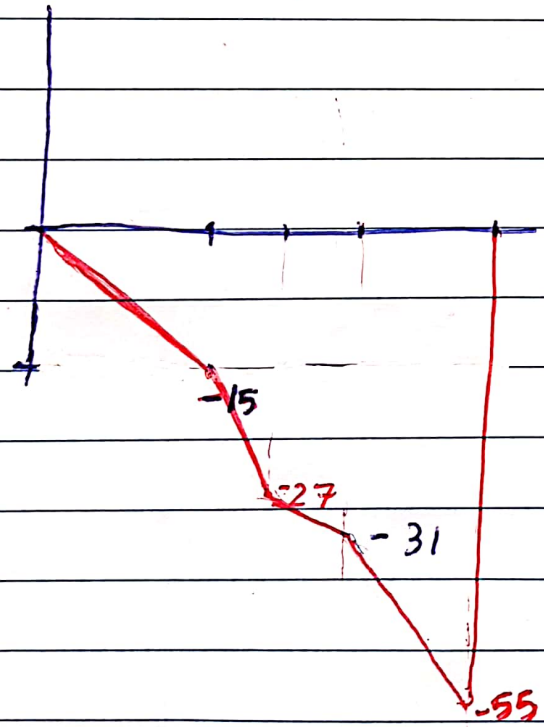
$B_x = 0$ / $B_y = 20 + 25 + 15 - 30 = {}^{+}30 \uparrow$

$M_B = 55$ clock wise



largest shear at interval $x \in [1, 1.3]$

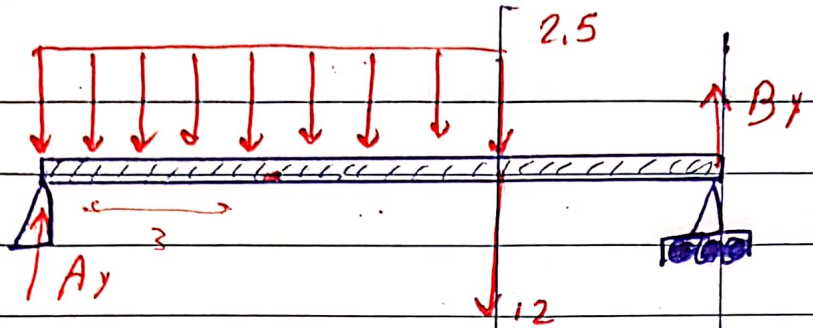
$= -40$ N



largest moment

$= -55$ N.M at Point B

P. 42



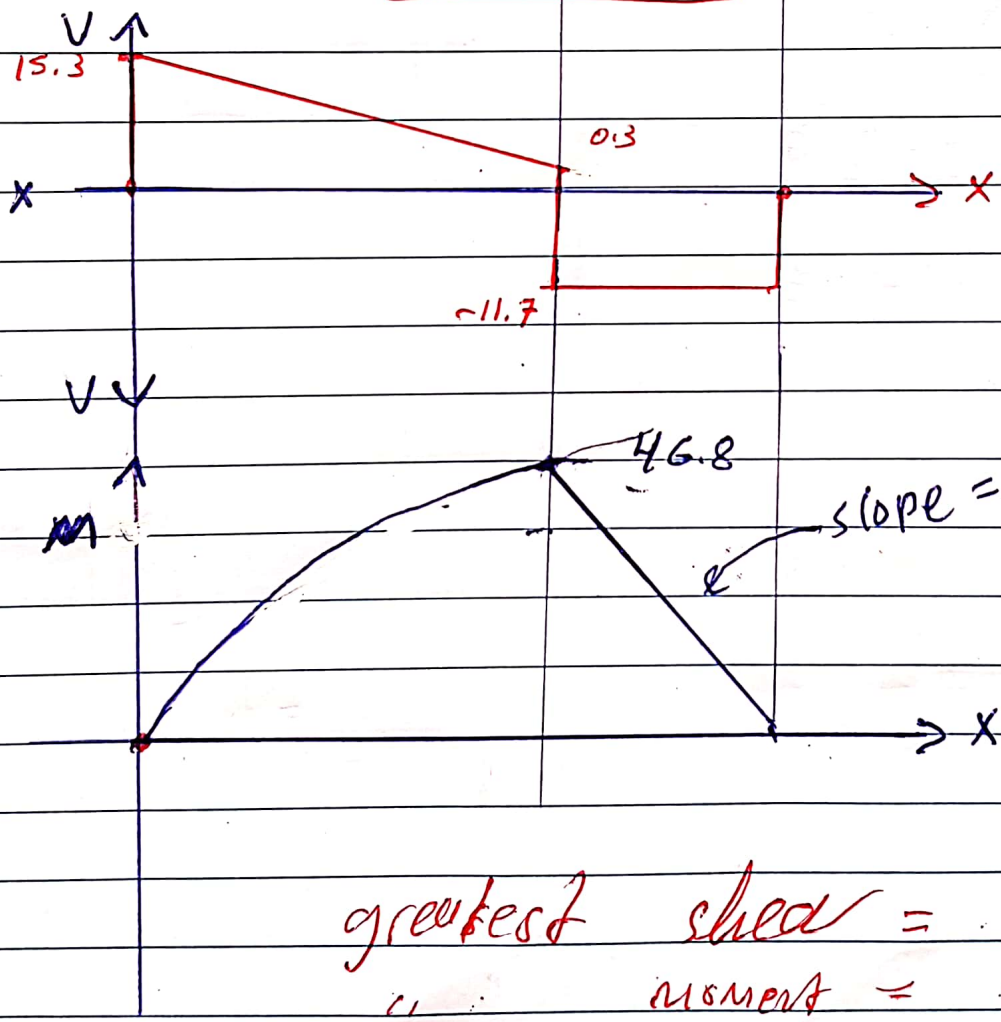
$M_A = 0 \rightarrow 2.5 * 6 * 3 + 12 * 6 + By * 10 = 0$

$45 + 72 + By * 10 = 0$

$\boxed{By = 11.7}$

$\Sigma f_y = 0 \rightarrow 11.7 - 15 - 12 + Ay = 0$

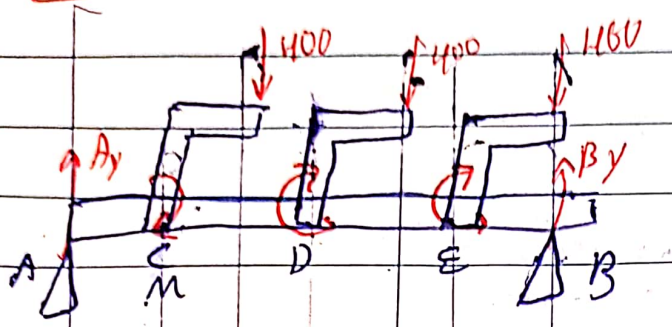
$\boxed{Ay = 15.3}$



greatest shear = 15.3

" moment = 46.8

P 50



$A_x = 0$

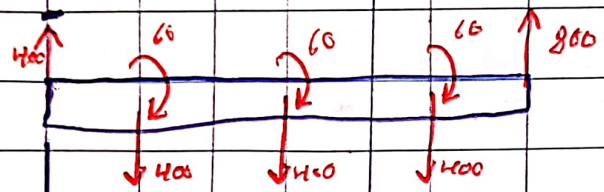
$\Sigma M_B = 0$

$A_y * 900 = 360000$

$A_y = 400\ N \uparrow$

$B_y = 1200 - 400$

$= 800\ N \uparrow$



$M = M_C = M_D = M_E$

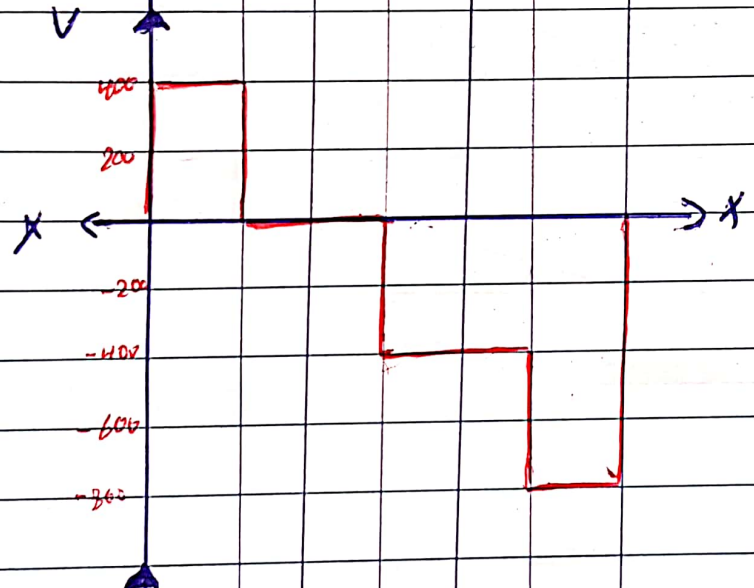
$= 400 * 150 * 10^{-3}$

$= 60\ N.m$ (C.W)

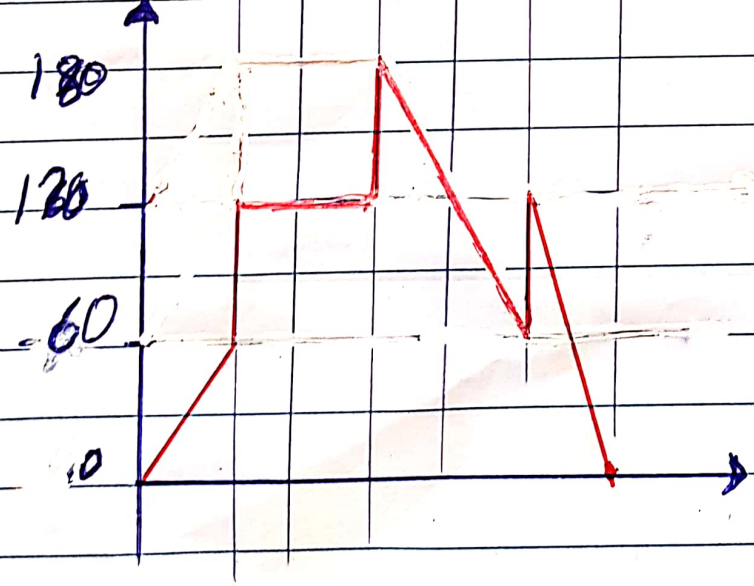
$C = 400\ N \downarrow$

$D = 400\ N \downarrow$

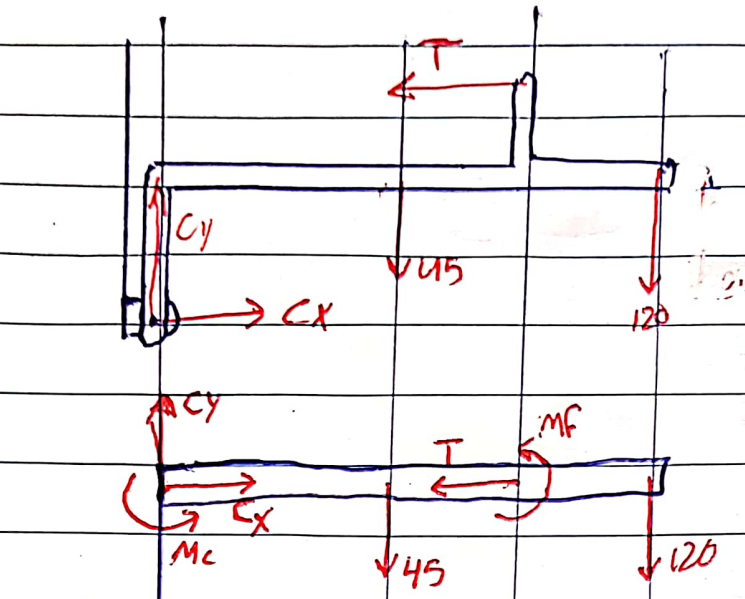
$E = 400\ N \downarrow$



$V_{max} = -800\ N$



$M_{max} = 180\ N.m$



$\Sigma M_A = 0$

$T * 9 = 120 * 21 + 45 * 9$

$T = -325 \uparrow$ lb

$C_x = 325 \uparrow$ lb

$C_y = 45 + 120$

$C_y = 165 \uparrow$ lb

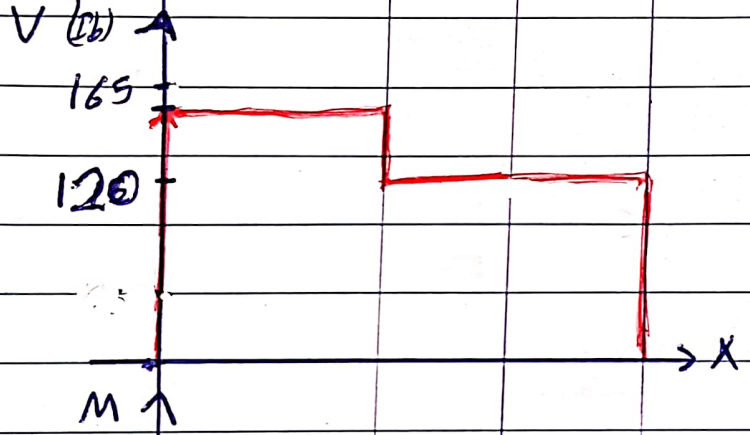
الآن نرسم القوى لـ AB

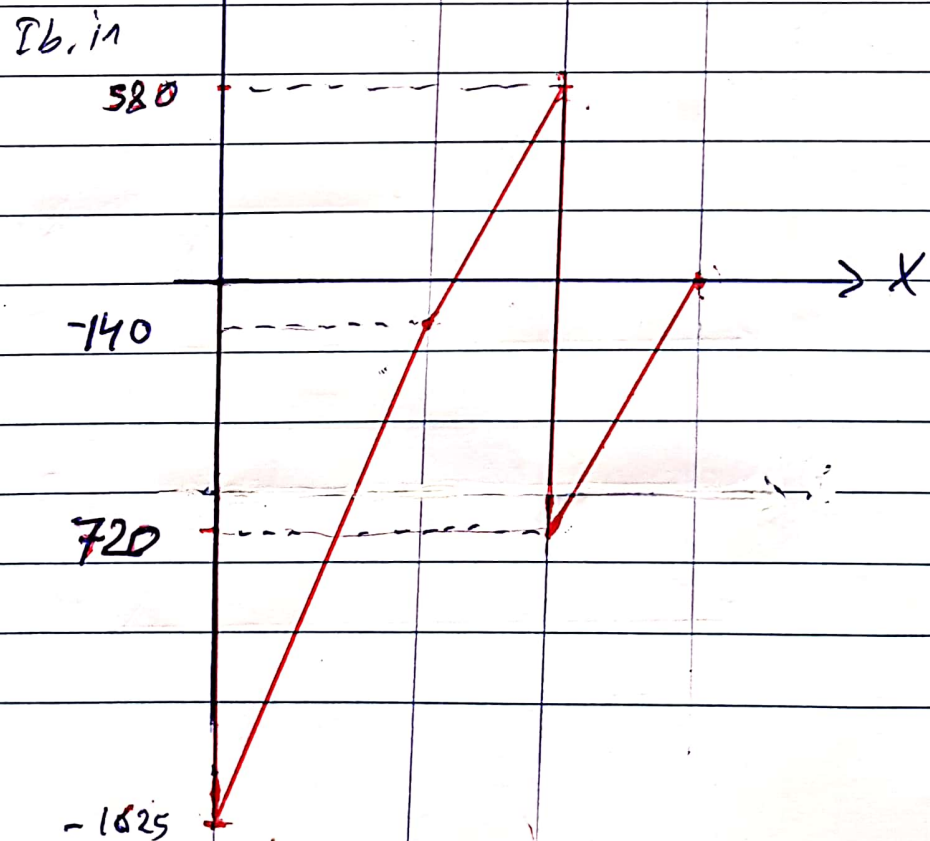
$M_f = T * 4$

$M_f = 1300$ lb.in

$M_c = C_x * 5$

$M_c = 1625$ lb.in

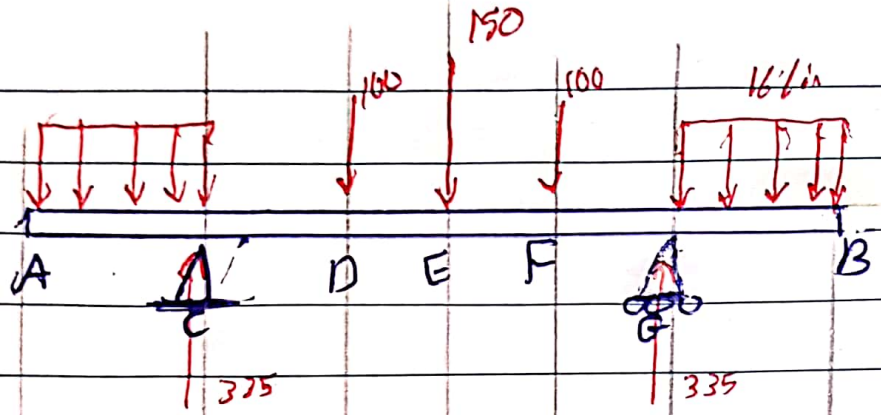




$V_{max} = 165$ lb

$M_{max} = -1625$ lb.in

P 76

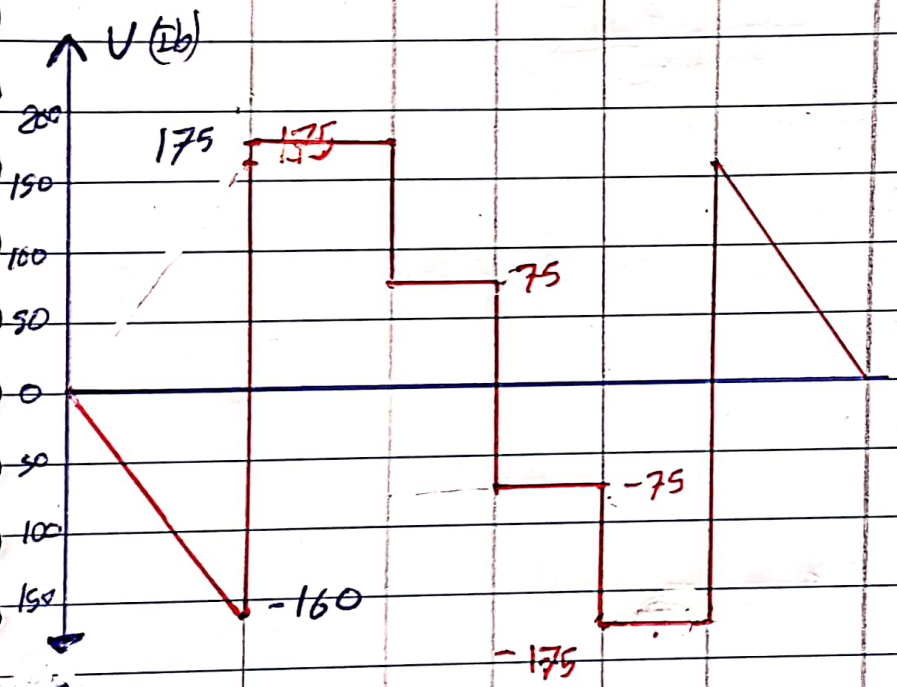


$C_x = 0$

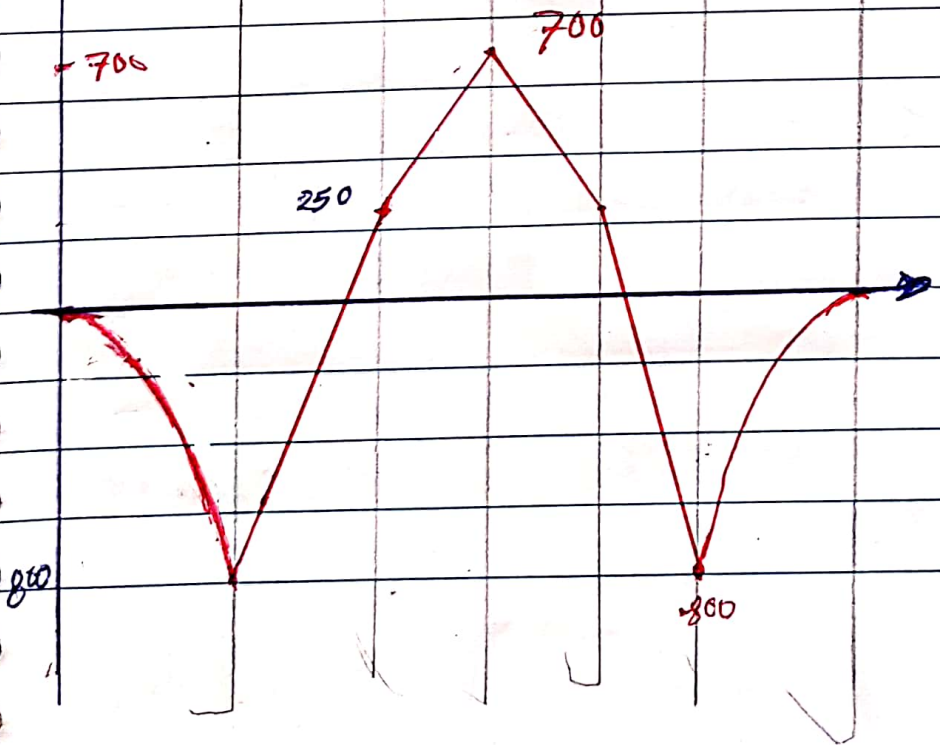
$C_y = G_y$

because of symetry

$C_y = G_y = 335$ lb

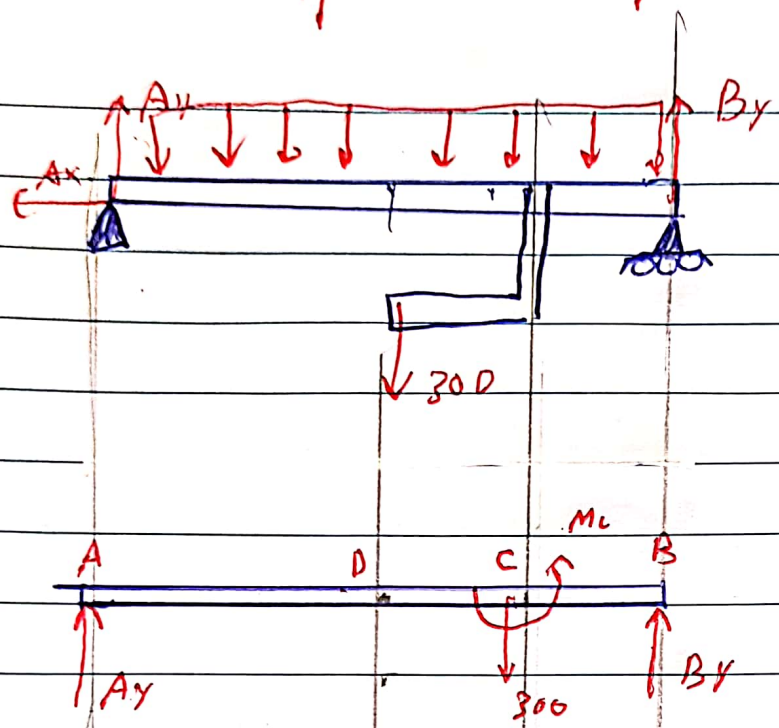


$V_{max} \approx 175$ lb



$M_{max} = -800$

Prob 83



$A_x = 0$

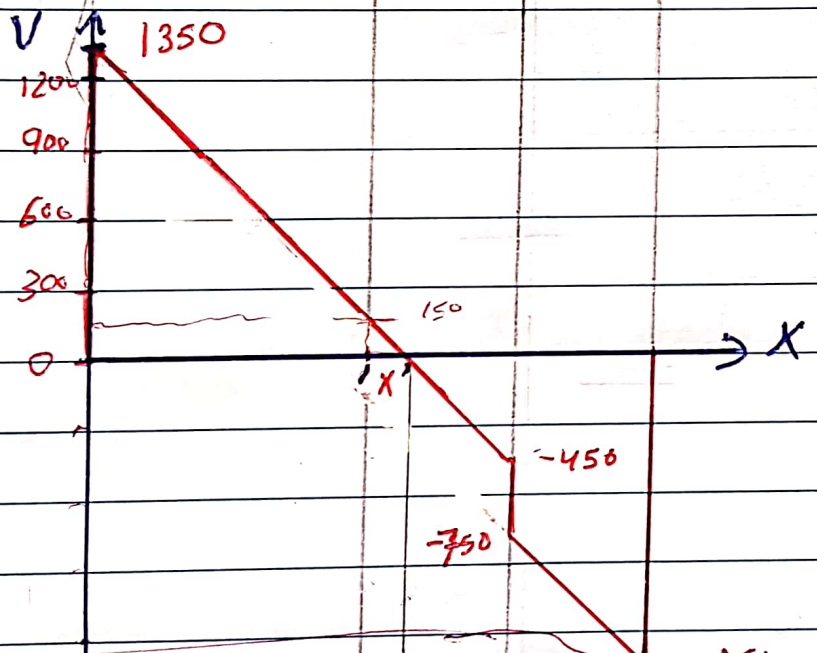
$B_y = A_y$

because of symetry

$A_y = B_y = 1350$ lb

$M_c = 300 \times 2$

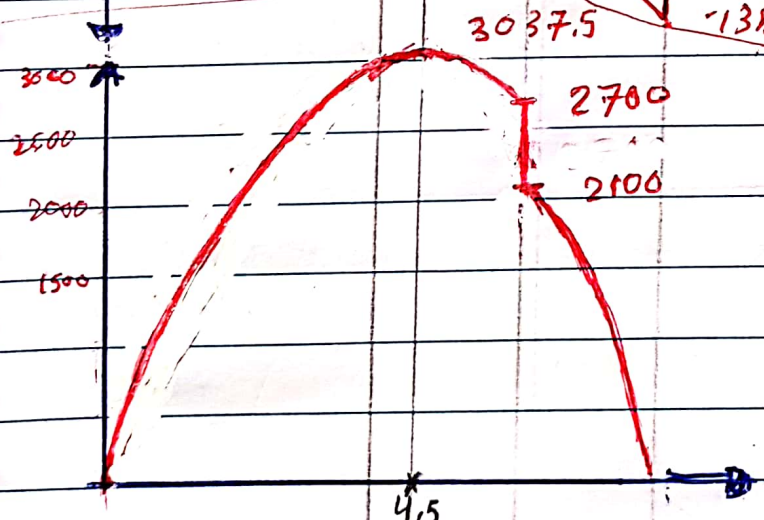
$= 600$ lb.ft



$V_{max} = 1350$ lb

$\frac{1350 - 150}{4} = \frac{150}{x}$

$x = 0.5$

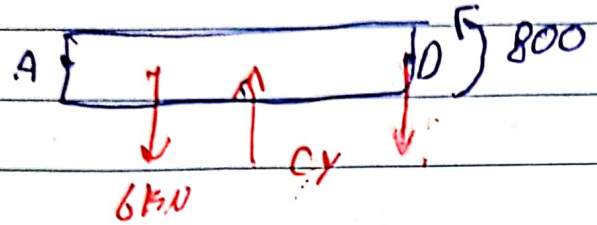


$V_{max} = 1350$ lb

$M_{max} =$ 3037.5 lb.ft at Point 4.5 ft

P (89)

Portion AD

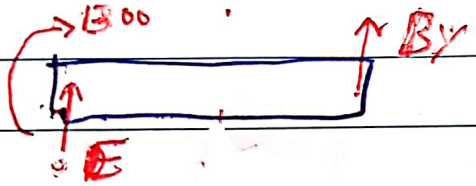


$M_D = 0$

$6000 * 0.145 - C_y * 0.3 + 800 = 0$

$\rightarrow C_y = 11.67\ KN\uparrow$

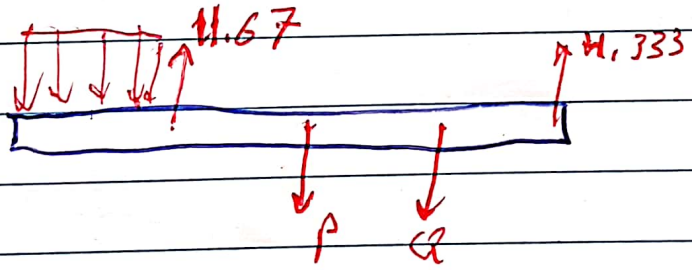
Portion EB



$M_E = 0 \rightarrow -1300 + B_y * 0.3 = 0$

$B_x = 4.333\ KN$

FBD for all Body



$M_P = 0$

$Q * .3 + 11.67 * 0.3 = 4.333 * 0.6 + .5 * 0.45$

$Q = 6\ KN$

$P = 4\ KN$