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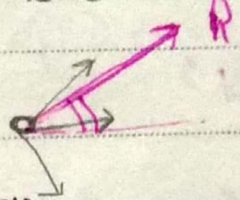
L2: Statics of Particles

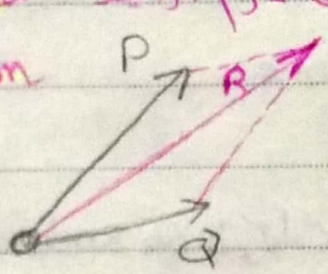
→ resultant force ايجاد الـ



* equilibriam → $\Sigma f = 0$

f = Vector → magnitued [XN], direction

- ايجاد المحصلة ← لازم اوجد magnitued المحصلة
- direction المحصلة



graphical

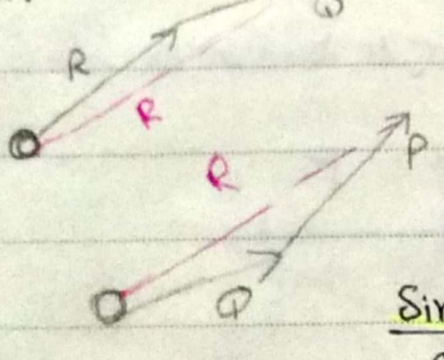
1) Triangle rule + TrapaZoid ⇒ graphical.

2) Law of cosines :-

$$R^2 = P^2 + Q^2 - 2PQ\cos B$$

الزاوية بين P, Q ⦟2

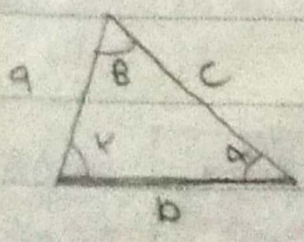
head to tail ارسمهم



3) Law of sines :

$$\frac{\sin A}{Q} = \frac{\sin B}{Q} = \frac{\sin C}{P}$$

• $\vec{P} + \vec{Q} = \vec{Q} + \vec{P}$, $\vec{P} - \vec{Q}$ → عكس الاتجاه Q



$$\Rightarrow \frac{a}{\sin \alpha} = \frac{b}{\sin B} = \frac{c}{\sin \gamma}$$

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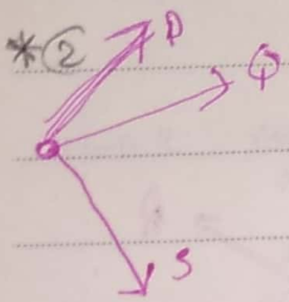
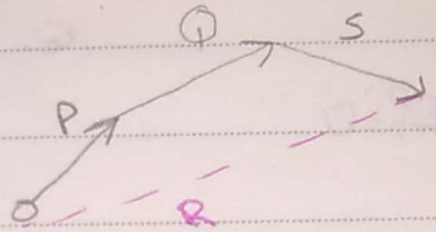
*②



⟹

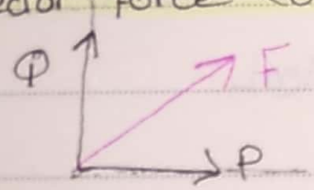


① * $\vec{P}+\underbrace{\vec{Q}+\vec{S}}$

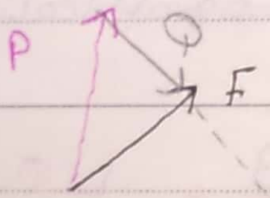
$\underbrace{P+R_1}_{R}$

* Concurrent forces → Point of application بيتطبقوا على نفس ال

√3 vector force components تحليل المحصلة لمركبات



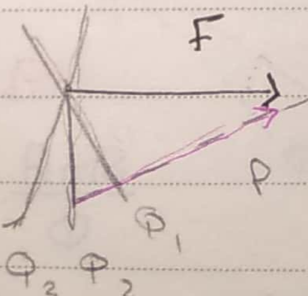
إذا بعرف F وبعرف واحدة من المركبات بنطلع المركبة التانية



إذا بعرف واحد من direction المركبات و F

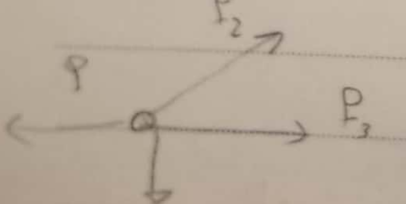
*minimum

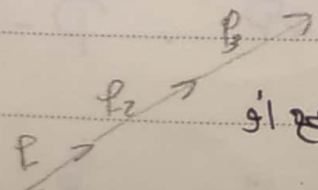
$Q \perp P$



لانهائيات ⟵ Q_3 Q_2

Concurrent forces

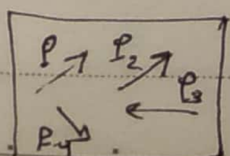




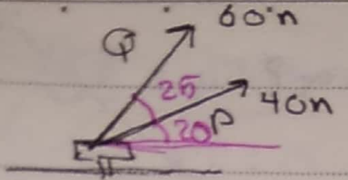
→ Collinear force

نفس ال Line of action بيجمع أو بيطرح.

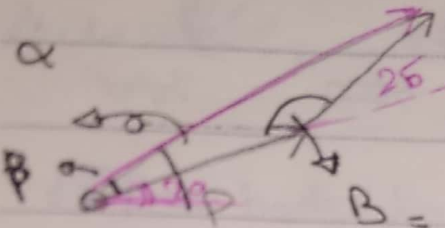
Coplanar forces ⟵



example :-



determine the $\underline{R}$



$R^2 = P^2 + Q^2 - 2PQ \cos B$

$R = \boxed{}$

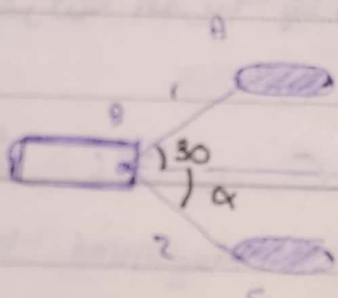
$B = 180 - 25 = 155$

$\alpha = 20 + \beta$

$\frac{60}{\sin \beta} = \frac{R}{\sin 155} = \beta = \boxed{}$

L3:-

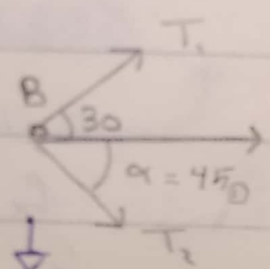
example :-



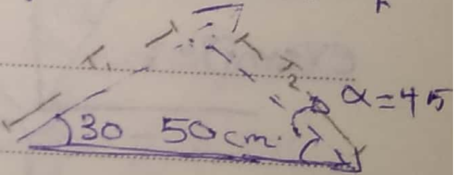
$R = 5000\ lbf$

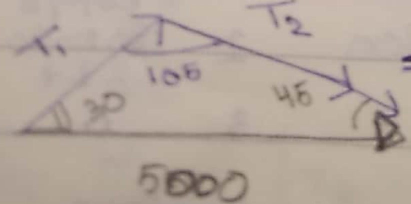
1) $T_1, T_2 ? : \alpha = 45°$

2) $\alpha ? : T_2$ minamom.



graphicly → 1 cm = 1000 lbf





$\Rightarrow R^2 = T_1^2 + T_2^2 - 2T_1 T_2 \cos B$

$\frac{5000}{\sin 105} = \frac{T_1}{\sin 45} = \frac{T_2}{\sin 30} \Rightarrow T_1 = 3660.2 lb$

$\Rightarrow T_2 = 2588.1 lb$

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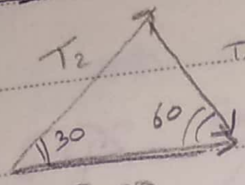
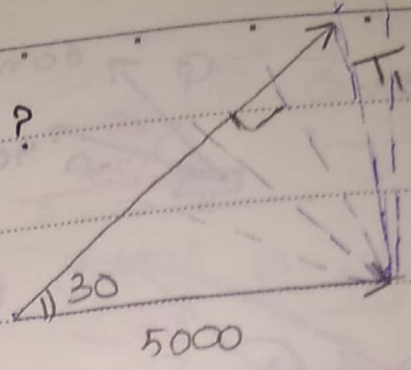
2) ~~T_2 ? α = min~~ T_2 minimum : α ?





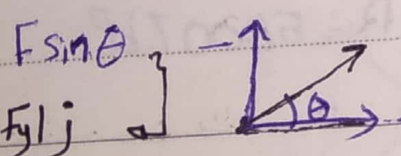
$T_1 = 5000 \cos 30$

$T_2 = 5000 \cos 60$

f_3 Rectangle component of force:

* يتحلل كل قوة لـ X com و Y com وناخذ محصلة مجموعهم

ـ بالتحليل : الحركة القريبة بناخد cos والبعيدة بناخذ sin



$\boxed{x}\, i$ $\quad |F_x|\, i$

الـ magnitude

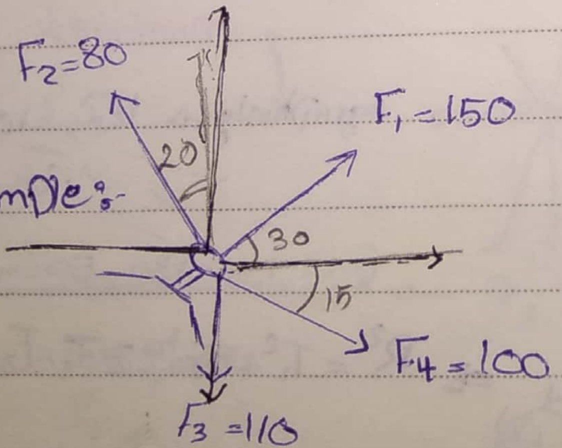
$(\Sigma f_x)\,\bar{i} + (\Sigma f_y)\,\bar{j}$

$* F = F_x \bar{i} + F_y \bar{j}$

$F_R = \sqrt{R_y^2 + R_x^2}$

$\theta = \tan^{-1} \frac{R_y}{R_x}$

Example:-

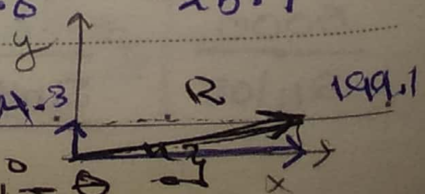


	f_x	f_y
1	$f_1 \cos 30$ (N) 129.9	$f_1 \sin 30$ (N) 75
2	$-80 \sin 20$ -27.4	$80 \cos 20$ 75.2
3	0	-110
4	$f \cos 15$ 96.6	$-f \sin 15$ -25.9

$R = 199.1\,\bar{i} + 14.3\,\bar{j}$

$R = \sqrt{(199.1)^2 + (14.3)^2}$ لـ الربع الأول

$= 199.6\,N$, $\theta = \tan^{-1} \frac{14.3}{199.1}$



$4.1^{\circ} = \theta$

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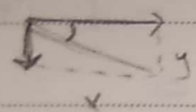
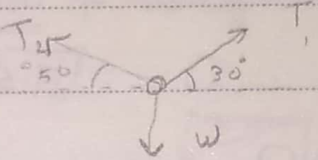


equilibrim of a particle

$\Sigma F = 0$

بناخد مثلث كام الزاويه

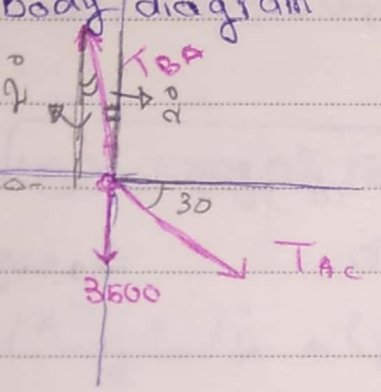
$\Sigma f_x = 0$ $\Sigma f_y = 0$



free body diagram

S.P

equilibrium



T_{AC} , T_{BC} ?

$\Sigma f_x = 0$ $\Sigma f_y = 0$

$T_{AC}x - T_{AB}x = 0$

$T_{AC} \cos 30 = T_{AB} \sin 2$

$0.86 T_{AC} = 0.034 T_{AB}$

$T_{AB} = 25.6 T_{AC}$

$0 = T_{BA} \cos 2 - 35000 - T_{AC} \sin 30$

$25.7 T_{AC} \cos 2 - 3500 - T_{AC} \sin 30$

$T_{AC} = 141.18 lb$

$T_{AB} = 3570 lb.$

*المفروض محصلة T_{AB} مع T_{AC} = 3500

التأكد من الحل (Solution check.)

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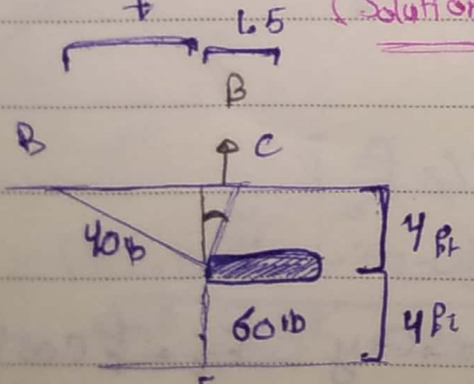
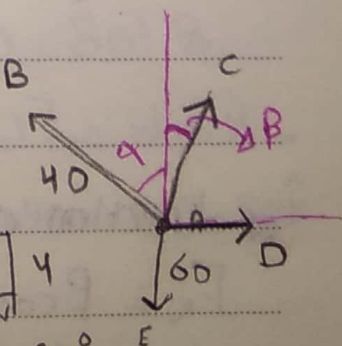
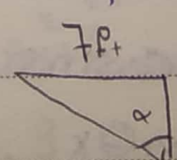


F? T_{AC} ?



$\alpha =$



$\tan^{-1} \frac{7}{4} = 60.25°$

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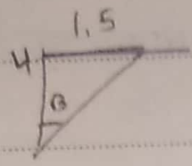
$\beta =$  $= \tan^{-1}\frac{1.5}{4} = 20.5$

$\Sigma F_x = 0$

$-40\sin 40.25 + T_{AC}\sin 20.55 + D = 0$

$D = \boxed{19.6}$ lb

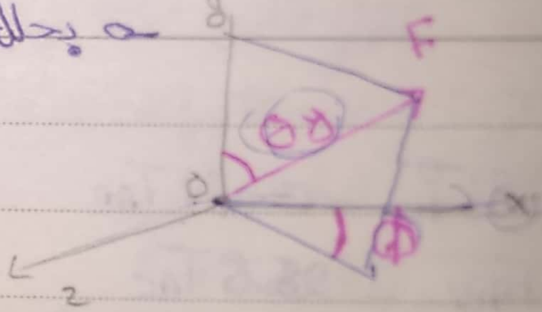
$\Sigma F_y = 0$

$40\cos 60.25 + T_{AC}\cos 20.55 - 60 = 0$

$T_{AC} = \boxed{43.18}$ lb ثم نعوض

*Rectangular component of a force in space.

Plan XZ عل, y_x يحلل القوة على



$F_y = F\cos\theta_y$

$F_{xz} = F\sin\theta_y$

$F_x = F_{xz}\cos\phi$, $F_z = F_{xz}\sin\phi$

$F\sin\theta_y$.

$F = F_x\bar{i} + F_y\bar{j} + F_z\bar{k}$

* direction cosins

$F_x = F\cos\theta_x$, $F_y = F\cos\theta_y$, $F_z = F\cos\theta_z$

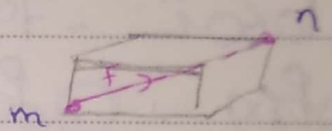
$\bar F = F_x \bar i + F_y \bar j + F_z \bar k$

$= F \bar\lambda$, $\bar\lambda = \cos\theta_x \bar i + \cos\theta_y \bar j + \cos\theta_z \bar k$

magnitued لـ $\bar F$

magnitued $\lambda = 1 \Rightarrow \cos^2\theta_x + \cos^2\theta_y + \cos^2\theta_z = 1$

$\bar d = d_x \bar i + d_y \bar j + d_z \bar k$



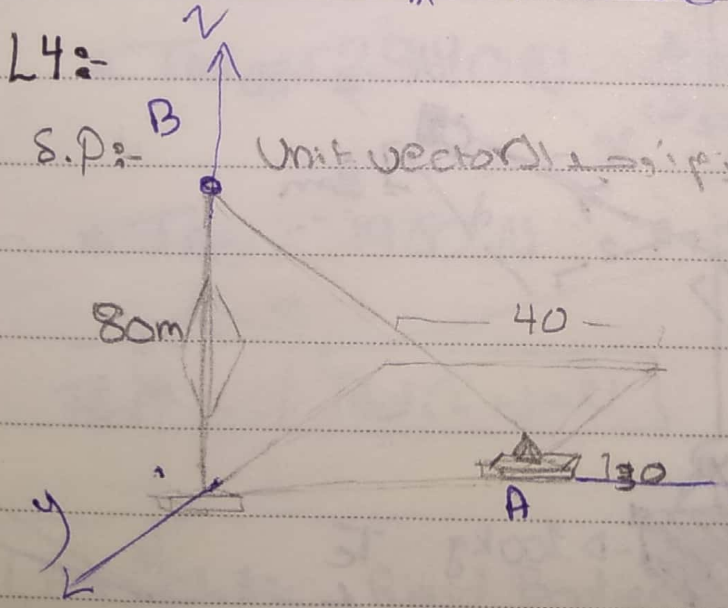
$|d| = \sqrt{(x_2-x_1)^2 + (y_2-y_1)^2 + (z_2-z_1)^2}$

$\hat\lambda = \frac{(x_2-x_1)}{d} i + \frac{(y_2-y_1)}{d} j + \frac{(z_2-z_1)}{d} k$

$\cos\theta_x + \cos\theta_y + \cos\theta_z$

L4:-

S.P:- لا يوجد معي الـ direction فلازم اوجد الـ Unit vector -



• لازم نطلع احداثيات A,B

(40,-30,0) A

(0,0,80) B.

• الاتجاه من لـ (B لـ A) عشان يشد

$\vec d = (40-0)\hat i + (-30-0)\hat j + (0-80)\hat k = 40\hat i - 30\hat j - 80\hat k$

$|d| = \sqrt{40^2 + 30^2 + 80^2} = 94.3$

$$\hat{\lambda} = \frac{40}{94.3}\hat{i} - 0.318\hat{j} - 0.848\hat{k}$$

0.424

$* \; T = 2500 * \hat{\lambda} \rightarrow 2500 \times (0.424\hat{i} - 0.318\hat{j} - 0.848\hat{k})$

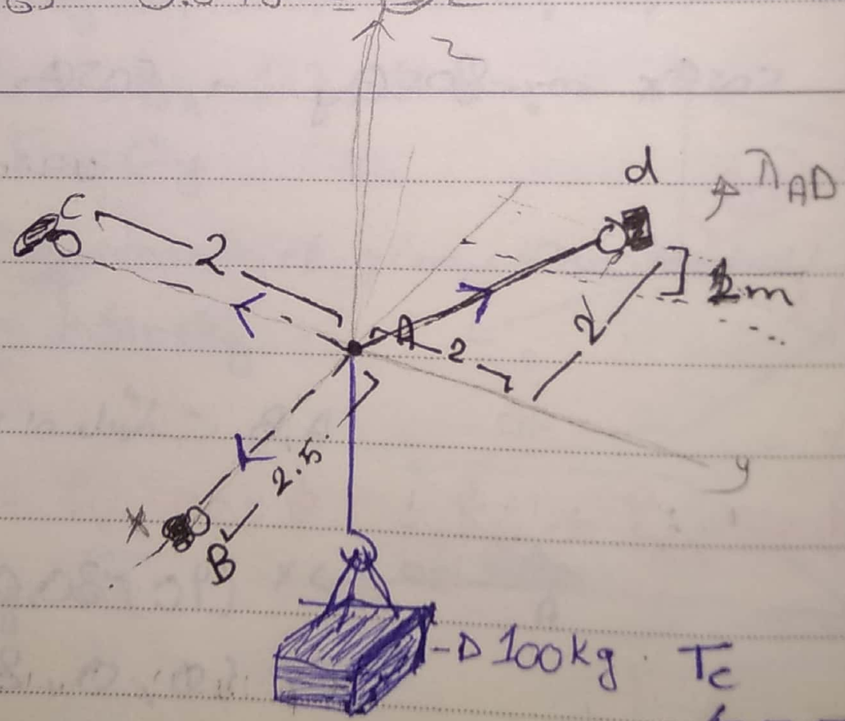
$\Rightarrow 1060\hat{i} - 795\hat{j} - 2120\hat{k}$

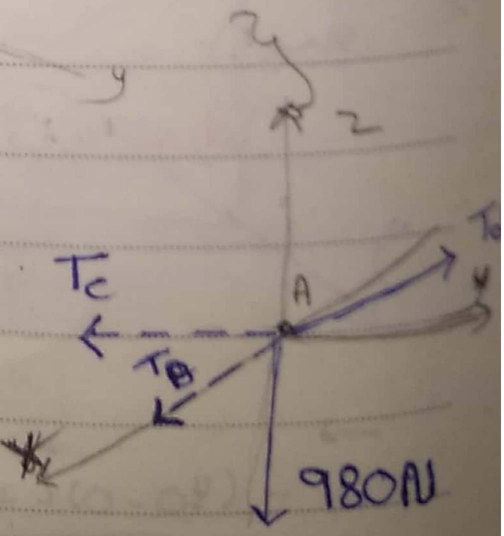
$F_{(x)}$	$F_{(y)}$	$F_{(z)}$
1060 N	−795 N	−2120 N

$\Rightarrow \cos^{-1} 0.424 \rightarrow \theta_x$, $\cos^{-1} -0.318 = \theta_y$

$\cos^{-1} -0.848 = \theta_z$

S.P:-





T AB, AC, AD ?

$* \; \bar{d}_{Ad} = (-2\hat{i} + 2\hat{j} + 1\hat{k})$

$\bar{\lambda}_{Ad} = -\frac{2}{3}\hat{i} + \frac{2}{3}\hat{j} + \frac{1}{3}\hat{k}$

$\bar{T}_{Ad} = \bar{T}_{Ad}\left(-\frac{2}{3}\hat{i} + \frac{2}{3}\hat{j} + \frac{1}{3}\hat{k}\right)$

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$\vec{T}_{AC} = -T_{AC}\,j$, $T_{AB} = T_{AB}\,i$, $\vec{W} = 980\hat{k}$

• هنا يكون التبا (T) تفحص ور.

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

* $-\frac{2}{3}T_{Ad} + T_{AB} = 0 \rightarrow (1)$ (x)

* $\frac{2}{3}T_{Ad} - T_{AC} = 0 \rightarrow (2)$ (y)

* $\frac{1}{3}T_{Ad} - 980 = 0 \rightarrow (3)$

* $T_{Ad} = 2940N$ عوض في

الله يعوض عليك

هنا العواملك كامل كل طالب (k)

* $T_{AC} = 1960N$, $T_{AB} = 1960N$

من الاصل

$\vec{T}_{Ad} = \boxed{T_{Ad}(\hat{i}+\hat{j}+\hat{k})}$

L5:- ch3:- Rigid Bodies "equivelent system of force"

*deformable body

* إذا ما كان ياترا ان : $\rightarrow$ moment, Rotation

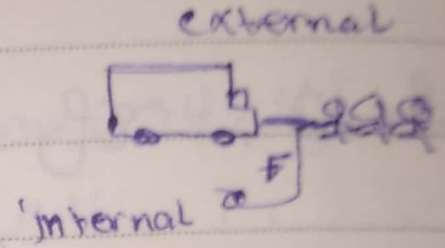
*Rigid body $\rightarrow$ Translation

حركة أو دوران

* تحويل القوى على ال rigid body لقوة واحدة و moment.

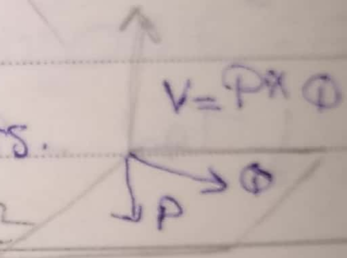
External and internal forces

section cut لو ما يتبين إلا إذا قطعنا



* يقدر أحرك ال Force على نفس ال line of action وبيعطي نفس التأثير

مش دايمًا صحيح إذا بنتعامل مع قوى داخلية.



* vector product of two vectors.

~~متجه عمودي على المستوى الي بيحتوي المتجهين~~

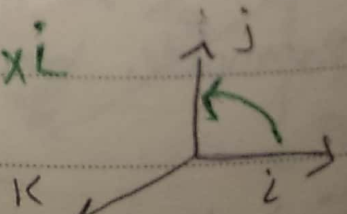
بيلزمني line of action و magnitued لـ (P, Q)

$|V| = PQ \sin\theta$, direction قاعدة اليمين

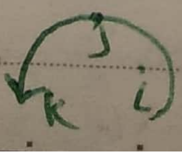
خواصها:-

- $Q \times P \neq (P \times Q) \to -(P \times Q)$ نفس ال magnitued بإتجاه مختلف
- $P(Q_1 + Q_2) = P \times Q_1 + P \times Q_2$
- $(P \times Q) \times S \neq P \times (Q \times S)$

$K = j \times i$



Rectanguler component



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$i \times i = 0$

$Q\ P \times Q$

$$\begin{array}{c|ccc|}
 & i & j & k \\
P & P_x & P_y & P_z \\
Q & Q_x & Q_y & Q_z
\end{array}$$

يلغي صف i وعمود

$\Rightarrow \vec{V} = i(P_y Q_z - P_z Q_y) - j(P_x Q_z - P_z Q_x) + k(P_x Q_y - P_y Q_x)$

Moment of a force about a point

عزم القوة = مقدار ميل القوة للدوران حول نقطة معينة بعيدة عن خط عملها (L_o) + عكس عقارب الساعة

$M_o = \vec{r} \times \vec{F}$ → magnitude, direction

$r F \sin\theta \rightarrow Fd$

L_o المسافة العمودية بين القوة ونقطة التأثير.

$\vec{r} \times (F_1 + F_2 + \dots) = \vec{r} \times \vec{F_1} + \vec{r} \times \vec{F_2} + \dots$

خواص :-

The moment of the group of forces about a Point equal the moment of the resultant about the point.

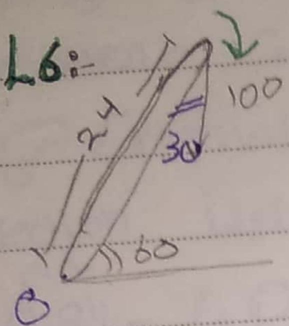
$$\begin{vmatrix} i & j & k \\ x & y & z \\ F_x & F_y & F_z \end{vmatrix} = (yF_z - ZF_y)i - (xF_y - yF_x)j + (yF_z - ZF_y)$$

3d

3d → F(i j), r(i j)

M → k [+ عكس, − مع]

L6:

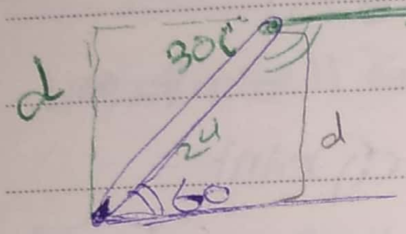


* $M_o = r_o \times F = 24 \times 100 \times \sin 30$ له

$= 1200$ lb in

$d = 24$

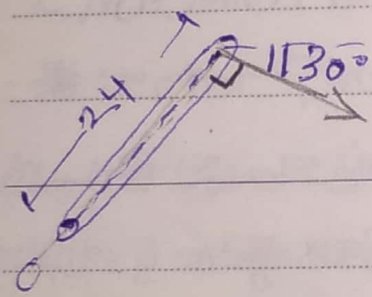
* Moment قوة أفقية تعطي نفس ال



$M = Fd \rightarrow 1200 = F \times 24 \cos 30$

$F = 57.7$ lb ل d

* Smalest force to produce same M



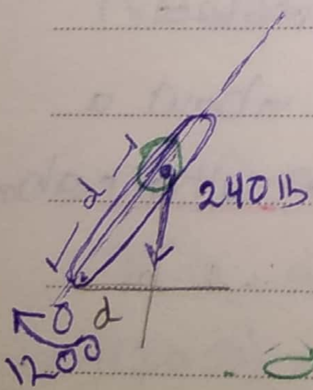
$M = F \times d$

Min ل Max ل

direction $\rightarrow \theta = 3°$ ⊥ OA

$1200 = F \times 24 \rightarrow F = 50$ lb

*Location of vertical force 240 lb



$M = F \times d$ $1200 = 240 \times d$

$d = 5$

مجيب المعادلة ـــه $d = OB \cos 60$

$OB = \frac{5}{\cos 60} = 10$ in

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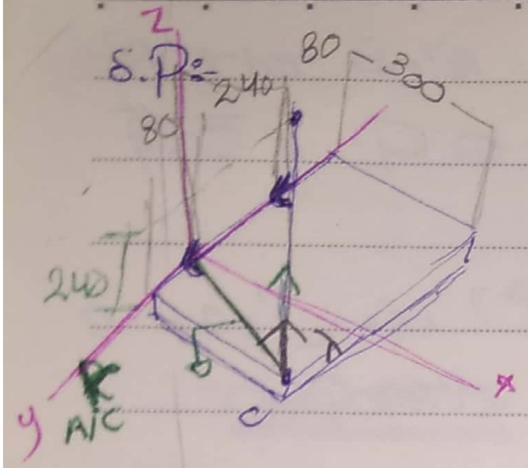

$M = \vec{r}_{c/A} \times \vec{F}$

$A = (0,0,0)$, $C = (300, 80, 0)$

$\therefore \vec{r}_{A/C} = 300i + 80j$

$\vec{F}$ نحل لأسلوب باتجاه القوة

$\vec{F} = 200\,\bar{\lambda}$, $\bar{\lambda} = \dfrac{d_{c/d}}{|d_{c/d}|}$

$D = (0, -240, 240)$

$\vec{d}_{cd} = -300i - 320j + 240k$

$|d_{c/d}| = 500$ mm

$\lambda = -0.6i - 0.64j + 0.48k$

$\vec{F} \therefore 200(\bar{\lambda}) = -120i - 128\hat{j} + 96\hat{k}$

$$\therefore M = \vec{r}_{A/C} \times \vec{F} = \begin{array}{ccc} i & j & k \\ 300 & 80 & 0 \\ -120 & -128 & 96 \end{array}$$

$i\,(\cancel{80\times96}\; 7680)$

$-j\,(28800)$

$+k\,(-28800)$

$\vec{M} = 7680\,\hat{i} + 28800\,\hat{j} - 28800\,\hat{k}$

$|M| = 14\,1447$ Nmm

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$\theta_x = \cos^{-1} \frac{7680}{41497} =$

$\theta_y = \cos^{-1} \frac{22800}{41447}$

$\theta_z = - \frac{28880}{41447}$

47:- Scalar product of two vectors

* $P \cdot Q = PQ \cos\theta$ بيستخدم غالبا "ليستخرج زاويه"

خصائص

$\bar{P} \cdot \bar{Q} = \bar{Q} \cdot \bar{P}$, $P(Q_1 + Q_2) = Q_1 P + Q_2 P$

$(\bar{P} \cdot \bar{Q}) \cdot \bar{S} \rightarrow$ غيرمعروفة

↳ Scalar quantity

$\bar{i} \cdot \bar{i} = 1$ و $\bar{j} \cdot \bar{j} = 1$ و $\bar{k} \cdot \bar{k} = 1$

$0 = k \cdot j$ او $i \cdot J = 0$ لكن

$\bar{P} \cdot \bar{Q} = P_x Q_x + P_y Q_y + P_z Q_z$

$\bar{P} \cdot \bar{P} = P^2 \rightarrow PP \cos 0 = P^2$

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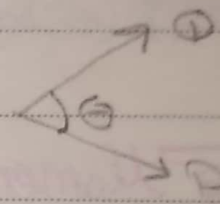
2vector الزاوية unknown.

$\bar{P}\cdot\bar{Q} = PQ\cos\theta = P_xQ_x + P_yQ_y + P_zQ_z$



باستخدام $(P.Q)$ نقدر أوجد أي

يا حول أي axis. components.

3d

Mixed Triple Product of 3 vector

لو ايجاد الـ M حول معين axis

$\bar{S}\cdot(\bar{P}\times\bar{Q})$ = scalar result.

خصائص:

$\bar{S}\cdot(\bar{P}\times\bar{Q}) = \bar{P}\cdot(\bar{S}\times\bar{Q}) = \bar{Q}\cdot(\bar{P}\times\bar{S}) = (-)$

ايجاد قيمة الـ Mixed triple :-

$$\begin{vmatrix} S_x & S_y & S_z \\ P_x & P_y & P_z \\ Q_x & Q_y & Q_z \end{vmatrix}$$

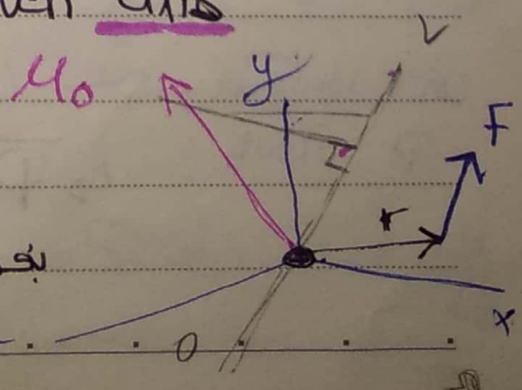
Moment of a force about a given axis

نوجد الـ M لـ $\vec{F}$ حول نقطة O

بعدين $\bar{M}_o$ بوجده حول

بعض المحاور وبين لقيت النقطة ol

ع يعوضني بنفس الـ M حول الـ axis



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1) * $M_o = \vec{r} \times \vec{F}$

2) * $M_{oL} = \bar{\lambda} \cdot \bar{M}_o = \bar{\lambda}\,(\bar{r} \times \bar{F})$

Moment of F about coordinate axes.

$$M_x = yF_z - zF_y$$
$$M_y = zF_x - xF_z$$
$$M_z = xF_y - yF_x$$

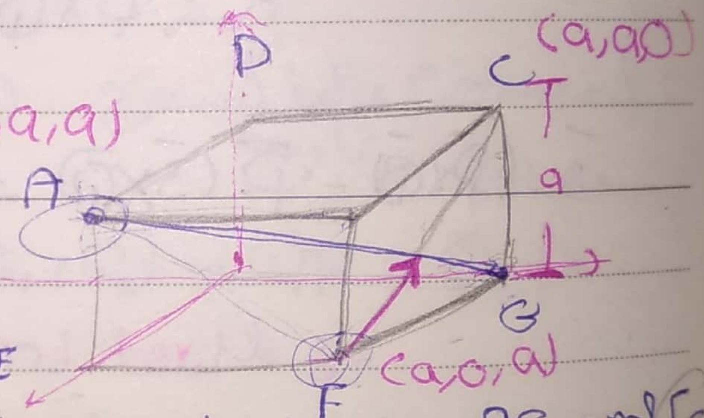
Example:-

a) about A (M)

b) about AB

c) about AG

d) perpendecular distance between AG and FC



$\bar{P}$

a: $M_A = \bar{r}_{AF} \times \bar{P}$

* $\bar{P} = P \times \bar{\lambda}$ → $\bar{\lambda} = \dfrac{FC}{|FC|} = \dfrac{0i + aj - ak}{\sqrt{a^2 + a^2}} = \dfrac{aj - ak}{\sqrt{2}\,a}$

unit vector لـ J
P باتجاه

→ $\bar{P} = \dfrac{P}{\sqrt{2}} j - \dfrac{P}{\sqrt{2}} k$

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$r_{af} = a\mathbf{i} - a\mathbf{j} - 0\mathbf{k}$

$$\Rightarrow \bar{r} \times \vec{P} \quad \begin{vmatrix} i & j & k \\ a & -a & 0 \\ 0 & \frac{P}{\sqrt{2}} & \frac{-P}{\sqrt{2}} \end{vmatrix} = \frac{aP}{\sqrt{2}}(i + j + k)$$

b) موازي الـ AB باتجاه unit vector لازم أوجد

X axis.

$$i \cdot M_A = M_{AB} = i \cdot \left(\frac{aP}{\sqrt{2}}(i + j + k)\right) = \frac{aP}{\sqrt{2}}$$

ملاحظة لو أخذنا الـ reference point B مثلاً" برضو هيطلع نفس M_{AB}.

c) بنطلع unit vector باتجاه AG

$$\bar{\beta} \cdot M_A = M_{AG}$$

$$\hookrightarrow \frac{d\, GA}{|GA|} = \frac{1}{\sqrt{3}}(i - j - k)$$

$$\frac{1}{\sqrt{3}}(i - j - k) \cdot \left(\frac{aP}{\sqrt{2}}(i + j + k)\right) = \frac{-aP}{\sqrt{6}}$$

d) $\vec{F} \times \vec{d} = \underset{F_c \text{ حول}}{M} = \frac{-aP}{\sqrt{6}} = Pd \rightarrow d = \frac{a}{\sqrt{6}}$

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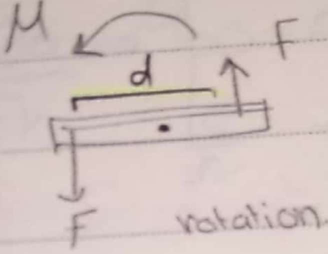
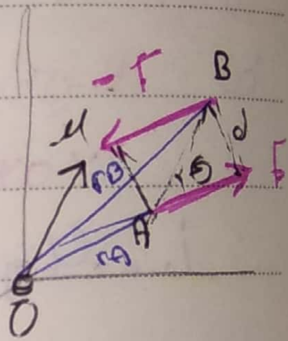
Moment of a couple

قوتين متساويات في المقدار ومتعاكسات في الاتجاه وبينهم مسافة





$$M = \bar{r}_A \times \bar{F} + r_B \times (-\bar{F})$$
$$= (r_A - r_B) \times \bar{F}$$
$$= r F \sin\theta = F\boxed{d}$$

العامودي

Ps: Moment vector لا يعتمد على ال origin

couple forces (لهم نفس M)

إذا كان

$F_1 d_1 = F_2 d_2$ ولازم يكونوا in the same plane

ويعطوني نفس ال rotation

إذا عنا مجموعة من ال couple forces مستويات مختلفة

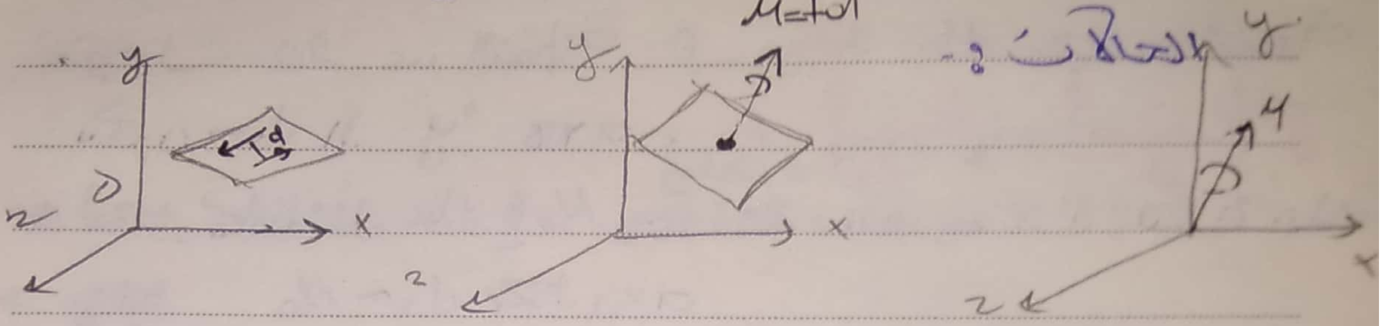
$M_1 = \bar{r} \times \bar{F}_1$ in plan P_1

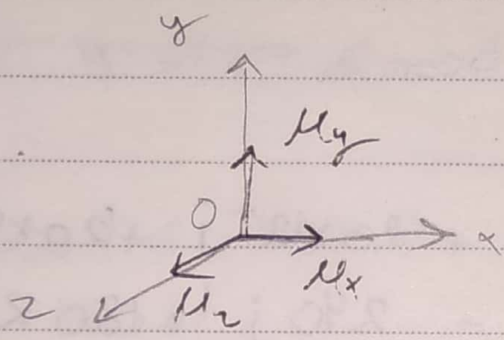
$M_2 = \bar{r} \times \bar{F}_2$ in plan P_2

بنفس الحالة محصلة واوجد ال M لكل ال R

$$M = \bar{r} \times \bar{R} = \vec{r} \cdot (F_1 + F_2)$$

الحالات :





L8:-

The Moment — لما بنقل قوة او بحركها لازم انقل ال effect تبعها معها

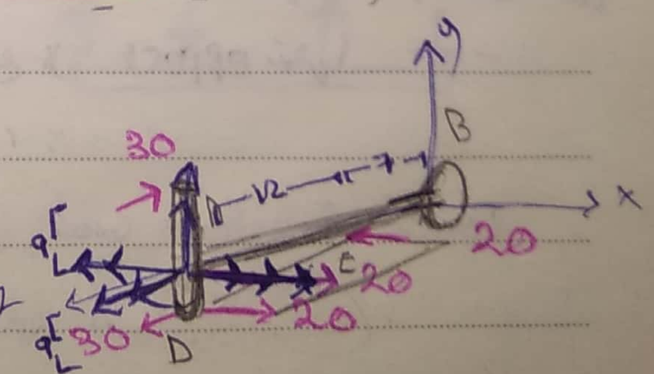
بحيث M_o بنفس اتجاه أثر القوة

← بنقل القوة على Point of intrests . بنقل كل القوة على الجسم لنقطة واحدة .

$\vec{M}_{o1} = \vec{r}' \times \vec{F}$ → free vector

← بقدر احركه لأي مكان على الجسم

SP:-



• أولاً عنا قوتين بال Zy فال M_o

عليهم حول ال x- axis

• القوتين 20 مش موجودات بنفس المستوى

فال M_o رح يكون عمودي على ال plan

* بحول 20 عند النقطة A ، مع ال M_0 تبعها عند النقطة بيكون حول ال $+y$ axis ،

* نسمي ثاني في عنا M_0 بين 20 الجديدة و ال 20 الأصلية بعملوا M_0 حول ال $\pm Z$ axis

* صار ال M عنا له 3 comPo ← M_x , M_y , M_z

* $M_x = (30 \times 18) i + (20 \times 12) j + (20 \times 9) k$
$= (-540 i + 240 j + 180 k)$ lb in

System of forces to a force and couple.

لو مش شرط القوى تلتقي بعض ، ما بيطلع عنا : Resultant force و Resultant Moment

" $M \rightarrow$ free vector . " بحركو وين ما بدي عادي "

" F vector . " لما انقله بنقل معها ال M تبعها "

R R

في حالة ال F و ال Moment عموديات على بعض بقدر أضيع وأحرك القوة عن النقطة وبنقل مع ال effect تبعها

إذا كانت ال Forces كلها على نفس ال Line of action او بنفس ال plane ، او كلهم متوازيات

المسافة اللي لازم احرك ← القوة فيها

$M = r \times F \rightarrow r = \frac{M}{F}$

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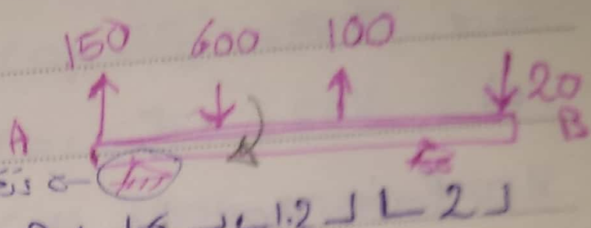
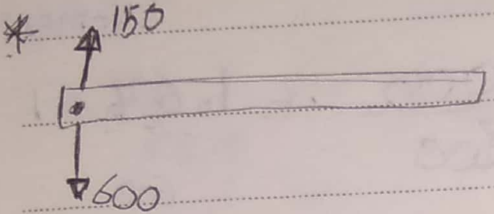


تكامل

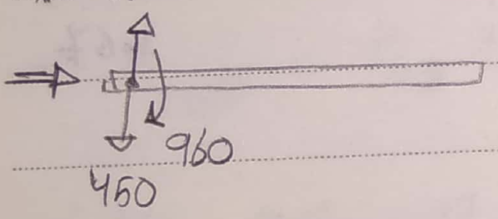
هدول عادي

a) force and M_o at A



$*\ M_1 = 600 \times 1.6 = -960$ Nm

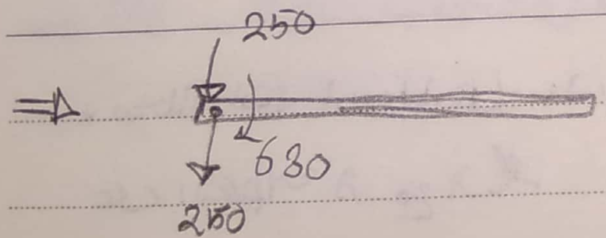
$*\ R_1 = -450$ N



$*\ M_2 = 100 \times 2.8 = 280$ NM

$M_{R_1} = -680$ NM

$F_R = -350$ N

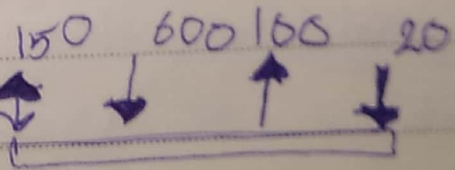


$M_3 = 250 \times 4.8 = -1200$

$M_P = -1880$ Nm

$F_R = -600$ N

b) F and M at B



$*\ R_F = 600$

$M_1 = -200$ Nm

$M_3 = -720$

$M_2 = 1920$

$\rightarrow R = 600$ N , $M = 1000$ ccw

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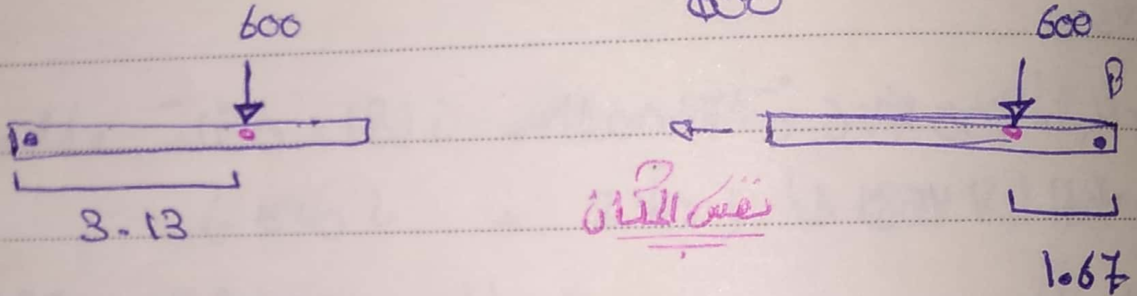
c)

force most be to the ~~right~~ left to produce effect (Moment)

$M = F \times d \rightarrow d = \frac{1000}{600} = 1.67$



L9:-

SP → الرسمة من السلايدات 3d

* بنحلل القوى لنحصل على ال vector form لها، بعدين بنقلها على النقطة A مع ال M

• $F_B = 700(\bar{\lambda})$

$\bar{\lambda} \rightarrow \frac{r_{B/E}}{|r_{B/E}|}$

$\frac{75i - 150j}{167.7}$

• B = (75, 100, 100)
• E = (150, -50, 100)
• C = (75, 100, 0)
• D (100, 0, 0)
• A (0, 100, 150)

$= 700(0.44i - 0.89j)$

$= (308i - 623j)\ N$

• $F_c X = 1000 \cos 45 = 707.1\ N$

$F_{cz} = 1000 \cos 45 = 707.1\ N$

$707.1i + 707.1j$

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- $f_{Dx} = 600$ → $r_{ab} = 75j + 50k$ mm
- $f_{Dy} = 1039.2$ → $r_{ac} = 75j - 50k$ mm

$600i + 1039.2$ → r_{ad} $100j - 100i - 50k$

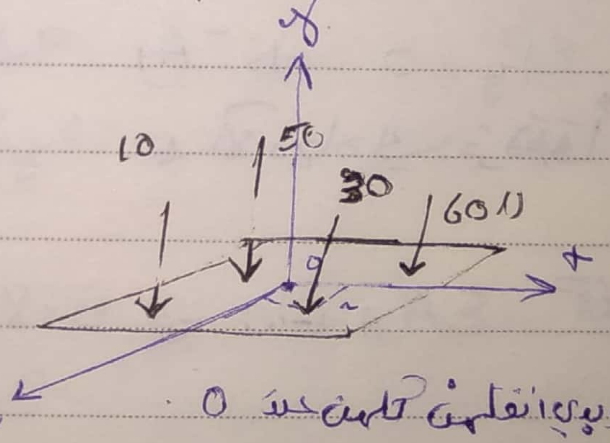
$$* M_{F_B/A} = r_{AB} \times F_B = \begin{array}{c} \begin{array}{ccc} i & j & k \end{array} \\ \left| \begin{array}{ccc} 75 & 50 & 0 \\ 388 & -603 & \end{array} \right| \end{array} = 30i - 45k \; N$$

$$* M_{F_C/A} = r_{AC} \times F_C = 17.68j \; Nm$$

$$* M_{F_D/A} = r_{AD} \times F_D = 153.9 k$$

$$\rightarrow M_A = 30i + 17.68j + 118.9k \; Nmm$$

$$\rightarrow R_A = 1615.1 i$$



القوة 30 بيتقل معها 2 M واحد حول
z، وواحد حول ال y

لو بدي انقلهن كلهن عند O
بحسب ال M فلازم نعرف المسافة لـ ح نحركها

Ch4 :- <u>equilibriam</u> of rigid body.

لما مافي حركة، ولا دوران $M_x = 0, M_y = 0, M_z = 0$

$\Rightarrow \Sigma f = 0$, $\Sigma M = 0$ $f_x = 0, f_y = 0, f_z = 0$

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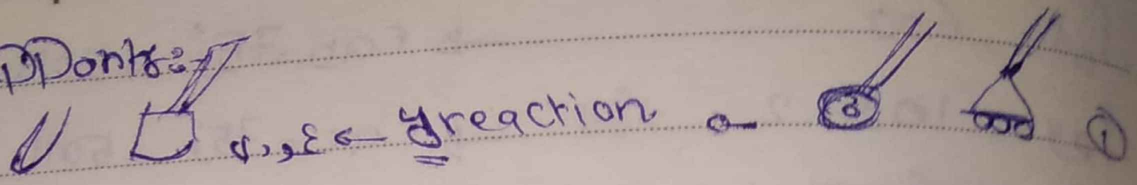
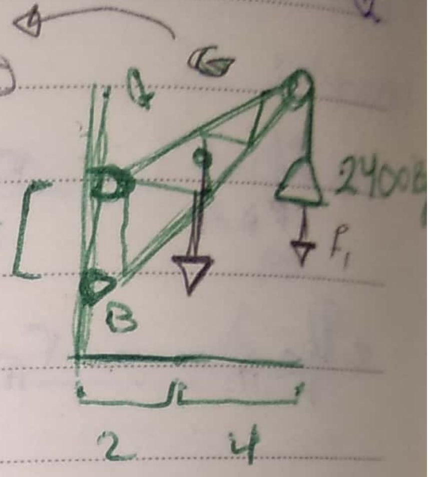
Supports:



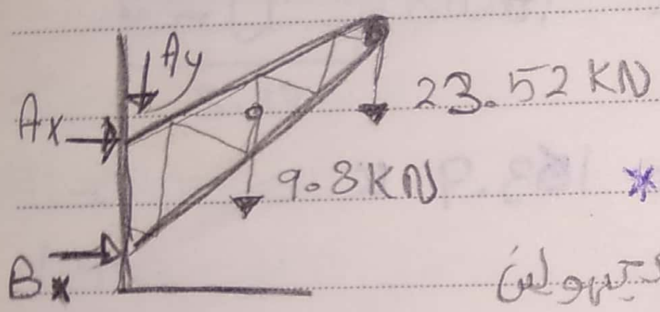
L10:

← 9.8x1000



$* P = 2400 \times 9.8$

$23520\ N \Rightarrow 23.5\ KN$



$* \sum F_x = 0 \quad , \sum F_y = 0$

له مجهولين   مجهول واحد

$\sum M = 0$

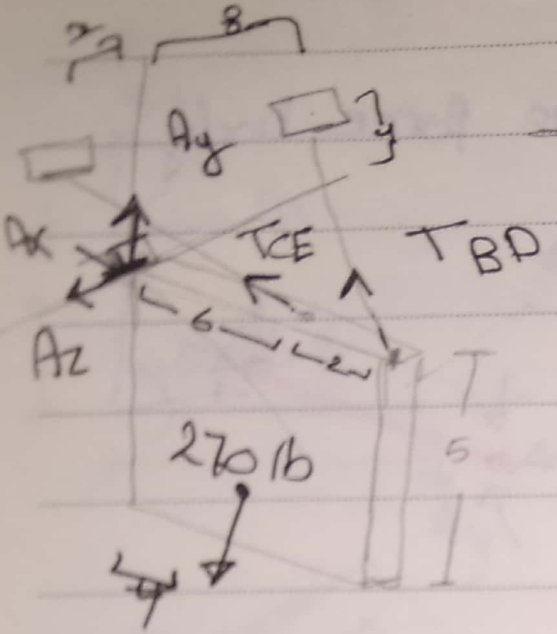
$\sum F_y = 0 \Rightarrow -A_y - 9.8 - 23.52 = 0$

× الاتجاه لي فرضناه خطأ ← $A_y = 33.32\ KN$

$\sum M_A = 0 \Rightarrow B_x \times 1.5 - 9.81 \times 2 - 23.52 \times 6$

$B_x = 107.1\ KN$

$\sum F_x = 0 \Rightarrow A_x + B_x = 0 \Rightarrow A_x = -107.1k$



$\Sigma F_x = 0 \quad \Sigma F_y = 0$

$\Sigma F_z = 0$

$\Sigma M_x = 0 \quad \Sigma M_y = 0$

$\Sigma M_z = 0$

*reaction $\vec{A} = A_x i + A_y j + A_z k$

* $\vec{W} = -270 j$

→ T_{CE} → $\lambda_{CE} = \dfrac{d_{CE}}{|CE|} =$

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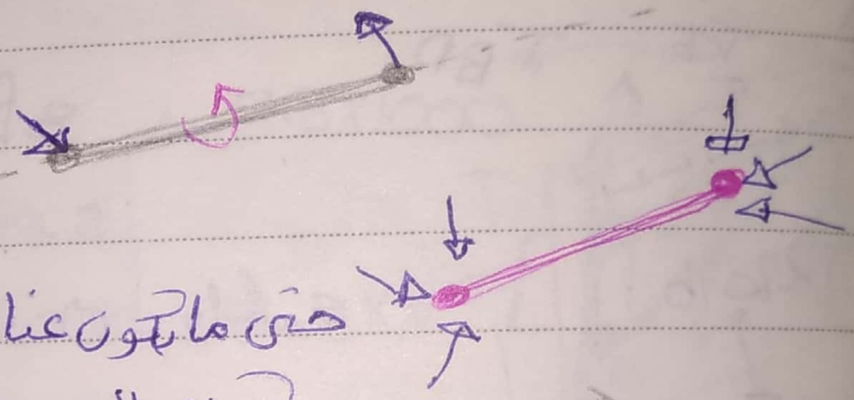
L11 :- Equilibriam of two force body.

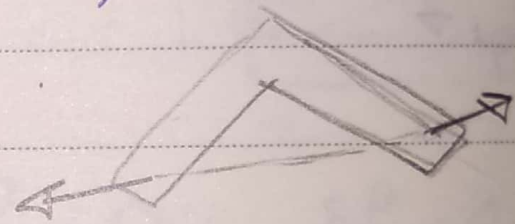
حركة الأطراف ←



حتى ما يكون عنا حركة و rotation

لازم ال R يكونوا على نفس

LOA لل member



1. RF متساوية مقداراً ومعاكسة

بالاتجاه

2. اتجاههما مع اتجاه ال member

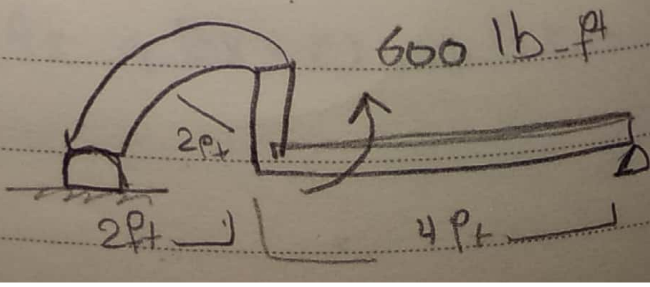
axis

Equilibriam of a 3 force body :-

1) concurrent forces (بيمروا بنفس النقطة)

2) parallel forces.

* Example :-



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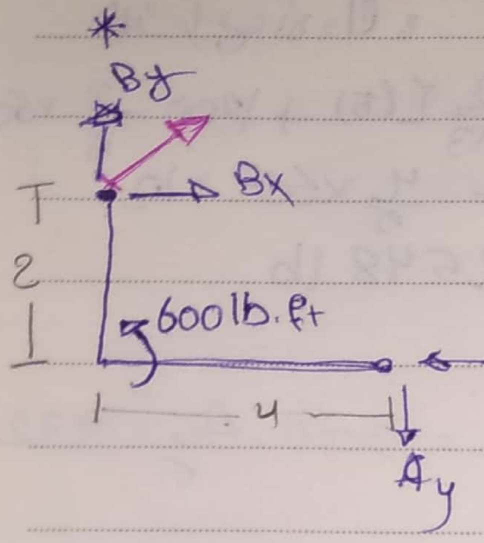

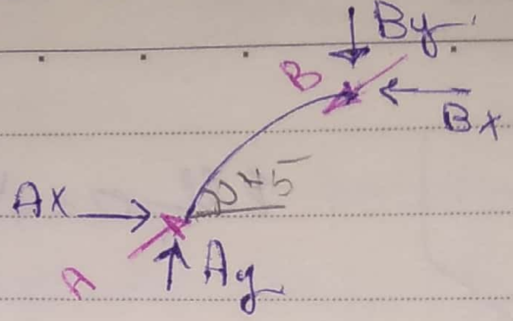

$By = 0.707 \rightarrow By$

$= B\cos 45$

$* \Sigma M_c = 0 = 0.707B(4) - 0.707B(2) + 600$

$B = 141.4 \text{ lb}$

$\rightarrow Bx = 99.97 \text{ lb}$, $By = 99.97$

$\Sigma f_x = 99.97 - Cx = 0 \rightarrow Cx = 99.97 \text{ lb}$

$\Sigma f_y = 99.97 - Cy = 0 \rightarrow Cy = 99.97 \text{ lb}$

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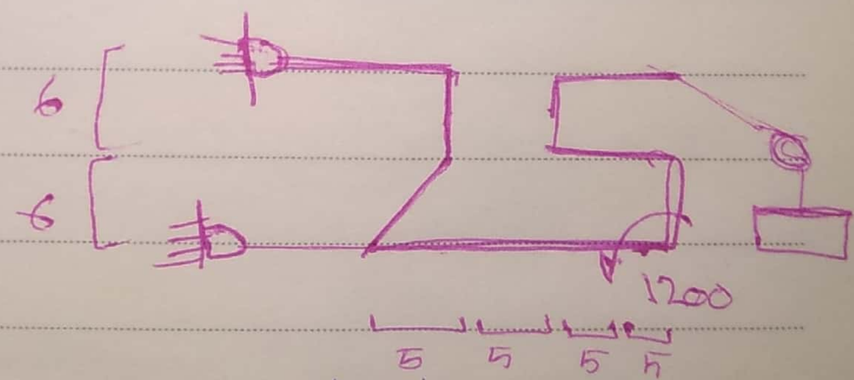
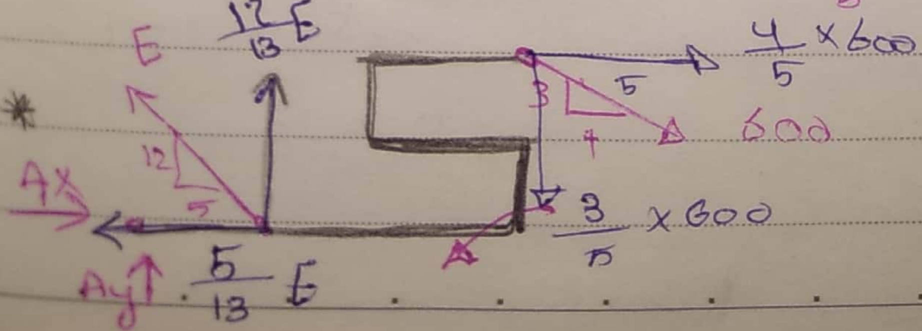
* Example



*



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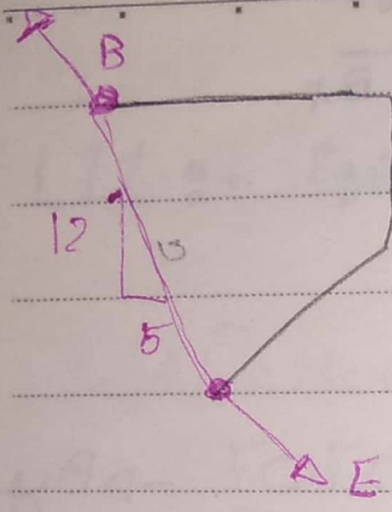
السؤال الثاني :



$$\Sigma M_A = 0 = +\frac{12}{13}E(5) + 1200 - \frac{3}{5}\times 600 - \frac{4}{5}\times 600 \times 12$$

$$E = 2548\ lb$$

$$\Sigma F_x = 0 \rightarrow A_x = 560\ lb,\ A_y = 1992\ lb$$

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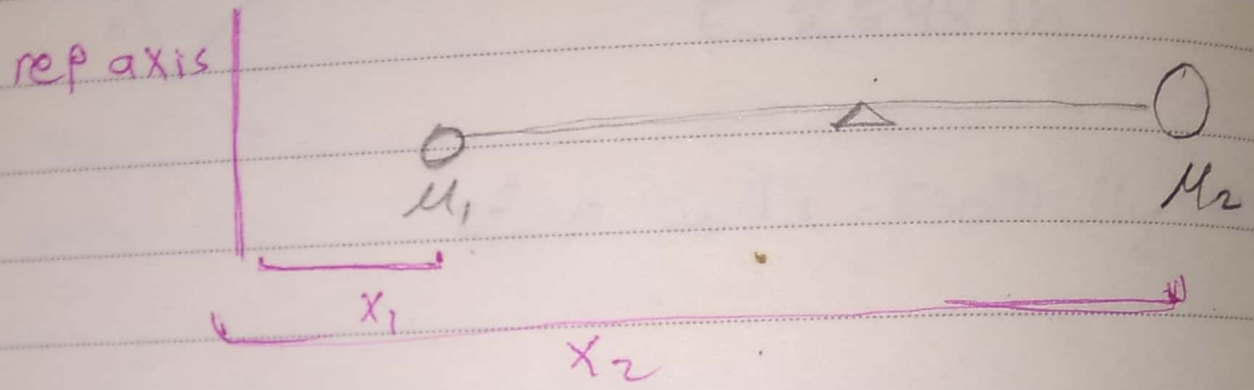
Ch5:-

Distributed Forces centroied and center of gravity.



$$x_1 m_1 + x_2 m_2 = (m_1 + m_2)\,\overline{x}$$

$$x_{cm} = \frac{m_1 x_1 + m_2 x_2}{m_1 + m_2}$$

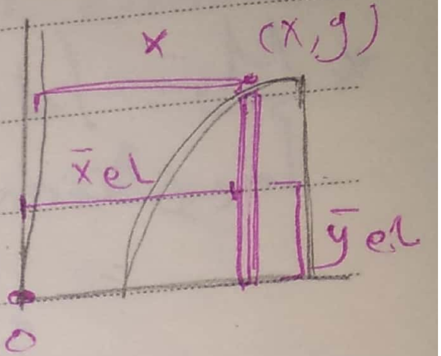
* center of gravity

$$\overline{x} = \frac{\int dm\, x}{\int dm}$$

* center of gravity of a 2D Body

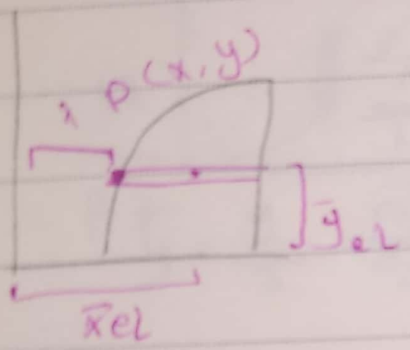
$$\Sigma M_y = \overline{x}\, w = \Sigma x \Delta w \rightarrow \int dw$$

$$\Sigma M_x = \overline{y}\, w = \Sigma y \Delta w \rightarrow \int dw.$$



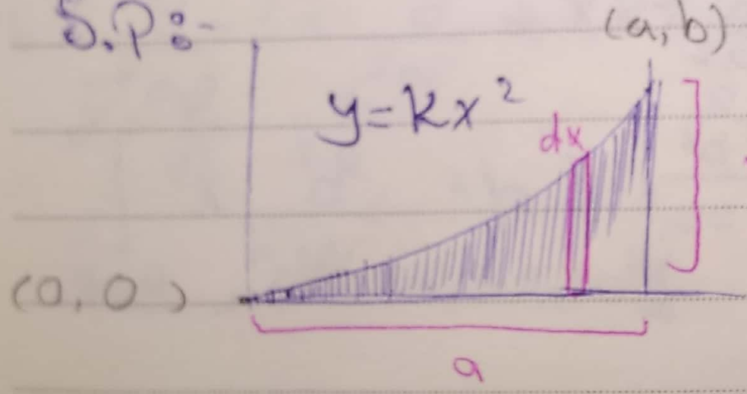
$\bar{X} A = \int \bar{x}_{el}\, dA = \int x (y\, dx)$

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



$\bar{X} A = \int \bar{x}_{el}\, dA = \int \frac{a+x}{2}$

S.P:- determine the centroi



*بنجيب k بدلالة a,b

$x = a,\ y = b$

$y = \frac{b}{a^2} X^2 \leftarrow b = k a^2 \rightarrow k = \frac{b}{a^2}$

→ vertecal strips $\rightarrow A = \left(\frac{b}{a} x^2\right)(dx)$

dM_y "Pirst M of A about y" $= A * X$

$\rightarrow A = \int_0^a \frac{b}{a^2} x^2 dX = \frac{b}{a^2} \frac{X^3}{3} \Big]_0^a = \frac{ba}{3}$

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$$* M_y = \int_0^a dM_y = \int_0^a \left(\frac{b}{a^2} x^2 \right) dx \cdot x$$

$$= \int_0^b \frac{b}{a^2} x^3 \, dx = \frac{b}{a^2} \frac{x^4}{4} \Big]_0^a$$

$$= \frac{b a^2}{4}$$

$$* \text{ Location :- } \quad \bar{x} = \frac{\frac{b a^2}{4}}{\frac{b a}{3}} = \frac{\Sigma M}{\Sigma A}$$

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

$\bar{y}$:-

$$dM_x = dA \times \frac{y}{2}$$

$$\frac{b}{a^2} x^2 dx * \frac{b}{2a^2} x^2 = \frac{b^2}{2a^4} x^4 dx$$

$$\rightarrow M_x = \int_0^a \frac{b^2}{2a^4} x^4 \, dx \rightarrow \frac{b^2}{10 a^4} x^5 \Big|_0^a$$

$$= \frac{b^2 a}{10}$$

$$\bar{y} = \frac{M_x}{A} = \frac{\frac{b^2 a}{10}}{\frac{b a}{3}} = \frac{3}{10} b$$

CamScanner المسوحة ضوئيا بـ

محمد الوزنة

Ch5 → center of mass

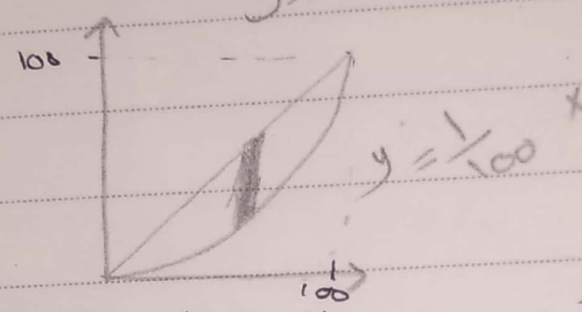
*cente of area

← وين النقطة يلي بطابق عليها الجسم.

$A = \int dA$

$\bar{x} = \int \tilde{x}\, dA$

$\bar{y} = \int \tilde{y}\, dA$



← شريحة طولية

$\tilde{y} = \frac{y_1}{2} + \frac{y_2}{2}$

"بنحول كل y لقيمتها بال x"

$\tilde{x} = x \quad , \quad dA = (y_1 - y_2)\, dx$

← شريحة بالعرض

$\tilde{x} = \frac{x_1}{2} + \frac{x_2}{2}$

$\tilde{y} = y \quad , \quad dA = (x_1 - x_2)\, dy$

$*A = \int dA \quad , \quad \bar{x} = \frac{\int \tilde{x}\, dA}{A} \quad , \quad \bar{y} = \frac{\int \tilde{y}\, dA}{A}$

$*dA = y\, dx \quad , \quad dA = x\, dy$

بالطول — بالعرض

$\tilde{x} = x , \tilde{y} = \frac{y}{2} \qquad \tilde{x} = \frac{x}{2} , \tilde{y} = y$

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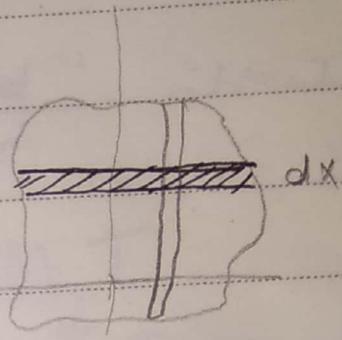
Wire : $\bar{x} = \frac{\int x \, dL}{L}$, $\bar{y} = \frac{\int y \, dL}{L}$

$I_x = \Sigma \bar{x} A$, $I_{y} = \Sigma \bar{y} A$ ✓ Q_x , Q_y

الممسوحة ضوئيا بـ CamScanner

Ch6:-

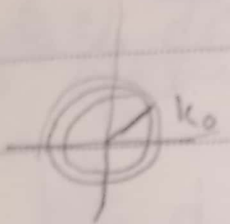
Radius of gyration of an area :-



$$I_x = A(k_x)^2$$

$\bar{k_x}$ ↳ radius of gyration

$$I_y = k_y^2 A \rightarrow k_y = \sqrt{\frac{I_y}{A}}$$



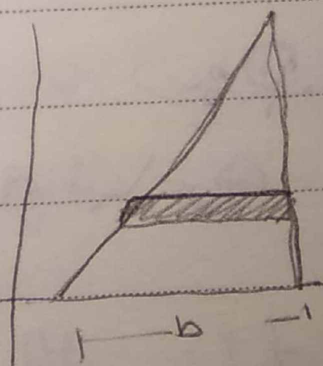
$$I_y = k_y^2 A \rightarrow k_y = \sqrt{\frac{I_y}{A}}$$

$$J_o = k_o^2 A \rightarrow k_o = \sqrt{\frac{J_o}{A}}$$

$$* \; k_o^2 = k_x^2 + k_y^2$$

S.P:-

determine the moment about the base.

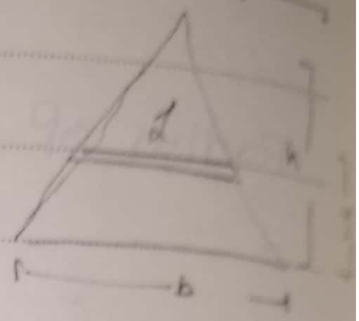


بناخد شريحة موازية لمحور الدوران

$$dI_x = dA \times y^2 \rightarrow \int$$

كده لازم اعرف حدود التكامل + المساحة للشريحة.

المسوحة ضوئيا بـ CamScanner



$$dI_x = dy \times L$$

تشابه مثلثات " $\dfrac{b}{h} = \dfrac{L}{h-y}$

لهما تشابهات

$$L = b - \frac{b}{h} y$$

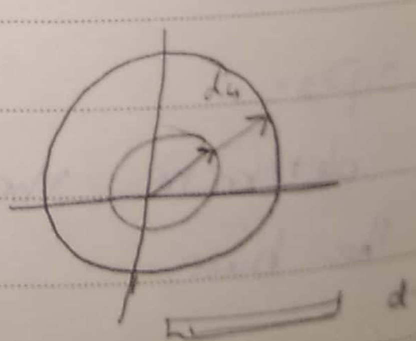
$$dI_x = y^2 dy \left(b - \frac{b}{h} y\right) \Rightarrow b y^2 - \frac{b}{h} y^3 dy$$

بالتكامل $I_x = \int_0^h b y^2 - \dfrac{b}{h} y^3 \, dy = \dfrac{b}{3} y^3 - \dfrac{b}{4h} y^4 \Big|_0^h$

$$= \frac{b h^3}{3} - \frac{b}{4} h^3 = \boxed{\frac{b h^3}{12}}$$

8.P3-

بناخد شريحة دائرية لها عرض du

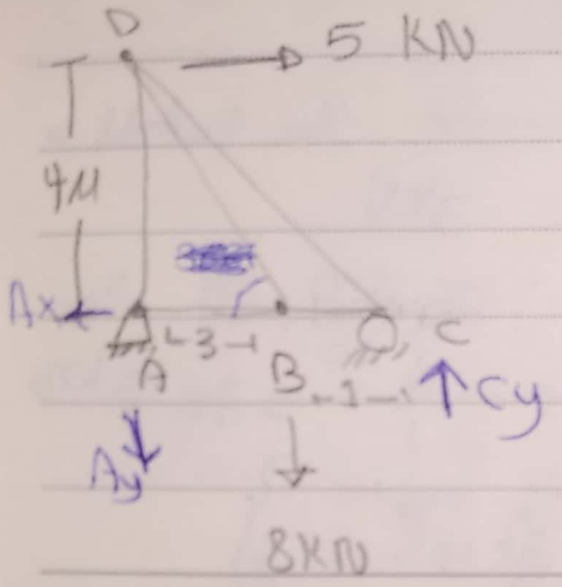


$$dI_o = dA \times u^2$$

$$2\pi u$$

Analysis of structrue

Trusses "Method of joints"



AB = 5KN T
BC = 11KN T
AD = 3KN T
CD = 15.58 KN C
BD = 10 KN T

1) find global equelibriam.
2) find the reaction of the supports.

$$\Sigma M_A = 0 = -5(4) - 8(3) + Cy(4)$$
$$20 + 24 = 4Cy$$

$$Cy = 11.$$

$$\Sigma F_y = 0 \quad = 11 - 8 - Ay$$
$$Ay = 3KN$$

$Ax = 5KN$

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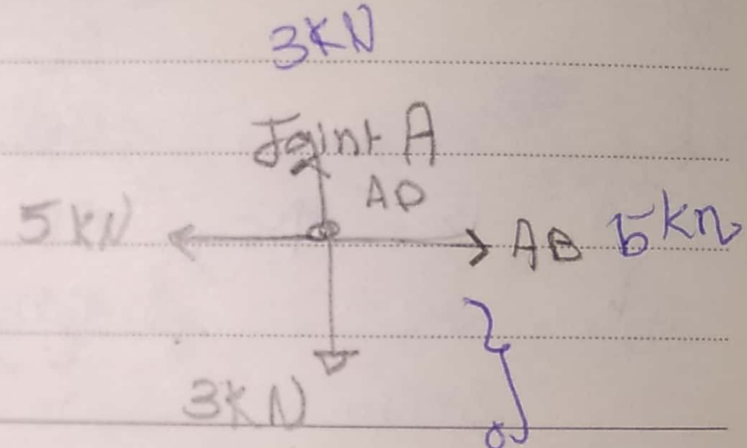
* select a joint
لو نختار مفصل عليه تكثر مو 2unknown

* Draw FBD of joint

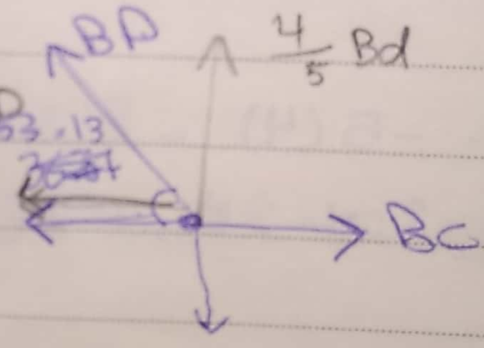
* solve
* Repeat



$\Sigma F_x = 0$
$\Sigma F_y = 0$

away is always tension.

Joint B

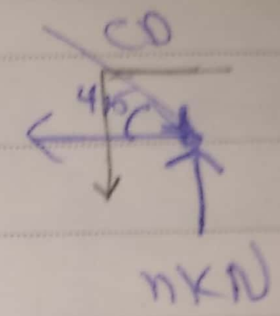


$\Sigma F_x = 0$
$\Sigma F_y = 0$

$BC - 5 - \frac{3}{5} BD = 0$ ① $BC = 11\,KN$ T

$\frac{4}{5} BD - 8 = 0 \longrightarrow$ ② $BD = 10\,KN$ T

• Joint C :-



$\sum F_y = 11 - CD \sin 45 = 0$

$CD = 15.56$ KN

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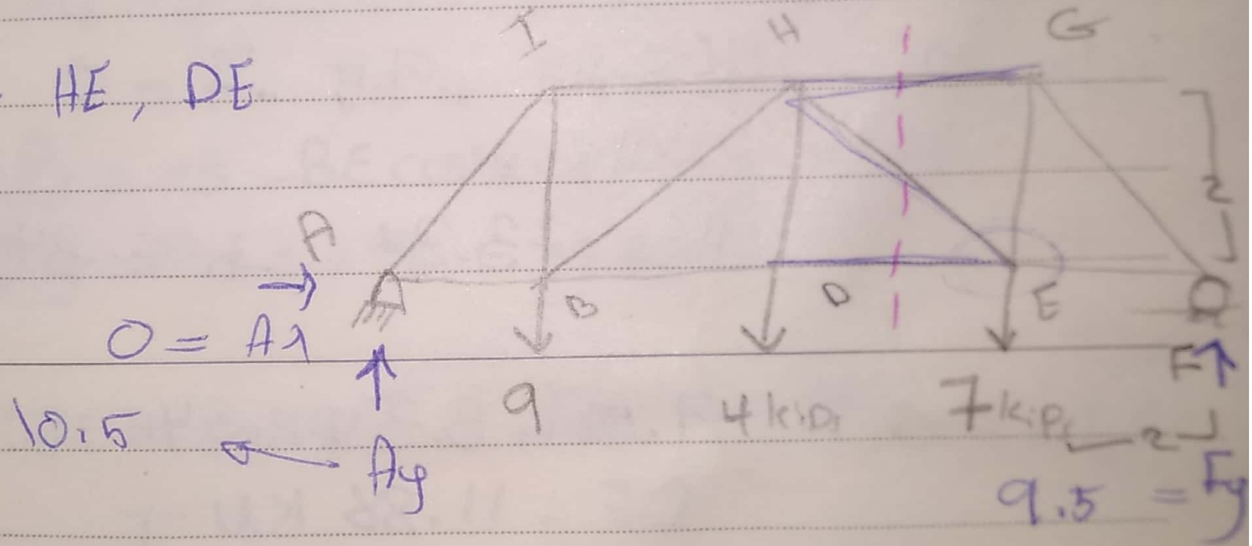
* Method of sections

GH, HE, DE



• $\sum M_A = 0 = 8F_y - 7(6) - 4(4) - 9(2)$

$F_y = 9.5$ kips.

• $\sum F_y = 0$, $A_y = 10.5$

٥ اقطع الجزء المطلوب ← فقط Members 3
ما تقطع أكثر من 3

$\sum F_x = 0$, $\sum F_y = 0$, $\sum M = 0$

٥ ارسم الجانب الأسهل

الممسوحة ضوئيا بـ CamScanner

NO. 9.5 = HG

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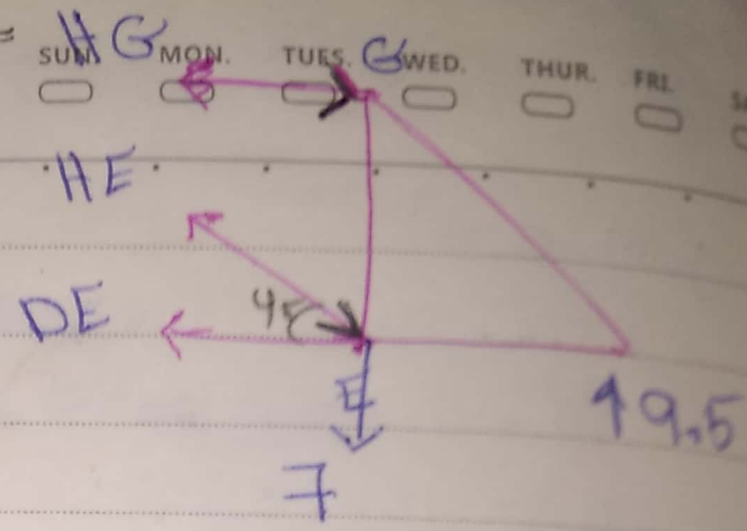


$\Sigma M_E = 0 = -HG(2) + 9.5(2) = 0$

$HG = -9.5 \Rightarrow 9.5\,C$

$\Sigma F_y = 0 = HE\sin 45 + 9.5 - 7 = 0$

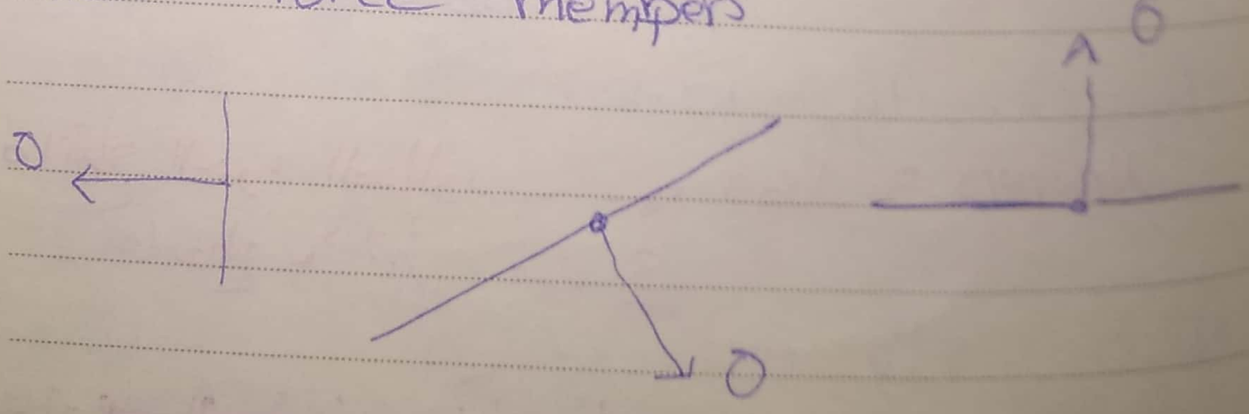
$HE =$

$HE = -3.34 \Rightarrow 3.34\,C$

$\Sigma F_x = 0 = 9.5 + 3.34\cos 45 - DE = 0$

$DE = 11.88\ kN\ T$

Zero force members



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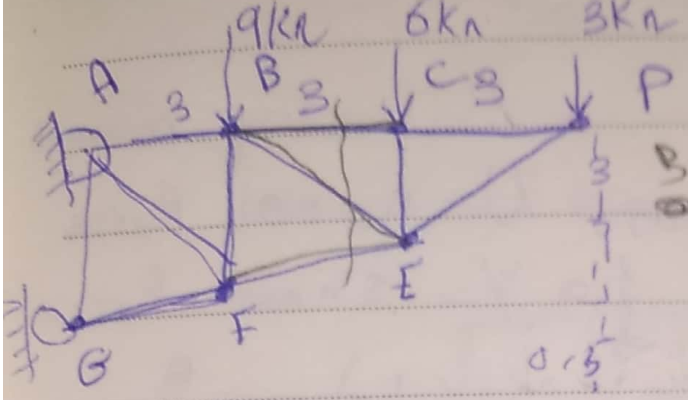
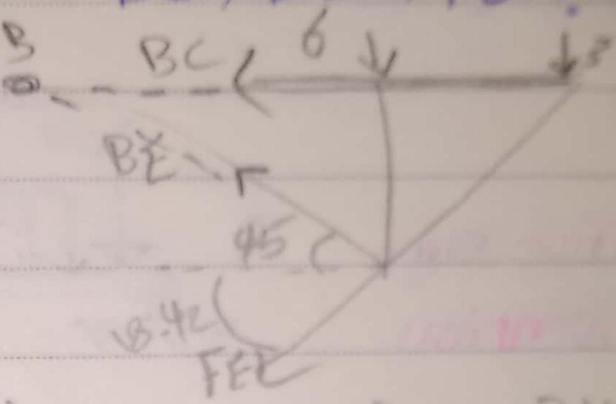


BC, BE, FE ?



$\Sigma M_E = 0 = BC(3) - 3(3) \rightarrow BC = 3\,KN\,T$

$\Sigma F_x = -3 - BE\cos 45 - FE\cos 18.42 = 0$

$\Sigma F_y = BE\sin 45 - FE\sin 18.42 - 6 - 3$

$BE = 8.49\,T \quad FE = -9.49 = 9.49\,C$

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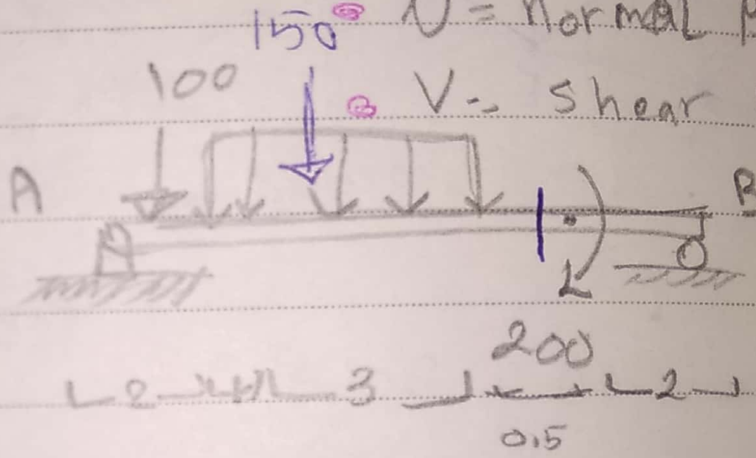
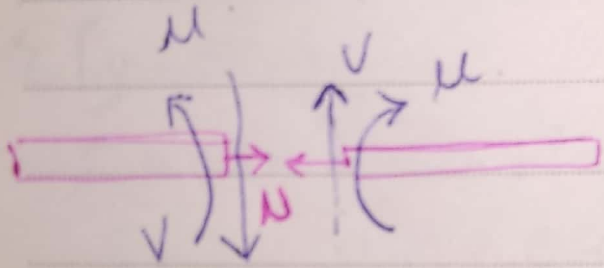
Internal forces

- M = bending moment
- N = normal force
- V = shear force



- Positive sign convention



$\Sigma M_A = 0 \rightarrow B_y =$