Statics

ENCE

232

شرح صيفي

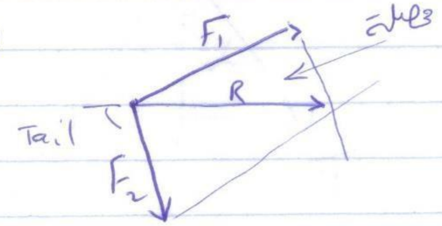
الدكتور جمال زلاطيمو

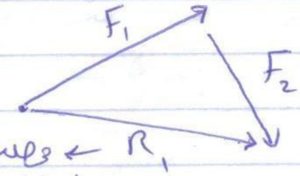
بشار عاص ي

Ch2

Force:

1)

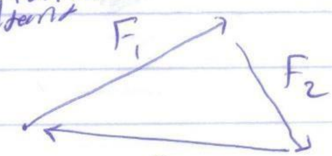




$\leftarrow R_1$

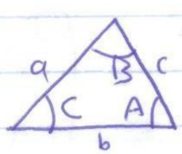
~~Equilibrium~~

Resultant



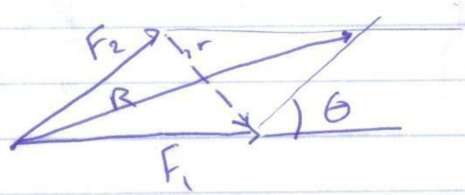
$\leftarrow R_2$

~~Resultant~~ · Equilibrium



$$c^2 = a^2 + b^2 - 2ab \cos C$$

$$\frac{\sin C}{c} = \frac{\sin B}{b} = \frac{\sin A}{a}$$



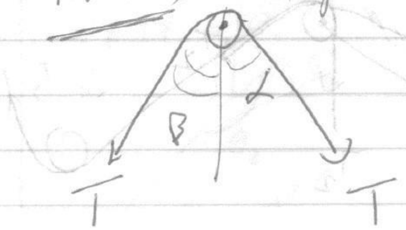
$$R^2 = F_1^2 + F_2^2 + 2F_1F_2 \cos\theta \qquad (\cancel{\sin\ law})$$

$$r^2 = F_1^2 + F_2^2 - 2F_1F_2 \cos\theta \qquad (\cos\ law)$$

~~Sin~~

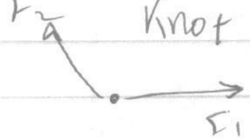
$\Sigma F = 0 \Rightarrow \Sigma F_x = 0 \ , \ \Sigma F_y = 0$

Frictionless Pully



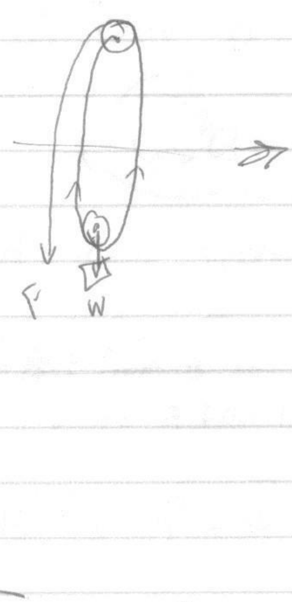
دائماً في البكرات يكون الشد متساوي
في جميع الحبال حول البكرة

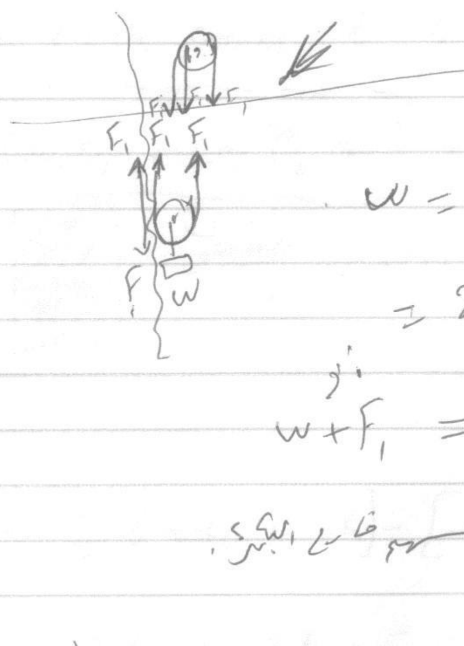
لو القوتين غير متساوين ، تتحرك



$F_1 \neq F_2$

Free-Body





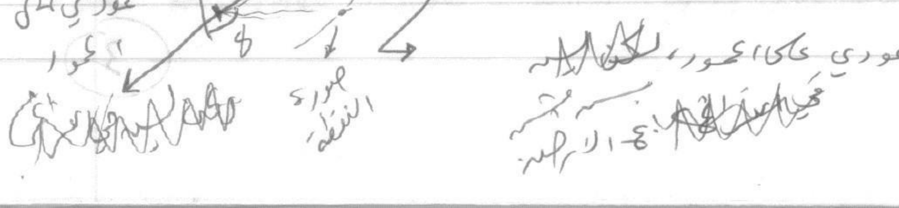
$w = \cancel{3F_1}$

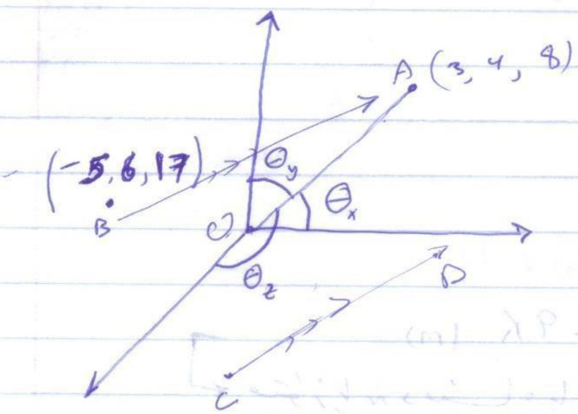
$= 2F_1$

أو

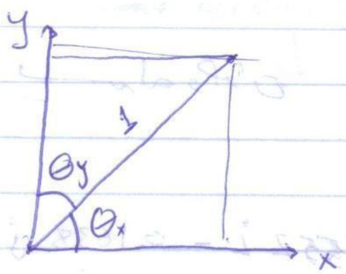
$w + F_1 = 3F_1$

* دائماً السهم خارج البكرة.





$\theta_x, \theta_y, \theta_z \neq 90$



$\cos^2(\theta_x) + \cos^2(\theta_y) = \mathbf{1}$

* dirictonal cosines : [the cosines of θ_x, θ_y, θ_z]

$$\cos^2\theta_x + \cos^2\theta_y + \cos^2\theta_z = 1$$

* dirictonal vector — محدد الاتجاه ، الخط الخارج من نقطة ~~...~~ لأخرى

$\overrightarrow{BA}$: from B to A
A/B : to A from B.

$$\overrightarrow{BA} = \vec{A} - \vec{B} = [3i + 4j + 8k] - [-5i + 6j + 17k]$$

$$= 8i + -2j + -9k \quad (m)$$

$$= \cancel{(8, -2, -9)}$$

$|\overrightarrow{BA}| = 12.21$ m

* positional vector (with refers to the origin) $\overrightarrow{OA}$; $\overrightarrow{rA}$
* Dirictonal vector (with refers to another point)

$\vec{OA} = +3i + 4j + 8k$ (m)
$\vec{r_A}$

$OA = 9.434$ m

* $\vec{CD} = \vec{BA} = +8i - 2j - 9k$ (m)

متوازيان ومتساويان

$\vec{\lambda}$ (unit vector) $= \dfrac{\vec{AB}}{|AB|}$ يساويه وموازي .
(unitless)

$\vec{\lambda}_{BA} = \dfrac{(+8i - 2j - 9k)\,\cancel{m}}{12.21\,\cancel{m}} = +0.6552\,i - 0.1638\,j - 0.7371\,k$

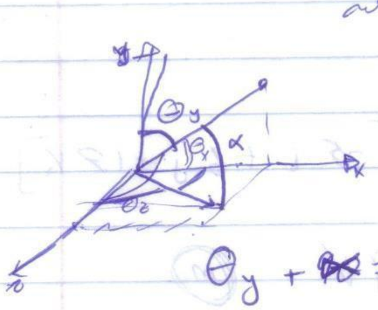
$\cos\theta_x \qquad \cos\theta_y \qquad \cos\theta_z$

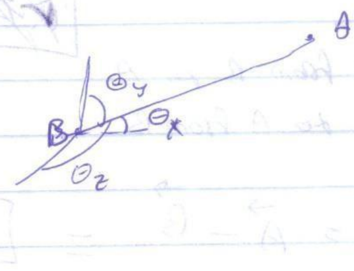
* $|\lambda| = 1$

$\theta_x = 49.06^\circ \qquad \theta_y = 99.43^\circ \qquad \theta_z = 137.48^\circ$

$\theta_x + \theta_y + \theta_z \neq 90 \neq 180$

الا بالصدفة





$\theta_y + \alpha = 90$

مركباتها
الآن نحصل على θ_x و θ_y يجب اخذ مركبتين ~~...~~ و بعد اخذ مركباتها α .

★ $\vec{F}_{CD}$; $= +65.52\,i - 16.38\,j - 73.71\,k$ N.

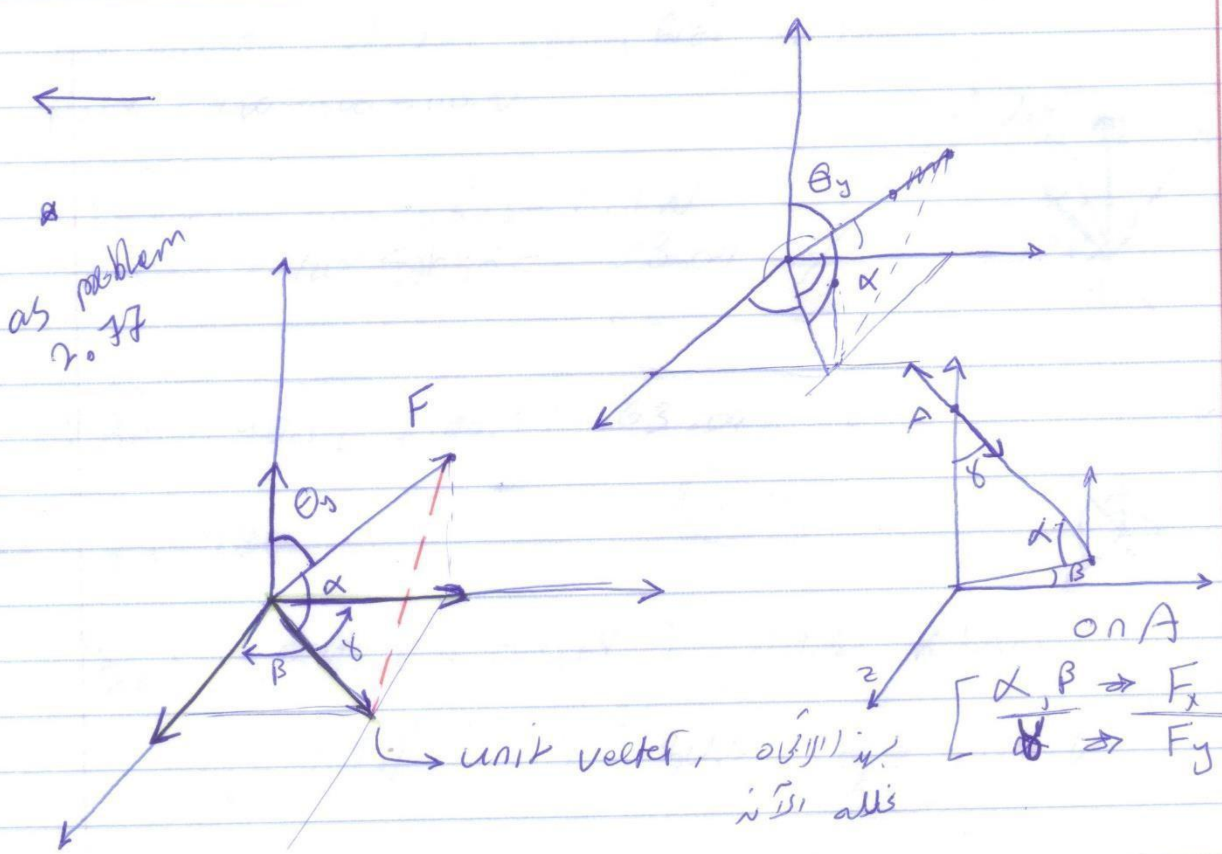
$\vec{F}_{D/C}$ $\qquad\qquad\qquad\qquad$ $\vec{\lambda}_{BA}$ منه

$\vec{F}_{CD} = 100$ N

* الـ vector لا يحدد مكانه الخط والنقط !!
هو يحدد فقط طوله واتجاه.

the force is a sliding vector, can be moved anywhere on its line of ~~actor~~ action .. القوة .. نفس خط العمل

* الخطوط المتوازية لها نفس $\vec{\lambda}$!!



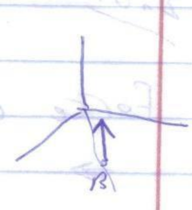
$$\left[\ \frac{\alpha,\ \beta \Rightarrow F_x,\ F_z}{\gamma \Rightarrow F_y}\right.$$

$\Rightarrow F_y = F \sin\theta_y$

$\Rightarrow F_x = F \cos\alpha \cos\gamma = F\cos\alpha \sin\beta$

$\Rightarrow F_z = F\cos\alpha \sin\gamma = F\cos\alpha\cos\beta$

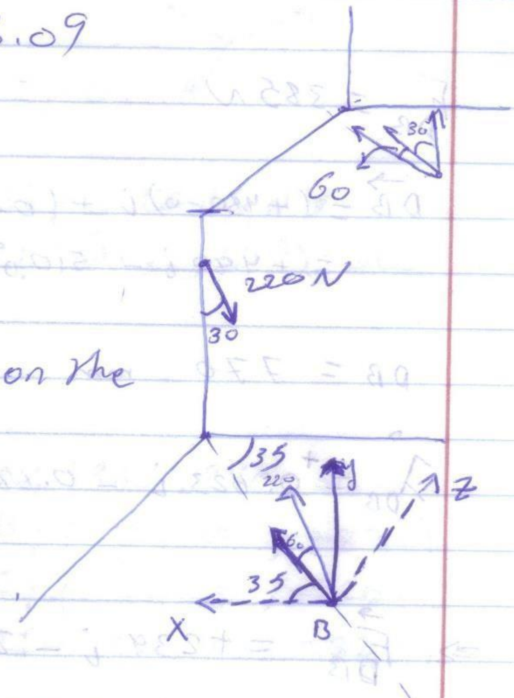
2.75



$F_x = -F \cos 60 \cos 35 = -90.107$

$F_y = F \cancel{\cos 60 \cos 30} \sin 60 = 190.526$

$F_z = -F \cos 60 \sin 35 = -63.09$



Sol

y - component $220 \sin 60 = +190.5$ N

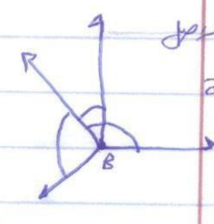
The projection of the spring force on the plate $= 220 \cos 60 = 110$ N

x - compon $= 110 \cos 35 = -90.1$ N

z - comp $= 110 \sin 35 = -63.09$

$\overrightarrow{F_{BA}} = -90.1 i + 190.5 j - 63.09 k$ N

** $F_{BA} = 220 = \sqrt{}$ للتأكد



* تقع الزوايا على النقطة

$\lambda_{BA} = -0.410 i + 0.867 j - 0.287 k$ (N)

$\theta_x = 114.2^\circ \quad \theta_y = 30.2^\circ \quad \theta_z = 106.6^\circ$

2.89

mm

D (0, +510, +280)

Force on D

⇒ باتجاه B

F_{DB} ← (+480, 0, +600)

↳ from D to B

B

$F_{DB} = 385\,N$.

$\vec{DB} = (+480-0)i + (0-510)j + (+600-280)K$ mm.

$= +480\,i - 510\,j + 320\,K$ mm.

$DB = 770$ mm

$\vec{\lambda}_{DB} = +0.623\,i - 0.662\,j + 0.416\,K$

$\Rightarrow \vec{F}_{DB} = +239\,i - 254.9\,j + 160.2\,K\ (N)$

~~xx~~ supports : نقاط ارتكاز

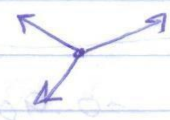
reaction :

$\rightarrow$

Equilibrium : $\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma F_z = 0$



لا يتولد هنا عزم !! ، العزوم تتولد عندما ~~يكون~~ يكون هناك مسافة بين نقاط تأثير القوى والمركز ! اي ليست نقطة

$\leftarrow$

2.107

A : (960, 240, 0)

~~B : (0, 0, 380)~~

~~C : (0, 0, -320)~~

D : (0, 960, -220)

$F_{AD} = 305$

~~$\vec{AD} = (-900, 720, 0)$~~

$\vec{AD} = -960\,i + 720\,j + {}^{-}220K \; N$

$|AD| = 1220$

$\lambda = -0.787i + \overset{0.590}{\cancel{0.6}}\, j + {}^{-}0.180\; K$

~~$\vec{F}_{AD} = -244\,i + 183\,j$~~

$\vec{F}_{AD} = -240.0\,i + 179.9\,j + {}^{-}54.9$

$\Rightarrow$ ~~$P = 240\; N\; i$~~

$\leftrightarrow$

$\vec{\lambda}_P = +1\,i + 0\,j + 0K$

$\vec{P} = (+)P\,i$

$\vec{AB} = -960i - 240j + 380k$ mm [1060] mm.

$$\vec{\lambda}_{AB} = \frac{-960i}{1060} - \frac{240j}{1060} + \frac{380}{1060}k$$

$$= -0.9057i - 0.2264j + 0.3585k$$

$$\vec{F}_{AB} = -0.9057F_{AB}i - 0.2264F_{AB}j + 0.358F_{AB}k$$

$\vec{AC} = (-960, -240, -320)$

$AC = 1040$

$\lambda_{AC} = -0.9231i - 0.2308j - 0.3077k$

$F_{AC} = -0.9231F_{AC}i - 0.2308F_{AC}j - 0.3077F_{AC}k$

From $\Sigma F_y = 0$

$\Rightarrow -0$

$F_{AC} = 341.7\ N$

$F_{AB} = 447.5\ N$

$P = 960.8\ N$

$\boxed{2.108} \Rightarrow$

2.109

$F_{AC} = 60N$

the weight of the plate equal the y-component at point-A.

A : (0 , +480 , 0)
B : (-320 , 0 , +360)
C : (+450 , 0 , +360)
D : (+250 , 0 , -360)

So we first find the all component of F_{AC}, F_{AB}, F_{AD}

① $\vec{AB} = -320\,i - 480\,j + 360\,K$

$AB = 680$ m

$\lambda_{AB} = -0.4706\,i - 0.7059\,j + 0.5294\,K$

$\vec{F}_{AB} = -0.4706 F_{AB}\,i - 0.7059 F_{AB}\,j + 0.5294 F_{AB}\,K$

② $\vec{AC} = 450 i - 480\,j + 360\,K$

$AC = 750$

$\lambda_{AC} = 0.6\,i - 0.64\,j + 0.48\,K$

$\vec{F}_{AC} = 36\,i - 38.4\,j + 28.8$

③ $\vec{AD} = 250\,i - 480\,j - 360\,K$

$AD = 650$

$\lambda_{AD} = \overset{0.3846}{\cancel{0.4}}\,i - 0.7385\,j - 0.5538\,K$

$\vec{F}_{AD} = \overset{0.3846}{\cancel{0.4}} F_{AD}\,i - 0.7385 F_{AD}\,j - 0.5538 F_{AD}\,K$

No from $\Sigma F_y = 0$, and $\Sigma F_z = 0$ ⇒

$\Sigma F_x = -0.4706 F_{AB} + 36 + 0.4 F_{AD} = 0$

$$F_{AB} = \frac{36 + \overset{0.3846}{\cancel{0.4}} F_{AD}}{0.4706} \qquad \text{—} (1)$$

$\Sigma F_z = 0 = 0.5294 F_{AB} + 28.8 + {}^{-}0.5538 F_{AD} = 0$

$$\frac{0.5294}{0.4706}\left[36 + \overset{0.3846}{\cancel{0.4}} F_{AD}\right] + 28.8 - 0.5538 F_{AD} = 0$$

$$= 1.125\left[36 + 0.4 F_{AD}\right] + 28.8 - 0.5538 F_{AD} = 0$$

$$40.5 + 28.8 + \overset{0.4327}{\cancel{0.45}} F_{AD} - 0.5538 F_{AD} = 0$$

$$F_{AD} = \frac{69.3}{0.1211} = \overset{572.2}{\cancel{667.6}}\ N$$

$$\Rightarrow F_{AB} = \frac{36 + \overset{0.3846}{\cancel{0.4}}(\overset{572.2}{\cancel{667.6}})}{0.4706} = \overset{544}{\cancel{643.9}}\ N$$

Now, $\Sigma F_y = 0$

$$-0.7059(\overset{544}{\cancel{643.9}}) - 38.4 - 0.7385(\overset{572.2}{\cancel{667.6}}) + P = 0$$

$P(\text{weigh}) = \cancel{985.9}\ 845$

لأن مجموع القوى على A باتجاه y تكون
لأنه [illegible] [illegible] وزن [illegible]

$$T_{AB} = -T_{BA}$$

2.125

First we work on point $\underline{\underline{A}}$ $A(0, +155, 0)$

$B(+200, 0, z)$

But, at first we must fin the coordinate (z) (460)

By Pr, $\underline{(525)^2} =$ $P = 341$

$(525)^2 = (155)^2 + (OB)^2 \Rightarrow (OB) = 501.6$

and then

$\underline{(OB)^2} = (501.6)^2 = (200)^2 + z^2 \Rightarrow \boxed{z = 460}$

او بنعوض ؟

طول السلك $= 525$

$\sqrt{0^2 + 0^2 + z^2}$

$\leftarrow \quad \vec{P} = 0\, i + 341\, j + 0\, K$

(A) Now we work at point A.

$\vec{AB} = 200\, i - 155\, j + 460\, K$

$AB = 525$

$\Sigma F_x \neq 0$

$\Sigma F_z \neq 0$

يعني بحال الاحداثيات ولا ناخذ العمودي فقط

$\lambda_{AB} = 0.3809 i - 0.2952 j + 0.8762 K$

$\vec{T} = 0.3809T\, i - 0.2952T\, j + 0.8762T\, K$ F

, But $\Sigma F_y = 0$, So

$341 = P = 0.2952T \Rightarrow T = 1155\ N.$

(B) $\cancel{\vec{BA} = -200 i + 155 j - 460 K}$

$\cancel{AB = 525}$

$T_{BA} = -T_{AB} = -0.3809T\, i + 0.2952T\, j - 0.8762T\, K.$

now, $\Sigma F_z = 0$ (on B)

$Q = 0.8762\ T$
$= 0.8762\ (1155)$
$Q = 1012.011\ N$

← 1140292

$\boxed{2.120}$

$F_{DA_x} = -T \cos 60 \cos 40 = 0.$
$F_{DA_y} = -T \sin 60 =$
$F_{DA_z} = T \cos 60 \sin 40 =$

$F_{DB_x} = T \cos 60 \cos 40 =$
$F_{DB_y} = -T \sin 60 =$
$F_{DB_z} = T \cos 60 \sin 40 =$

$F_{DC_x} = T \cos 60 \cos 60 =$
$F_{DC_y} = -T \sin 60 =$
$F_{DC_z} = -T \cos 60 \sin 60 =$

$\Sigma F_x = 0$

$\Sigma F_y = 0 \qquad [\qquad] + P = 0$

$\Sigma F_z = 0$

14

2.108

AD is taut $\Rightarrow$ الحبل مشدود ، أي الشد فيه أكبر من صفر.

$$\vec{P} = +1200i + 0 + 0$$

$$\vec{F}_{AB} = -0.9057 F_{AB} i - 0.2264 F_{AB} j + 0.3585 F_{AB} k$$

$$\vec{Q} = 0 \, i + Q \, j + 0$$

$$\vec{F}_{AD} = -0.7869 F_{AD} i + 0.5902 F_{AD} j - 0.1803 F_{AD} k$$

$$\vec{F}_{AC} = -0.9231 \vec{F}_{AC} i - 0.2307 F_{AC} j - 0.3077 F_{AC} k$$

* at first, let AD be not taut

على فرض أن السلك غير مشدود ، أي القوة فيه = صفر.

$$\Rightarrow \text{let } \vec{F}_{AD} = 0 + 0 + 0$$

$$1200 - 0.9057 F_{AB} - 0.9231 F_{AC} = 0$$

$$\Rightarrow F_{AB} = \frac{1200 - 0.9231 F_{AC}}{0.9057} = 605.8 \text{ N}$$

$$0.3585 F_{AB} - 0.3077 F_{AC} = 0$$

0.3958

$$\frac{0.3585}{0.9057}\left[1200 - 0.9231 F_{AC}\right] - 0.3077 F_{AC}$$

$$474.9 - 0.3654 F_{AC} - 0.3077 F_{AC} = 0$$

$$F_{AC} = 705.5 \text{ N}$$

$-0.2264F_{AB} + Q - 0.2307F_{AC} = 0$

$Q = \cancel{299.9} = 300N$

then $Q \leq 300 \Rightarrow$ تكون tans (المشد مرخي
مشدود

اذا اكثر ← AD رح يكون مرخي

2.112

$AC = 3.68\ kN$

$A(0, 18, \cancel{18}\ 0)$
$B(-9, 0, 6)$
$C(6, 0, 13)$
$D(4, 0, -12)$

$\vec{AB} = -9i + \cancel{6} -18j + 6k$

$AB = \cancel{44.1}\ 21$

$\lambda = -\cancel{0.0204}\ 0.4286\,i - \cancel{0.0408}\ 0.8571\,j + \cancel{0.0136}\ 0.2857\,k$

$\vec{F}_{AB} = -\cancel{0.0204}\ 0.4286\,F_{AB}\,i - \cancel{0.0408}\ 0.8571\,F_{AB}\,j + \cancel{0.0136}\ 0.2857\,F_{AB}\,k$

$\vec{AC} = 6i - 18j + 13k$

$AC = \cancel{19.90}\ 23$

$\lambda_{AC} = \cancel{0.3015}\ 0.2608\,i - \cancel{0.9045}\ \cancel{0.5657}\ 0.7826\,j + 0.3015\,k$

$F_{AC} = \cancel{1.109}\ 0.9597\,i - \cancel{3.329}\ \cancel{2.079}\ 2.879\,j + \cancel{1.109}\ 2.079\,k$

2.112

$AC = 3.68$

$A(0, 18, 0)$
$B(-9, 0, 6)$
$C(6, 0, 13)$
$D(4, 0, -12)$

$\vec{AB} = -9\,i - 18\,j + 6\,K$
$AB = 21$

$\lambda_{AB} = -0.4286\,i - 0.8571\,j + 0.2857\,K$

① $F_{AB} = -0.4286 F_{AB}\,i - 0.8571 F_{AB}\,j + 0.2857 F_{AB}\,k$

$\vec{AC} = 6\,i - 18\,j + 13\,K$
$AC = 23$

$\vec{\lambda}_{AC} = +0.2608\,i - 0.7826\,j + 0.5652\,K$

② $F_{AC} = +0.9595\,i - 2.879\,j + 2.079\,K$

$\vec{AD} = 4\,i - 18\,j - 12\,K$
$AD = 22$
$\lambda_{AD} = 0.1818\,i - 0.8181\,j - 0.5454\,K$

$\vec{F}_{AD} = 0.1818 F_{AD}\,i - 0.8181 F_{AD}\,j - 0.5454 F_{AD}\,K$

$P = 0 + P\,j + 0\,K$

$$\Sigma F_x = 0$$

$$-0.4286 F_{AB} + 0.9595 + 0.1818 F_{AD} = 0$$

$$\therefore F_{AB} = \frac{0.9595 + 0.1818 F_{AD}}{0.4286}$$

$$\Sigma F_z = 0$$

$$0.2857 F_{AB} + 2.079 - 0.5454 F_{AD} = 0$$

$$\frac{0.2857}{0.4286}\left[0.9595 + 0.1818 F_{AD}\right] + 2.079 - 0.5454 F_{AD} = 0$$

$$0.6396 + 0.1212 F_{AD} + 2.079 - 0.5454 F_{AD} = 0$$

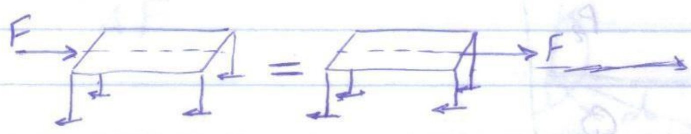
$$F_{AD} = \frac{2.719}{0.4242} = 6.409 \text{ N}$$

$$F_{AB} = \sim$$

$$P = 123 \sim$$

Ch3

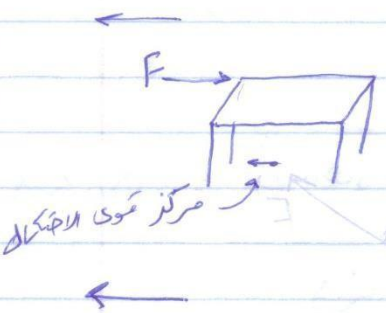
Ch3

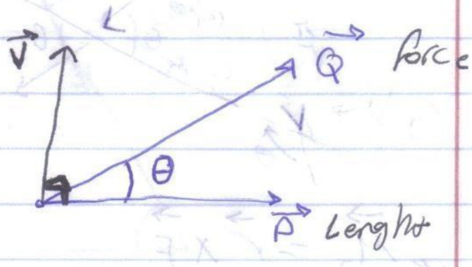


عند نقطة الالتقاء
لو رضنا ، رحمة o

▲ Force is a sliding vector. مادامت على خط عملها لها نفس التأثير

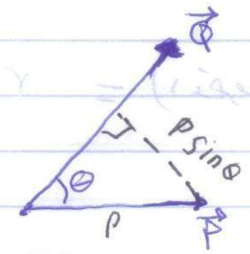
▲ principle of transmissibility.



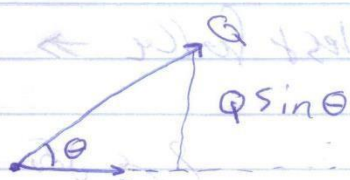


$$\vec{V} = \vec{P} \times \vec{Q}$$

$$V = PQ \sin\theta$$



$$\vec{P} \times \vec{Q} = -\vec{Q} \times \vec{P}$$



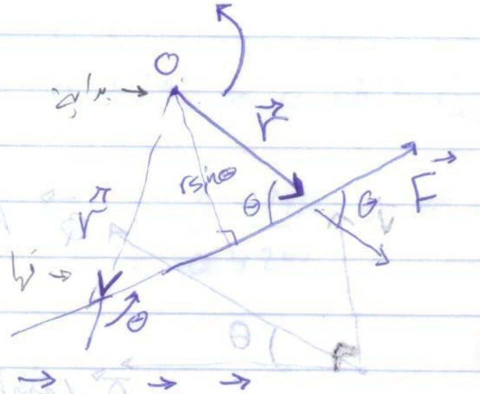
$$\vec{P} = P_x i + P_y j + P_z K$$

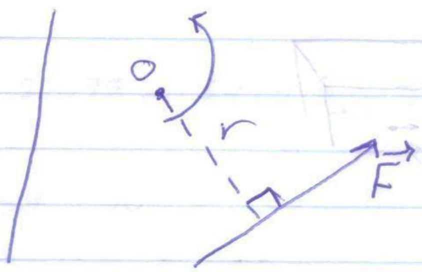
$$\vec{Q} = Q_x i + Q_y i + Q_z K$$

$\vec{V} = \vec{P} \times \vec{Q}$ $\boxed{\vec{V} = \vec{r} \times \vec{F}}$

$$\begin{array}{c} \quad + \qquad\quad - \qquad\quad + \\ = \begin{vmatrix} i & j & K \\ P_x & P_y & P_z \\ Q_x & Q_y & Q_z \end{vmatrix} \end{array}$$

$$= +i\,\underbrace{(P_y Q_z - P_z Q_y)}_{V_x} - j\,\underbrace{(P_x Q_z - P_z Q_x)}_{V_y} + K\,\underbrace{(P_x Q_y - P_y Q_x)}_{V_z}$$

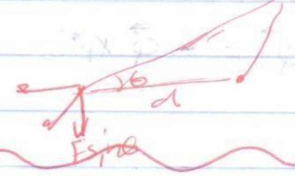




$\vec{M}_o = \vec{r} \times \vec{F}$ ← العزم

(المسافة) العمودي $= r \sin\theta$

لسه بالعمود التعامل مع القوة عند نقطة تأثيرها على الخط ، ما يهم هو خط تأثير القوة ونقطة الدوران ، اما المسافة فهي عمودية ثابتة

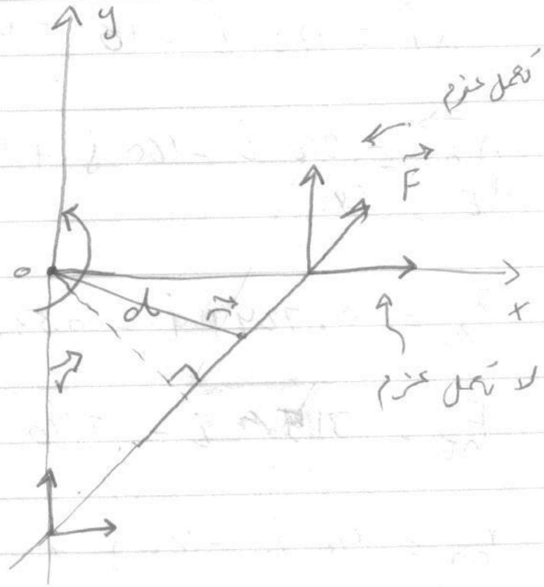


★ smallest force ⇒ r is maximum

اذا كانت القوة تمر بالنقطة ، لا تعمل عزم

Varignon's Theorem:

$$\overrightarrow{M_o^F} = \vec{r} \times \vec{F}$$

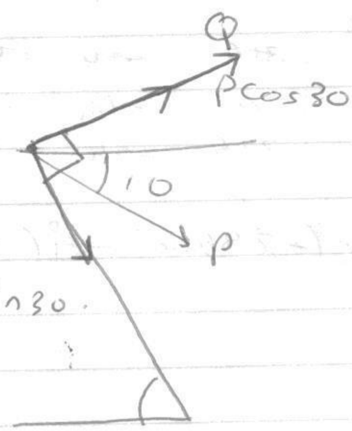


3.8

Q:

* تمل P للمركبتين Psin30 ، لا تعمل عزم

Pcos30 تعمل عزم



$Q = 51.32 \cos 30 = 44.4\ N$

$M_B = Q\,(450)$

$\Rightarrow Q =$ ______

3.21 on A , F_{AB}

3.21

$\overrightarrow{M}_o^{F_{AE}}$

$\vec{F}_{AE}$

A

(A) $\vec{AE} = 216 i - 160 j + 120 k$ $(-90, +160, 0)$

$\vec{AE} = 290$

O $(0,0,0)$

$\vec{\lambda}_{AE} = 0.7241 i - 0.5517 j + 0.4138 k$

E $(120, 0, 120)$

$\vec{F}_{AE} = 315 i - 240 j + 180 k$ $\boxed{N}$

$\vec{r}_{OA} = -90 i + 160 j + 0 k$

$$\overrightarrow{M}_o^{F_{AE}} = \begin{vmatrix} +i & -j & +k \\ -90 & 160 & 0 \\ 315 & -240 & 180 \end{vmatrix}$$

$= i(+28800) - j(-16200) + k(-28800)$ N.mm

$\vec{F}_{AE} = +315 i \cancel{+} 240 j + 180 k$

$\vec{r}_{OE} = 120 i + 0 j + 120 k$

$$\overrightarrow{M}_o^{F_{EA}} = \begin{vmatrix} +i & -j & +k \\ 120 & 0 & 120 \\ +315 & \cancel{+}240 & +180 \end{vmatrix} \text{ mm}$$

$= i(+28800) - j(-16200) + k(-28800)$ N.mm

$= 28800 i + 16200 j - 28800 k$ N.mm

B $\vec{M}_o^{F_{EA}} = -28.8i - 16.2j + 28.8k$ (N.m)

* الـ $\vec{r}$ ليس مهم اين ، نوجده في العزمية . * * * * *

27 Now, determine ~~de~~ the perpendicular ~~d~~ O → AG

$M_o = 43.8$

$d = \frac{M_o}{F} = \frac{43.83}{435} = 0.1008$ m

$\boxed{3.25}$

Force = 200 // $\theta_z = 60$ A (0, -50, 0)

$\vec{F}_{CA}$, $\theta_y = 30$ B (0, 0, 0)

C (60, 25, 0)

~~$\vec{CA} = -60i - 75j + 0k$~~

~~$F = 200 \cos 60\, i - 200$~~

$F = 0i - 200\cos 30 j + 200 \cos 60 K$

$\vec{F}_C = 0i - 173.2 j + 100 K$

① → $\vec{r}_{AC} = 60i + 75j + 0K$

$$\vec{M}_A^{F_c} = \begin{vmatrix} i & j & k \\ 60 & 75 & 0 \\ 0 & -173.2 & 100 \end{vmatrix} = i(7500) - j(6000) + K(-10392) \text{ N.mm}$$

HW

3.34

Assume $F_{AB} = 100$ N

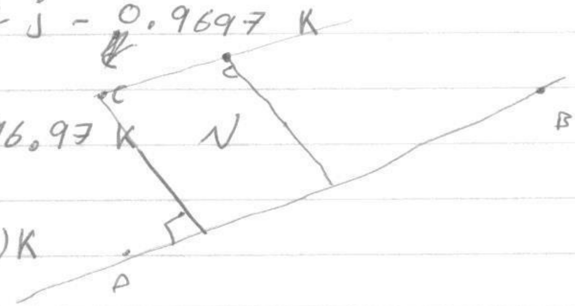
A(14 , -7 , 22)
B(21 , -3 , -10)
C(0 , -2 , L)
~~D(0 , 0 , 30)~~

$\vec{AB} = 7i + 4j - 32k$

$AB = 33$

$\vec{\lambda}_{AB} = 0.2121\, i + 0.1212\, j - 0.9697\, k$

$\vec{F}_{AB} = 21.21\, i + 12.12\, j - 96.97\, k$ N



$\vec{r}_{CA} = 14\, i - 5\, j + (22 - L)\, k$

$$M_C \begin{vmatrix} i & j & k \\ 14 & -5 & 22 - L \\ 21.21 & 12.12 & -96.97 \end{vmatrix}$$

$= i(218.2 + 12.2L) - j(\cancel{218.2 + 12.12L}\ \ -1826 + 21.21L) + k(275.7)$

$\sqrt{(218.2 + 12.2L)^2 + (-1826 + 21.21L)^2 + (275.7)^2} = d \times F$

$= (218.2 + 12.2L)\, i + (1826 - 21.21L)\, j + (275.8)\, k$ N.m

$= \left[(218.2 + 12.2L)^2 + (1826 - 21.21L)^2 + (275.8)^2\right]^{\frac{1}{2}}$

$1000 = 2(218.2 + 12.12L)\,12.12 + 2(1826 - 21.21L)(-21.21) + 0 = 0$ — d

$.38499.14$

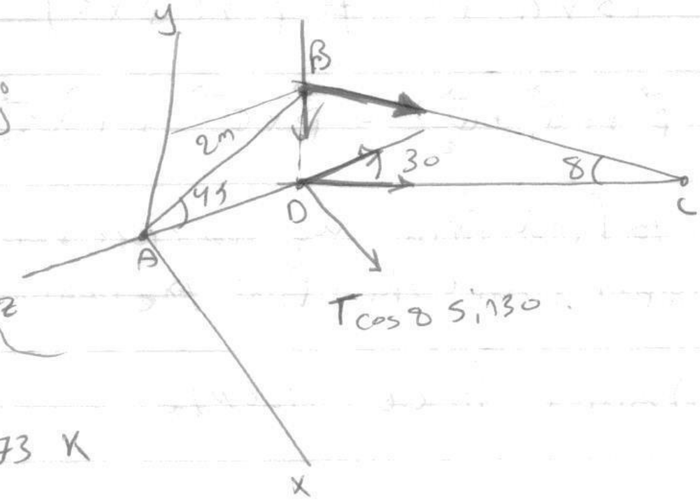
* $(\vec{P} \times \vec{Q}) \times \vec{S} \neq \vec{P} \times (\vec{Q} \times \vec{S})$

* $\vec{P} \times (\vec{Q}_1 + \vec{Q}_2) = \vec{P} \times \vec{Q}_1 + \vec{P} \times \vec{Q}_2$

* to find Area, we do cross product and between to vector, and then find the magnitude.

* Assume force $(100N)_{53°}$

3.23 $T = 30$



$F_y = -T\sin 8 = -4.175\, j$

$F_{xz} = T\cos 8 = 29.71$

$F_x = T_{xz} \sin 30 = 14.86\, i$ z

$F_z = -T_{xz} \cos 30 = -25.73\, K$

$\vec{F} = 14.86\, i - 4.175\, j - 25.73\, K$

$\vec{r}_{AB} = 0\, i + 2\sin 45\, j - 2\cos 45\, K$

$\vec{r}_{AD} = 0\, i + 1.414\, j - 1.414\, K$

$$M_A = \begin{vmatrix} +i & -j & +K \\ 0 & 1.414 & -1.414 \\ 14.86 & -4.175 & -25.73 \end{vmatrix}$$

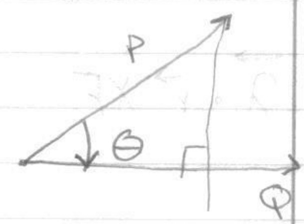
$= i(-42.28) - j(21) + K(-21)$

Fuuu

Dot Product:

$$S = \vec{P} \cdot \vec{Q} = \vec{Q} \cdot \vec{P}$$

PR



$$= PQ\cos\theta$$

Projection (λ_Q)

P on Q $\Rightarrow \lambda_Q$

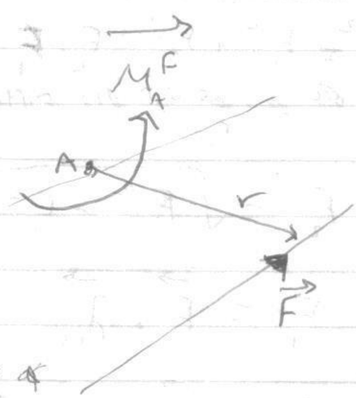
Q on P $\Rightarrow \lambda_P$

A force may be moved with respect to the original location to a new point of application if a moment is added.

عقيل

~~مجمع العزوم~~

نضيف عزم مساوي مراحل للحظة على الحركة الى الاول



كيف تكون القوة موازية للمحور ، بس له عزم

Mixed Triple Product:

Dot + cross

$\vec{U}, \vec{P}, \vec{Q}$

λ_U

* محور الدوارنة حوله

M_{OL} moment about an axis $= \begin{vmatrix} \lambda_x & \lambda_y & \lambda_z \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$ $\vec{\lambda}_{OL}$ of the axis

$\vec{\lambda} \cdot \vec{r} \times F$

λ لمحور الدوارنة

لاتشكل صفاضة تقاط

$\vec{r}$

$\vec{r}$: a vector connecting the two lines between any two random points ; المستقين اي نقطتين عشوائية

An imaginary force vector acting along the direction of the "other" line

لدينا خطين = نريد ايجاد العلاقة العمودية بينهما = ويكون لدينا ثلاث متجهات = للخط الاول، الخط الثاني، والمسافة بين اي نقطتين بينهما

← الخط الاول نجد له $\vec{\lambda}$

← الخط الثاني نجد له $\vec{F}$

← والمسافة بينهما تعتبر r

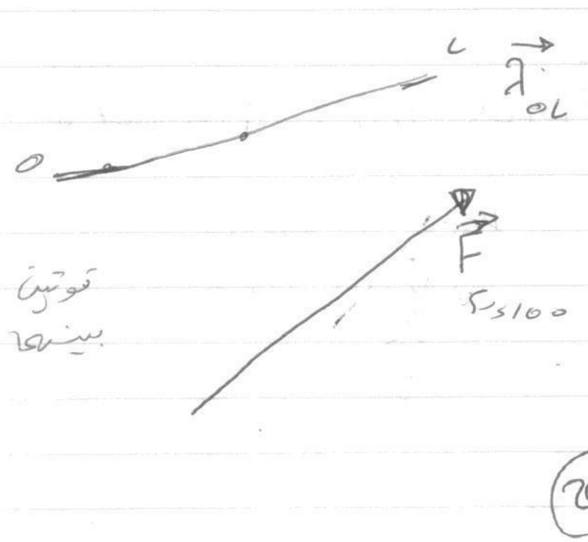
F لها مركبتين، F_1، F_2 $\quad F^2 = F_1^2 + F_2^2$

احداهما موازية للخط الاخر F_1 والاخرى عمودية على اتجاهه F_2

$$F_2 = \sqrt{F^2 - F_1^2}$$

* $\boxed{F_1 = \vec{F} \cdot \vec{\lambda}_{OL}}$ $\rightarrow$ $\boxed{M_{OL} = d F_2}$

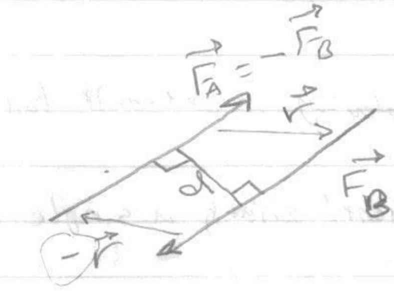
$$\boxed{M_{OL} = \vec{\lambda}_{OL} \cdot r \times \vec{F}}$$



Couple ? عزم الازدواج

قوتين متساويتين متعاكستين في الاتجاه بينهما مسافة

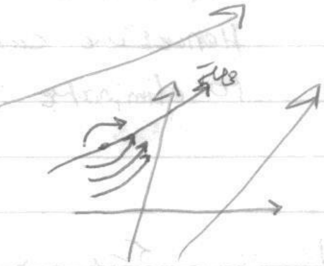
* الكمية المتوازية التي لا تعتمد vector



moment ~~of~~ a couple

$$M = F_A d = F_B d$$

* لا يمكن ايجاد المحصلة لخطين لا يلتقيان .



* لتجميع القوة في نقطة والدوران لكل ~~خط~~ خط
يكون له عزم .

[3-D]

* يوجد محصلة قوى ،
* يوجد محصلة عزوم] ← مش شرط متعامدات

* the resultant force "$\vec{R}$" and the resultant moment $\vec{M}$ are perpendicular to each other in the cases only:

$F \perp M$

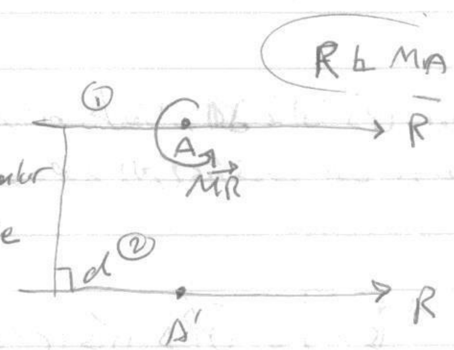
(1) Concurrent متقاطعات ، (~~المتزحلقة~~)

(2) Coplaner ، ~~تجمع القوة عمودي~~ نفس المستوى (~~القوى الثلاث متوازية~~ 2-D)

(3) ~~Parallel~~ Parallel القوى الثلاث متوازية

$R \perp M_A$

system: one force and one moment, perpendicular to each other, and replace it with a single force



تحل

30

متعامدات
force + عزم → force 1 → 2

متعامدات
force → force + عزم 2 → 1

Particularly important for two-dimensional problem -

Concurrent: already a single force

parallel } 1 resultant force and 1 couple that are
coplanar } perpendicular to each other,
Hence: we can move the force to a new point
to eliminate the moment.

في سؤال رقم 3.76 ، بالنسبة للقوتين DC ، يمكن تحليل كل منهما
اما على المستوى ABCD وإيجاد العزم الذي يكون عمودي على نفس المستوى ،
ثم نجد مركبات العزم
او تحليل على المستويات الاحداثية ونطلع العزم مباشرة .

Equivalent System

$\Sigma F = 0$
$\Sigma M = 0$

3.91 * مشابه [illegible] ننقل القوى ، العزم يضل هو نفسه بالحجم

* في سؤالي 3.111 , 3.114 ، هناك طريقتان للحل ، اما نفرض نقطة افتراضيا
ويكون محصلة العزم عندها صفر ، او نجد محصلة العزم عند نقطة اخرى ، ونفرض ان القوة
موجودة عند تلك النقطة (المحصلة)

3.120 / 3.124 سؤال !! * انتبه ، اتجاه للدائرة عمودي على مماس الدائرة

* اذا طلب عزم عند نقطة معينة ، بالامكان ايجاد العزم والمحصلة عند نقطة + العزم الناتج عن
المحصلة عند النقطة المطلوبة ?

3.47

$\vec{M}_O^{F_{AB}} = \quad i \quad j \quad k$

لإيجاد العزوم حول المحاور نجد العزم حول نقطة الاصل.

العزم حول محور x هي نفسها المركبة السينية للعزم حول نقطة الاصل

570

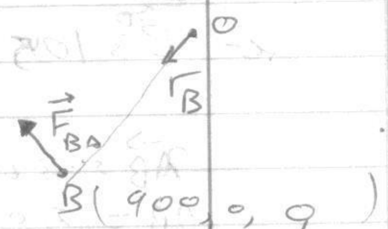
$\vec{BA} = -900\,i + 600\,j + 360\,k$ A (0, 600, 360)

$BA = 1140$

$\vec{\lambda}_{BA} = -0.7895\,i + 0.0526\,j + 0.3158\,k$

$\vec{F}_{BA} = \cancel{78.95}$

$\vec{r}_B$



$\vec{M}_O^{F_{AB}} = \vec{r}_B \times \vec{F}_{BA}$ → القوة تقطع الـ x-axis ← لا عزم

$= +i(\ 0\ ) - j(\ 162\ ) + k(\ 270\ )$

this is the component of the moment created by force $\vec{F}_{BA}$ that acts about the x-axis

if only the component about the axis is required

$$\begin{vmatrix} i=1 & 0 & 0 \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$$

$\vec{i} \cdot \vec{r} \times \vec{F}$

66

$\vec{r}_{AD}$

$\vec{r}_{CD}$

(235)

$\frac{34}{56} = \frac{y}{25} \Rightarrow y = 15$

$\frac{30}{2}$

3.57 $\cancel{\vec{X}}$ M^{P}_{AB} $\vec{\lambda}_{AB} \cdot \vec{r}_{BD} \times P$ ~~طالع حول اي نقطة~~

to find $\vec{P}$

C : ~~(16 , 15 , 12)~~

D : (16 , 38 , 12)

G : (37 , $\cancel{30}$, 30)

$\vec{DG} = 21\,i - 38\,j + 18\,k$

$DG = \cancel{25.47}\ 47$

~~$\vec{\lambda}_{DG} = 534.8\,i - 203.7\,j - 305.6\,k$~~

~~$P = 0.8245\,i - 0.3141\,j - 0.4711\,k$~~

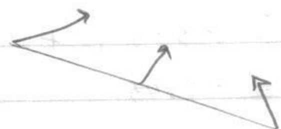
$\vec{\lambda}_{DG}\ 0.4468\,i - 0.8085\,j + 0.3829\,k$

A (0 , 30 , 24)

B (32 , 0 , 0)

$\cancel{\lambda_{AB}}$

← $\vec{P} = 105\,i - 190\,j + 90\,k$ N



$\vec{AB} = 32\,i - 30\,j - 24\,k$

$AB = 50$

← $\lambda_{AB} = 0.64\,i - 0.6\,j - 0.48\,k$

← $\vec{BD} = -16\,i + 38\,j + 12\,k$ cm

to find $\vec{P}$

$\vec{DG}$

$\vec{\lambda}_{DG}$

$\vec{P} = 325$

$\cancel{\vec{X}}$ M^{P}_{AB} ليس فيه

$$M^{P}_{AB} = \begin{vmatrix} \overset{+}{0.64} & \overset{-}{-0.6} & \overset{+}{-0.48} \\ -16 & +38 & +12 \\ +105 & -190 & +90 \end{vmatrix}$$

$\vec{\lambda}_{AB} =$

$\vec{r}_{BD} =$

$\vec{P} =$

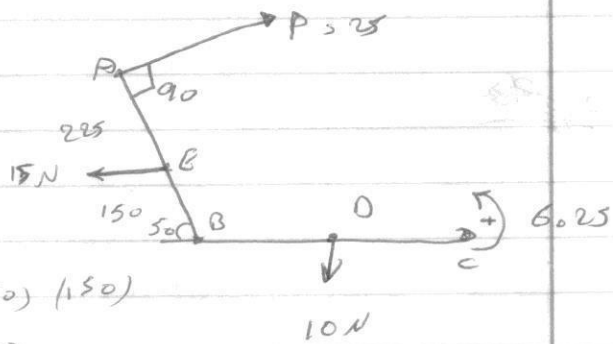
$= +\cancel{(0.64)}($

$3648 + \cancel{(0.6)} - 1620 + 456$

$= +2484$

33

$\Sigma F_x = 4.15 \; i$
$\Sigma F_y = 6.0 \; j$



$\Sigma M_B = (25)(375) - (15)(5+150)(150)$
$+ (10 \times 150) - 6.25 \times 1000$

$= 2901. \; N.mm$
$2.9 \; N.m$

$F = 7.35 \; N \quad \angle 55.6$

←

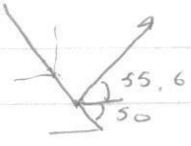
Between B and C

$2.9 = (7.35 \times \sin 55.6) \, d$

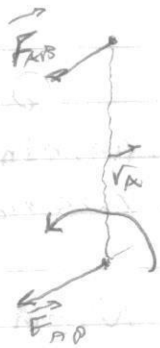
$d = 0.478 \; m$

between A and B

$2.9 = (7.35) \sin(55.6 + 50) \, d$



$d = 0.4096$



A(0, 32, 0)
B (-16, 0, 4)

$$\vec{M}^{F_{AB}} = \vec{r}_A \times \vec{F}_{AB}$$

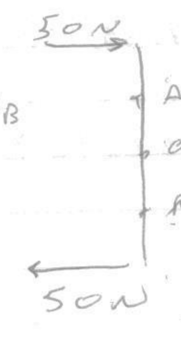
Force-couple system that replaces the original force applied at B

* قوتان متعاكستان في الاتجاه خط عملهما ليس واحد يحدثان عزم *
العزم = احداهما × المسافة بينهما (المسافة العمودية)

* في مثال 3.6 ، القوتان لـ 150 ، يعملان equivalent couple ، كما تنشأ العزم.
بينما الـ 100 كل واحدة عزمها مختلف ،

* القوة تمر بالمحور ، او موازية له ⟸ لا عزم

$M_A = M_O = M_B$



3. 99

$E\,(250,\ 0,\ 70)$

$H\,(310,\ 60,\ 0)$

$J\,(250-d,\ 30,\ 0)$

$B\,(0,\ 83.3,\ 0)$

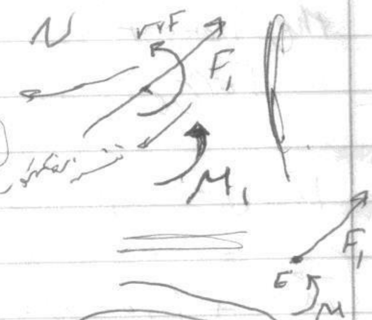
$\overrightarrow{EH} = 60\,i + 60\,j - 70\,K$

$EH = \cancel{92.7}\ 110$

$\vec{\lambda}_{EH} = 0.5454\,i + 0.5454\,j - 0.6363\,K$

$\vec{F}_{EH(1)} = 42\,i + 42\,j - 49\,K \quad N$

$M_B^{F_1} = \vec{r}_{BH} \times \vec{F}_1$



at E

$\vec{M}_1 = 31\ N\cdot m$

$B \to EH$

[illegible] ← $\overrightarrow{EJ} = -d\ i + 30\ j - 70\ K \quad (mm)$

$\vec{r}_{EJ} = EJ = \sqrt{d^2 + 5800}$

$\vec{\lambda}_{EJ} = \dfrac{-d\ i + 30\ j - 70\ K}{\sqrt{d^2 + 5800}}$

at E ← $\vec{M}_1 = \dfrac{-31d\ i + 930\ j - 2170\ K}{\sqrt{d^2 + 5800}} \quad (N\cdot m)$

$\vec{r}_{BH} = 310\ i - 23.3\ j + 0\ K$

العزم الذي تحدثه القوة من مكانها
الأصلي حول B

$$M_B = \begin{vmatrix} i & j & K \\ 310 & -23.3 & 0 \\ 42 & 42 & -49 \end{vmatrix}$$

M_2 [illegible]

F_1, M_1 يسمى لها ازدواجة

$= i\,(1142) - j\,(-15190) + 14\,K$

$= 1142\,i + 15190\,j + 14\,K \quad (N\cdot m)$

37

$$\vec{F}_1 = 42i + 42j - 49k \quad N$$

$$\left.\begin{aligned} \vec{M}_1 &= \frac{-31d\,i + 930\,j - 2170\,k}{\sqrt{d^2+5800}} \xrightarrow{} 14 \\ \vec{M}_B^{F_1} &= 1.142 i + 15.19 j + 14.00 k \quad (N \cdot m) \end{aligned}\right\} M_2$$

$$\vec{M}_{2z} = \frac{\overset{N\cdot m}{-2170}}{\sqrt{d^2+5800}} + \overset{N\cdot m}{14} = 0 \qquad 155$$

$$\sqrt{d^2+5800} = \frac{2170}{14}$$

$$\boxed{d = \pm 135 \quad mm}$$

$$F_2 = F_1$$

$\cancel{M_1}$

unitless

mm mm

$$\frac{-31\,d\,i}{\sqrt{d^2+5800}} \qquad \lambda_x \quad \frac{d}{\sqrt{\ }}$$

$$M_1 = -31\left(\frac{135}{155}\right)i + \frac{930}{155}j - \frac{2170}{155}k \quad (N \cdot m)$$

$$M_1 = -27\,i + 6\,j - 14\,K \quad N \cdot m$$

$$M_B = 1.142\,i + 15.19\,j + 14.00\,k \quad N \cdot m$$

$$\vec{M}_2 = -25.86\,i + 21.19\,j + 0\,k \quad (N \cdot m)$$

$$\vec{F}_2 = 42i + 42j - 49k \quad N.$$

P2

3.124

$\cdot A(0,0,0)$

$\vec{F}_{50} = 0i - 50j + 0K$ N

$\dot{B}$ (200, 0, 0)

$\vec{F}_{300} = -300i + 0j + 0 \cancel{300}K$ N $\cdot D(200, 0, 160)$

$\vec{F}_{250} = 0i + 0j - 250K$ N

$E \cdot (200, \cancel{160}^{-160}, \cancel{100}^{160})$

$F_{120} = -120i + 0j + 0K$ N

$R = -420i + 50j - 250K$ N

$\vec{r}_{AB} = 200i + 0j + 0K$

$$\vec{M}_A^{F_{50}} = \begin{vmatrix} i & j & K \\ 200 & 0 & 160 \\ 0 & -50 & 0 \end{vmatrix} = (0)i - j(0) + -10 K \text{ N.m}$$

$$\vec{M}_A^{300} = 0i + 0j + 0K \text{ N.m}$$

$$\vec{M}_A^{F_{250}} = \begin{vmatrix} i & j & K \\ 200 & 0 & \boxed{0} \\ 0 & 0 & -250 \end{vmatrix} = 0i + j(50) + K(0) \text{ N.m}$$

$$\vec{M}_A^{F_{120}} = \begin{vmatrix} i & j & K \\ 0 & -100 & 160 \\ -120 & 0 & 0 \end{vmatrix} = i(0) - j(19.2) - K(12) \text{ N.m}$$

$$\vec{M}_A = 0i + 30.8j - 22K \text{ N.m}$$

3.152

$F_x = F\cos\theta\cos\phi$ $\qquad$ $A(-4, 11, -d)$

$F_y = -F\sin\theta$

$F_z = F\cos\theta\sin\phi$

$$M = \begin{vmatrix} i & j & k \\ -4 & 11 & -d \\ F\cos\theta\cos\phi & -F\sin\theta & F\cos\theta\sin\phi \end{vmatrix}$$

$= i(11F\cos\theta\sin\phi - dF\sin\theta) - j(-4F\cos\theta\sin\phi + dF\cos\theta\cos\phi) + k$
$+ k(-4F\sin\theta - 11F\cos\theta\cos\phi)$

$\dfrac{11 \times 70\cos 25\sin\phi}{100} - d\dfrac{70\sin 25}{100} = -7.32$

$\dfrac{697.8\sin\phi}{100} - \dfrac{29.58\,d}{100} = -7.32$ — (1)

$-4 \quad -11 \quad d$

$\dfrac{4 \times 70 \times \cos 25\sin\phi}{100} - \dfrac{d \times 70 \times \cos 25\cos\phi}{100} = M_y$

$\dfrac{253.8\sin\phi}{100} - \dfrac{63.44\,d\cos\phi}{100} = M_y$ — (2)

$+\dfrac{118.3}{100} + \dfrac{697.8\cos\phi}{100} = +5.16$ — (3)

$\cos\phi = \dfrac{-6.67}{69.78} = -0.0955$

$\phi = 24.63$ $\qquad$, $d = 0.3458$ m

$= 34.58$ cm

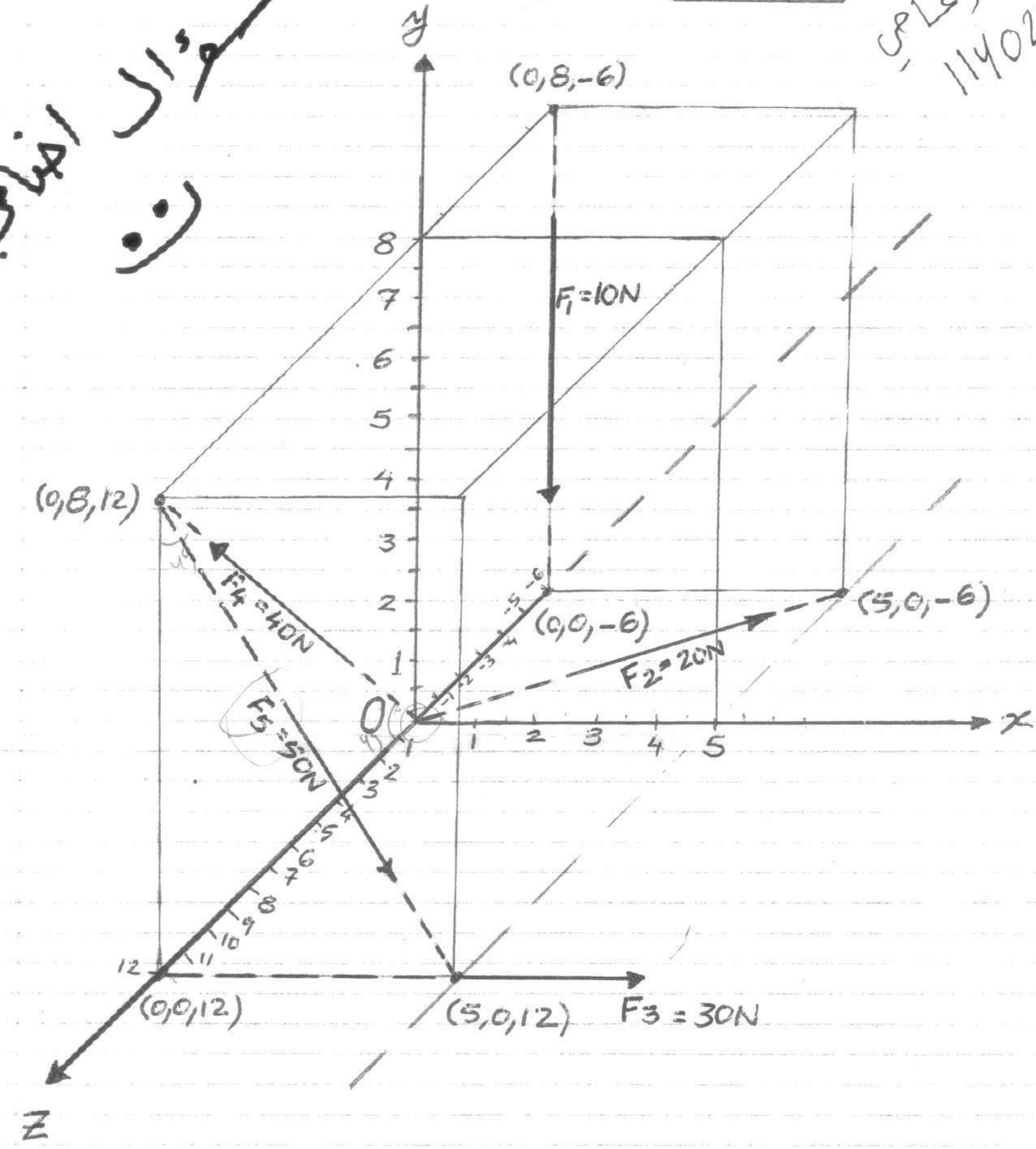
40

ENCE 232 Statics

Home work

سؤال امتحان

1140292



Determine:

a) $\vec{R}$ at O and $\vec{M}_o^R$ to replace the force system.

b) Perpendicular distance from O to $\vec{F_5}$.

c) Perpendicular distance between lines of action of $\vec{F_1}$ and $\vec{F_2}$.

Zero d) Perpendicular distance between lines of action of $\vec{F_1}$ and $\vec{F_4}$.

e) Perpendicular distance between line of action of $\vec{F_2}$ and $\vec{F_5}$.

f) Angle betwee lines of action of $\vec{F_1}$ and $\vec{F_4}$, and $\vec{F_2}$ and $\vec{F_4}$.

Bashar Assi 1140292 Additional H.w

$\overrightarrow{DE} = 0i - 8j + 0K$, $DE = 8$

$\overrightarrow{\lambda}_{DE} = 0i - 1j + 0K$

$\boxed{F_1 = 0i - 10j + 0K}$

$\overrightarrow{OC} = 5i + 0j - 6K$, $OC = 7.8$

$\overrightarrow{\lambda}_{OC} = 0.6410\,i + 0j - 0.7692\,K$

$\boxed{F_2 = 12.82\,i + 0j - 15.38\,K}$

$\boxed{F_3 = 30i + 0j + 0K}$

$\overrightarrow{OA} = 0i + 8j + 12K$

$OA = 14.42$

$\overrightarrow{\lambda}_{A} = 0i + 0.5556\,j + 0.8333\,K$

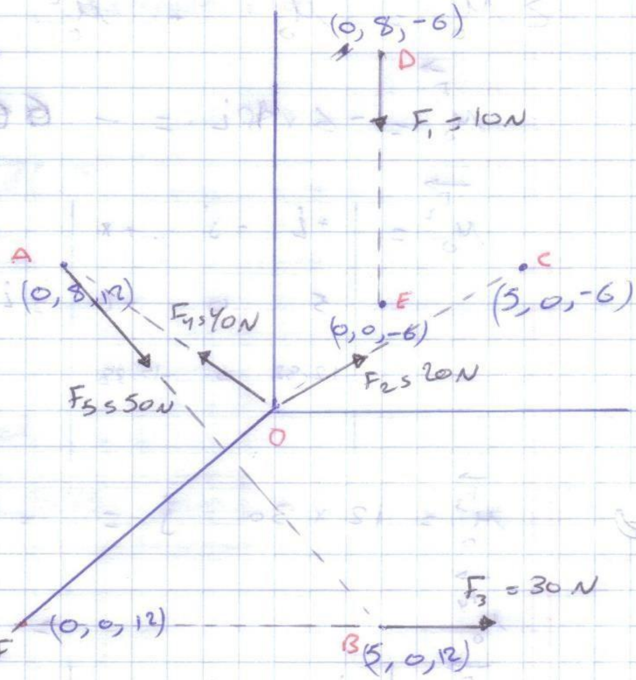
$\boxed{\overrightarrow{F}_4 = 0i + 22.22\,j + 33.33\,K}$

$\overrightarrow{AB} = 5i - 8j + 0K$

$AB = 9.434$

$\lambda_{AB} = 0.53\,i - 0.848\,j + 0K$

$\boxed{F_5 = 26.5\,i - 42.4\,j + 0K}$



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① $\overrightarrow{R}_o$ and $\overrightarrow{M^R_o}$

$\overrightarrow{R}_x = (0 + 12.82 + 30 + 0 + 26.5)\,i = 69.32\,i$

$\overrightarrow{R}_y = (-10 + 0 + 0 + 22.22 - 42.4)\,j = -20.18\,j$

$\overrightarrow{R}_z = (0 + 0 - 15.38 + 33.33 + 0)\,K = 17.95\,K$

$\overrightarrow{R}_o = 69.32\,i - 20.18\,j + 17.95\,K$

$$\Sigma M_0 = \overrightarrow{M_0^{F_1}} + \overrightarrow{M_0^{F_2}} + \overrightarrow{M_0^{F_3}} + \overrightarrow{M_0^{F_4}} + \overrightarrow{M_0^{F_5}}$$

$$M_0^{\vec{F_1}} = -6 \times 10 i = -60 i$$

$$M_0^{\vec{F_2}} = \begin{vmatrix} +i & -j & +k \\ 5 & 0 & -6 \\ 12.82 & 0 & -15.38 \end{vmatrix} = i(0) - j(0) + k(0)$$

$$M_0^{\vec{F_3}} = 12 \times 30 \; j = 0 i + 360 j + 0k$$

$$M_0^{\vec{F_4}} = 0 i + 0 j + 0 k$$

$$M_0^{\vec{F_5}} = \begin{vmatrix} i & j & k \\ 5 & 0 & 12 \\ 26.5 & -42.4 & 0 \end{vmatrix} = (508.8) i + (318) j + (-212) k$$

$$\Sigma M_0 = 448.8 i + 678 j - 212 k \quad N.m$$

(2) perpendicular distance from O to $\vec{F_5}$

$$M_0^{\vec{F_5}} = \sqrt{(508.8)^2 + (318)^2 + (212)^2} = 636.4 \quad N.m$$

$$M_0^{F_5} = dF = 50d = 636.4$$

$$\boxed{d = 12.73}$$

(3) perpendicular distance between $\vec{F_1}$ and $\vec{F_2}$

$$\lambda_{F_1} = 0i - 1j + 0k$$

$$F_{21} = \lambda . F_2 = (0i - 1j + 0k).(12.82i + 0j - 15.38k) \quad \text{(parallel force)}$$

$$= 0 + 0 + 0$$

$F_{22} = \sqrt{F_2^2 - F_{21}^2} = 20\ N$ (perpendicular force)

$r = 5i + 0j + 0k$

$$M_{F_1} = \begin{vmatrix} 0 & -1 & 0 \\ 5 & 0 & 0 \\ 12.82 & 0 & -15.38 \end{vmatrix} = 76.9$$

$M_{F_1} = d F_{22}$, $76.9 = 20d$

$$\boxed{d = 3.845\ mm}$$

d)

$\lambda_{F_1} = 0i - 1j + 0k$

$F_4 = 0i + 22.22j + 33.33k$

$r_{F_1 \to F_2} = 0i + 0j + 6k$

$F_{41} = \lambda_{F_1} \cdot F_4 = (0i - 1j + 0k) \cdot (0i + 22.22j + 33.33k)$ parallel

$= -22.22\ N$

$F_{42} = \sqrt{F_4^2 - F_{41}^2} = 33.26\ N$

$$M_{F_1}^{F_4} = \begin{vmatrix} 0 & -1 & 0 \\ 0 & 0 & 6 \\ 0 & 22.22 & 33.33 \end{vmatrix} = \text{Zero}.$$

there is no perpendicular distance between F_1, F_4

(c) perpindicular distance between lines of action of $\vec{F_2}$ and $\vec{F_5}$

$\lambda_{F_2} = 0.641\, i + 0\, j - 0.7692\, K$

$r = 0\, i + 0\, j + 18\, K$

$F_5 = 26.5\, i - 42.4\, j + 0K$

$$M_{F_2}^{F_5} = \begin{vmatrix} 0.641 & 0 & -.7692 \\ 0 & 0 & 18 \\ 26.5 & -42.4 & 0 \end{vmatrix} = 489.2 \quad N.m$$

$F_{51} = \lambda_{52} \cdot F_5 = (0.641\, i + 0j - 0.7692) \cdot (26.5\, i - 42.4j + 0K)$

$= 16.98$ parallel

$F_{52} = \sqrt{50^2 - (16.98)^2} = 47\ N$ perpindicular

$M_{F_2}^{F_5} = 489.2 = 47\, d$

$$\boxed{d = 10.41 \ m}$$

(f) $F_1 \cdot F_4 = (0i - 10j + 0K) \cdot (0i + 22.22j + 33.33K) = 10 \times 40 \cos\theta$

$-222.2 = 400 \cos\theta$

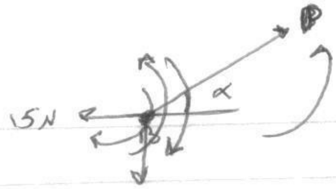
$$\boxed{\theta = 123.7}$$

$F_2 \cdot F_4 = (12.82i + 0j - 15.38K) \cdot (0i + 22.22j + 33.33K) = 20 \times 40 \cos\alpha$

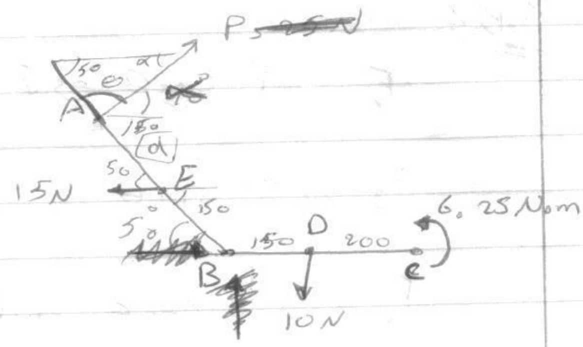
$-512.6 = 800 \cos\alpha$

$$\boxed{\alpha = 129.8^\circ}$$

:)



$\boxed{3.115}$, page



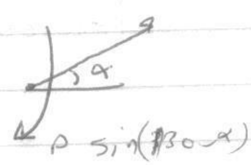
~~$\Sigma F_x = 25\cos 40 - 15 = 0$~~

~~$\Sigma M_B = 0$~~

~~$= -(150)(15)(\sin 50)k + (25)(\sin 90)(d+150) + (150)(10) - 6.25$~~

~~$-3520 - 25d = 0$~~

$d =$



$\theta = (130 - \alpha)$

$\Sigma F_x = P\cos\alpha - 15 = 0$

$P\cos\alpha = 15$

$\Sigma F_y = P\sin\alpha - 10 = 0$

$P\sin\alpha = 10$

$\alpha = 33.69°$

$P = 18.03$

$\Sigma M_B = P\sin(130-\alpha)(d+150) - (15)(150)\sin 50 + (10)(150) - 6.25$

$P\sin(130-\alpha)(d+150) - 3026 = 0$

$P(\sin 130\cos\alpha - \sin\alpha\cos 130)(d+150) - \cancel{3026}\ 6474 = 0$

$(15\sin 130 - 10\sin 130)(d+150) = \cancel{3026}\ 6474$

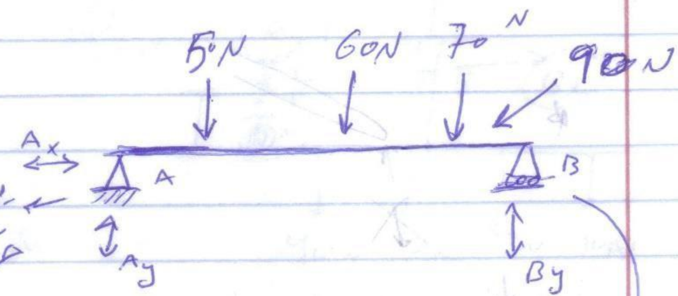
$(17.9)(d+150) = \cancel{3026}\ 6474$

$\boxed{d = \cancel{127}\ \text{mm}}$

211

Ch4

Ch4



يمنع الانتقال في حركتين

يمنع الحركة في اتجاه واحد (عمودي)

$\Sigma F_x = 0$

$\Sigma F_y = 0$

~~$\Sigma M_y = 0$~~

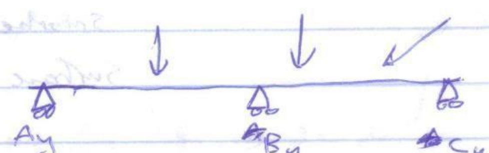
$\Sigma M = 0$

3-equations

3 unknowns

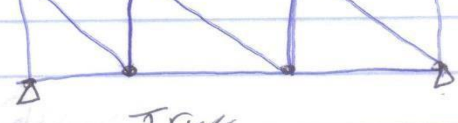
Statically determinate محدد استاتيكياً.

Rigid Body: الجسم ثابت الشكل.

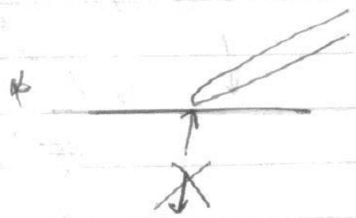


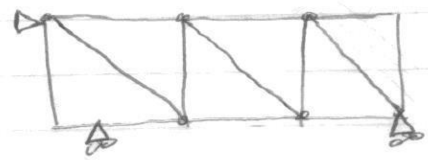
unstable, 3 unknown
3 equ
statically indeterminate

statically indeterminate
غير محدد استاتيكياً
لا يمكن ايجاد

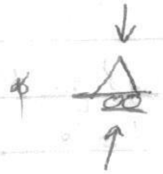


Truss

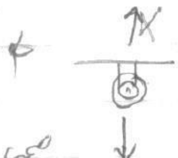




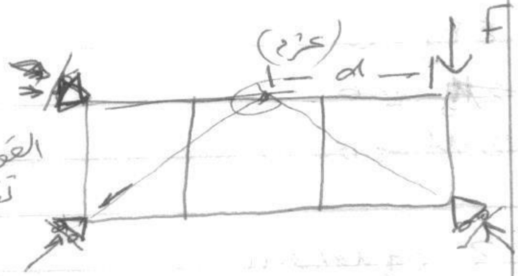
Stable الجسم لا يتحرك.



ما بطلع ولا بنزل

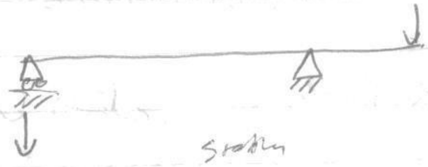


صحيح بنزل
بس ما بطلع



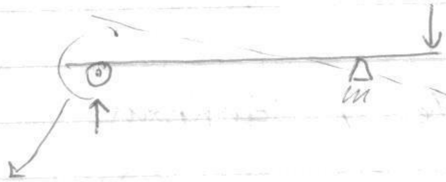
القوى كلتقي في
نقطة واحدة

Un Stable



Stable

Smothe
Surface

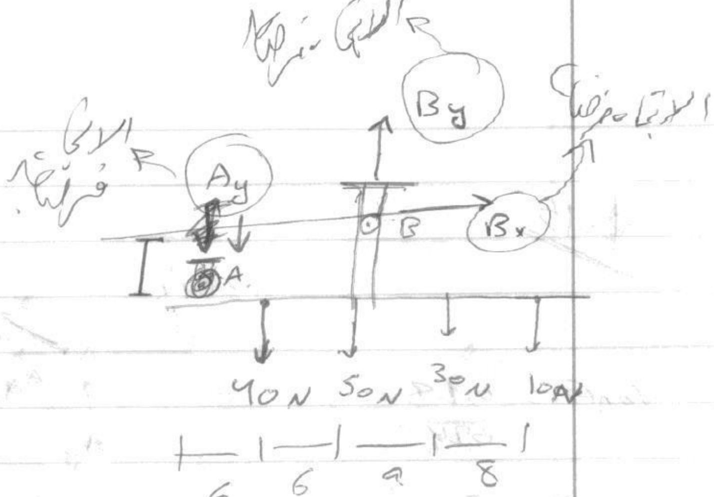


ولا كأنها موجودة

cable & T
pull ? T ? ضغط

4.3

(1) $a = 10$.



Pin: 2 reactions
1 reaction act on unknown angle.

Roller: 1 reaction
⊥ to the surface.

لو Bx موجودة

* $\Sigma F_x = 0$ $\xrightarrow{+}$

$\boxed{B_x = 0}$

نأخذ مجموع العزوم اما حول نقطة الـ... او حول نقطة تقاطع (المجاهيل)
حول نقطة فيها مجاهيل اما A أو B

* ΣM on $A = 0$ (+↻) — فرضا (+Bx)(cl)

$$+(40)(6) + 50(12) - B_y(12) + 30(22) + 10(30) = 0$$

$$\boxed{B_y = +150\,N} \uparrow$$

* $\Sigma F_y = 0$ $+\uparrow$

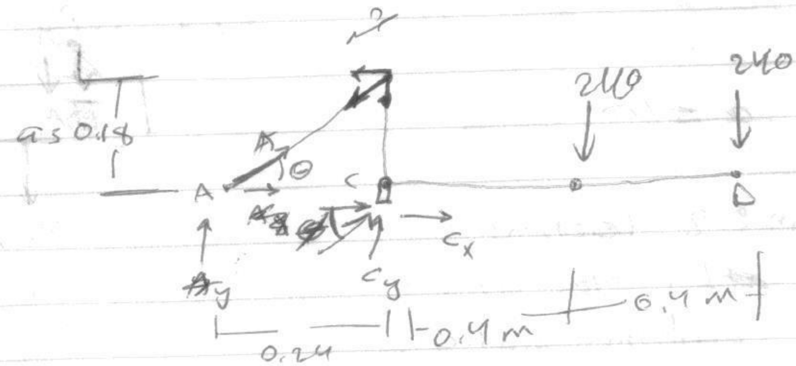
$$-A_y - 40 - 50 + 150 - 30 - 10 = 0$$

$$\boxed{A_y = +20\,N}$$

يعني الاتجاه كان صحيح

Assumed direction is correct

ϕ.15



$\tan\theta = \dfrac{0.18}{0.24}$

$\theta = 36.8^{\circ}$

$\Sigma F_x = 0 = A_x + C_x = 0$ $\xrightarrow{+}$

$T_A \cos 36.8 + C_x = 0$ — 1

$-0.8 T_A + C_x = 0$

$\uparrow +$

$\Sigma F_y = 0 = T_A \sin 36.8 + C_y - 240 - 240 = 0$

$= T_A \sin 36.8 + C_y = 480$ — 2

$-0.6 T_A + C_y = 480$

$T \cos 36.8$

$M_{about\ C} = 240(0.4) + 240(0.8) + T_x(0.18) = 0$ $\circlearrowleft +$

$T_x = \dfrac{288}{0.18} = 1600\ N = T \cos 36.8$

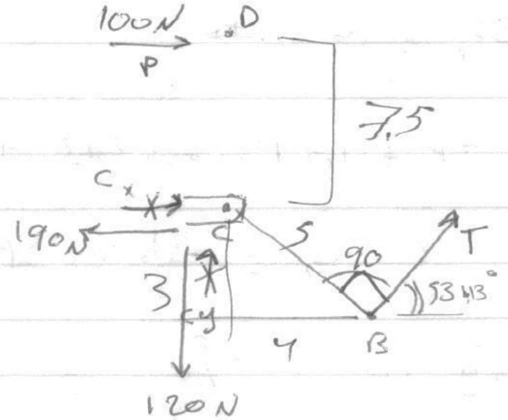
$T = {}^{+}1998\ N$ ← يجب ان يكون موجب لانه شد.

$C_x = 0.8 \times 1998 = +1598.4\ N$

$C_y = 480 + 0.6 \times 1998 = 16~~98~~$

$\phi = 46.4$ $\tan\phi = \dfrac{1680}{1600}$

14.17



$\Sigma M_C = 0 \circlearrowright^{+}$

$= \cancel{+}\, 100(7.5) - F_{rod}(5) = 0$

$F_{rod} = +150\ N.$

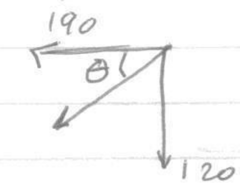
$\Sigma F_x = 0 = 100 + C_x + \overset{150}{T} \cos 53.13$ $\xrightarrow{+}$

$= C_x = -190\ N$

$\Sigma F_y = 0$ $\uparrow +$

$\overset{150}{T} \sin 53.13 + C_y = 0$

$C_y = -120\ N$



$\theta = 32.27$

$R = 224.7\ N$

4.18

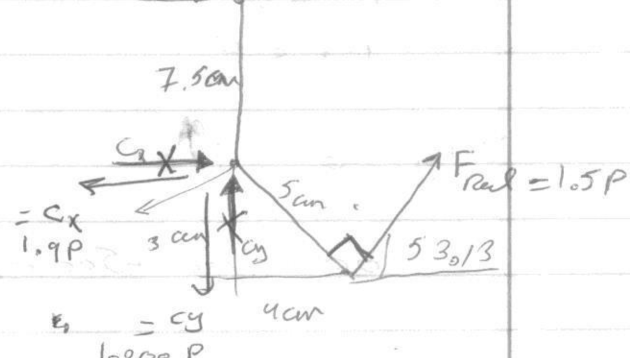
Max $F_c = 250N.$

$C_x = \quad C_x =$

ΣM abt $C = 0 \quad \circlearrowright^{+}$

$+P(7.5) - F_{Rod}(5) = 0$

$F_{Rod} = 1.5\ P$



Σ

~~4.39 H.w~~

$\Sigma F_x = 0$ $\xrightarrow{+}$

$+P + 1.5P\cos 53.13 + C_x = 0$

$C_x = -1.900\,P$

$\Sigma F_y = 0$ $+\uparrow$

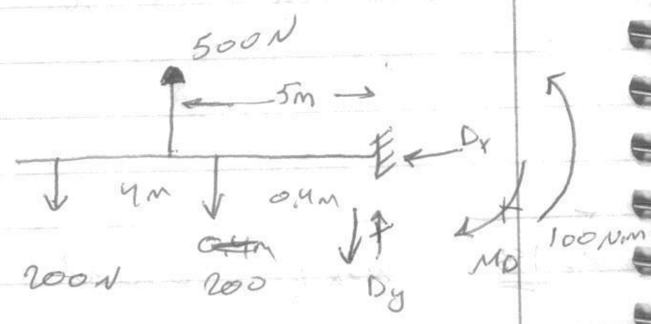
$+C_y + 1.5P\sin 53.13 = 0$

$C_y = -1.200\,P$

$\sqrt{(1.2P)^2 + (1.9P)^2} \le 250\,N$

$P \le 111.3\,N.$

4.43



$\Sigma F_x = 0$ $\xrightarrow{+}$

$-D_x + 0 = 0$
$D_x = 0$

$\Sigma F_y = 0$ $+\uparrow$

$-200 - 200 + 500 + D_y = 0$ $D_y = -100\,N$

$\Sigma M_D = \cancel{0}$ $+\circlearrowleft$

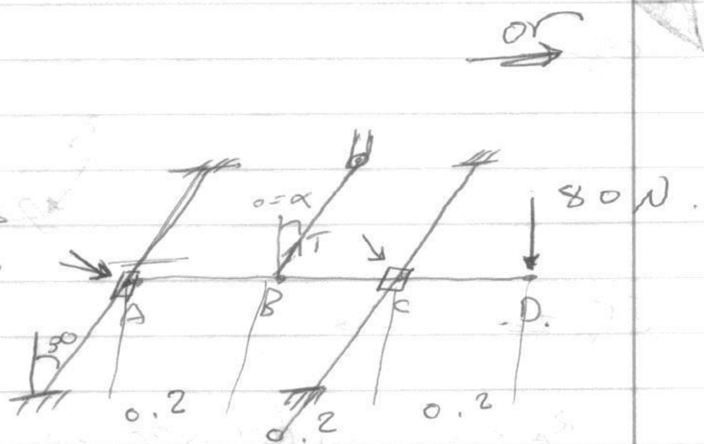
$-200(8) + 500(5) - 200.4(4)$ ~~+100~~ $= \cancel{0}\ M_D$

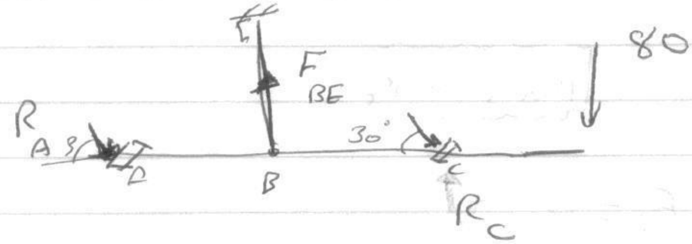
$M_D = -100\,N$

47

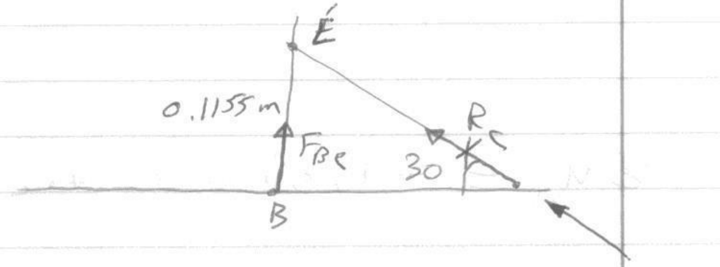
4.39

* اما نجد العزم عند نقطة تلتقي فيها اثنين من المجاهيل (النقطة تقاطع بين قوتين) E'
* لو نجد العزم حول نقطتين مختلفتان





$\Sigma F_x =$



$M_{about\ E'} = -(R_A \cos 30)(0.1155) - R_A(\sin 30)(0.2) + 80(0.4) = 0$

$R_A = +160$ الاتجاه صحيح

$\Sigma F_x = 0 = +160 \cos 30 + RC \cos 30 = 0$

$R_C = (-)160\ N$

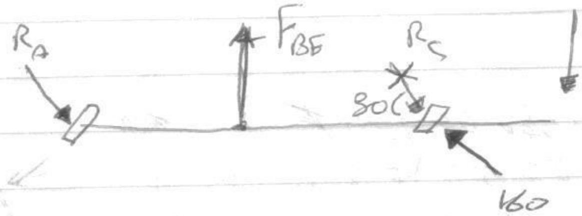
$\Sigma F_y = 0 \quad +\uparrow$

$-160 \sin 30 + 160 \sin 3 + F_{BE} - 80 = 0$

$F_{BE} = +80\ N$

48

39



$\Sigma F_x = 0 \quad \xrightarrow{+}$

$+R_A \cos 30 + R_C \cos 30 = 0$

$\boxed{R_A = -R_C}$

$\Sigma F_y = 0 \quad +\uparrow$

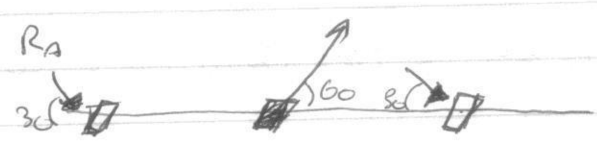
$-R_A \sin 30 - R_C \sin 30 + F_{BE} - 80 N = 0$

$\Sigma M_B = -R_A(\sin 30)\,0.2 + R_C \sin 30\,(0.2) + 80(0.4)$

$-R_A \sin 30\,(0.2) - R_A \sin 30\,(0.2) + 80(0.4)$

$R_A = +160$

40



$\Sigma F_x = R_A \cos 30 + T_{BE} \cos 60 + R_C \cos 30 = 0$

$\Sigma F_y = -R_A \sin 30 + T_{BE} \sin 60 - R_C \sin 30 - 80 = 0.$

$$\Sigma F_x = R_A + T_{BE}(0.577) + R_C = 0$$

$$\Sigma F_y = -R_A + T_{BE}(1.73) - R_C = \frac{80}{\sin 30}$$

$$2.307\, T_{BE} = \frac{80}{\sin 30}$$

$$\boxed{T_{BE} = \cancel{34.67}}\ N$$

$$\Sigma M_{abou} = $$

12

particle $*$ 2-dimensions

$\Sigma F_x = 0$
$\Sigma F_y = 0$ 2
$\cancel{\Sigma F}$

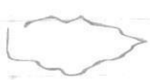
3-dimen

$\Sigma F_x = 0$
$\Sigma F_y = 0$ 3
$\Sigma F_z = 0$

rigid Body

2-dimensions

$\left.\begin{array}{lll} \Sigma F_x & & \Sigma F_x \\ \Sigma F_y & \text{or} & \Sigma M \\ \Sigma M & & \Sigma M \end{array}\right\} 3$



3-dimensions

$\left.\begin{array}{ll} \Sigma F_x & \Sigma M_x \\ \Sigma F_y & \Sigma M_y \\ \Sigma F_z & \Sigma M_z \end{array}\right\} 6$

Two-force member (body)

Pin دبوز

Pin

** pins at the ends of the member

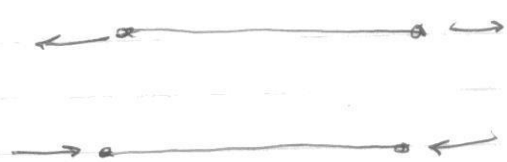
pin

عرضي/جانبي احمال
~~No~~ transverse loads along its

length

tension

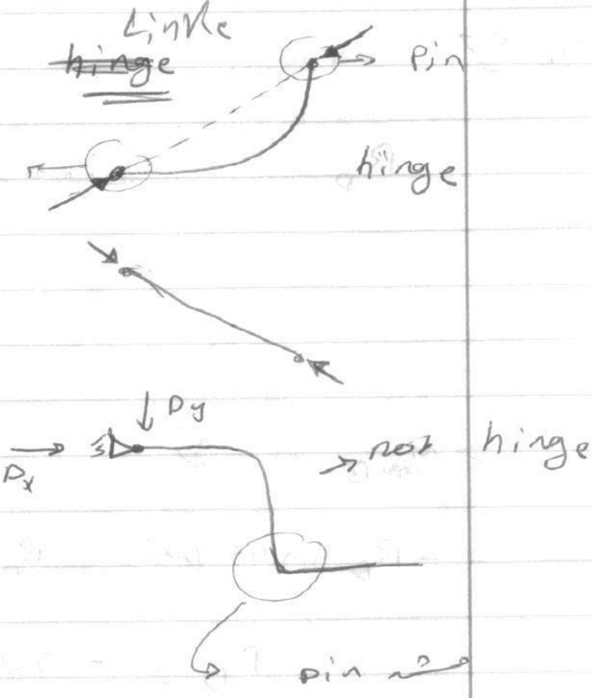
شد ، ~~ضغط~~



Cables
cords (chords) حبال
Links

51

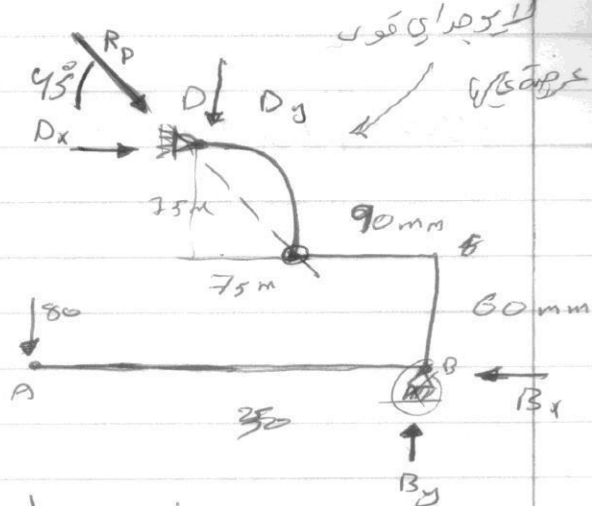
Two-force member



انتبه في المسألة (مثلاً 9.45)، تحويله ~ محصلة العزم عند B من القوتين صفر. لكن لا تنس عند A أخذ العزم الناتج من الحامل.

No. 67

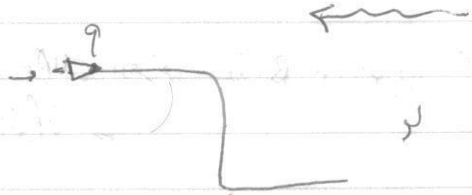
R_D اتجاهه معروف.



$\sum M_{about\, B} = 0$ (+↺) بنلغي ~~قوى~~ المجاهيل

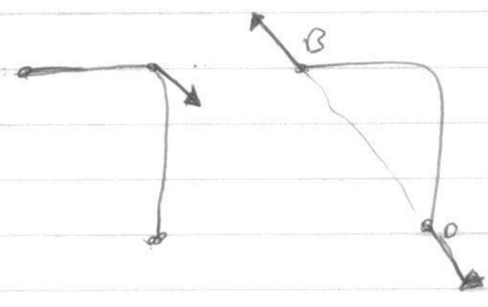
$$-R_D \sin 45 (165) + R_D \cos 45 (135) - 80(250) = 0$$

$$R_D = -942.8 \text{ N}$$



لا يمكن ~~ح~~ حل هذا السؤال

No. ~~107~~ 66



53

4.107

محصلة العزوم عند A ← يعطي ثلاث مجاهيل.

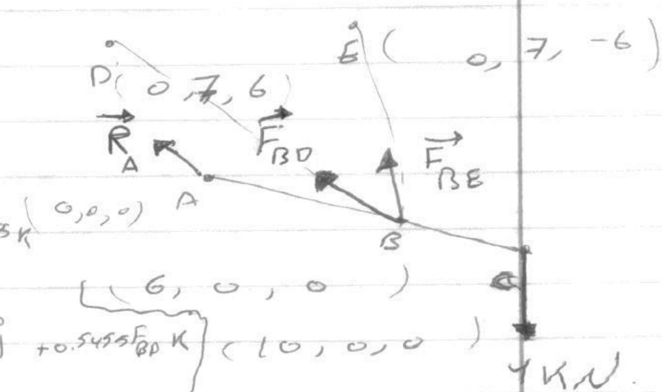
محصلة العزوم حول محور DA ← يعطي مجهول واحد.

$$\boxed{\vec{F}_y = 0\,i - 4j + 0K \quad KN}$$

$\vec{BD} =$

$BD =$

$\lambda_{BD} = -0.5455\,i + 0.6364\,j + 0.5453K$



$$\boxed{\vec{F}_{BD} = -0.5455F_{BD}\,i + 0.6364F_{BD}\,j + 0.5455F_{BD}\,K}$$

$$\boxed{R_A = R_{Ax}\,i + R_{Ay}\,j + R_{Az}\,K}$$

$\vec{BE} = -6\,i$

$$\boxed{F_{BE} = -0.5455F_{BG}\,i + 0.6364F_{BE} - 0.5455F_{BE}\,K}$$

ثلاث معادلات بثلاث مجاهيل، يمكننا حلها لأنه :

يمكن إيجاد العزم لكل واحدة حول المحور DA

$$\vec{\lambda}_{AD}\cdot(\vec{r}_B \times F_{BE}) =$$

$$+\ \vec{\lambda}_{AD}\cdot(\vec{r}_C \times F_4)$$

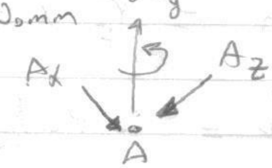
R_A لا يعمل عزم على المحور

مجموع 0

4,121

$\overrightarrow{R}_{MA} = M_{Ax} i + 0j + R_{MAz} K$ N.mm

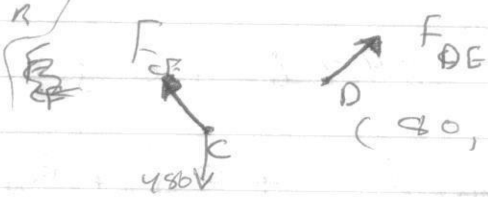
~~ΣF_x~~ =



$\overrightarrow{CF} = -80i + 60i + 0K$ F (0, 60, 135) (0,0,0) E (80,120,0)

CF = 100

$\lambda_{CF} = -0.8 i + 0.6 j + 0K$



$F_{CF} = \frac{F}{\cancel{x}}$

(80, ~~90~~ 0, 90)

(80, 0, 135)

$\boxed{F_{CF} = -0.8F_{CF} i + 0.6 F_{CF} j + 0K}$

$\overrightarrow{DE} = 0i + 120j - \cancel{135}\,90 K$

DE = ~~180.0~~ 150

$\lambda_{DE} = 0i + 0.8\cancel{644} j - 0.6\cancel{475} K$

$F_{DE} = 0i + 0.8\cancel{644} F_{DE} j - 0.6\cancel{475} F_{DE} K$

$F_{480} = 0i$

$\Sigma F_x = -0.8 F_{CF} + 0i + A_x = 0.$ (1

$\Sigma F_y = 0.6 F_{CF} + 0.6644 F_{DE} - 480 = 0$ (2

$\Sigma F_z = 0 - 0.7475 F_{DE} + A_z = 0.$ (3

~~$-F_{CF} + 0 + 1.25 A_x$~~

$\overrightarrow{R}_{FA}$ $F_{on\,A}$

$\overrightarrow{F_{CF}} = -0.8 F_{CF} i + 0.6 F_{CF} + 0K$ N

$\overrightarrow{F_{DE}} = 0i + 0.8 F_{DE} i - 0.6 F_{DE}$ N

$\overrightarrow{F_{480}} = 0i - 480j + 0K$ N

$\overrightarrow{R}_{FA} = R_{FAx} i + 0j + R_{FAz} K$ N

N

G

$$\vec{M}_A^{F_{CF}} = \vec{r}_F \times \vec{F}_{CF} = -81 F_{CF}\, i - 108 j + 48 k$$

$$\vec{M}_A^{F_{DE}} = -72 F_{DE}\, i - 108 F_{CF}\, j + 48 F_{CF}\, k$$

$$\vec{M}_A^{480} = 64.8\, i + 0\, j - 38.4\, k$$

$$\vec{R}_{MA} = R_{MAX}\, i + 0\, j + R_{MAZ}\, k$$

$$\Sigma M_y = 0 = -108 F_{CF} + 48 F_{DE} = 0$$

$$\boxed{F_{DE} = +2.25 F_{CF}}$$

$$\Sigma F_y = 0 = 0.6 F_{CF} + 0.8 F_{DE} - 480 = 0$$

$$= +0.6 F_{CF} + 0.8(2.25 F_{CF}) - 480 = 0$$

$$\boxed{F_{CF} = 200\ N}$$

$$\boxed{F_{DE} = +450\ N}$$

$R_{FAX} = +160\ N$

$R_{FAZ} = +220\ N$

$R_{MAX} = -16.2\ N \cdot m$

$R_{MAZ} = 0\ N \cdot m$

4.133

$A(0, \cancel{200}\ 0, 0)$

$B(480, -200, 0)$

$C(480, -200, 400)$

$D(0, 0, 400)$

$E(240, 400, 0)$

$\vec{CE} = -240i + 600j - 400k$

$CE = 760$

$\lambda_{CE} = -0.3158i + 0.7895j - 0.5263k$

$\vec{F}_{CE} = -0.3158F_{CE}i + 0.7895F_{CE}j - 0.5263F_{CE}k$

~~$\vec{R}_F = 0i + F_{Fy}j + F_{Fz}k$~~

$w(240, 400, 200)$

$\vec{F}_w = 0i - 490.5j + 0k$

$\vec{AB} = 480i - 200j + 0k$

$AB = 520$

$\lambda_{AB} = 0.9231i - 0.3846j + 0k$

لما كان في R at A و R at B لن تدخل في العزم حول AB

بالاضافة انه لا يوجد لها، عندها هنا ال 2- hinges نعتبرهم

pall and sealed، لا يوجد لها

$$M_{AB} = \begin{vmatrix} \overset{+}{0.9231} & \overset{-}{-0.3846} & \overset{+}{0} \\ 240 & -100 & 200 \\ 0 & -490.5 & 0 \end{vmatrix} = +90.56 + \text{ N.m.}$$

$$M_{AB}^{F_{CE}} = \begin{vmatrix} 0.9231 & -0.3846 & 0 \\ 240 & 400 & 0 \\ -0.3158F_{CE} & 0.7895F_{CE} & -0.5263F_{CE} \end{vmatrix} = -0.1943F_{CE} - 0.0486F_{CE}$$

$-0.2429F_{CE}$

$F_{CE} = 372.8$

$F_P = \cancel{+}0i - P\,j + 0k$

$F_D = -F_D\cos45\,i + F_D\sin45\,j + 0\,k$

$F_B = F_B\cos45\,i - F_B\sin45\,j + 0\,k$

$F_C = 0 - F_C\sin45\,j + F_C\cos45\,K$

$R_F = R_{Fx}\,i + R_{Fy}\,j + R_{Fz}\,k$

A (0, 80, 0)
B (0, 80, -200)
C (200, 80, 0)
D (0, 80, 200)
E (-200, 80, 0)

$\Sigma M_F = M_P + F_D + F_B + F_C$

$\vec{M}_F^{P} = 0\,i + 0\,j + 200P\,k$

$$\vec{M}_F^{F_D} = \begin{vmatrix} i & j & k \\ 0 & 80 & 200 \\ 0.7071\,F_D & .7071\,F_D & 0 \end{vmatrix} = i(141.4F_D) - j(141.4\,F_D) + k(56.57\,F_D)$$

$$\vec{M}_F^{F_B} = \begin{vmatrix} i & j & k \\ 0 & 80 & -200 \\ 0.7071\,F_B & -0.7071\,F_B & 0\,F_B \end{vmatrix} = i(-141.4F_B) - j(141.4\,F_B) + k(-56.57\,F_B)$$

$$\vec{M}_F^{F_C} = \begin{vmatrix} i & j & k \\ 200 & 80 & 0 \\ 0 & -.7071\,F_C & 0.7071\,F_C \end{vmatrix} = i(56.57F_C) - j(141.4\,F_C) - k(141.4F_C)$$

Ch5

center of gravity
Centroid , Area

ch5

total weight $= \Sigma \Delta w = w$

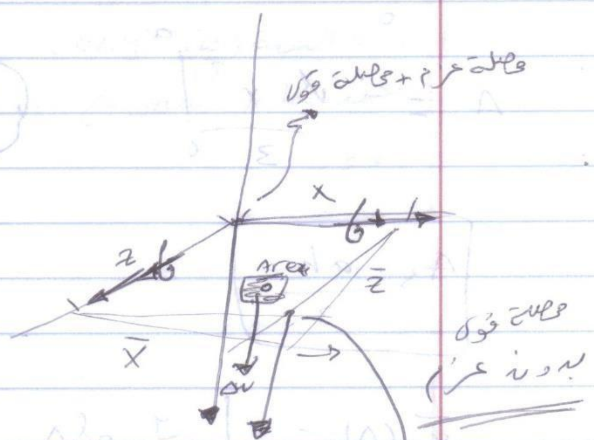
total moment about the x-axis $= \sum_{i=1}^{n} z_i \, \Delta w_i$

n = total number of pieces

$$\bar{z}\, w = \int z \, dw$$

$$\bar{x}\, w = \int x \, dw$$

$$\bar{y}\, w = \int y \, dw$$



$$w = \sum_{i=1}^{n} \Delta w_i$$

center of gravity
Centroid.

the thickness is constant
and the material is uniform

$$\Delta w = (\Delta A)(t)(\gamma)$$

نجد المحصلة للعزم والقوى الى نقطة الاصل
ثم ننقل القوة بحيث تلغي العزم

$$\bar{x}(A t \gamma) = t\gamma \int x \, dA$$

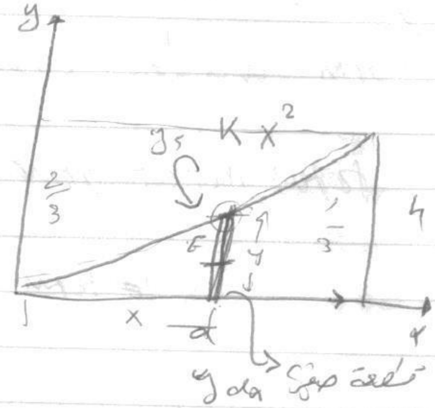
نضرب كل مساحة بالبعد عن المرجع
المحاور الاساسية او اي محور آخر

$$\boxed{\bar{x} A = \int x \, dA}$$

Determine line Datum

Find the centroid

Page 225



$dA = y\,dx$

$dA = Kx^2\,dx$

$A = K\int_0 x^2\,dx$

$A = \frac{Kx^3}{3}\Big|_0^a$ $\quad K = \frac{h}{a^2}$

$\boxed{A = \frac{ah}{3}}$

E: أي نقطة

مركز لل خط عمودي $\frac{y}{2}$

$\bar{y}(A) = \int \frac{y}{2}\,dA$

$\bar{y}(A) = \int \frac{y}{2}\,Kx^2\,dx$

$= \int_0^a \frac{Kx^2}{2}\,Kx^2\,dx$

$\bar{y}(A) = \frac{K^2}{2}\int_0^a x^4\,dx$

$\bar{y}(A) = \frac{K^2}{2}\frac{x^5}{5}\Big|_0^a$, $\bar{y}(A) = \frac{K^2 a^5}{2 \times 5}$

$\bar{y}(A) = \frac{h^2}{2a^4}\frac{a^5}{5}$

$\bar{y}(A) = \frac{h^2 a}{10} \Rightarrow \bar{y} \frac{ah}{3} \quad \bar{y}\frac{\cancel{a}h}{3} = \frac{h^2\cancel{a}}{10}$

$\bar{y} = \frac{3h}{10}$

(61)

$$\bar{x}\,(A) = \int x\, dA$$

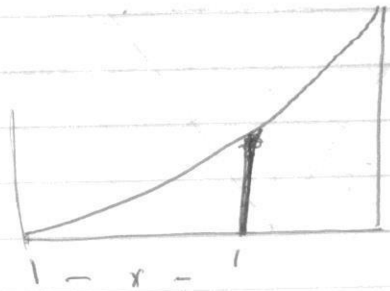
$$= \int x\, K x^2\, dx$$

$$= K \int_0^a x^3\, dx$$

$$\bar{x}\ \frac{ah}{3} = K \left.\frac{x^4}{4}\right|_0^a$$

$$\bar{x}\ \frac{ah}{3} = \frac{h}{a^2}\ \frac{a^{4}}{4}$$

$$\boxed{\bar{x} = \frac{3}{4} a}$$

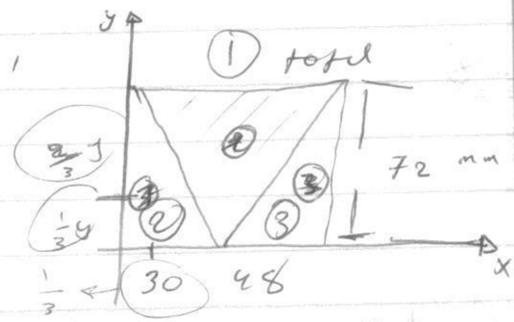


نأخذ النقطة (O) (origin)
عند مماس المنحنى مع
المحور

$\boxed{5.2}$

المساحة المقطوعة [illegible]
سالبة مثل (2)، (3)

$$A = \frac{1}{2} \times y$$

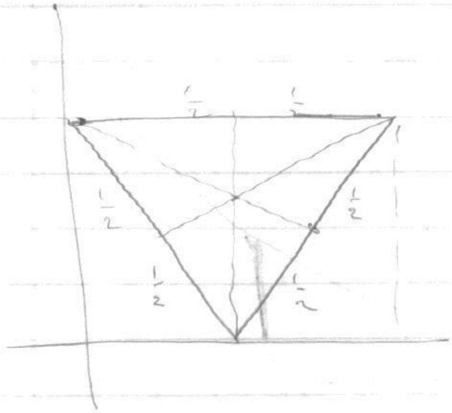


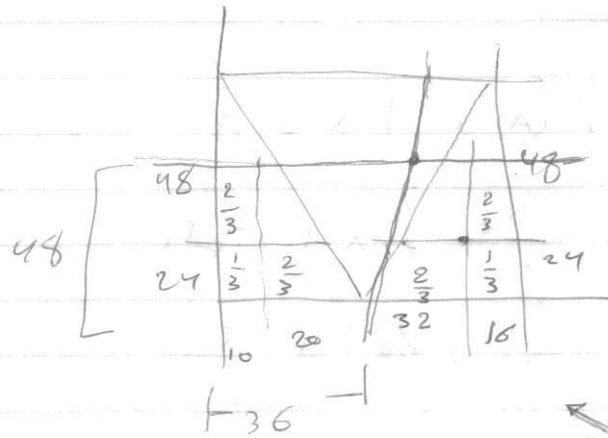
shape	Area (element) $(mm)^2$	mm $\bar{x}_{element}$	$(\bar{x}_{element})(\text{Area}_{element})$ mm^3	$\bar{y}$ mm	$\bar{y} \times$ Area element $(mm)^3$
1	$+(78 \times 72)$	$+39$	$39 \times 78 \times 72$ 219024	$+36$	$36 \times 78 \times 72$ $+202176$
2	-1080	$\frac{1}{3} \times 30$ 10	-10800	$\frac{1}{3} \times 72$ $+24$	-25920
3	-1728	$30 + \frac{2}{3} \times 48$ 62	-107136	$+24$	-41472
Σ	2808	36	101088	48	134784

$$\bar{x} = \frac{101088}{2808}$$

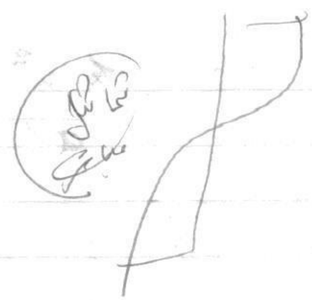
$$\bar{y} = \frac{134784}{2808}$$

62

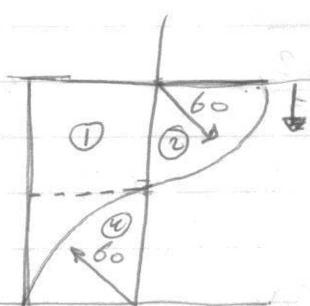




مساحة   فوق المحور مضافة +
تحت المحور مضافة +
فوق المحور مقتطعة −
تحت المحور مقتطعة −
طول   فوق المحور موجب
تحت المحور سالب.



5.8

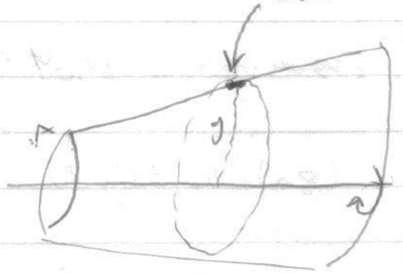


Shape	Area(el)	$\bar{X}$ elm	$(\bar{X}el)(A\,el)$	$\bar{y}el$	$\bar{y}el(A\,el)$
1	+ 3600	−30	−108000	+90	
2	+ 2827	+ 25.46	+71975	+(120 − 25.46)	
3	+ 3600	−30		+30	
4	− 2827	− 25.46		+25.46	

$\bar{X} = \frac{0}{0} = -10\text{ mm}$ $\bar{y} = +87.5$

~~Pappus Guldinus~~

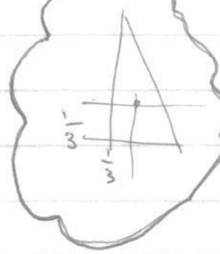
pappus Guldinus



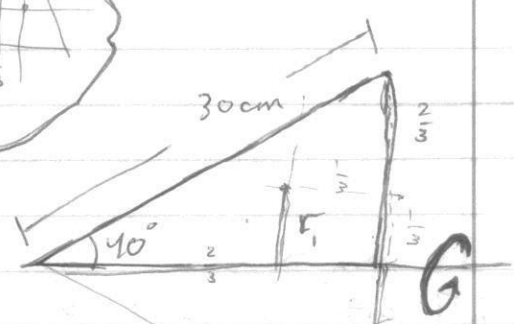
دورانه حول
يشكل

[2] the volume = Area of the shape being rotated to generate the volum X Distance traveled by the centroid.

حاصل ضرب AB في y
= مساحة الشكل ×



$r_1 = \frac{1}{3}(19.284)$



Distance travelel by the centroid

$= 2\pi r_1 = 2\pi\left(\frac{1}{3} \times 30 \times \sin 40\right)$

Area of the triangle $= \frac{1}{2}(30\sin 40)\,30(\cos 40)$

$$\text{Volume} = \underbrace{\left[\frac{1}{2}(30\sin 40)(30\cos 40)\right]}_{\text{Area}}\underbrace{\left[2\pi\,\frac{1}{3} \times 30 \times \sin 40\right]}_{\text{Distance}}$$

Volume = 8949 cm^3

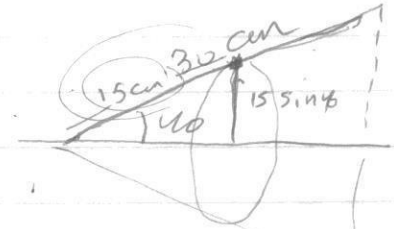
$= 8949.14$!!

$\frac{1}{3}\pi r^2 h$

$\frac{2}{3} h \pi r$

surface area $= 30(2\pi)(15\sin 40) =$

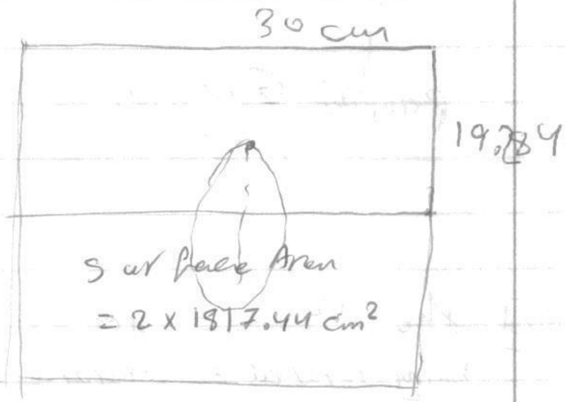
[1] = Length of the line rotated to create the shape $\underset{3}{X}$ Distance by the centroid



← ح = $35048\ cm^3$ = مساحة القاعدة × الارتفاع

volume $(30)(19.284)(2\pi)\left(\frac{19.284}{2}\right)$

$= 35048\ cm^3$

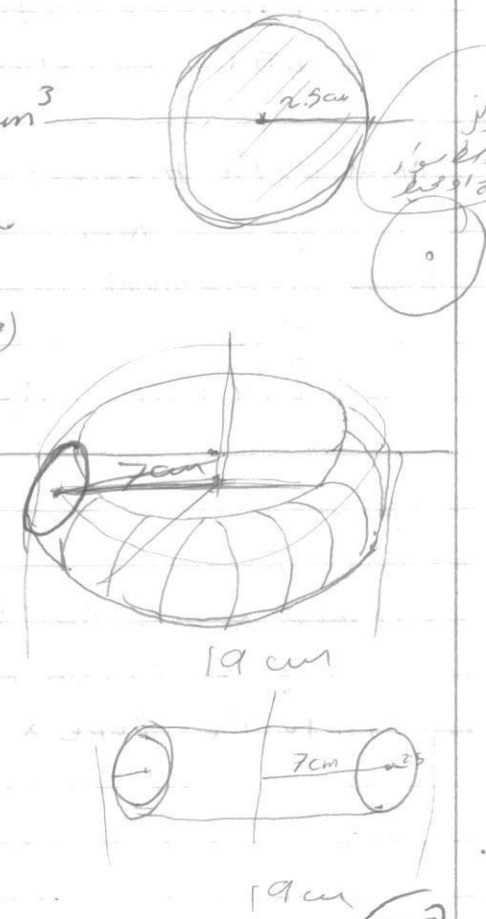


محيط القاعدة × الارتفاع / 2

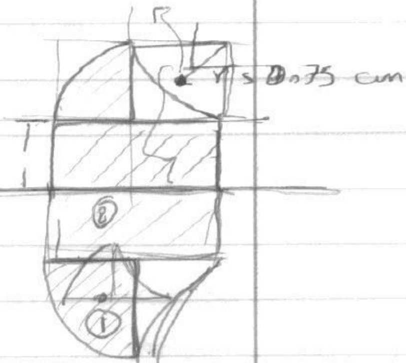
$$\left[\pi(2.5)^2\right]\left[2\pi \times 7\right] = 862.7\ cm^3$$

Area distance by center

$$\text{Surface Area} = (2\pi \times 2.5) \times (2\pi \times 7) = 690.87\ cm^2$$



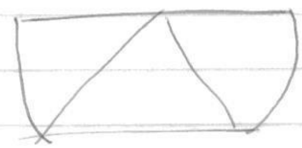
5.56



مستطيل + ربع دائرة + باقي ربع الدائرة ⟵ مستطيل مربع − ربع دائرة

ع   ع   ع   ع   ع

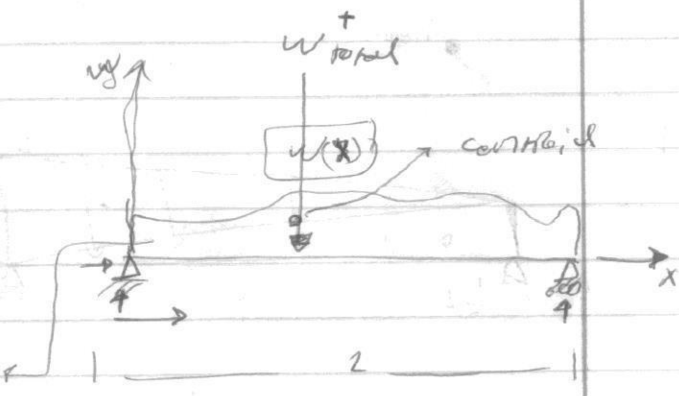
5.64



Distributed Loads

Beams

$$w_{total} = \int_0^L w(x)\,dx$$

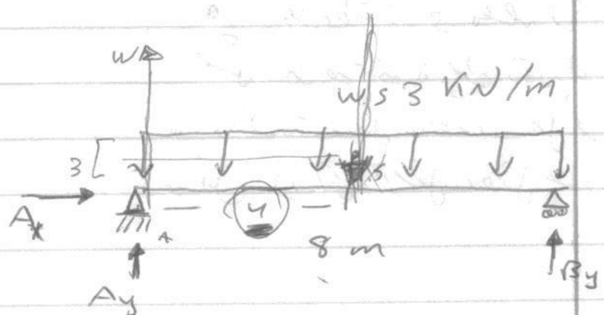


* W_{total} + point of application

* may be applied for equilibrium purposes only

to determain the unknown forces (Reactions)

Ex uniformly Distributed



$w_{total} = 3 \times 8 = 24\,KN$

$\sum F_x = 0 \quad \boxed{A_x = 0}$

$\sum M_A = 0$

$+(24 \times 4) - (B_y \times 8) = 0$

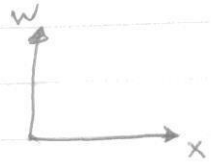
$\boxed{B_y = +12\ KN}$

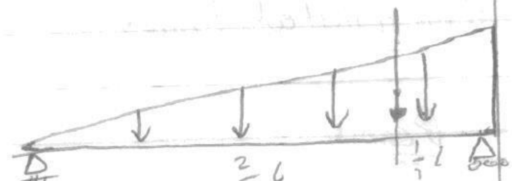
$\sum F_y = 0 \;+\!\uparrow$

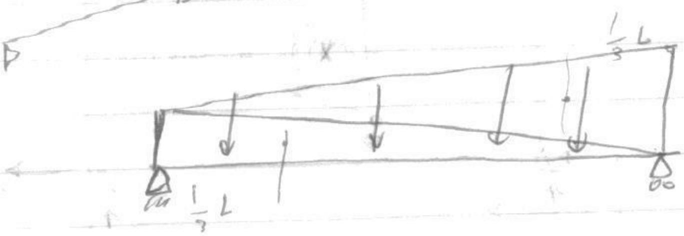
$+A_y - 24 + 12 = 0 \quad A_y$

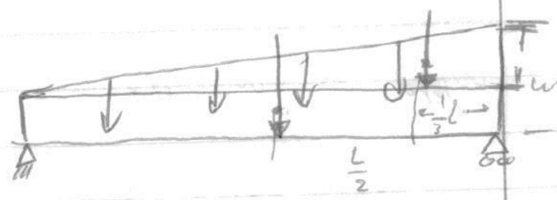
$A_y = +12\ KN$

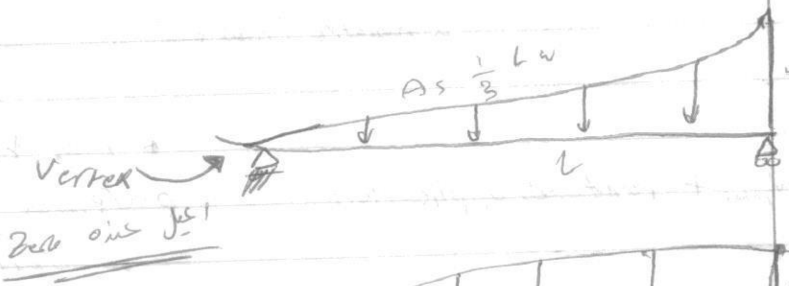
Ex

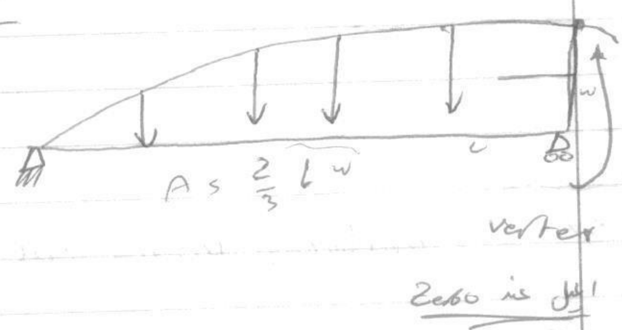




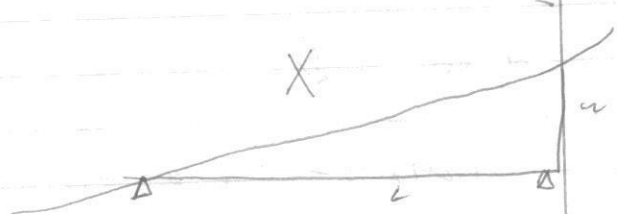






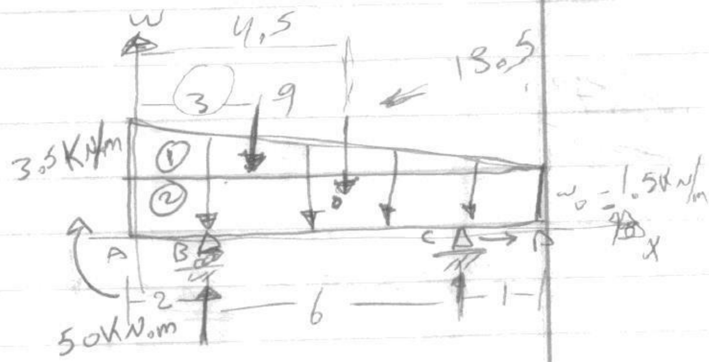


* ملاحظة: في بعض الأسئلة يمكن اضافة قوة بحيث يكون لها ~~الصافة~~ قوة معاكسة، مثل اضافة مستطيل لحساب قوتين للأعلى والأسفل، مثل صفحة 72



$\boxed{\text{area} = \cancel{\tfrac{1}{3}} \, Lw}$

5.74

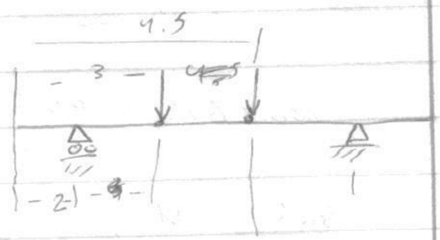


$C_x = 0$

$w_1 = 3.5 \times \frac{1}{2} \times 9$

$= 9 \; \cancel{15.75}$ KN

centroid = 3



$w_2 = 1.5 \times 9 \times$

$= 13.5$ KN

centroid = 4.5

$\Sigma M_B = 0$

$50 + 9 + 13.5\,(2.5) - C_y\,(6) = 0$

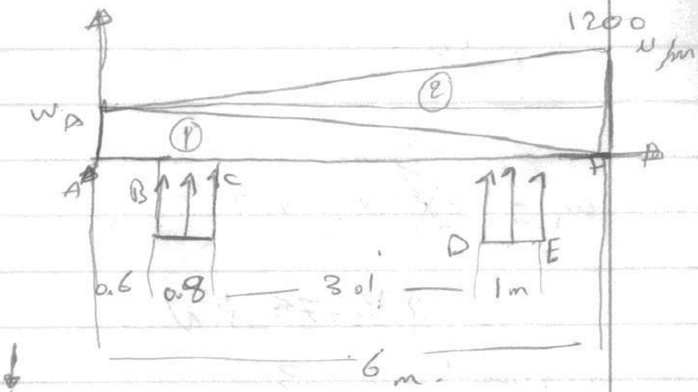
$C_y = 15.46$

$\Sigma F_y = 0 \;+\!\uparrow$

$+B_y - 9 - 13.5 + 15.46 = 0$

$B_y = 7.0416$

$\boxed{5.79}$



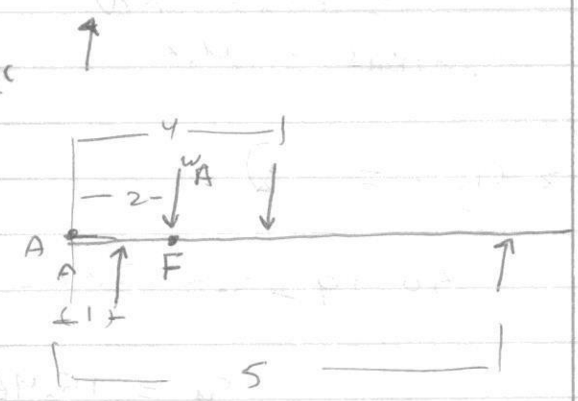
$w_1 = w_A \times \frac{1}{2} \times 6 = 3w_A$ N ↓

Centroid = 2 m

$w_2 = 1200 \times 6 \times \frac{1}{2} = 3600$ N ↓

centroid = 4 m

$w_{BC} = 0.8\,W_{BC} = \underline{0.8\,w_{BC}}$ ↑



Centroid = 1 m

$w_{DE} = w_{DE}$ ↑

Centroid = 5 m

$\Sigma F_y = 0 = -3w_A - 3600 + 0.8w_{BC} + w_{DE} = 0$ ↑+

$-3w_A - 3600 + 1.8\,w_{BC} = 0$

$\Sigma M_F = 0$

$\Rightarrow \boxed{w_A = \cancel{460}\ 763.6\ N/m}$

$= +0.8\,w_{BC} + \cancel{3w_A} + 2(3600) - 3(w_{DE})$

$0.8\,w_{BC} + 7200 - 3W_{BC}$

$\boxed{w_{BC} = \cancel{3600}\ 3272.7\ N/m}$

$\boxed{w_{DE} = \cancel{3600}\ 3272\ N/m}$

Boundary conditions

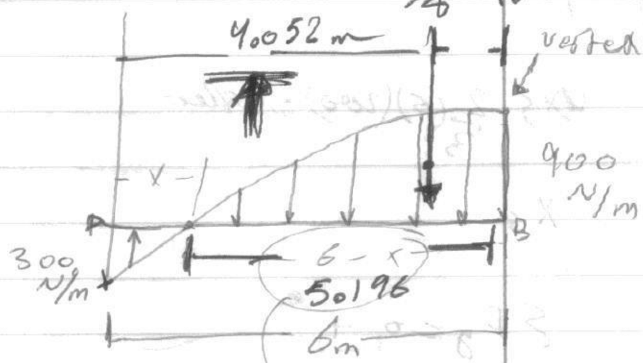
5.72

$y = ax^2 + bx + c$

$w = ax^2 + bx - 300$

$-300 = a(0) + b(0) + c$

$\boxed{c = -300}$



$900 = a(6)^2 + b(6) - 300$

$\boxed{\frac{dw}{dx} = 2ax + b}$ ⇒ first derivative

5.196

$0 = 2a6 + b$

$\boxed{b = -12a}$

$36a + (-12a)(6) - 300 - 900 = 0$

$\boxed{a = -33.33}$

$\boxed{b = +400}$

ممكن نكمل بالتكامل

$\boxed{w = -33.33x^2 + 400x - 300}$

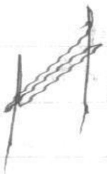
for $w = 0 \Rightarrow x =$

$0 = -33.33x^2 + 400x - 300$

$$x = \frac{-400 \mp \sqrt{400^2 - 4 \times -33.33 \times -300}}{2 \times -33.33}$$

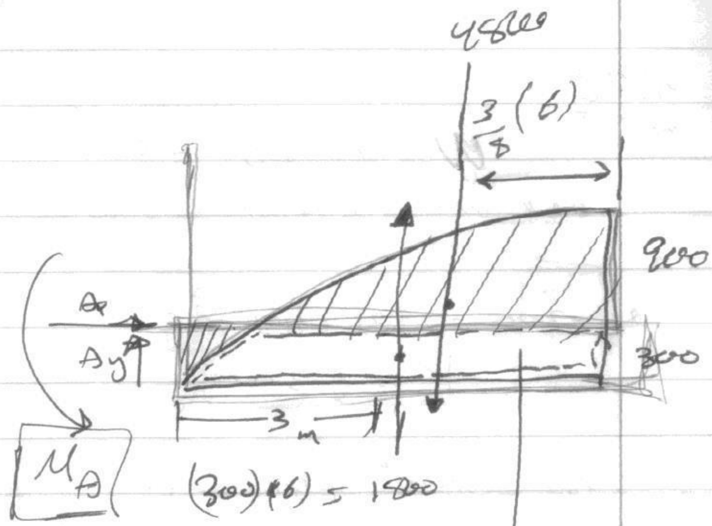
11. ~

$$\frac{-400 + 346.4}{-66.66} = \boxed{0.804\ m}$$ ✓



$W = \frac{2}{3}(6)(1200) = 4800$

$X =$



$\sum F_y = 0 \; +\uparrow$

$+A_y + 1800 - 4800 = 0$

$A_y = 3000 \text{ N}$

* نحسبه مرة للاعلى مرة للاسفل

⇐ طلعنا بـ محصلة

$\sum M_{\text{at } A} = 0$

$-M_A - 1800(3) + 4800(6 - 2.25) = 0$

$M_A = +\underline{12600} \text{ N.m}$

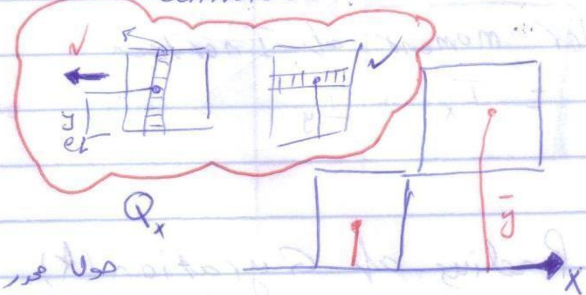
Ch9

ch9

First moment of the area (الطريقة السابقة)

لحساب centroid

Q



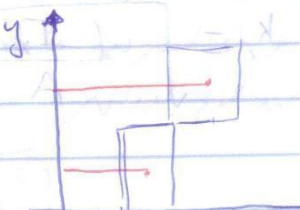
$$\boxed{Q_x = \bar{y} A}$$

Q_x حول محور $\underline{X}$

$$= \int \underbrace{y}_{\text{element}} \, dA$$

$$\boxed{Q_y = \bar{x} A}$$

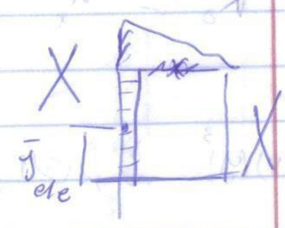
Q_y حول محور y



* Second moment of the area

moment of inertia

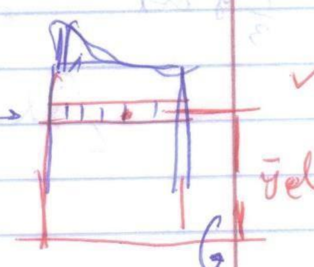
$$I_x = \int y_{\text{element}}^2 \, dA$$



$$I_y = \int x_{el}^2 \, dA$$

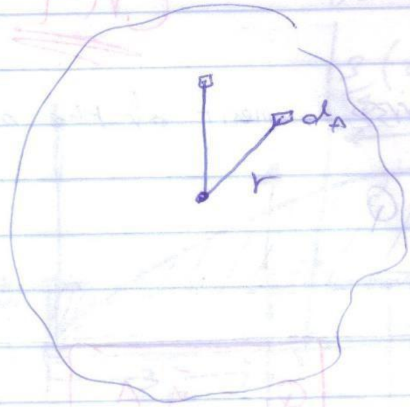
moment of inertia لايجاد عزم القصور الذاتي بالتكامل ، الشريحة يجب ان تكون جميع اجزائها على مسافة واحدة من خط المرجع

كلها لها نفس ال $\bar{y}$



from the axis about which the moment of inertia is to be determine

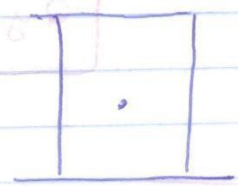
* $J_o = \int r^2 \, d_A$



* polar moment of Inertia $= I_x + I_y$

* Radius of Gyration (k) حول محور عمودي على الصفحة (نقطة)

* $k_x = \sqrt{\left(\frac{I_x}{A}\right)}$



* $k_y = \sqrt{\left(\frac{I_y}{A}\right)}$

* $K_o^2 = k_x^2 + k_y^2 = \left(\frac{J_o}{A}\right)$

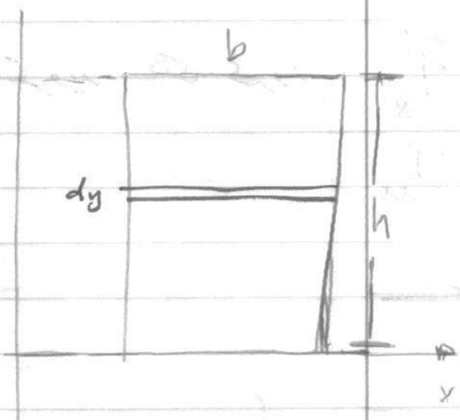
$\frac{1}{3}(x)(y)^3$ ممكن أخذ شريحة عمودية على المحور حسب القانون

$\frac{1}{3} y^3 d_x$

I_x حول محور x

$\bar{I}_x$, I_{xy}

↳ moment of inertia about the centroidal axis



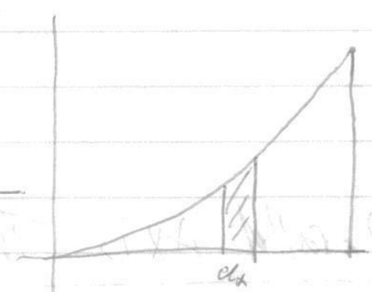
$I_x = \int y^2 \, dA$ $\quad \boxed{dA = b\,dy}$

يجب ان تكون ابعاد
اجزاء الشريحة متساوية
عند محور الدوران

$= \int y^2 (b) \, dy$

$= b \int_0^h y^2 \, dy = b \left[\frac{y^3}{3} \right]_0^h = \boxed{\frac{b h^3}{3}}$

بشرط ان الشريحة مستطيلة



$I_y = \int x^2 \, dA$

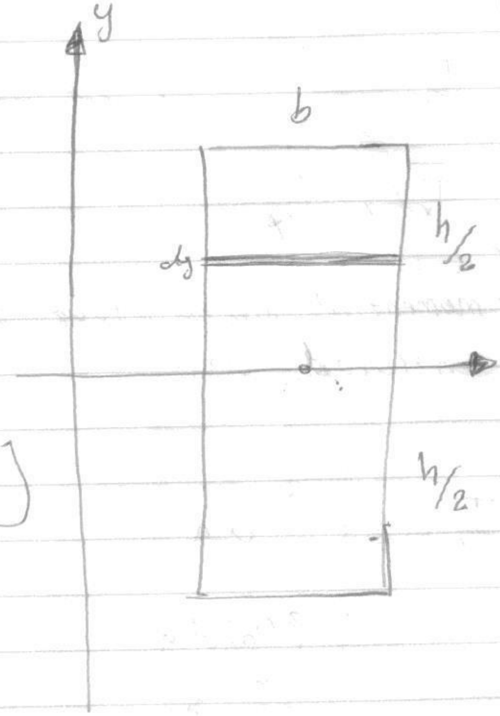
$= \int x^2 (y \, dx)$

$dI_x = \frac{d_x \, (y^3)}{3}$

$dI_x = \left[\frac{y^3}{3} \, d_x \right]$

$\bar{I}_x$ بما ان السنترويد على المحور

I_{xx}



$$\bar{I}_x = \int y^2 \, dA \qquad \boxed{dA = b\,dy}$$

$$= \int_{-\frac{h}{2}}^{\frac{h}{2}} y^2 (b) \, dy$$

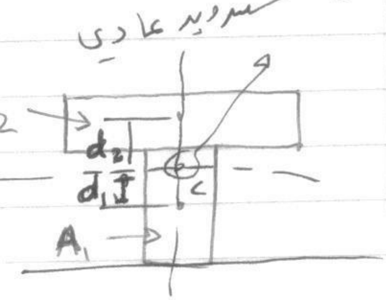
$$= \frac{by^3}{3} \Big|_{-\frac{h}{2}}^{\frac{h}{2}} = \frac{b}{3}\left[\frac{h^3}{8} + \frac{h^3}{8}\right]$$

$$= \boxed{\frac{b\,h^3}{12}}$$

* Parallel Axis Theorem

$$\bar{I}_{Composit} = (\bar{I}_x)_{A_1} + A_1$$

حول c



A_1 حول محور — A_2 حول محور — حول

$$\bar{I}_{composite} = (\bar{I}_x)_{A_1} + (A_1)(d_1)^2 + (\bar{I}_x)_{A_2} + (A_2)(d_2)^2$$

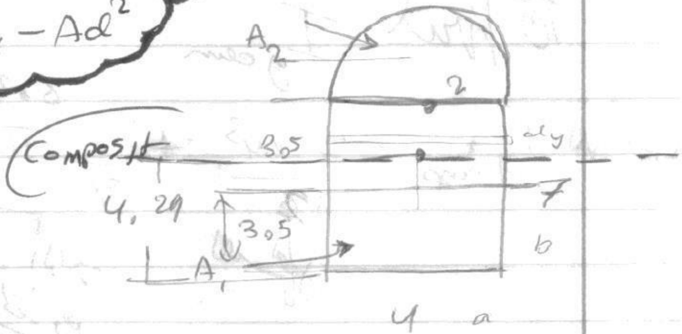
$\hookrightarrow$ with respect to the centroidal axis

في حالة اجزاء متساوية ، $\bar{I}_x - Ad^2$ -

$$\bar{I}_x = \bar{I}_x + A d^2$$

$$\bar{I}_x = I_x - A d^2$$

find $\bar{I}_{composite}$



$$(\bar{I}_x)_{A_1} = \int_{-3.5}^{3.5} y^2 \, dA$$

$$= \int_{-3.5}^{3.5} 4 y^2 \, dy$$

$C_1 = 3.5 \quad A_1 = 28$

$C_2 = \frac{4r}{3\pi} = 0.849 + 7 \quad A_2 = 6.28$

simplify

$$4 \frac{y^3}{3} \Big|_{-3.5}^{3.5} = \frac{4}{3}\left[3.5^3 + 3.5^3\right]$$

$$= 114.3$$

$$\left[(\bar{I}_x)_{A_2} = \frac{1}{8}\cancel{\pi} r^4 = \cancel{6.28}\right] = \frac{\pi(2)^4}{8} - (6.283)(0.8488)^2$$

$A \quad d^2$

$$= 1.757 \text{ cm}^4$$

composite centroid :

$$\bar{y}_{comp} = \frac{(3.5)\times(28) + (7.849)\times(6.28)}{28 + 6.28} = 4.296$$

$d_1 = 0.796 \quad , d_2 = 3.553$

Area	$I_x d$	d	Ad^2
			17.79
			79.27

$114.3 + 1.757 + 17.79 + 79.27$

$$\bar{I}_{x\,com} = 213.1 \text{ cm}^4$$

$$\bar{I}_{comp} = 114.3 + \cancel{6.28}\,1.757 + 0.796^2 (28) + 3.553^2 (6.28) = \cancel{160.6}$$

$\cancel{160.7}$

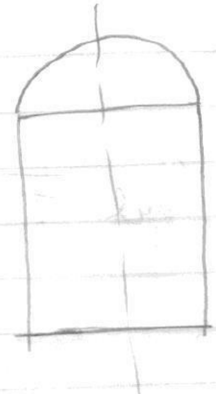
77

To find $I_{y\,cen}$

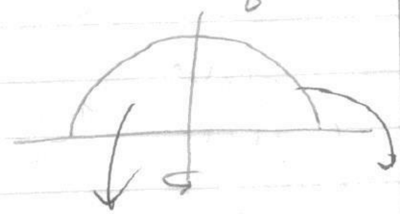
$$\bar{I}_{y\,comp} = \frac{7 \times 4^3}{12} + \frac{1}{8}\pi r^4 = \quad 6.283$$

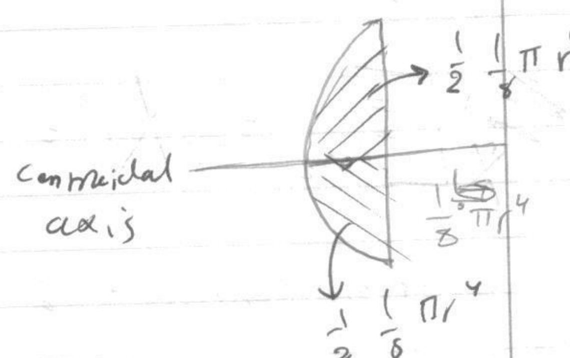
للمستطيل

لنصف الدائرة
حول الخط وهو
نفسه مشترك محور

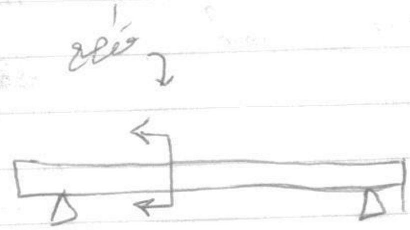


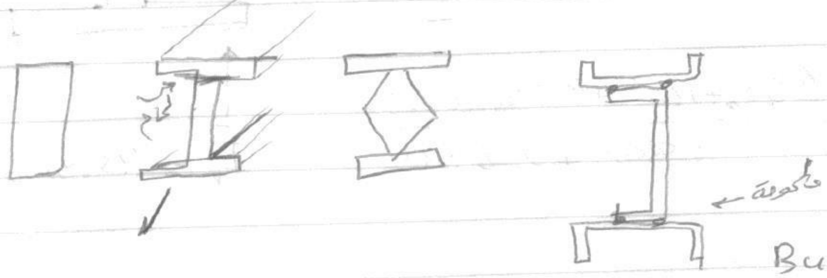
$$I_x = \frac{1}{8}\pi r^4$$



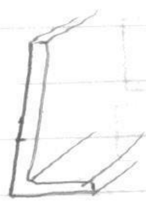


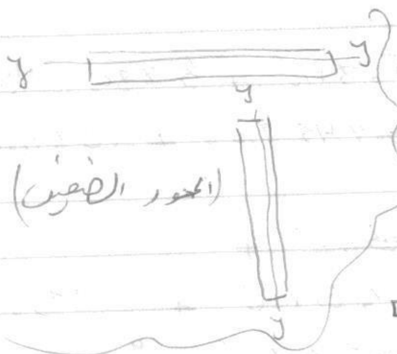
Hot Rolled shapes



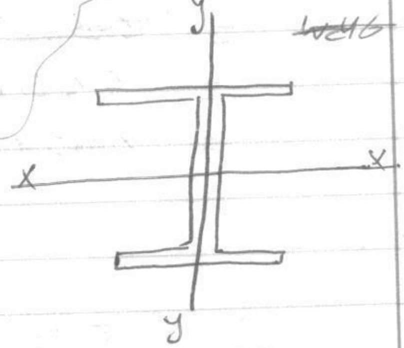


Built-up shapes



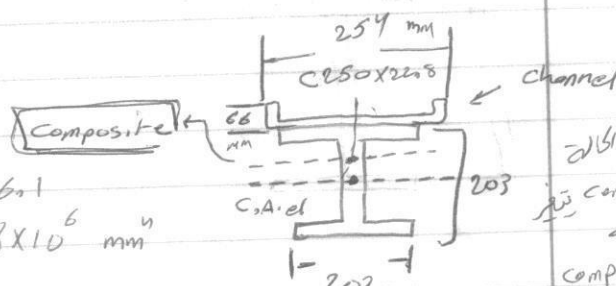


plates



$\bar{I}_x$

((I له اكبر بكثير)) ← strong axis



في هذه الحالة ال centroid يتغير مكانه composite

* لكن هنا حول محور X لأننا قلبنا القطعة

$\bar{I}_y = 0.945 \times 10^6 \ mm^4$

for chanel

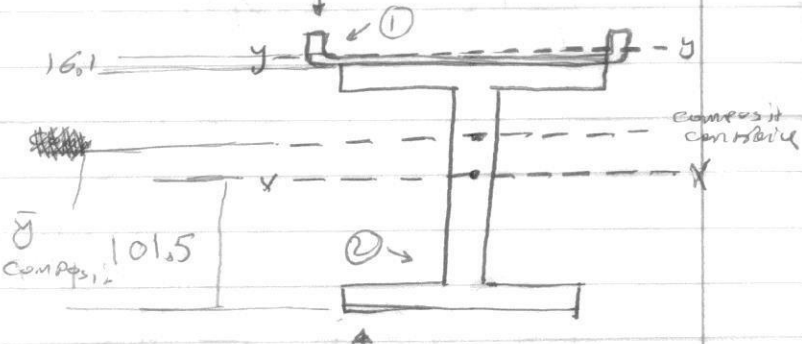
W200 x 46.1

$\bar{I}_x = 45.8 \times 10^6 \ mm^4$

$\bar{I}_y = 0.945 \times 10^6 \ mm^4$

$A_1 = 2890 \ mm^2$

$A_2 = 5880 \ mm^2$



$$\bar{y}_{composite} = \frac{(2890)(203.+16.1)+(5880)(101.5)}{2890+5880}$$

$\bar{I}_x = 45.8 \times 10^6$

$= 140.25 \ mm$

$$\bar{I}_{x\,composite} = \left[45.8\times10^6 + (5880)(140.25-101.5)^2\right] + \left[(0.945\times10^6) + (2890)(\cancel{140.25+16.1})\right]$$

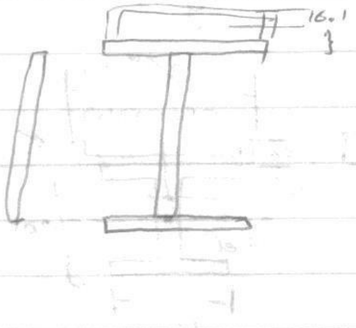
$(203+16.1-140.25)^2$

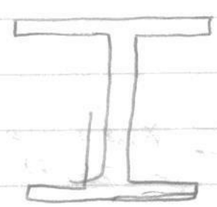
$= \cancel{145.05 \times 10^6} +$

$= 54.63\times10^6 + 18.91\times10^6$

$= 73.54 \times 10^6 \ mm^4$

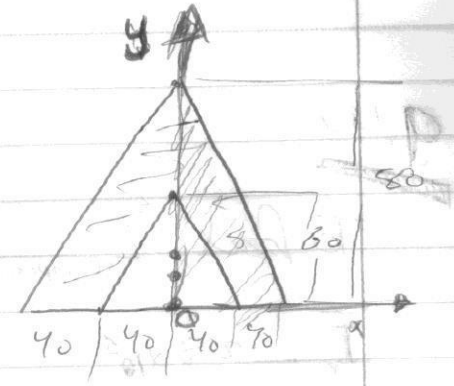
W460 x113





لا يوجد سالبة

I



9.47 → صعب عمل تكامل مباشرة

$J_o = I_x + I_y$

مساحة الكبر $I_{B_x} = \frac{1}{12} bh^3 = \frac{1}{12} \times (80)^3 \times (\cancel{1}60)$

$= 6.827 \times 10^6 \ mm^4$

$I_{S_x} = \frac{1}{12} (80)(60)^3 = 1.440 \times 10^6 \ mm^4$

$I_x = I_{Bx} - I_{Sx} = 5.387 \times 10^6$

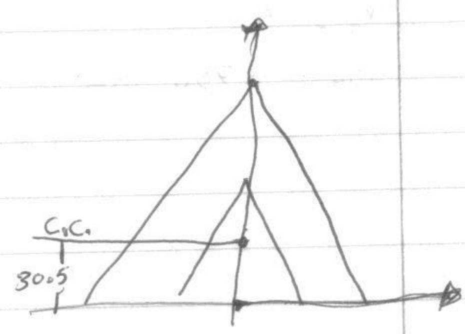
$\bar{I}_{By} = 2\left(\frac{1}{12}\right)(80)(80)^3 = 6.827 \times 10^6 \ mm^4$ نعمل كل مثلث على $\boxed{\text{قاعدة}}$

$\bar{I}_{Sy} = 2\left(\frac{1}{12}\right)(60)(40)^3 = 0.640 \times 10^6 \ mm^4$

$\bar{I}_y = I_{By} - I_{Sy} = 6.187 \times 10^6 \ mm^4$

$J_o = I_x + I_y = 11.57 \times 10^6 \ mm^4$

B at Centroid



#	mm^2 Area	$\bar{y}_d$	$\bar{y}A$
B	+6400	$\frac{80}{3}$	$+1.7 \times 10^5$
S	-2400	$\frac{60}{3}$	-48000

$\bar{y} = 30.5$

$\bar{I}_{Bx} = \frac{1}{36} \times 160 \times 80^3 = 2.275 \times 10^6 \ mm^4$

$\bar{I}_{Bx \, (\text{composite centre } C.C.)} = 2.275 \times 10^6 + 6400\left(30.5 - \frac{80}{3}\right)^2 = 2.384 \times 10^6$

$$- \begin{cases} \bar{I}_{Sx} = \frac{1}{36} \times 80 \times 60^3 = 0.48 \times 10^6 \ mm^4 \\ \bar{I}_{Sx(C.C.)} = 0.48 \times 10^6 + 2400 \times (30.5 - 20)^2 = 0.745 \times 10^6 \end{cases}$$

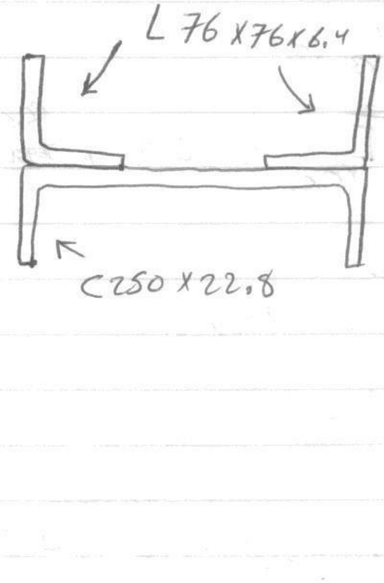
B − S

$\bar{I}_{x\,(C.C.)} = 1.639 \times 10^6 \ mm^4$

$\bar{I}_{y\,(C.C.)} = 6.187 \times 10^6$ يتغير ؟

$\rightarrow \bar{J}_{(C.C.)} = \bar{I}_{x\,C.C.} + \bar{I}_{y\,C.C.} = 7.826 \times 10^6 \ mm^4$

← 9.55



* ما تنسى تعوض الصفر.

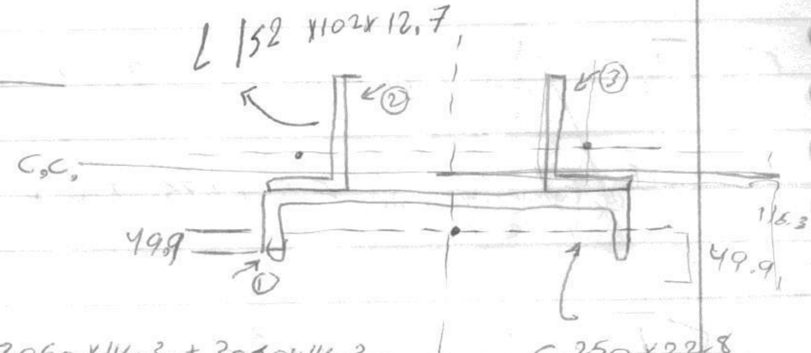
* $(y_2 - y_1)\,dx$

$\left(\frac{1}{3}y_2^3 - \frac{1}{3}y_1^3\right)dx$

* انتبه لما يكون مثلث ، بنوخذ كل نص لحالة ، كل جزء هو جسم منفصل اله $I + Ad^2$

Adel

A	$\bar{y}$	$\bar{y}A$
2890	49.9	
3060	~~50.3~~ 111.3	
3060	116.3	



$$\bar{y}_{composite} = \frac{2890 \times 49.9 + 3060 \times 116.3 + 3060 \times 116.3}{2890 + 3060 + 3060}$$

$$= 95 \text{ mm}$$

$$\bar{I}_{x_1} = 0.945 \times 10^6$$

$$\bar{I}_{x_1 C.C.} = 0.945 \times 10^6 + 2890 \times (95 - 49.9)^2 = 6.8 \times 10^6$$

$$\bar{I}_{x_2} = 7.20 \times 10^6$$

$$\bar{I}_{x_2 C.C.} = 7.20 \times 10^6 + 3060(116.3 - 95)^2 = \cancel{7.21}\ 8.6 \times 10^6$$

$$\bar{I}_{x_3 C.C.} = \cancel{7.21}\ 8.6 \times 10^6$$

$$\Rightarrow \bar{I}_{x C.C.} = (6.8 + \cancel{7.21}\ 8.6 + \cancel{7.21}\ 8.6) \times 10^6 = \cancel{14.8.8}\ \cancel{14.49}\ 24 \times 10^6$$

mm

$$\bar{I}_y = 28 \times 10^6$$

$$\bar{I}_{y C.C.} =$$

$$\frac{254}{2} - 102 + 24.9$$

$$\bar{I}_{y C.C.} = [(28 \times 10^6)] + 2\left[2.59 \times 10^6 + 3060\left(\frac{254}{2} - 102 + 24.9\right)^2\right]$$

$$= \cancel{174.4 \times 10^6}\ \cancel{44}\ 48.4 \times 10^6 \text{ mm}^4$$

Ch6

Ch 6

Analysis of structures:

✓ Trusses

✓ Frames

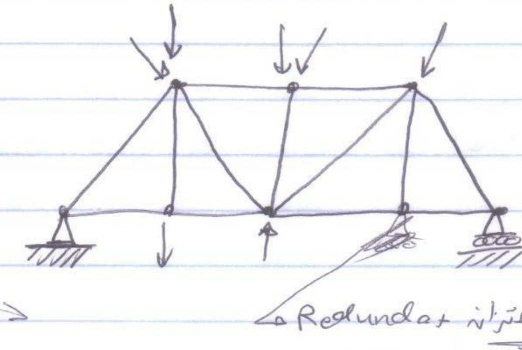
X Machines

Trusses

rods + Bars

* Stability

statically indeterminate



Redundant إضافة ركيزة مستقرة

زائدة كان

* statically Indeterminate

↓

1- External indeterminacy

2- Internal

* Redundancy

* الأحمال فقط على النقاط

Trusses members ـــ شكلها أحمال

(2-Force members)

← فقط قوى ضغط أو شد.

① find Reactions

② Determine the force in some or all members

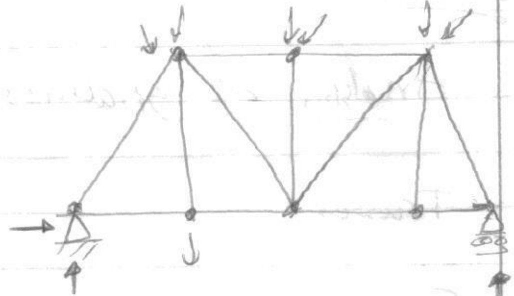
?? indeterminate statically

عدد ال members

عدد ال Reaction

unknown $\leq N + R$

$= 13 + 3 = 16$

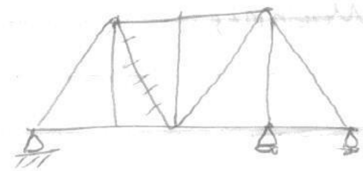


Joints = 8

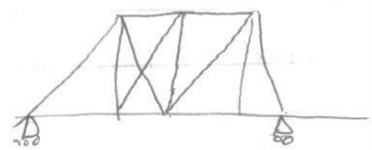
عدد النقاط

عدد المعادلات = 16

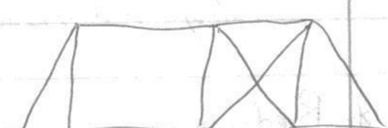
عند كل نقطة معادلتين اتزان $F_x + F_y$



unstable + indeterminate



indeterminate



unstable + Internal indeterminate

16 , 61 but

Method of Joints → كلهم ، نحلل نقطة نقطة ، معادلتين معادلتين

Method of sections → جزء منهم ، نقطع في مكان معين ، ومكان القطع يكون هناك قوى

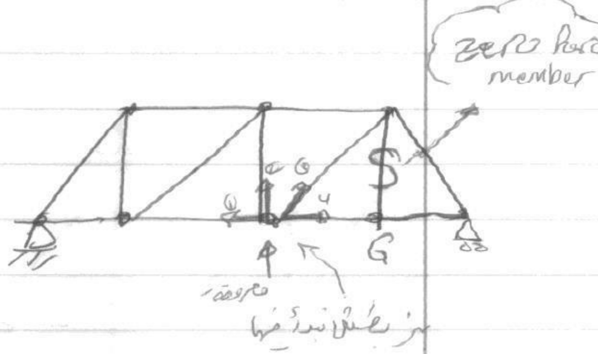
Method of Joints

① Determine the Reaction

usually : ΣM about Pin

ΣF_x

ΣF_y

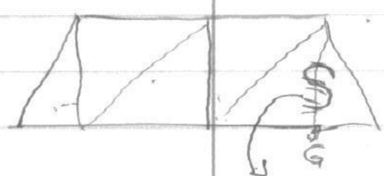


② take 1 joint at a time :

a - at least one known force

b - No more than ~~four~~ 2 unknown forces

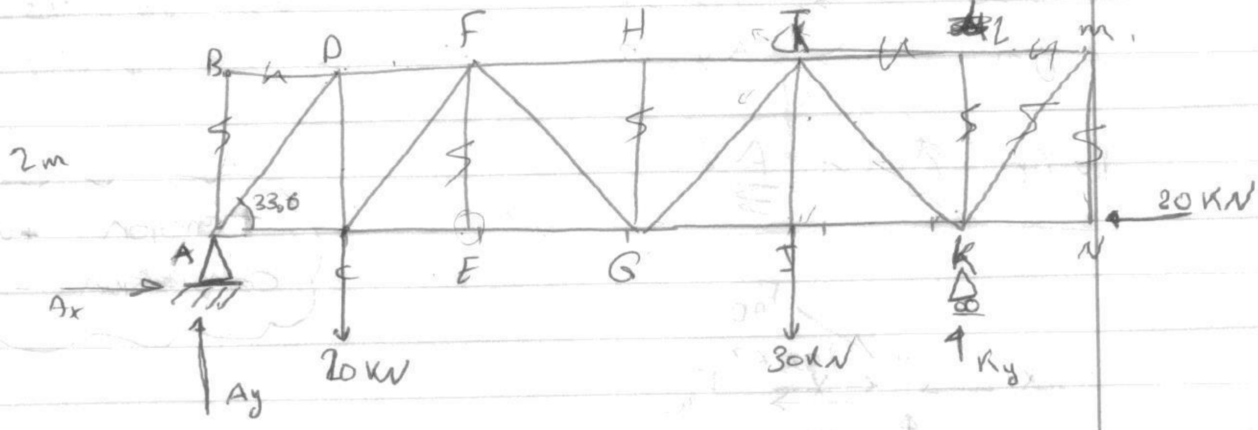
* Identify all the zero-force members



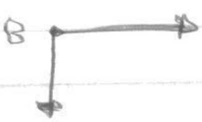
Zero force members

[illegible]

$\Sigma F_y = 0 \; +\uparrow$

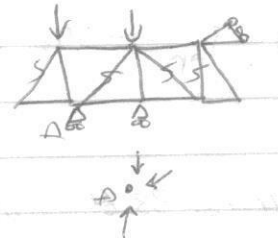


FH , FG , EC

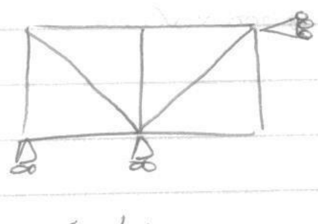


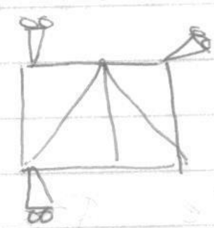
تساوي صفر لا يوجد شيء تقاومه

مثال



اذا تقاطع مقاومة العزم
في نقطة تقاوم الدوران
وتكون Stable





Stable

الجسم هنا يدور unstable

عند تعويضه
تدل على اتجاه الفرض فقط

اذا موجب صح، واذا خطأ سالب، اما الجواب تكون الاشارة

الحل $\sum M_A = 0$ $+\circlearrowleft$

$+20(3) + 30(+2) - K_y(15) = 0$

$\boxed{K_y = 28}$

محصلة العزوم الناتجة
عن القوى الخارجية

$\Sigma F_x = 0 \longrightarrow A_x = 0$

$\Sigma F_y = 0 \longrightarrow A_y = 22.$

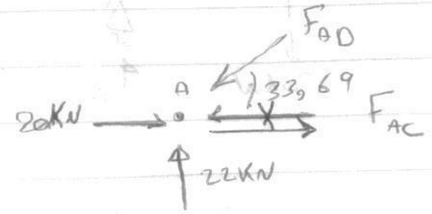
محصلة القوى الخارجية

محصلة القوى الداخلية

Tension +ve

Compression −ve

Take joint A :



$\Sigma F_y = 0 + \uparrow$

$-F_{AD} \sin 33.64 + 22 = 0$

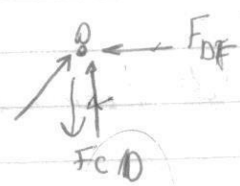
$F_{AD} = +39.66$ KN

$\Sigma F_x = 0 \quad + \rightarrow$

$20 - 39.66 \cos 33.64 = F_{AC}$

$F_{AC} = -13.000$ KN

Take joint D



$\Sigma F_x = 0 \quad + \rightarrow$

$39.66 \cos 33.64 - F_{DF} = 0$

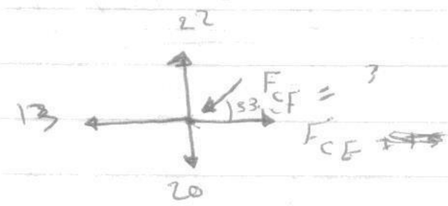
$F_{DF} = +33$ KN

$\Sigma F_y = 0 \quad \uparrow +$

$39.66 \sin 33.64 + F_{CD} = 0$

$F_{CD} = -22.0$ KN

Take Joint at C:



$\Sigma F_y = 0 \uparrow +$

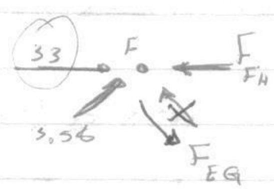
$22 - 20 - F_{CF} \sin 33.64 = 0$

$F_{CF} = +3.5$

$\Sigma F_x = 0 \xrightarrow{+}$

$F_{CE} = +15.97$

Take Joint at F:



$\Sigma F_y = 0 \uparrow +$

$3.58 \sin 33.64 + F_{FG} \sin 33.64 = 0$

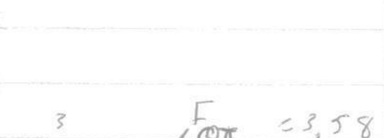
$F_{FG} = -3.059 \text{ kN}$

$\Sigma F_x = 0 \xrightarrow{+}$

$33 + 3.58 \cos 33.64 + 3.58 \cos 33.64 - F_{FH} = 0$

$F_{FH} = +36.99$

Take Joint at G



$\Sigma F_y = 0 \uparrow$

$3.58(\sin 33.64) - F_{GF} \sin 33.64 = 0$

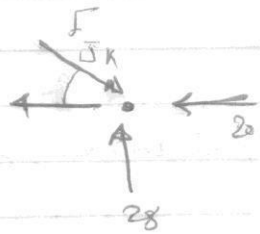
$F_{GF} = 3.58$

$\Sigma F_x = 0 \xrightarrow{+}$

$-3.58 \cos 33.96 + 3.58 \cos 33.64 - 15.97 + F_{GI} = 0$

$F_{GI} = 21.9$

take joint at K

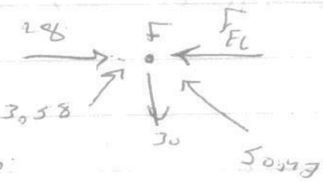


$\Sigma F_y = 0 \uparrow$

$28 - F_{JK} \sin(33.04) = 0$

$F_{JK} = 150.47$ kN

Take joint at F:



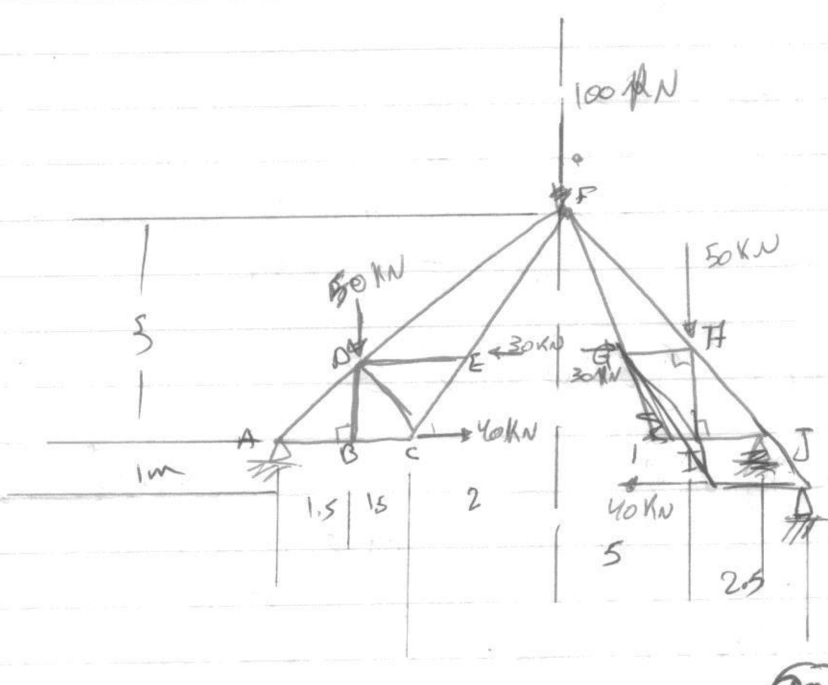
$\Sigma F_x = 0 \rightarrow$

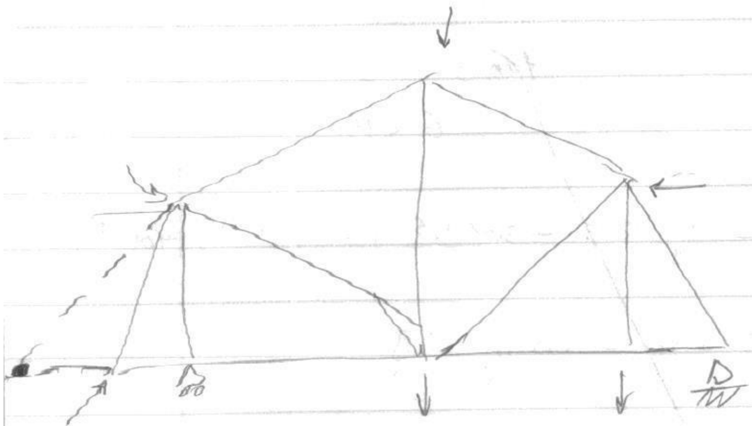
$38.45 + 3.58 \cos 31.64 - 50 \cos 33.69 \; F_{JI} = 0$

$F_{JI} = 0$

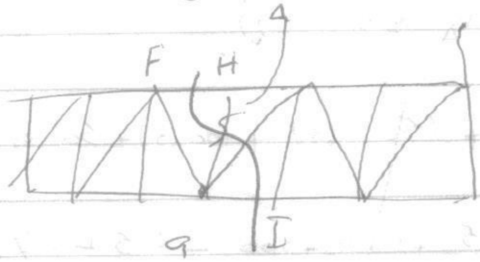
راجع الحل

H.W





مقطع فرض



F_{FH}

F_{GJ}

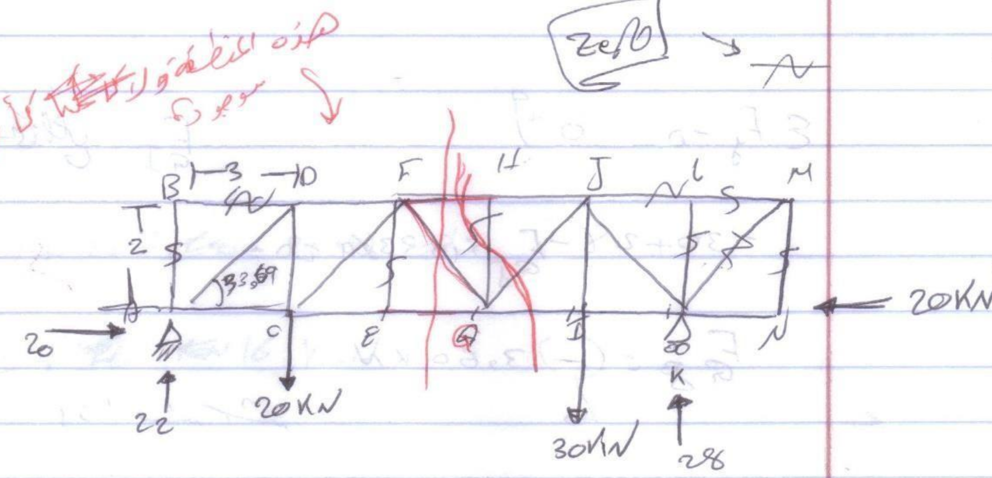
F_{GI}

Zero

F_{FH}

F_{FG}

F_{EG}



Method of sections:

1) Determine the reactions
2) Identifing the zero force members
3) take a section that passes ~~through~~ through the members for which the internal forces to be determined.

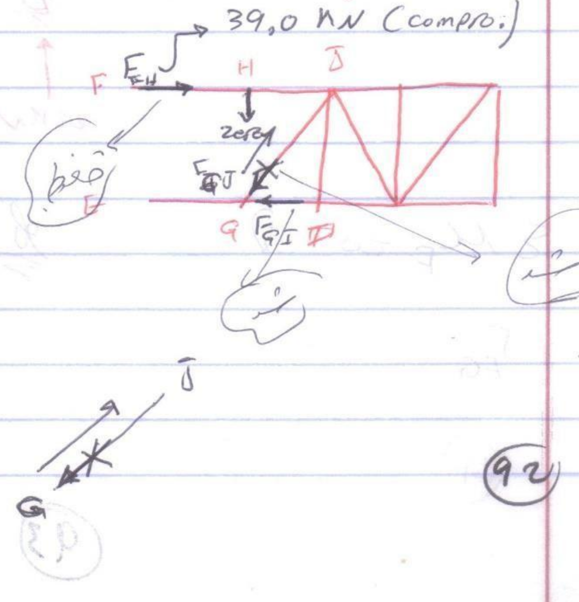
Do not cut through more than three members with unknown forces at one time.

F_{FH} 39.0 (comp.), F_{GJ} (comp), F_{GI} ⟶ Tension

$\Sigma M_G = 0$

$+F_{FH}(2) + 30(3) - 28(6) = 0$

$F_{FH} = +39.0\,KN$



92

$\Sigma F_y = 0 \quad \circlearrowleft^{+}$ ناخذ مقطع y. مجهولين F_{GI}

$-30 + 28 - F_{GJ} \sin 33.69 = 0$

$F_{GJ} = - 3.60\ kN$

اذا معناه شد

أيضاً ... F_{GI} ، ممكن ناخذ ΣF_x ، او ناخذ محصلة العزم عند J

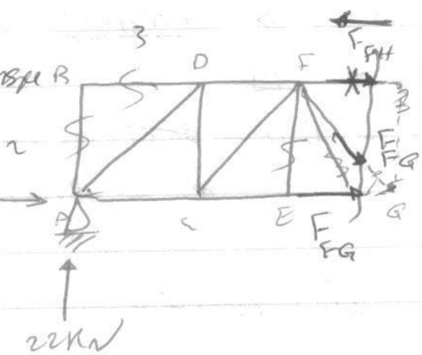
$\Sigma M_{at\ J} = 0$

$+F_{GI}(2) - 28(3) + 20(2) = 0$

$F_{GI} = +22.0\ kN$

F_{FH} , F_{FG} , F_{EG}

39 kN Comp | 3.6 kN tension | 16 tension



$\Sigma M_F = 0 \quad \circlearrowleft$ or $\Sigma M_G = 0 \quad \circlearrowleft$

F_{EG} F_{FH}

$\Sigma F_y = 0 + \uparrow \Rightarrow F_{FG}$

16 يكون معنا قطعة لها وزن ، وقسمناها ، ~~عن~~ القطعة الصغرى الناتجة
كان لها وزن !! انتبه 7.23

Adel

$\Sigma M_g = 0$ ↻

$$-F_{EG}(2) - (20)(2) + 22(6) - 20(3) = 0$$

$$F_{EG} = +16 \text{ kN}$$

$$F_{FH} = -39 \text{ kN}$$

* المقصود بالعكس مش الـ Frame هو (يمين شمال) (تحت فوق)

* في سؤال 83 ، ما بنربط توجد القوة بزاوية ، لانو في حمل على المسمار.
اما في صفحة 84 ، مشه حمل فنربط عادي

* ركز انه بدو سؤال ، مشه دائما بنبدأ بـ <u>Reaction</u> ، 6.139

Frames

* Dismembering

* مش شرط تكون مربوط بـ pin

axial { Compr. / tensn

N axial

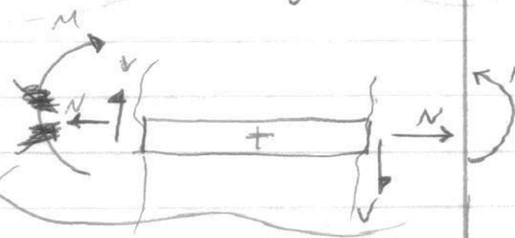
V shear

M Bending moment

two force member : → pins (hinges) → No transverse load

truss

قوى داخلية Internal force



* Internal forces

Sigin convention

هذه الاتجاهات هي الموجبة

~~torsion~~

$M = 0$:

$\frac{dM}{dx} = 0$

$V = 0$

* القوى المشتركة في عضو بحالها

6,100

$\Sigma M_{at} E = 0$

$+2400(3.6) - F_y(4.8) = 0$

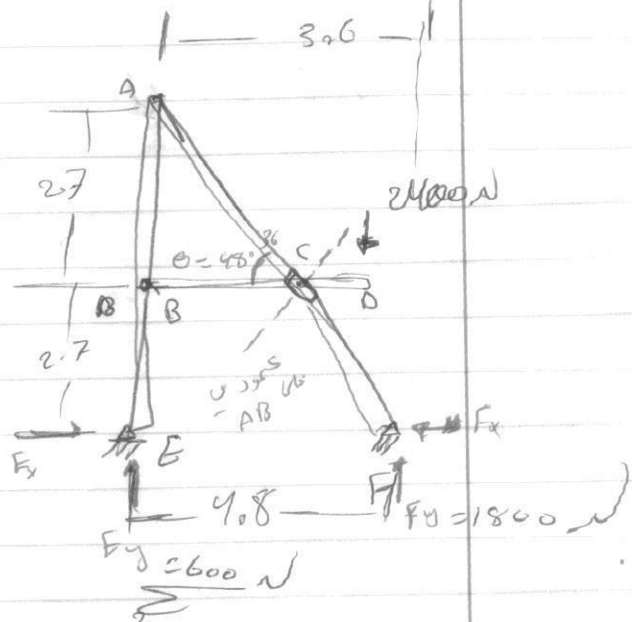
$F_y = 1800$

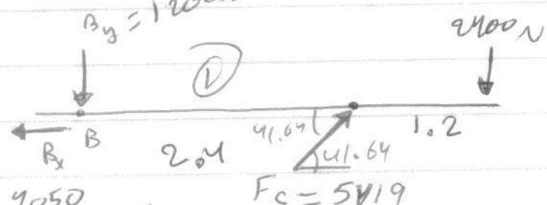
$\Sigma F_y = 0$

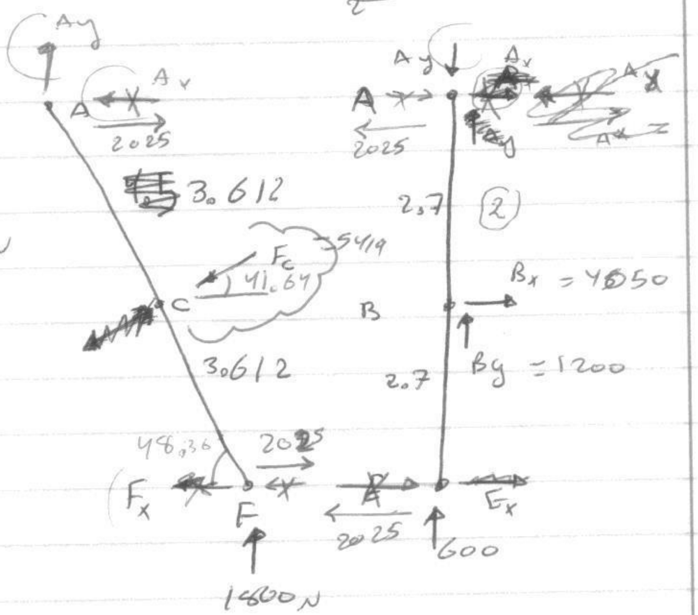
$-2400 + E_y + 1800 = 0$

$E_y = 600$

اذا ما بين تعكس الاتجاه







$\textcircled{1}\ \Sigma M_{at} B = 0$

$-F_c \sin(41.63)]\ 2.4 + 2400 \times 3.6 = 0$

$F_c = 5419$ N

$\Sigma F_x = 0 \qquad B_x = 4050$

$\Sigma F_y = 0 \quad = 5419 \sin 41.63 - 2400 - B_y = 0$

$B_y = 1200,$

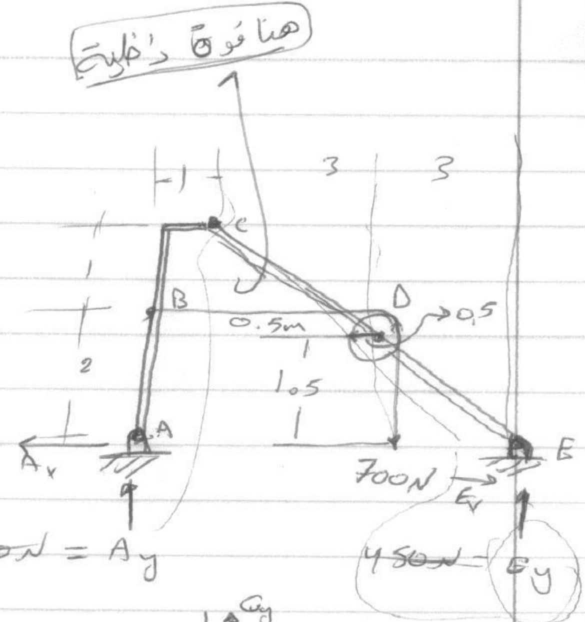
6.93

$\Sigma M_{at\ A} = 0$ ↺

$700(4.5) - E_y(7) = 0$

$E_y = 450\ N$

$A_y = 250\ N$



$\Sigma M_{at\ A} = 0$ ↺

$+C_x(3) - C_y(1) + 700(2) = 0$

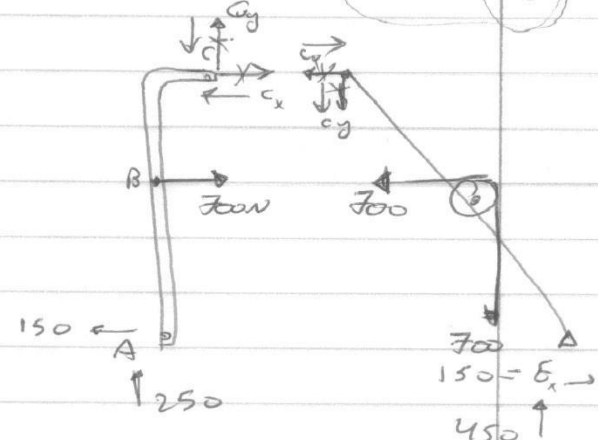
$\Sigma M_{at\ E} = 0$ ↺

$-3(C_x) - C_y(6) - 700(2) - 700(2.5) = 0$

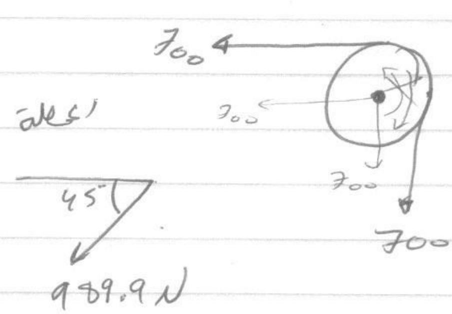
$C_y = -250$

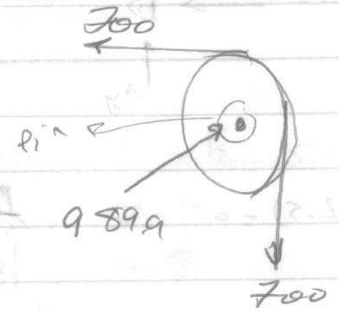
$C_x = \dfrac{+C_y - 1400}{3} =$

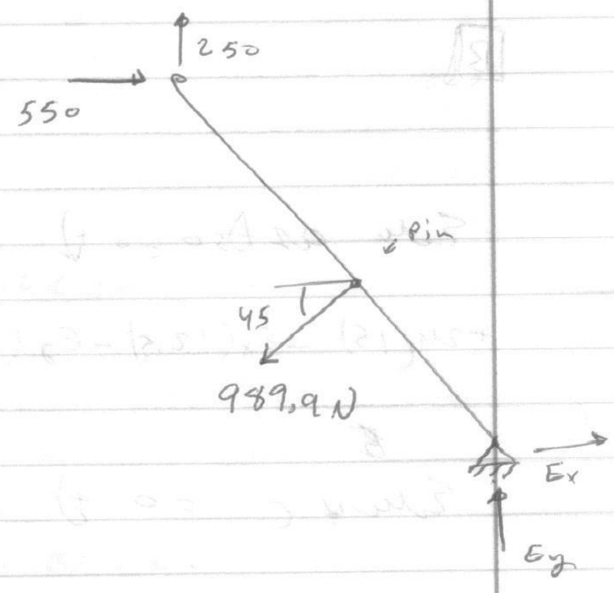
$C_x = \dfrac{-250 - 1400}{3} = -550$



لايجاد القوى عند D







$\Sigma F_y = 0$ ↑

$\cancel{E}\,250 - 989.9\sin 45 + E_y = 0$

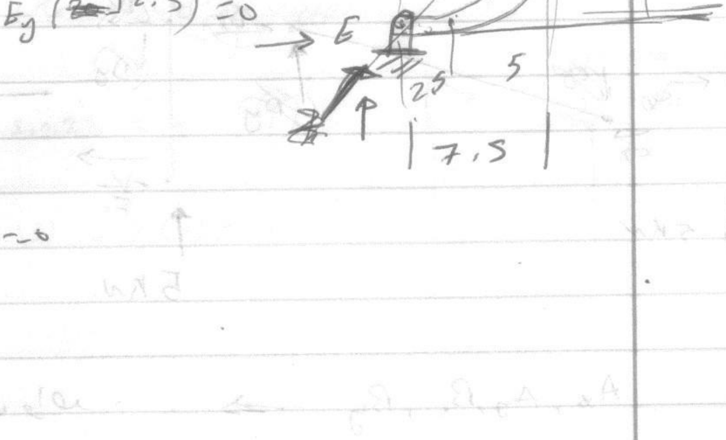
$E_y = 450$

$\Sigma F_x = 0 \quad \xrightarrow{+}$

$550 - 989.9\cos 45 + E_x = 0$

$E_x = 150$

6.87



(A) $\Sigma M_{at\,A} = 0$ ↺ (CCW)

$-24(15) - E_x(12.5) - E_y(\cancel{20}\,12.5) = 0$

$\Sigma M_{at\,C} = 0$ ↺

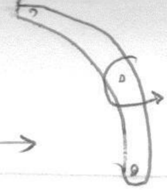
$-E_x(7.5) + E_y(7.5) = 0$

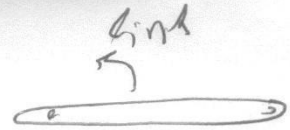
$\boxed{E_x = +E_y}$

$\rightarrow E_x = +14.4$

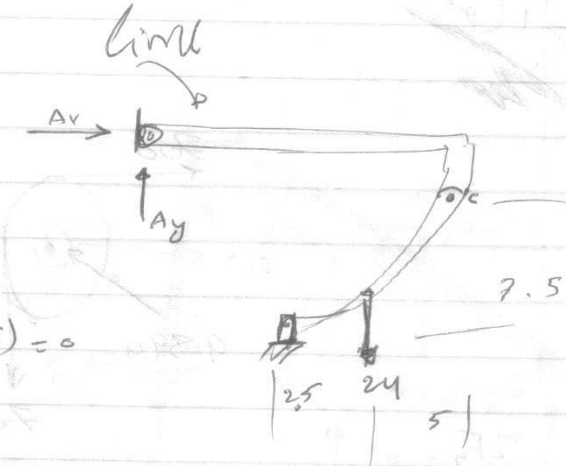
$E_y = 14.4$

Link →





$\boxed{B}$



$\sum M$ at $D = 0$

$$+24(15) - E_x(12.5) - E_y(12.5) = 0$$

E

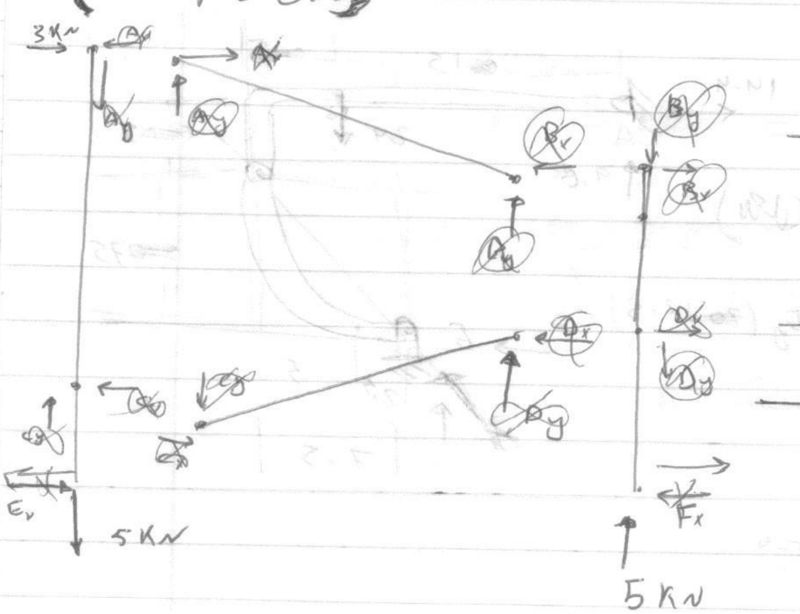
$\sum M$ at $C = 0$

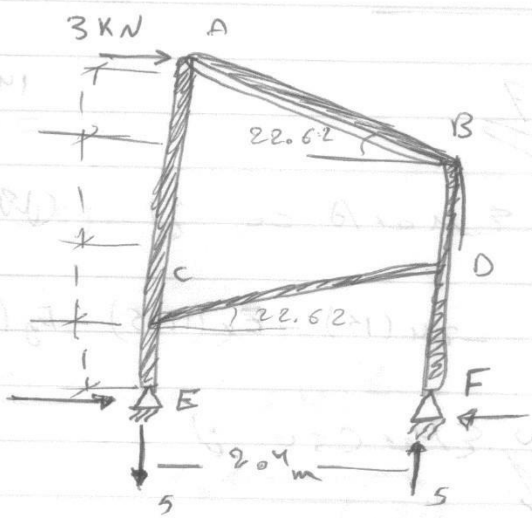
$$-24(5) - E_x(7.5) + E_y(7.5) = 0$$

$E_x =$

$E_y =$

Example 6.6





A_x, A_y, B_x, B_y → مجهول واحد

✿

$\frac{A_y}{A_x} = \tan 22.62$

$\sum F_y = 0 \uparrow^+$

$① \Rightarrow -5 + F_{CD} \sin 22.6 + F_{AB} \sin 22.6 = 0$

$F_{CD} = 7.8$

$F_{AB} = 5.2$

$\sum M_{at} F = 0$

$-F_{CD} \cos 22 (2) + F_{AB} \cos 22.6 (3) = 0$

$F_{CD} = F_{AB}$

$\sum M_{at} F = 0$

$+F_{CD} \cos 22.6 (1) + 3(4) - F_{AB} \cos 22.6 (4) = 0$

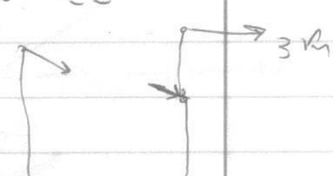
① بالتعويض في $F_{CD} =$

F_{AB}

rigid Body ✱ لو نقلنا ~~القوة~~ $(\frac{3}{5})$ لعند ~~F_B~~ ، لن

تتغير ؟ ~~Sliding vector~~ على الـ Reaction

$\Rightarrow -5 + F_{CD} \sin 22 + F_{AB} \sin 22 = 0$ ①'



$\Rightarrow -F_{CD} \cos 22 (2) + F_{AB} \cos 22 (3) + 3(4) = 0$

$F_{CD} = 10.4$ kN

$F_{AB} = 2.6$ kN

حدث تغير على جميع القوى الداخلية ، وال Reaction أكبر

ليس Rigid Body

هناك ٤ فواصل

ΣM at $E = 0$

$+ F_{CD} (\cos 22.6)(1) - F_{AB} \cos 22.6 (4) = 0$

(١) مقارنة

$F_{CD} = 10.4$

$F_{AB} = 2.6$

في المرحلة الأولى ، $F_x = 2.4 \rightarrow$ $E_x = 5.4 \leftarrow$

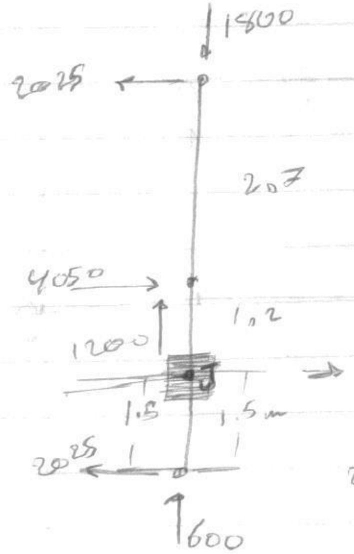
بعد التعديل $F_x = 4.2 \rightarrow$ $E_x = \cancel{5.4}\ 7.2 \leftarrow$

Ch7

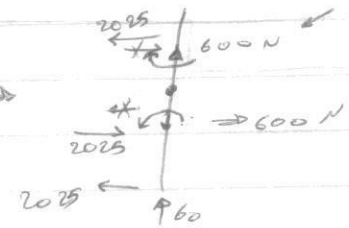
ملاحظة : آخر مثال بهاد التشابتر , مشروح كيف انحل خطوة بخطوة " بآخر صفحتين " , وتقريبا بلخص آلية الحل بهاد التشابتر

Ch 7

Determine the Internal Forces at J



الاتجاهات بالعكس



ΣM حول اي نقطة خلال J

$\Sigma M_{at\ J} = 0$

$+2025(1.5) - M_J = 0$

$M_J = +3037.5\ N.m$

$\Sigma M \text{ at } C = 0$

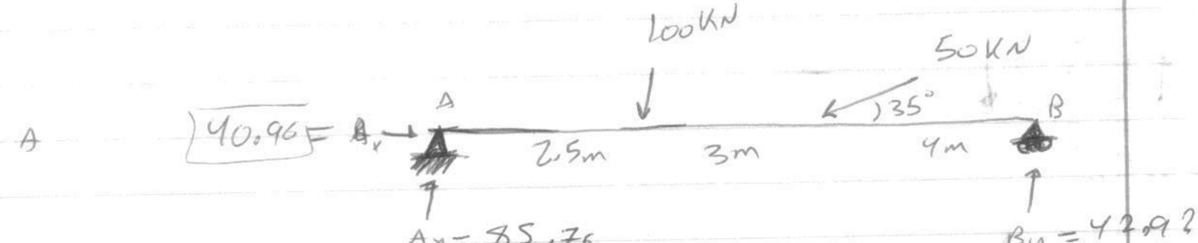
$-M_J + 2025(1.5) = 0$

$M_J = 3037.5\ N.m$

$\Sigma M_{at\ J} = 0$

$+4050(1.2) - 2025(3.9) + M_J = 0$

$M_J = +3037.5\ N.m$



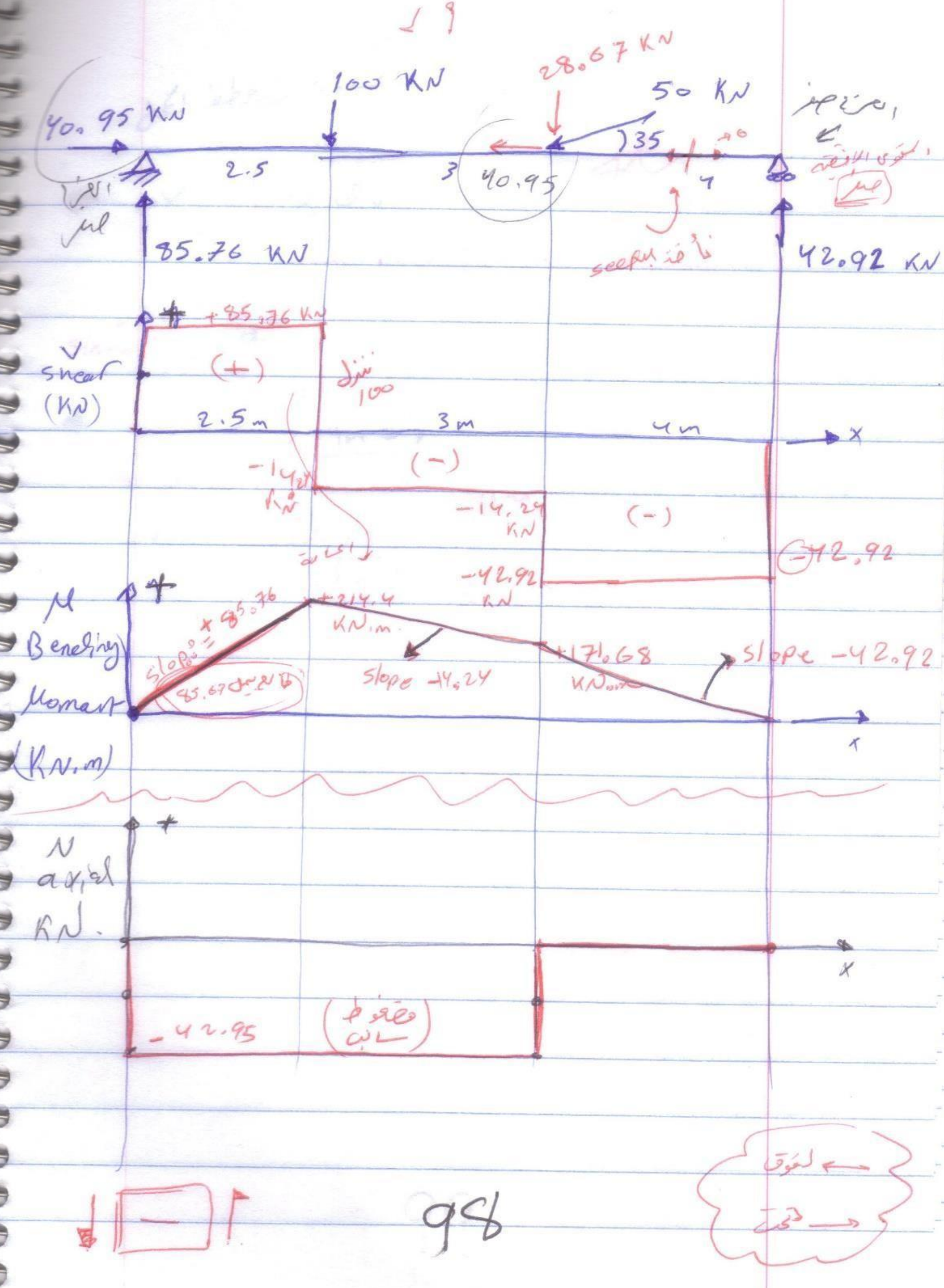
$\Sigma M \text{ at } A = 0$

$100(2.5) + 50(\sin 35)(5.5) - B_y(9.5) = 0$

$\boxed{B_y = 42.92}$ N.

$\boxed{A_y = 85.76}$

98


100 KN
28.67 KN
50 KN
40.95 KN
35
2.5
3
4
40.95
85.76 KN
42.92 KN
V
Shear
(KN)
+85.76 KN
(+)
2.5m
3m
4m
x
(−)
−14.24 KN
−42.92 KN
−42.92
M
Bending
Moment
(KN.m)
+214.4 KN.m
+171.68 KN.m
slope = +85.76
slope −14.24
slope −42.92
N
axial
KN.
−42.95
x

المساحة تحت خطوط الحمل

* $\Delta V = \int w_{(x)} \, d_x$

Distributed load.

$w_{(x)} = \frac{d_V}{d_x}$

slope. الميلة

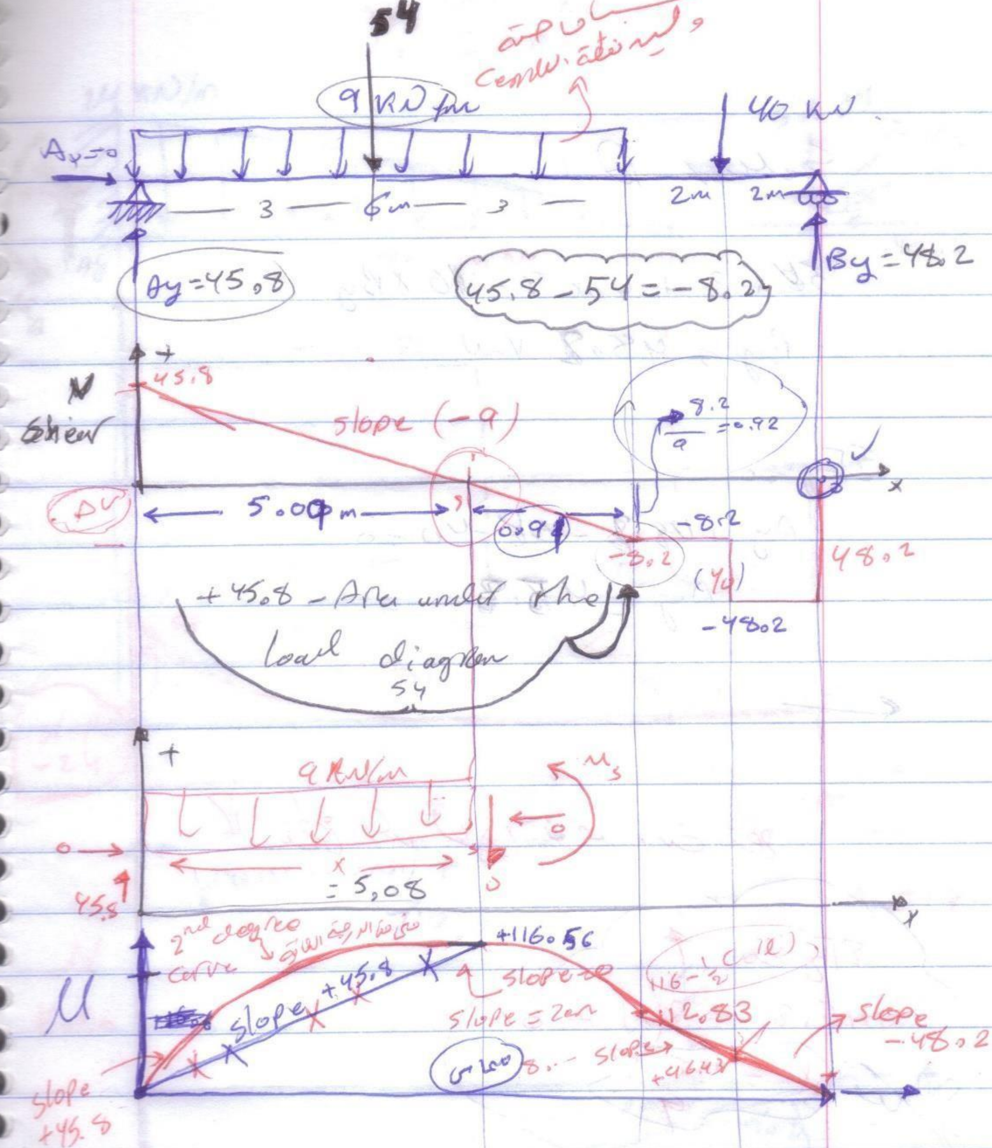
* $\Delta M = \int V_{(x)} \, d_x$

Change in M

Area under V

$V_{(x)} = \frac{dM}{d_x}$

ميل الخط



درجة أولى ← درجة ثانية ← درجة ثالثة

Σ M at B

$54 \times 3 + 40 \times 8 = 10 \times B_y$

$B_y = 48.2$ kN

$\Sigma F_y = 0$

$A_y + 48.2 - 54 - 40 = 0$

$A_y = 45.8$

لما يقطع الخط ال(x) نوجد وين يقطع

$\Sigma F_y = 0 \uparrow$

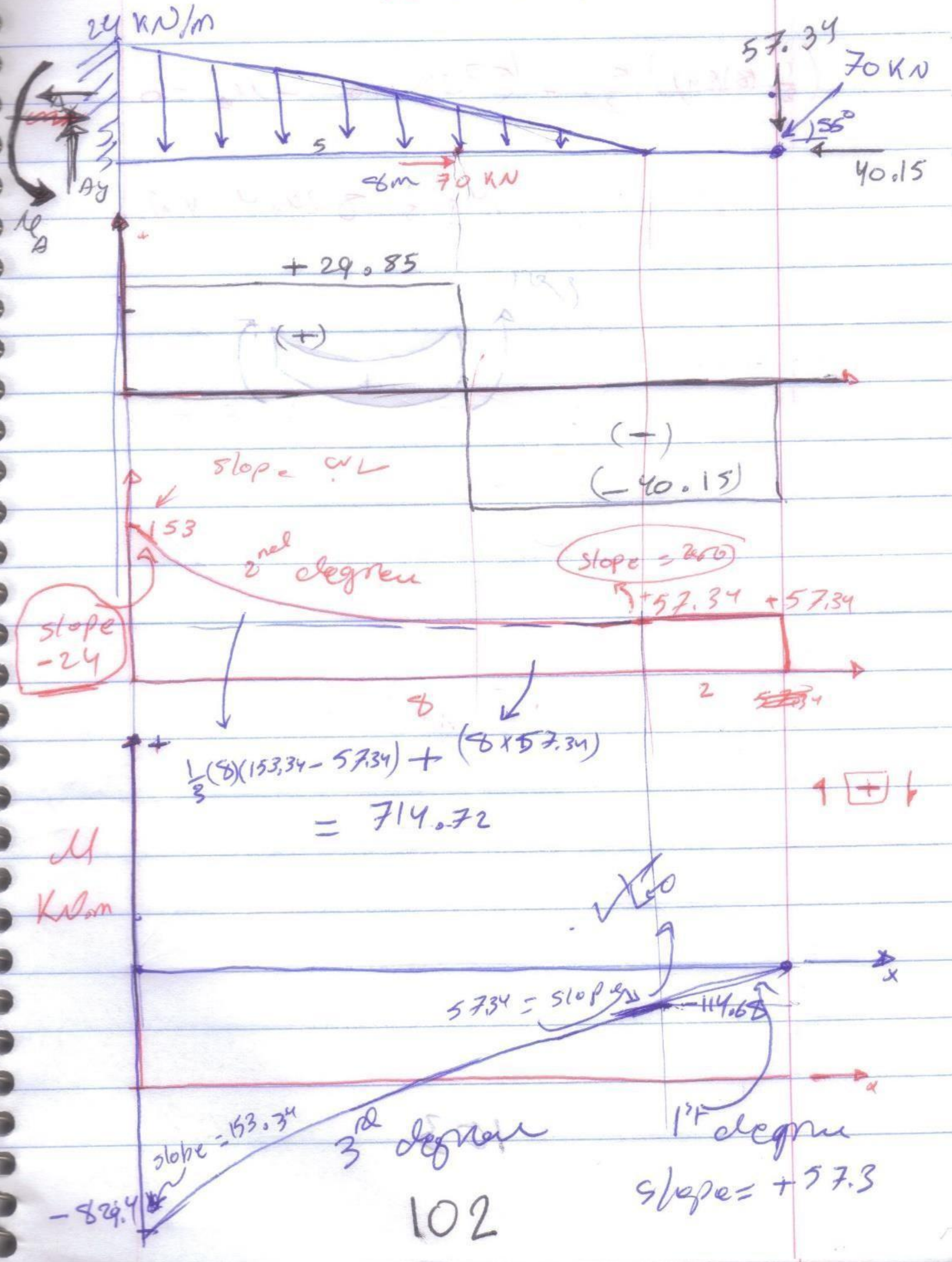
$+45.8 - 9(x) = 0$

بقطع $x = \dfrac{45.8}{9}$

$A_x = \cancel{40.15}\ 29.85\ KN$

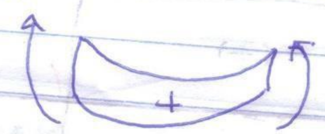
$A_y = 153.34\ KN$

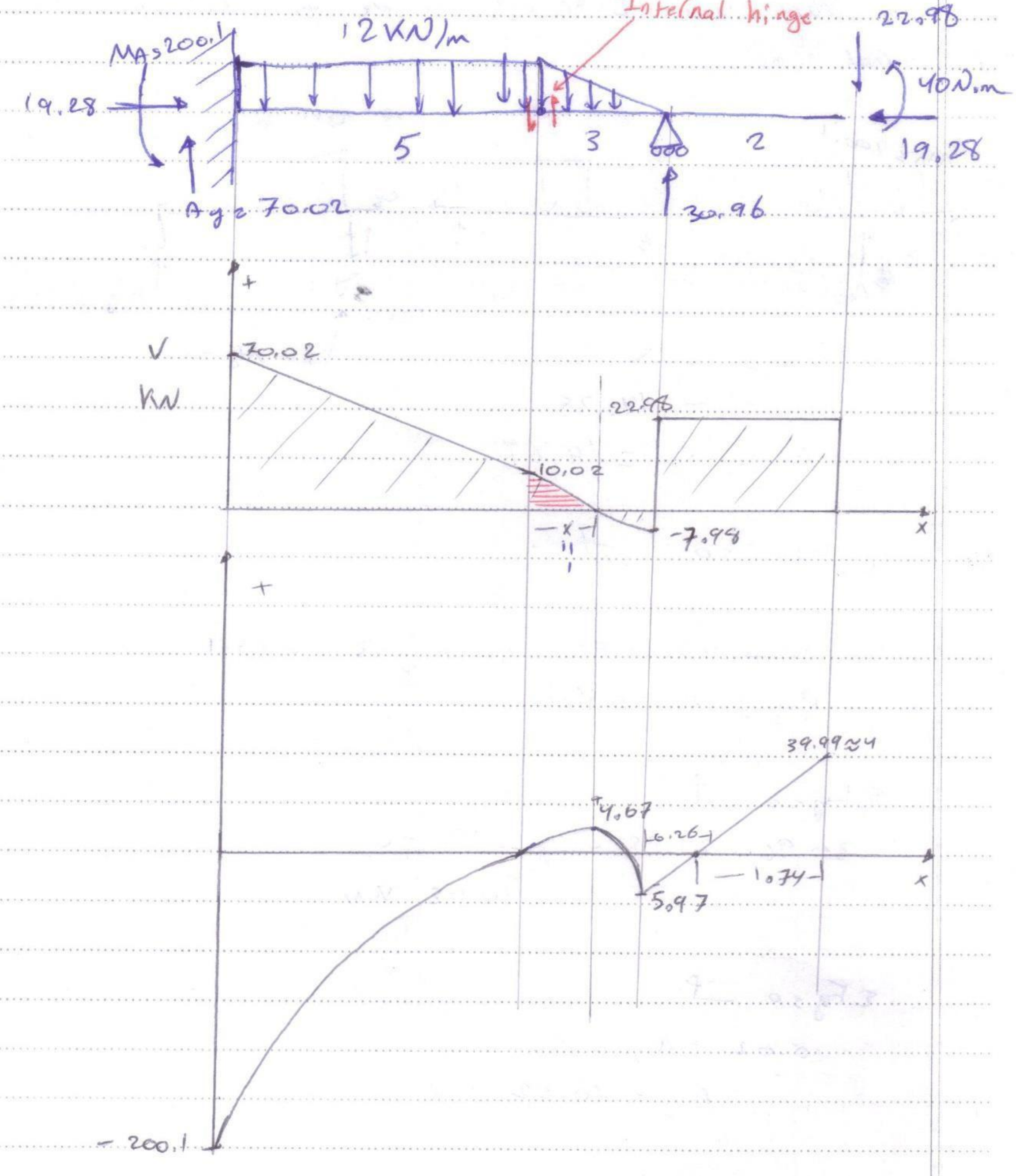
$M_A = 829.4\ KN.m$



$$\left(\frac{1}{2}\cdot(8)(24)\right)\left(\frac{8}{3}\right) + (57.34)\times 10 - M_A = 0$$

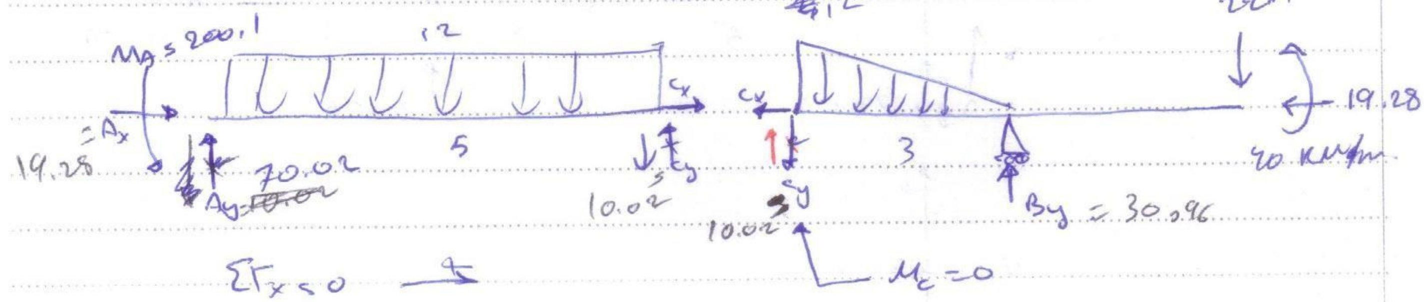
$$M_A = 829.4 \text{ kN.m}$$





Internal hinge
12 KN/m
MA=200.1
19.28
Ay=70.02
5
3
2
30.96
22.98
40N.m
19.28
V
KN
+
70.02
22.98
10.02
-7.98
x
x
+
39.99≈4
4.67
6.26
1.74
-5.97
x
-200.1

we have four unknowns, so we will take a section at point C (Internal hinge),



$\Sigma F_x = 0 \quad \xrightarrow{+}$

$C_x = -19.28$

$A_x = -C_x = 19.28$

$\Sigma M \text{ at } C = 0$

$-B_y(3) + 22.98(5) - 40 + \frac{1}{3} \times 3 \times \frac{1}{2} \times 3 \times 12 = 0$

$B_y = 30.96 \text{ KN}$

$\Sigma F_y = 0 \quad \uparrow$

$30.96 - 22.98 - C_y - 18 = 0$

$C_y = 10.02 \text{ KN}$

$\Sigma F_y = 0 \quad \overset{+}{\uparrow}$

$-10.02 + A_y - 5 \times 12 = 0$

$A_y = 70.02 \text{ KN}$

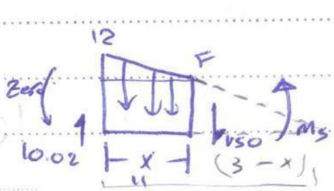
$\Sigma M \text{ at } C = 0$

$70.02 \times 5 - 12 \times 5 \times \frac{5}{2} - M_A = 0$

$M_A = 200.1 \text{ KN.m}$

To find $\frac{x}{3}$, we take a section with some known

$\frac{3-x}{3} = \frac{F}{12} \Rightarrow F = \frac{(3-x)}{3} 12 = 8 \Big|_{x=1}$



من تشابه المثلثات

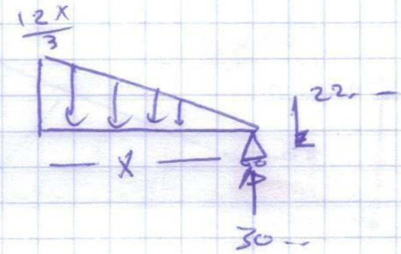
$\Sigma F_y = 0 \quad x = 1$

From Section :

$\Sigma M_{at\ C} = 0$ $\circlearrowright^{+}$

$\frac{1}{2} \times 1 \times 4 \frac{\cancel{20}}{\cancel{2}} \times \frac{1}{3} + \cancel{M_s = 0}\ 8(1)(\frac{1}{2}) - M_s = 0$

$M_s = \cancel{8} + 4.67$



3

$30.\cancel{98} - 22.98 - \frac{12}{3}x \times \frac{1}{2}x = 0$

$x = 1.99.$

هسا اذا بتشوف آخر مثال بالشرح , بتلاحظ تدرج بالمنحنيات المرسومة , يعني اذا كانت القوة على شكل مربع , برسمة الshear بتصير مثلث وبرسمة ال moment بتصير منحنى وهيك , كيف كنا نرسمها ببساطة , كل رسمة بتعتمد ع كل اللي قبلها , رسمة الshear بتعتمد ع قيم التغير بالفورس بالرسمة الاصلية , وميل الخطوط او المنحنيات بكون هو قيمة ال force اللي اضفناها , ورسمة المومنت بتعتمد ع شغلتين , قيم المومنت بالرسمة الاصلية , وكمان قيم الshear عند عدة نقاط برسمة الshear , قيم ال shear " اكتبيها " هي بتمثل <<ميل>> المنحنى عند اسقاط هديك النقطة برسمة المومنت !

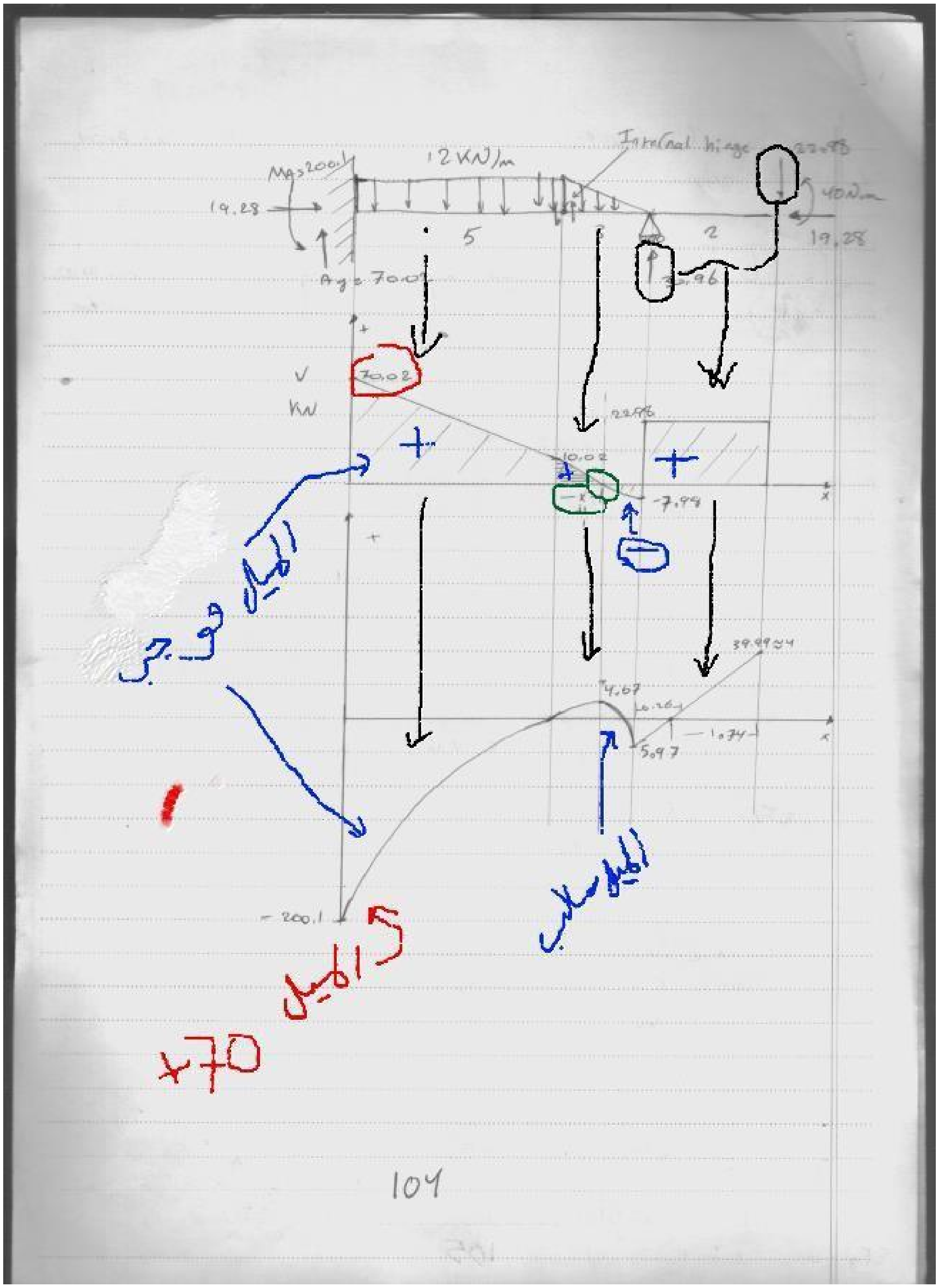
هسا كيف هون رسمنا ال shear مثلا , بدأنا ب + 70.02 , ولأنو عنا load مستطيل الشكل رح يصير خط مائل , القيمة الي رح ينتهي عندها هي

(+70.02 –)5* 12)) = +10.2 وميله افتراضيا هو) 5*12(, هسا ال load اللي ع شكل مثلث , رسمه رح يكون منحنى , ببدأ بنفس الميل اللي قبله) 5*12(

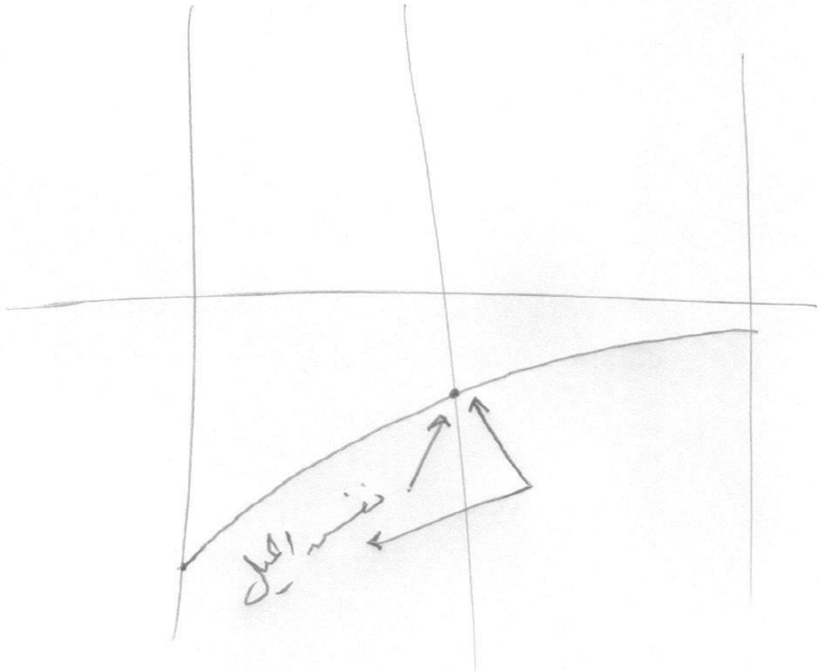
والقيمة اللي رح ينتهي عندها هي+) 10.02 –)3*12((= - 7.98 بس رح تنتهي بميل صفر , بنهاية المثلث عندك قوة للاعلي , ع نفس نقطة نهاية المثلث ! ف رح نطلع لفوق) -7.98 + 30.96(= + 22.98 , وبعدها القوة الجديدة اللي رح تأثر مش load ف رح يكون خط افقي

أما رسمة المومنت , بدأنا بمومنت – 200.1 **)) صحيح ضروري تعرف كيف تتعامل مع الاشارات متى الموجب ومتى السالب لل shear & moment (** بعدها منحنى , بنتهي عند) - 200.1 +) مساحة شبه المنحرف+) 200.1(((= صفر , ببدأ بميل 70.02 وبنتهي بميل 10.02 , بعدها رح نوقف عند النقطة x اللي ميل منحنى المومنت عندها صفر) صفر + مساحة المنطقة (بس هالمنحنى مش معطى قانونه بالجدول) مش قطع مكافئ (, فهون بناخذ مقطع من الشكل الاصلي وبنوجد المومنت حسابيا ! , بعدها الجزء اللي تحت المحور قطع مكافئ , بنحسب مساحتها وبنقصها من 4.07 , بعدها خط مائل بنتهي ب) - 5.97 + مساحة المستطيل (والميل رح يكون 22.98 +

الدائرة الخضرة لأنو قطع المحور , فلازم تلقي المسافةx عشان تقدري توجدي المومنت عندها) مشروحة بال pdf (



دائما عند كل خط عمودي اوجدي قيمة المومنت , والميل من الجهتين لأنو يمكن يختلف , هاي اجتنا بالفاينل وحسيتها مقصودة الشغلة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