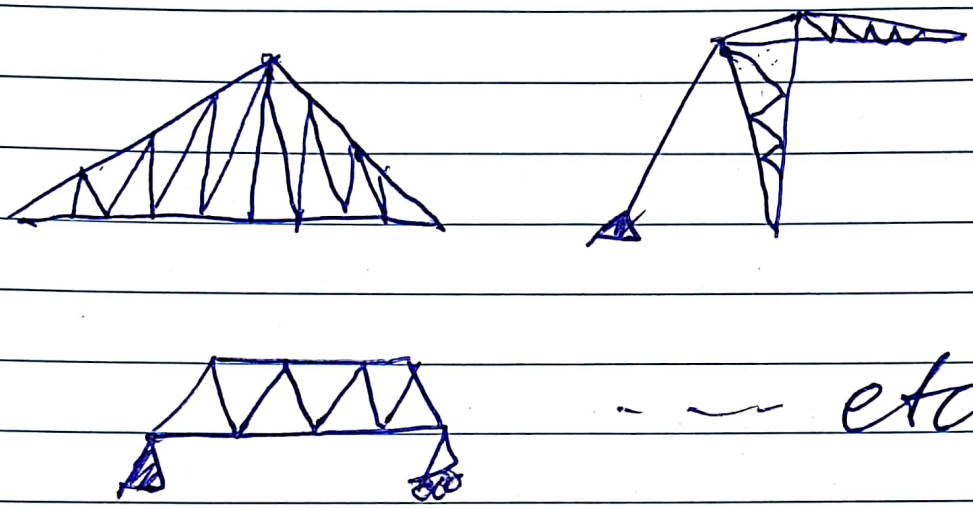
Statics ch. 6

common types of truss structures



etc

Forces in members of trusses

assumptions to simplify the analysis

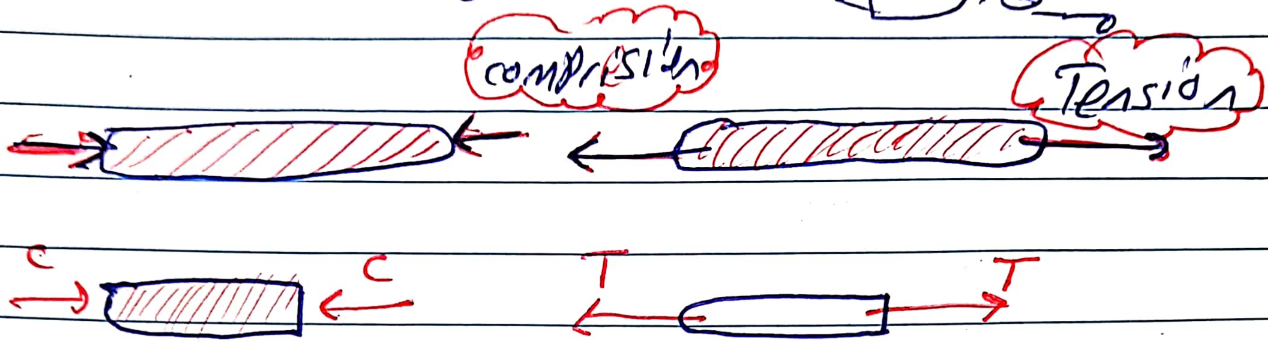
1 all members are in the same plane ذلك لعدم تحليل قوى في ٣ ابعاد

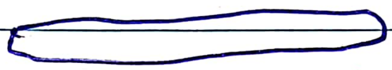
2 Loads and reactions are applied only at the joints of the truss تؤثر في المفاصل

3) all members are connected with friction-less pins لا يوجد عزم

4) all members are straight and 2 force members

ما يهمنا انه بمقدورنا معرفة (line of action) القوة
وانه هذه القوى لا تنتج عزماً وهي ايضاً
متساوية





يمكن معاملة كل joint على انه particle يتأثر
بقوى من الـmember ~~كقوة~~

لانه القوى 2 force member تعطي 2 معادلات ~~معادلة~~

الـ تزايد معادلتين على كل Joint حيث
انه القوى concurrent لذلك لا يوجد
عزم ~~فى~~ على الـJoints

$\Sigma F_x = 0$

$\Sigma F_y = 0$

or by triangle

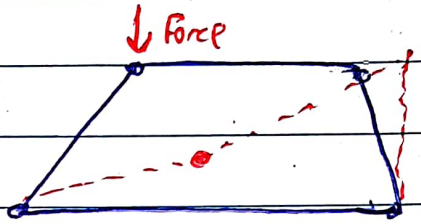
lami's law

Two methods :

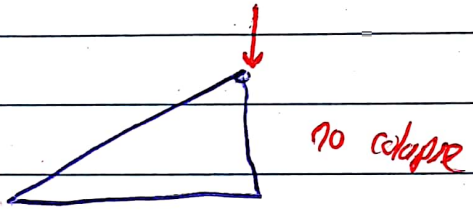
method of joints

method of sections

simple trusses

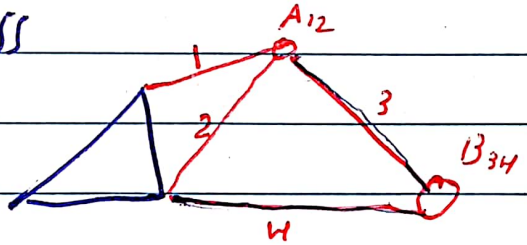


1- always made of triangle



2- rigid truss will not collaps under aplication of loads

3- simple truss is constructed by successively adding two members and one joint to the basic triangular truss

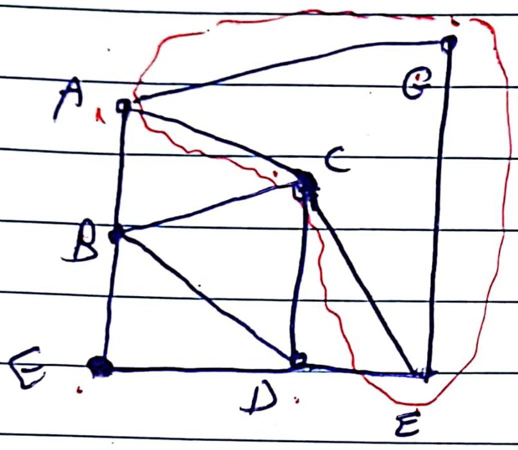


4- in simple trusses $m = 2n - 3$

: m = members

n = number of joints

simple truss is not nessesarly made of triagles



→ this is not a triangle but it's two mempers aded to the truss and connected with one joint

7 Joints 11 members

$$2n - 3 = 2*7 - 3$$
$$= 14 - 3$$
$$= 11 \checkmark$$

لاحظ احنا حتى يصير كسر لـ truss في الاشكال
نأخذ الـ Joints E / A لازم تتحرك
~~و~~ لكن هذه الجوينتس تشكل مثلثات
اذن مستحيل تتحرك لذلك
لا يتكسر

to have simple truss

remember

2 * Joints − 3 = members

→ r = reactions عدد

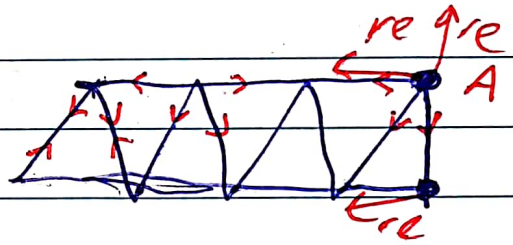
→ m = members

→ J = Joints

! عدد المجاهيل = عدد الـ (members) + عدد الـ reactions

لماذا ؟

لأنه عند القوى المؤثرة على كل (Joint) هو
عدد الـ (members) المتصلة به
وأيضاً عدد الـ reactions التي



Joint A has
2 reactions and
3 members
and also it has (3+2) forces
what a coinsidence!

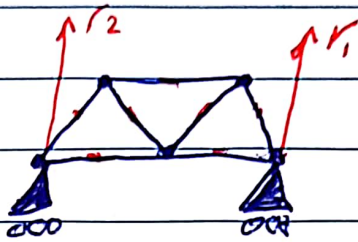
بكل Joint عدد المعادلات
تمثل معادلة
لأنه عدد الـ reactions + members
لازم يكونوا 2* J

to be determinate

$$r + m = 2J$$

حسب النقطة أعلاه

$M + r < 2J$ has partial fixity

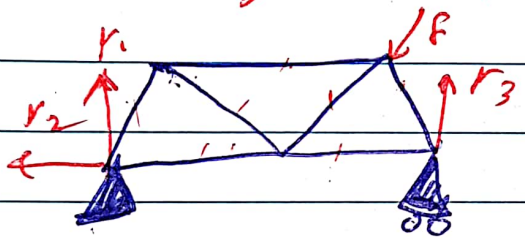


$= M + r < 2*5$

$= 7 + 2 < 10$

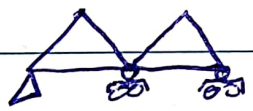
$M + r = 2J$

if fixed → statically determinate



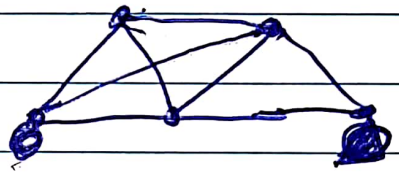
$3 + 7 = 2*5$ ✓

+ fixed ✓



→ the same

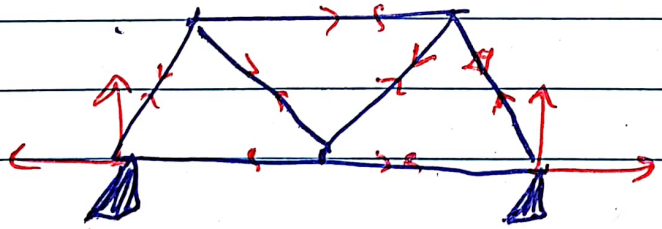
has partial fixity → in determinate



$2*8 + 2 = 10$ ✓

but not fixed

$M + r > 2J$



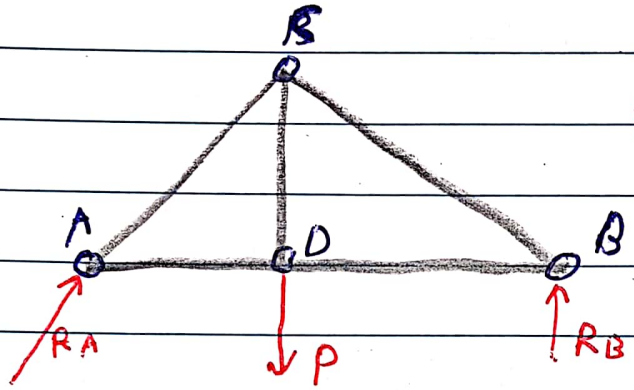
$4 + 7 > 2*5$

fixed or not / not determinate

method of joints

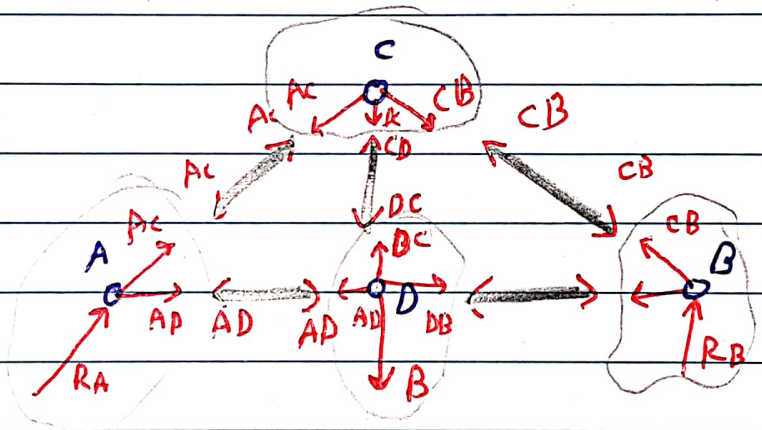
objective : to know reactions and internal force in each member

Note : treat each joint as a particle



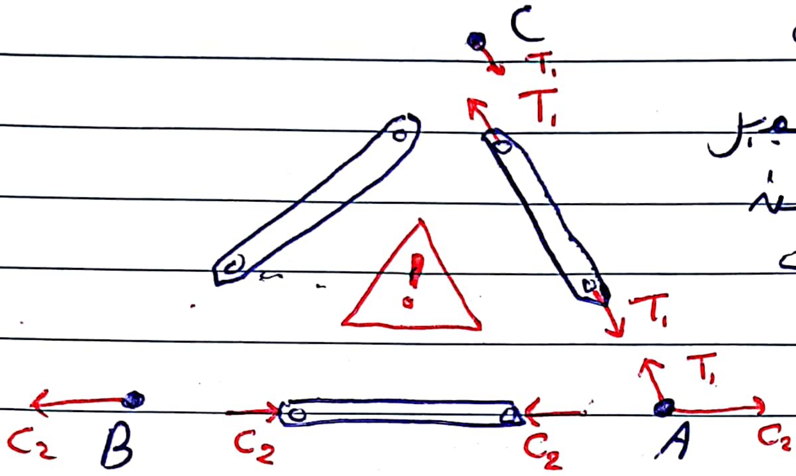
1 Dismembering

=



no need to work on equilibrium of members — because they are 2force members

3rd law of newton



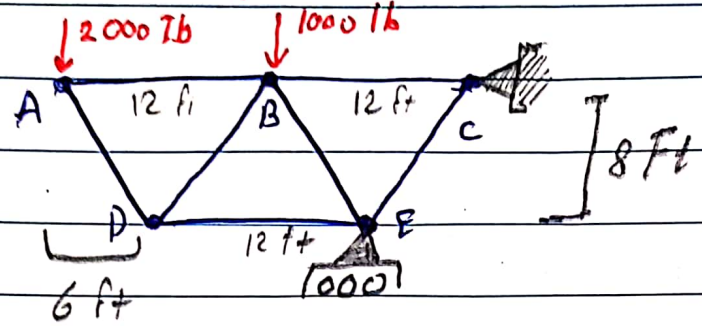
اذا فرضت
تنشنه على الحبل
رح يكون تنشنه
على الجوينت
نحو
اتجاه
الاتجاه
جيداً يكون
عكسه

⚠ افرض كل الـ members
in tension

if result = −T
then it's C

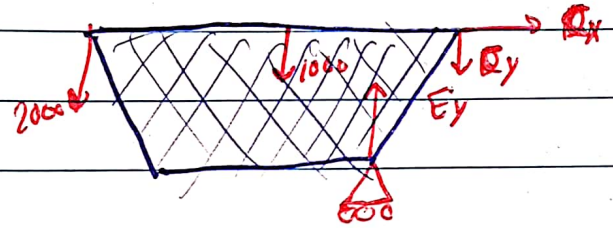
if result is = +T
then it's T

Sample problem 1



Using the method of joints: Find the force in each member of the truss

Solution ; notice it is easy to find reactions but you need to treat the truss as a rigid body



$\Sigma M_C = 0 \rightarrow \quad 2000 * (12+12) + 1000 * 12 - 6E_y$

$0 = 48000 + 12000 - 6E_y$

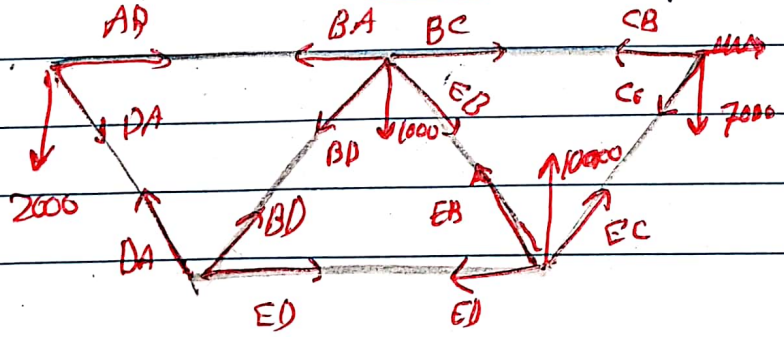
$60000 = 6E_y$

$E_y = +10000 \uparrow$

$\Sigma F_y = 0 \quad 10000 - 3000 - C_y = 0$

$C_y = -7000 \downarrow$

$C_x = 0$

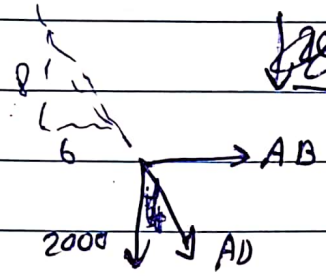


supose all in tension

always choose the easiest joint

C / ~~B~~ / A are possible
because each has 2 unknowns
and 2 equations

take joint A



Be careful and don't take all triangles as equilateral triangles

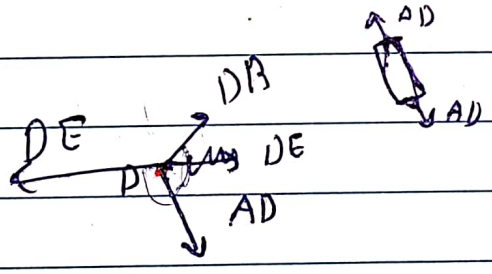
$AD \cos 30 = -2000$

$AD \Rightarrow 2309$ comp

$AB = AD \sin 30$

$AB = 1500.0$ Tension

now Point B has 3 unknowns
D " 2 unknowns

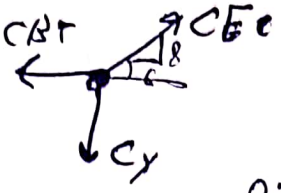


$\frac{DE}{0.96} = \frac{DB}{0.8} = \frac{AD}{0.8}$

$DB = 2500$ T

$DE = 3000$ (C)

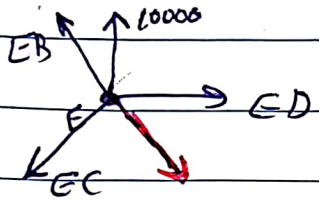
Point C



$C_y = CE * \sin 60 = 8750$ comp $= CE$

$CE \cos 60 = CB = 5250$ T

Point E



$EB \sin 60 * 0.8 + 10000 = EC \sin 60 * 0.8$

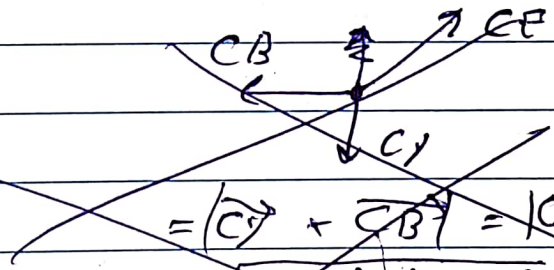
$EB \sin 60 = -3000$

$EB = -3750 \Rightarrow EB = 3750$ comp

Point (B) notic you did not need reactions at c

it's better to try for points so the error is not affecting every thing

Point (C) :



$= (Cy + CB) = |CE|$

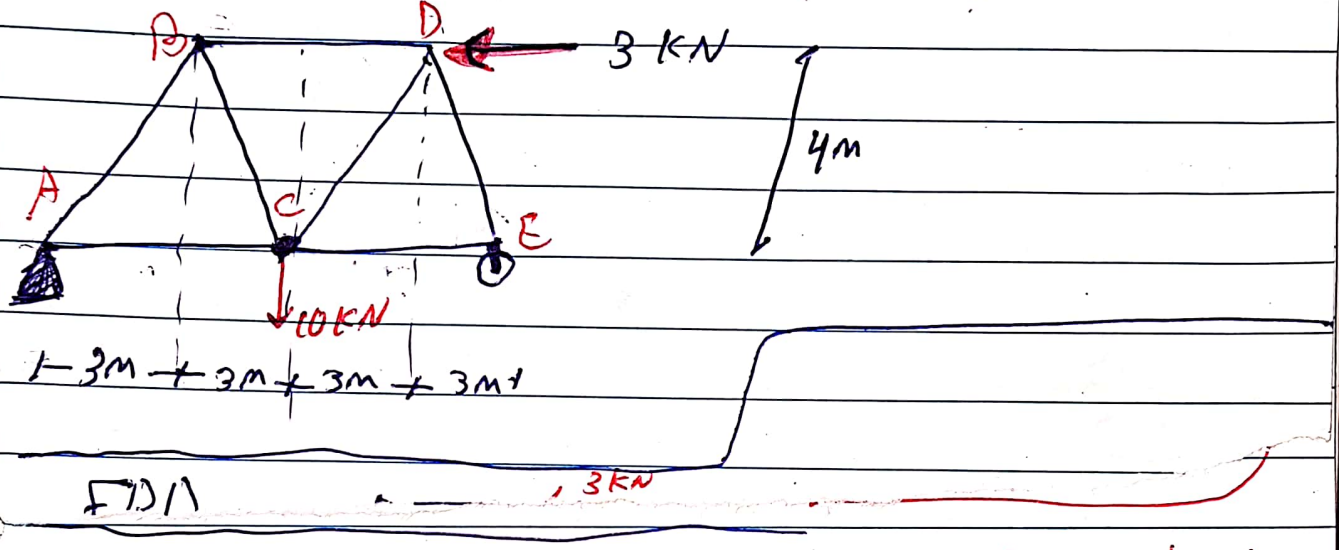
$\sqrt{(CE)^2 - (Cy)^2} = CB$

$CB = 2309$ T

now every thing is known but for more insure try point B

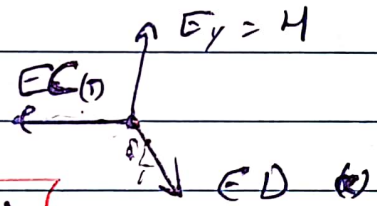
Sample 6.1

use the method of joints to deter mine the force supported by each member of the truss shown in the figure



$\sum F_y = 0$, 3KN

Joint E

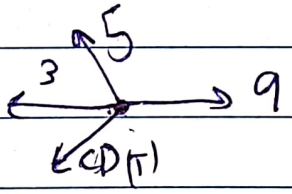


سوا نشد
سرا تصبر شد

$ED = 5$ (C)

$EC = 3$ (T)

Joint (D)

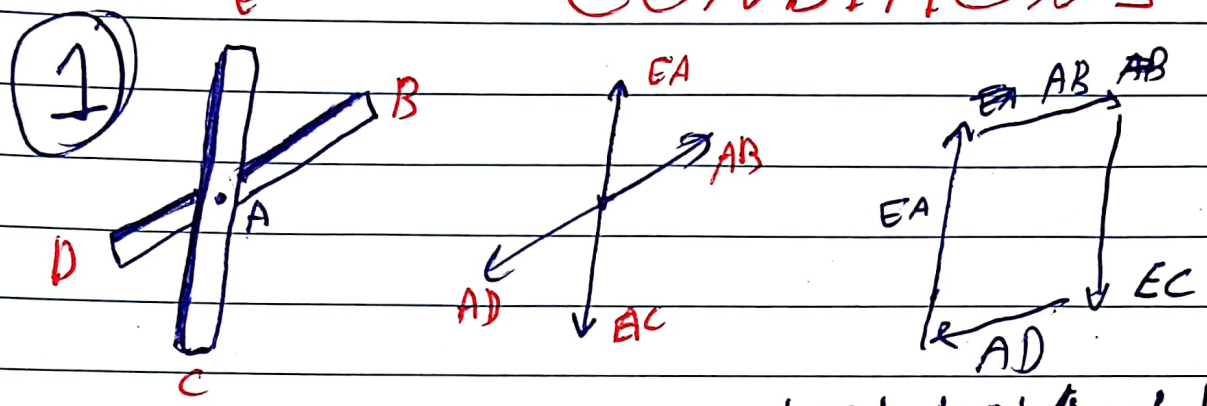


$CD = 5$ T

to make sure Joint C

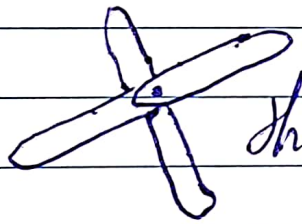
Joints UNDER SPECIAL LOADING CONDITIONS

1



$|AB| = |AD| \;/\; |EA| = |EC|$

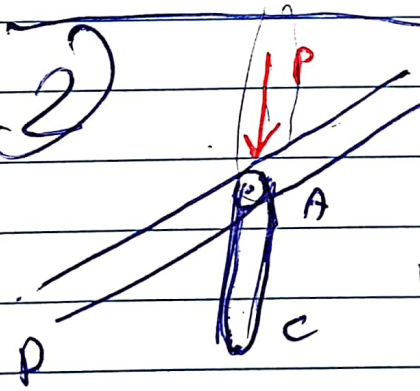
Forces in opposite members inter secting in two straight lines at a joint are equal



the same

No need to work on it it's known

2

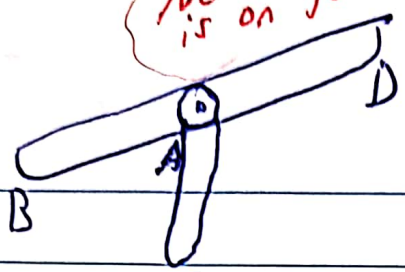


if $(\vec{P})$ is colinear with AC then it's the same as above

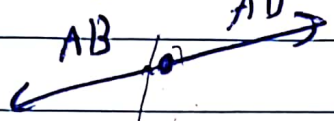
$|P| = |AC| \;/\; |AB| = |AD|$

Force in member $AC = |P|$ compression

3

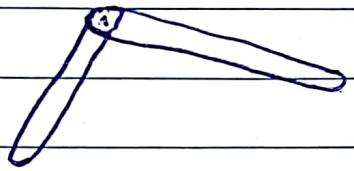


unless the opposite colinear forces AB AD



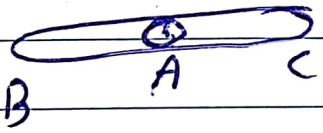
the member AC is zero force member ((I can remove the member))

4



the 2 members are zero force members if they were not colinear and only 2

5



$\overrightarrow{AB} = -\overrightarrow{AC}$

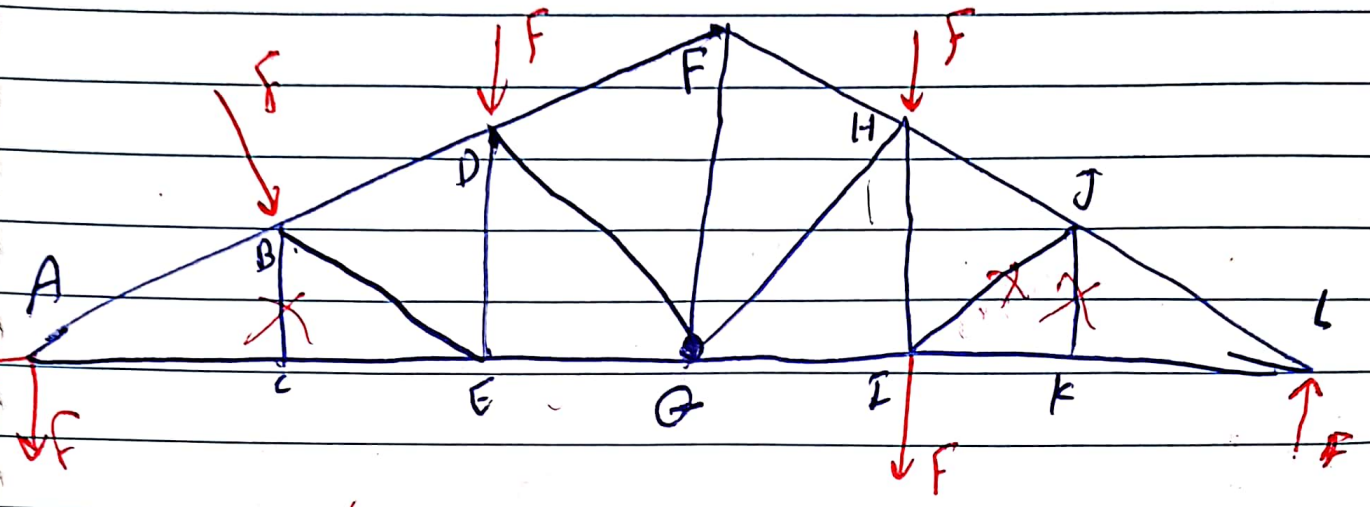
~~Two for~~ Zero Force members

اذا كان 2 members بينهم زاوية (Joint) ولا يوجد على الجوينت اي قوة اخرى

اذا كان عندنا 2members على نفس الخط

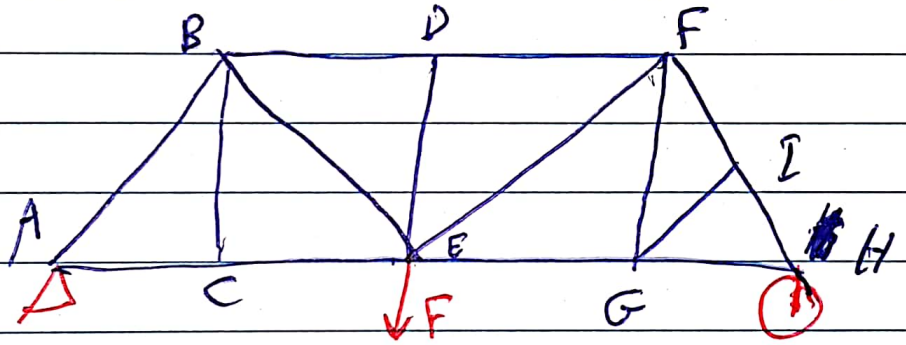
والـ member الثالث يصنع زاوية

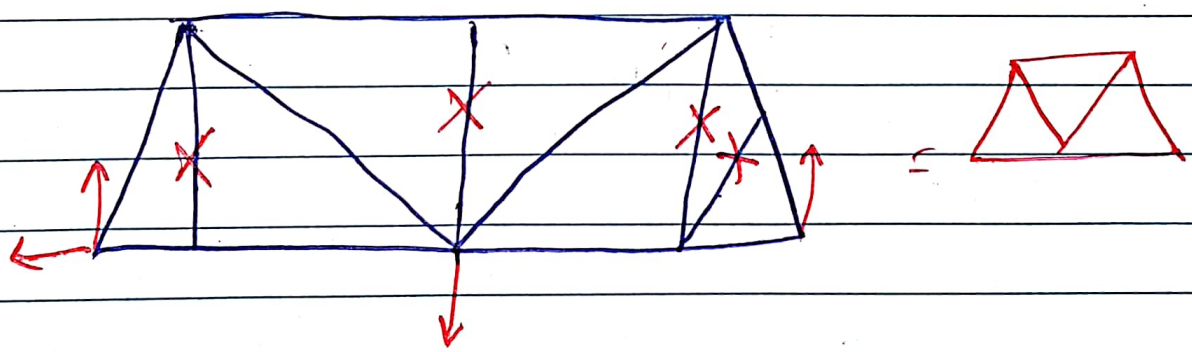
Find the zero force members



BC / JK / JI

Find zero force members



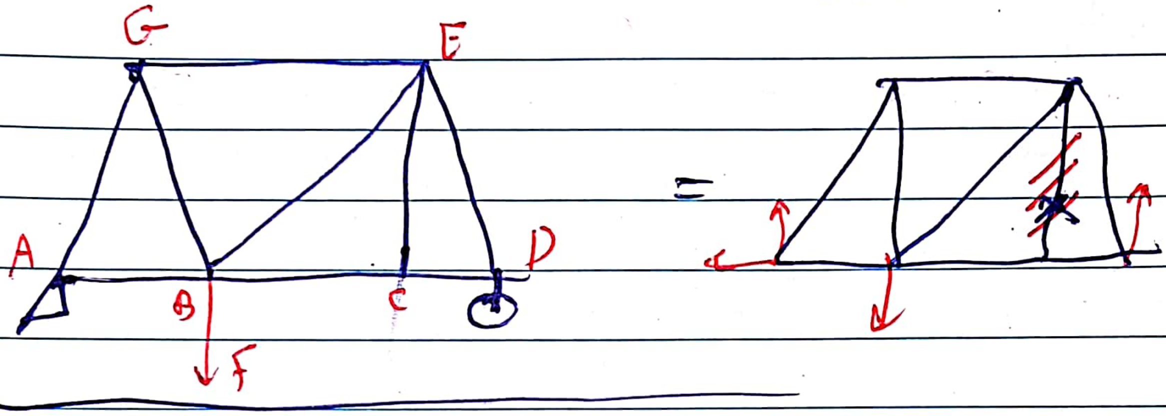


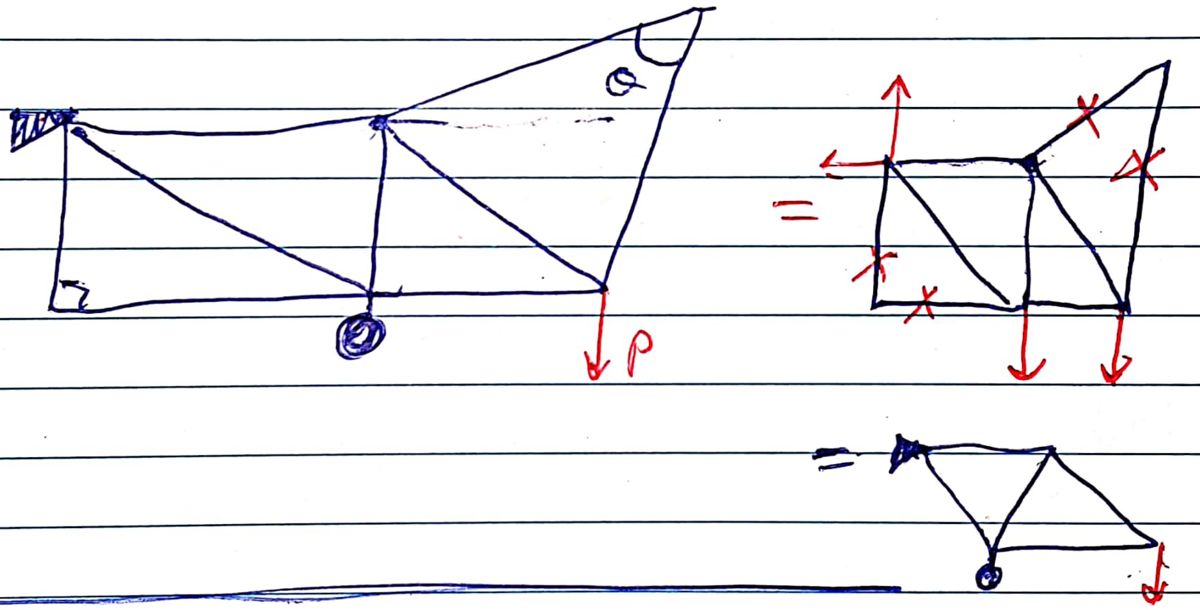
DE / BC / FG / IG

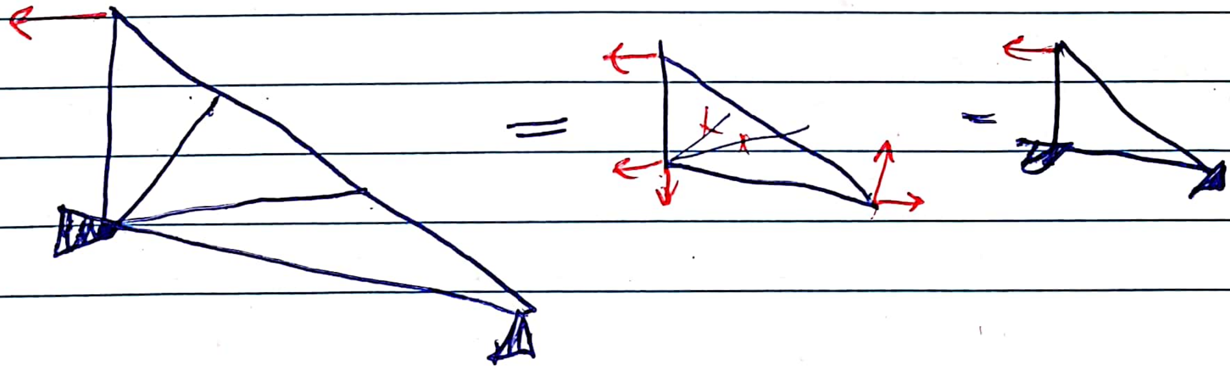
في الامتحان مهم تعرف

الـ zero force members لانك بتوفر وقت

امثلة

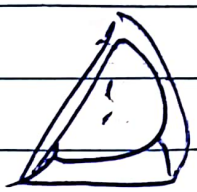




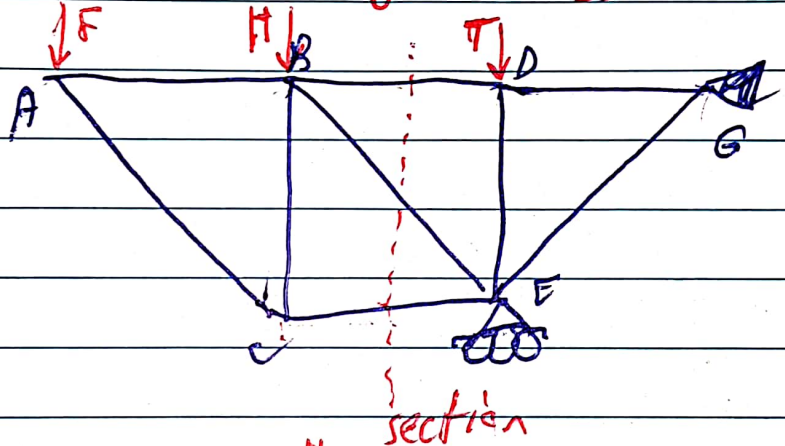


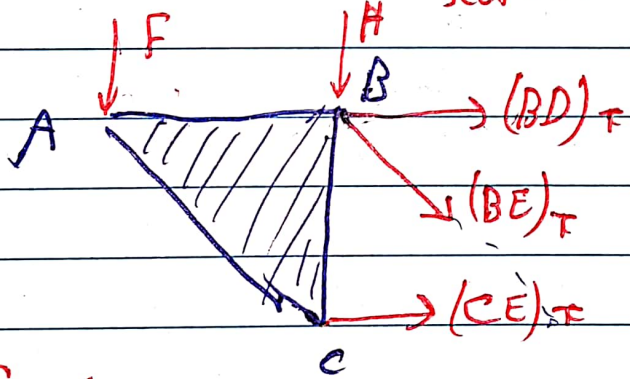
Method of Sections

عندما طلب القوى على one member
او القوى على عدد قليل لا يطلب
حساب كل القوى الداخلية
او داخل استخدام هذه الطريقة



الشكل مش مشكلة شوفه
المهم ما يقاطع مجموع كتير
او يقاطع كل او اغلب العلاقة





غالباً نستخدم moment
لانه يلغى قوى
مثلاً اذا طلب ~~BD~~ BD
(يكون عند التقاء BE/CE لتلغيهما)

for:
~~Real~~ BD → moment on E = 0

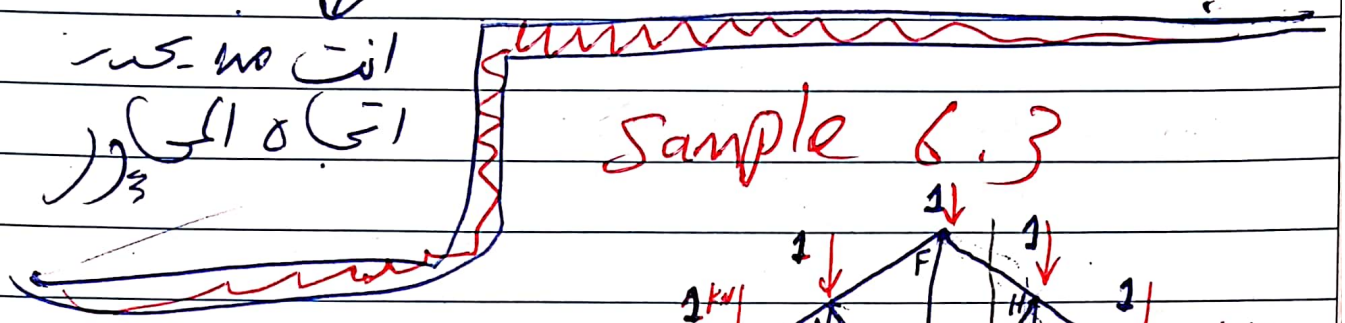
For CE → " " B = 0

For BE → BE y = (- F - H)

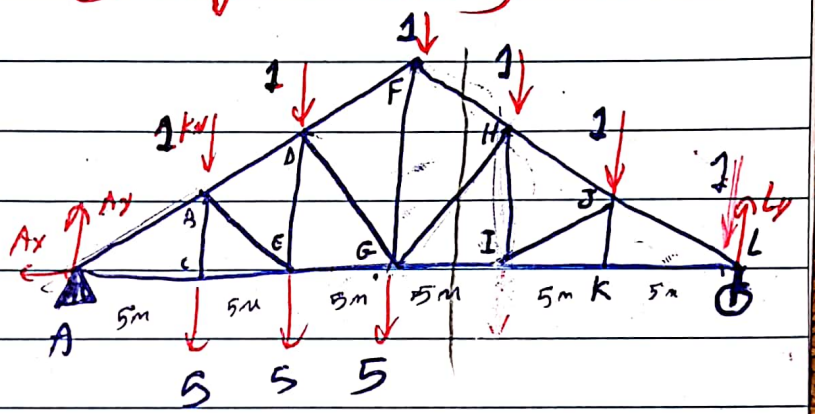
تذكر دوماً أول طريقة
لحل أي مسألة
هناك ثلاث معادلات

ΣF_x / ΣF_y / $\Sigma M_{\text{حول أي نقطة}}$

انت حر
اختار الي بدك ياه



Sample 6.3



Find forces in
FH / GH / GI

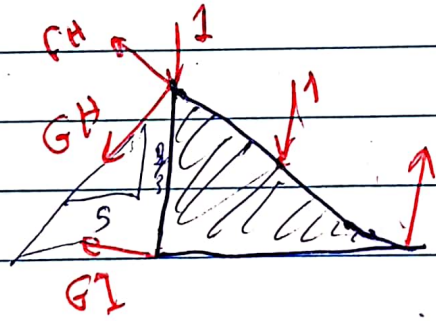
$\overline{FG}$ high = 8 m

first we'll need (Ly) ⇒

$Ly * 30 = 1(30 + 25 + 20 + 15 + 10 + 5) + 5(5 + 10 + 15)$

$Ly = 7.5 kN$

new FBD for section



GI = ?

$M_H = 0$

$8.5 * 10 = GI * \frac{8}{3} + 1 * 5$

$GI = 15\ (T)$ / $\Sigma ML = 0$

$$GH * 15 * \frac{16/3}{\sqrt{(16/3)^2 + 5^2}} + 1*10 + 1*5 = 0$$

$$15 = 15\ GH * 0.47$$

$GH = 1.37\ (C)$

$\Sigma M_G = 0$

$$5 + 10 - 8.5*15 - FH * 15 * \frac{8}{\sqrt{8^2+15^2}}$$

$FH = 16\ (C)$

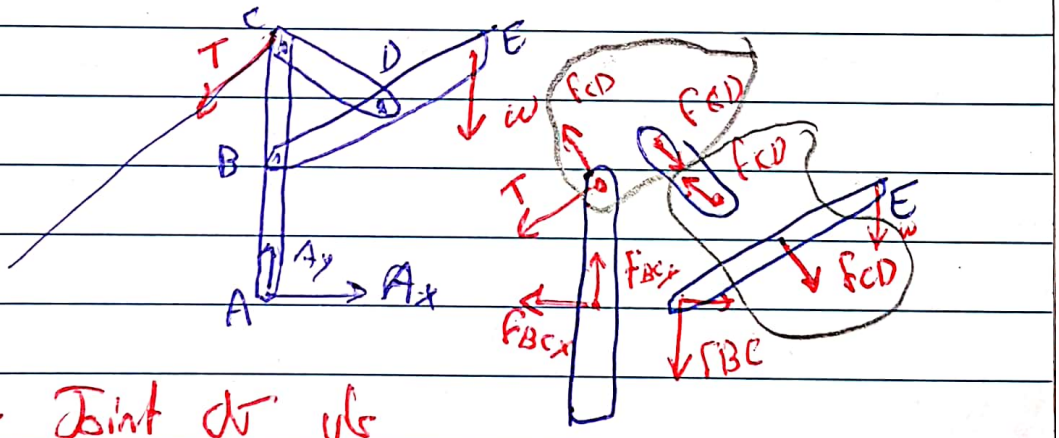
Analysis of Frames

Frames are different, ~~not~~ not the same as trusses ((Forces don't act on joints only))

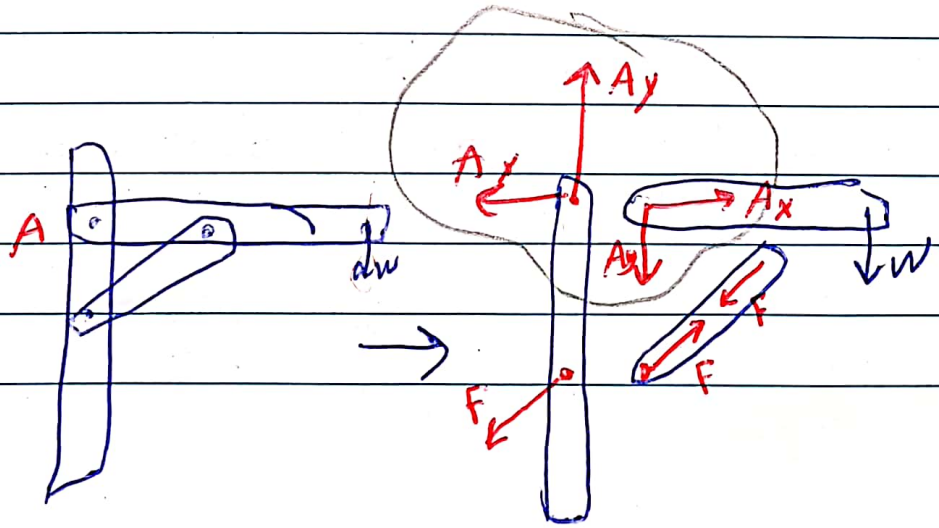
→ that means we work on members

→ some members have 2 forces
others have multi force effect

مهم جداً عند تحليل القوى
القوى الداخلية التي تؤثر على 2members
تكون متعاكسة حسب قانون نيوتن III



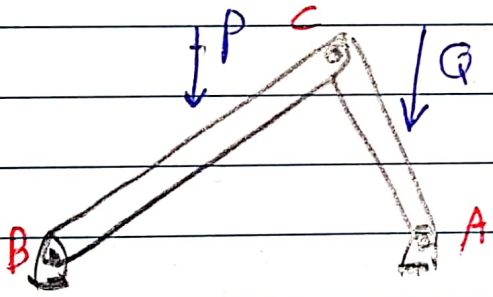
كل Joint تؤثر قوتين متعاكستين



وهنا A_x / A_y ولم نضع قوة
واحدة لاننا لم نعلم اتجاهها
ونحن نعلم وجود مركبتين
وذلك لانه ليست (2 force member)

2Force member معرفة
zero force ومعرفة
ومعرفة الاماكن التي فيها مركبتين
معرفة اختياري الـ member التي ليس فيه

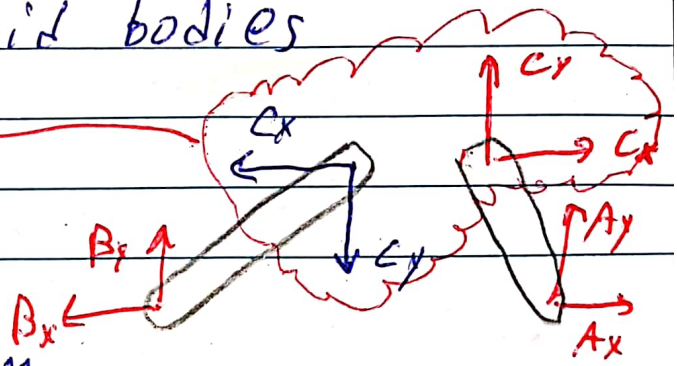
If some Frames may collapse if removed From their supports cannot be treated as rigid body



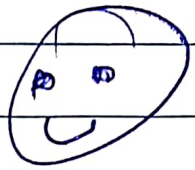
(1) notice we have 4 unknowns (reactions)

(2) so we dismember the frame and work on it as 2 rigid bodies but related rigid bodies

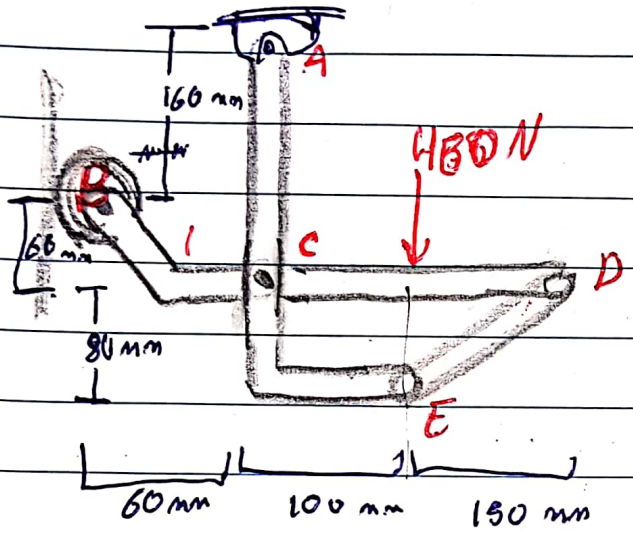
(3) the reactions on the joint should apply Newtons 3rd law
((equal but opposite))



when we do that we get 6 equations with 6 unknowns



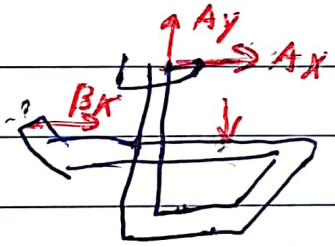
sample 6.4



members ACE/BCD are connected by a pin at C & by link DE

→ Find force in DE
→ and components of exerted at C in member BCD

First Find reactions ((3 easy))



$M_A = 0$

$480 * 100 = 160 * B_x$

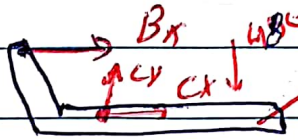
$B_x = 300 \uparrow N$

$A_x = -B_x = -300 N \uparrow$

$A_y = +480 \hat{j}$

DE is 2 Force member can't help

try BCD



$M_C = 0$

$B_x * 60 = E_{Dy} * 250 \rightarrow * E_D = 250 N$

DE ~~#5[illegible]~~ | 561 comp

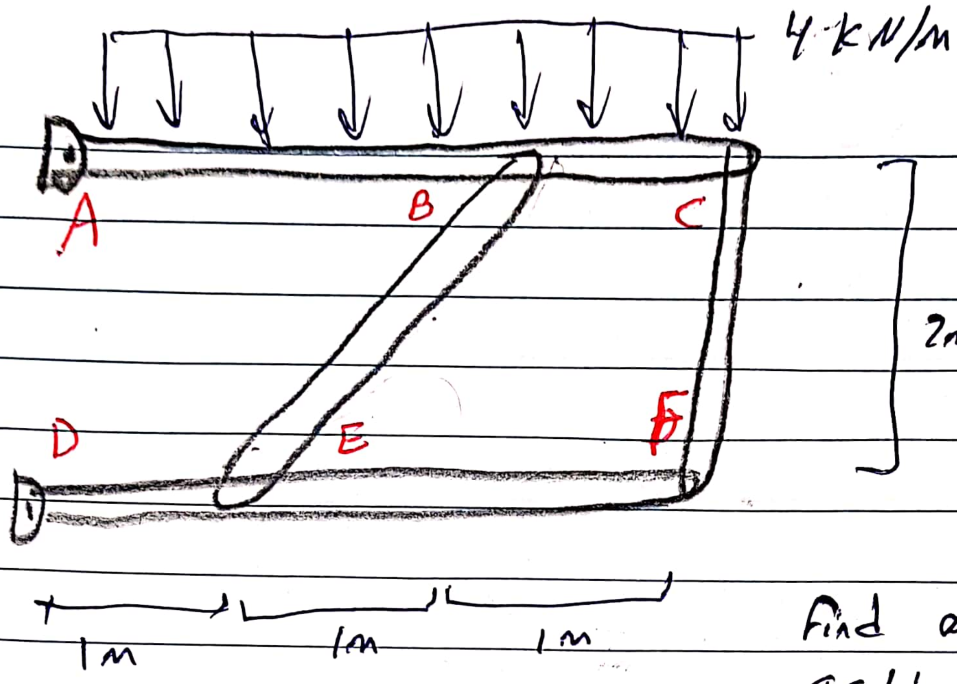
$\Sigma F_x = B_x + C_x + DE_x = 0$

$300 + C_x + \frac{150}{\sqrt{150^2+80^2}} \times 561$

~~[illegible]~~ $C_x = -745\ N$

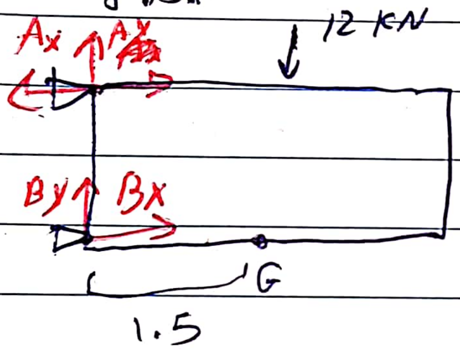
$C_y = ?$ 216 ↑ on pcb

For making sure try if $\Sigma M / \Sigma F_x / \Sigma F_y = 0$ at other member



Find all forces acting on ABC ~~(AND)~~ & DEF

F.B.D :-



$M_A =$ نجرب MA=0 حيث
نلغي By / A
ثم نجرب فنجد Bx / Ax

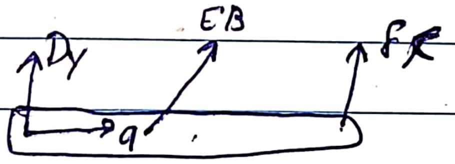
$M_A = 0 \rightarrow 12 * 3 = B_x * 2 \rightarrow$ **$B_x = 18$**

$A_x = -18$

~~$M_G = 0 \rightarrow 18 * 2 = (A_y + B_y) * 1.5$~~

$A_y + B_y = 12$ ---

FBD for FED



$\Sigma F_x = 0 \rightarrow 9 = EB * \frac{1}{\sqrt{5}} \rightarrow$ **$EB = 20$** comp

$D_y - EB * \frac{2}{\sqrt{5}} + F_c = 0$

$F_c = 18 - D_y$

$\Sigma M_D = 0$

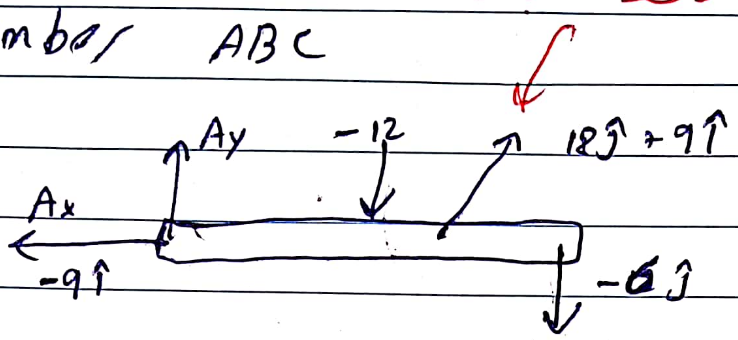
$18 = F_c * 3 \rightarrow F_c$ ...

$D_y = 12$

on member DEF $D_x = 9\hat{i}$ $D_y = 12\hat{j}$

$E = -18\hat{j}$ $-9\hat{i}$ $F = 6\hat{j}$

Member ABC



$\Sigma F_x = 0$ ✓ check

$\Sigma F_y = 0 \rightarrow$ $A_y = 0\hat{j}$

check $\Sigma F_y = 0$ on the whole body

$= 0 + 12 - 12 = 0$ ✓

On member ABC

$A_x = -9\hat{i}$ $A_y = 0$ $B_x = 9\hat{i}$ $B_y = 18\hat{j}$

$C_y = -6\hat{j}$

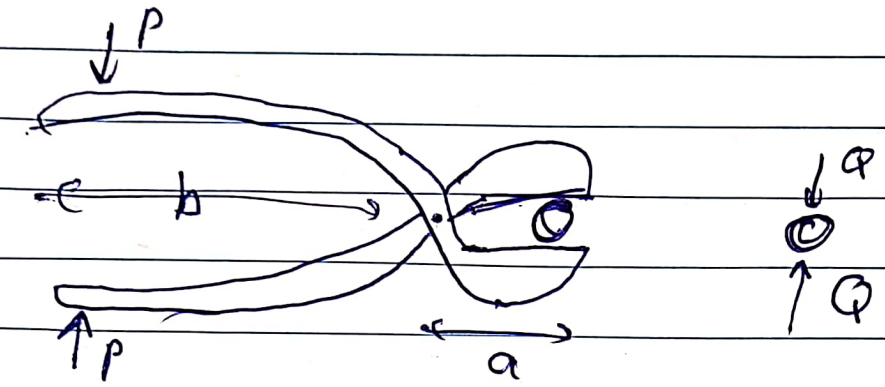
يمكننا اخذ القوة المسلطة لـ ال load

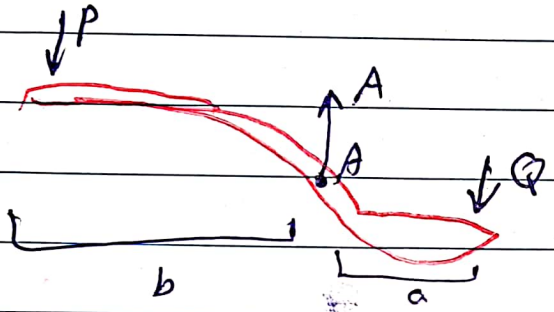
ذلك لاننا لانشتغل على الـ trusses

⚠ في حال وجود اكثر من مجهول

في الـ frame

Machines are structure





$\Sigma M_A = 0 \rightarrow P * b - Q * a = 0$

$\rightarrow \frac{bP}{a} = Q$

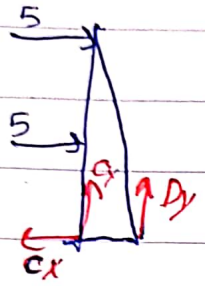
$Q = P * \frac{b}{a}$: $b/a \gg 1$

Home work 6 !

Naseem Hamed 1200502

Prob 8)

FBD for the rigid body



$\Sigma F_x = 0 \rightarrow 10\,KN - E_x = 0$

$\rightarrow E_x = -10\,KN \leftarrow$

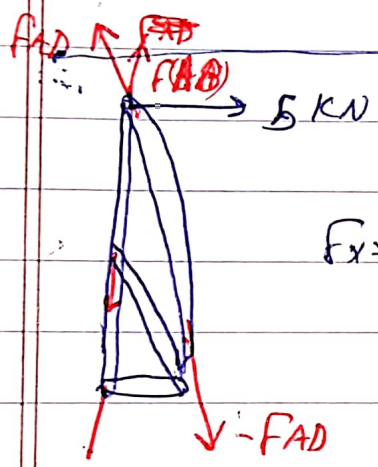
$\Sigma M_C = 0 \rightarrow 5*8 + 5*4 - D_y * 2 = 0$

$\rightarrow D_y = +30\,KN \uparrow$

$\Sigma F_y = 0 \rightarrow C_y + D_y = 0$

$C_x + 30\,KN = 0$

$\rightarrow C_y = -30\,KN \downarrow$



* Joint A :-

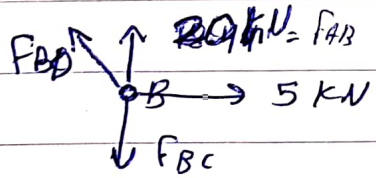
$F_x = 0 \rightarrow 5 = F_{AD} * \frac{2}{\sqrt{2^2+8^2}}$

$F_{AD} = 20.62\,KN$ (C)

$F_y = 0 \rightarrow F_{AB} + 20.62 * \frac{8}{\sqrt{2^2+8^2}} = 0$

$F_{AB} = -20\,KN = 20\,KN$ (T)

Joint B



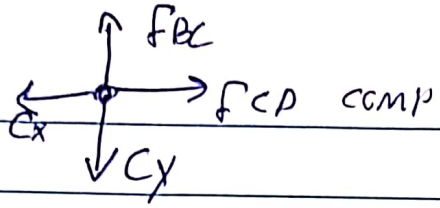
$\Sigma F_x = 0 \rightarrow 5\,KN = F_{BC} * \frac{2}{\sqrt{2^2+4^2}}$

$F_{BD} = 11.18$ (C)

$\Sigma F_y = 0 \rightarrow 20 + 11.18 * \frac{4}{\sqrt{16+4}} - F_{BC} = 0$

$F_{BC} = 30\,KN$ (T)

Joint C



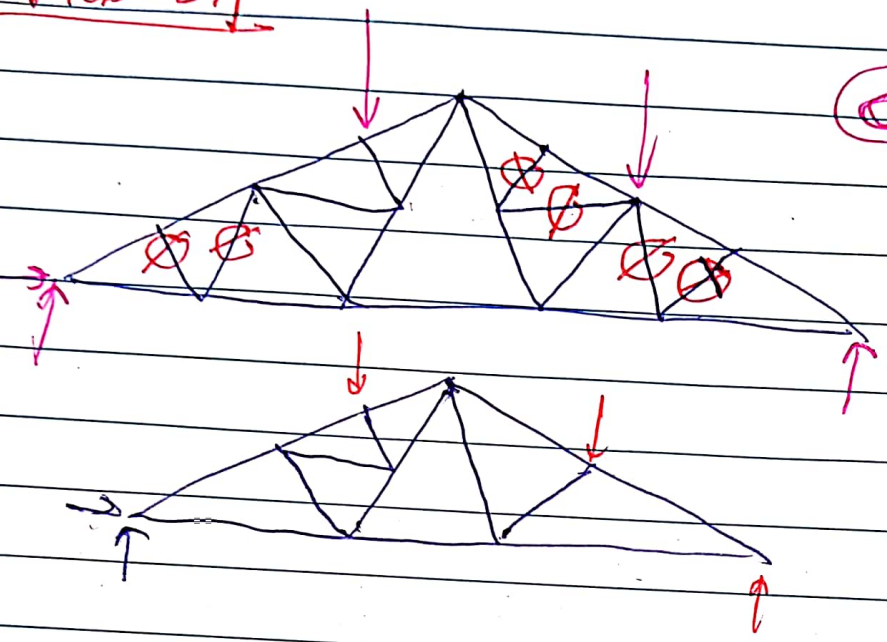
$F_{BC} = C_y$ ✓ check

$|C_x| = |F_{CD}|$ comp

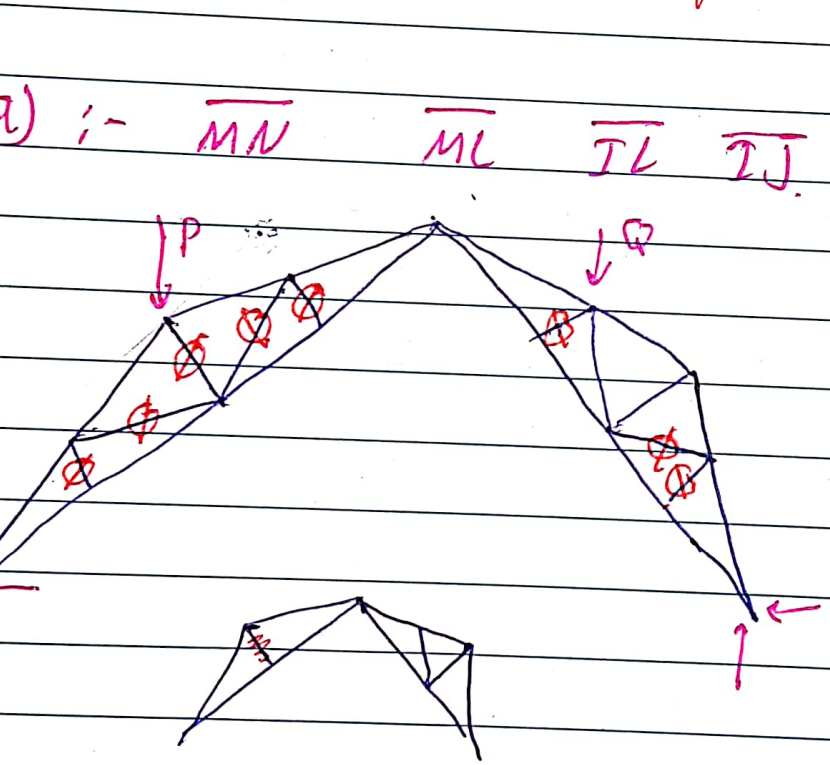
$F_{CD} = 10\ kN$ T

ملاحظة مهمة قوة الشد عندما
العقدة نشد ال joint اي داخلة
في العقدة

Prob. 31



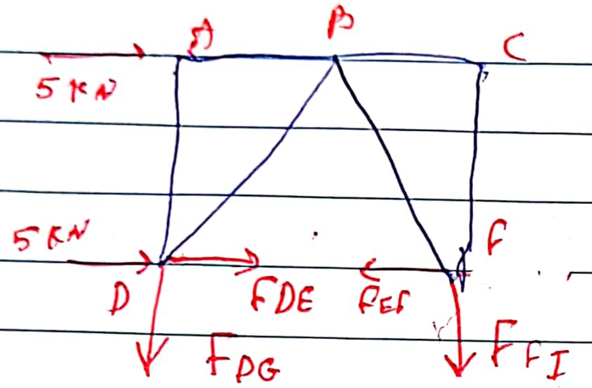
a



a) :- $\overline{MN}$ $\overline{ML}$ $\overline{IL}$ $\overline{IJ}$ $\overline{BC}$ $\overline{CD}$

$\overline{BC}$, $\overline{BE}$, $\overline{DE}$, $\overline{EF}$, $\overline{FG}$, $\overline{IJ}$, $\overline{KN}$, $\overline{MN}$

Prob 61



$M_D = 0$

$5 * 3 + F_{FI} * 4 = 0$

$-15 = 4 F_{FI}$

$F_{FI} = \frac{-15}{4}$

$= \frac{15}{4}$ Tension

$= 3.75$ Tension

$M_F = 0$

$-5 * 3 + F_{DG} * 4 = 0$

3.75

3.75 comprision

F (FI)	3.75	T
F (DG)	3.75	C

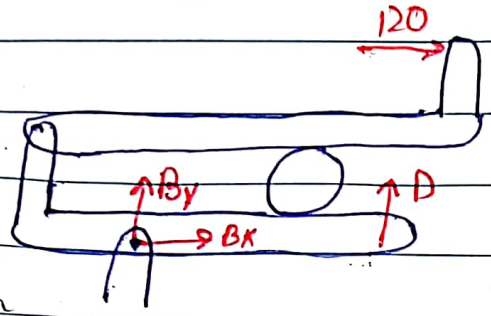
لاحظ شكل السكشن مش شرط مستقيم

اخذ سكشن مناسب واخذ المعادلة المناسبة بيساعد كثيرا

هونا 4 مجاهيل ومعنا 3 معادلات

لكن نستطيع الحل بسهولة

P 78



Take FBD for ~~the~~ ~~Body~~ whole Body as rigid body because reaction c/A are Inner forces

$M_B = 0$

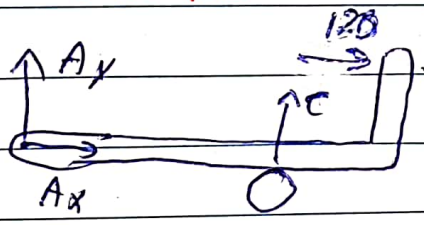
$D * 6 - 120 * 4 = 0$

$D = 80\ Ib\ \uparrow$ ✓

$\Sigma F_x = 0 \rightarrow B_x = -120\ Ib\ \uparrow$

$\Sigma F_y = 0 \rightarrow B_x = -80\ \uparrow\ Ib$

now we make the FBD for one member



$\Sigma M_A = 0$

$120 * 2 - C * 8 = 0$

$C = 30\ \uparrow\ Ib$

$\Sigma F_y = 0 \rightarrow Ay + C = 0$ ~~Ay~~

$-C = Ay$

$Ay = -30\ Ib\ \uparrow$

$\Sigma F_x = 0 \rightarrow Ax = -120\ \uparrow$

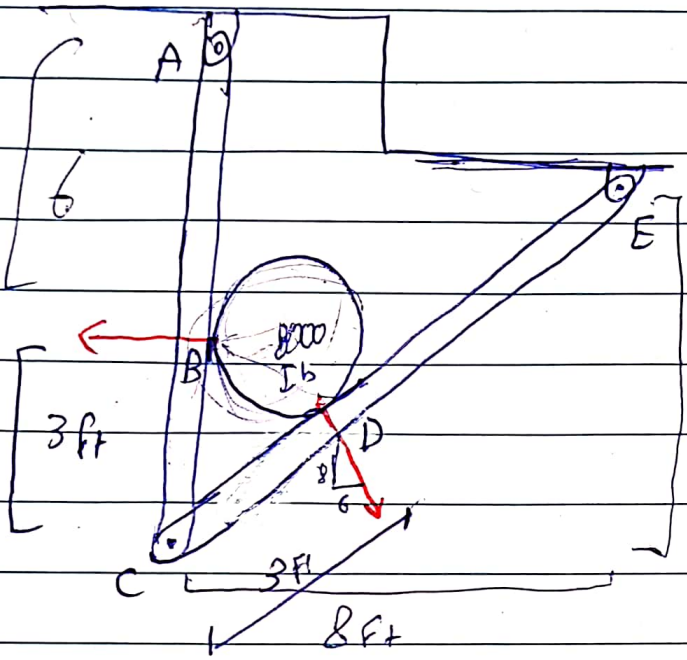
these are on member (AJE)

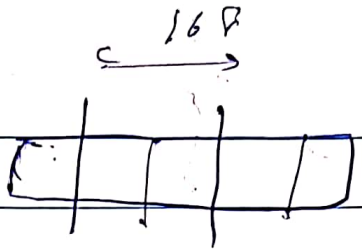
For (ABCD) :-

~~Ax~~ $= 120\ \uparrow$ $\quad B_x = -120\ \uparrow$ $\quad C = -30\ \uparrow$

$Ay = 30\ \uparrow$ $\quad B_y = -80\ \uparrow$ $\quad D = 80\ \uparrow$

P 93

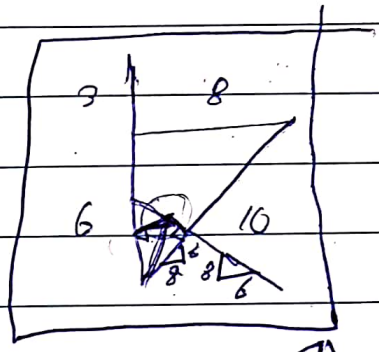




500 Ib/ ft

500 * 16 =

8000 Ib



First find D And B

$D_y = 8000$ Ib $\rightarrow \frac{8}{10} * D = 8000$

$|D| = 10000$ Ib

$D_x - B = 0$

$6000 - B = 0$

$B = -6000$ Ib

(F.B.D) for 'ABC

$M_A = 0$

$C_x * 9 = 6000 * 6$

$C_x = 4000$ ↑

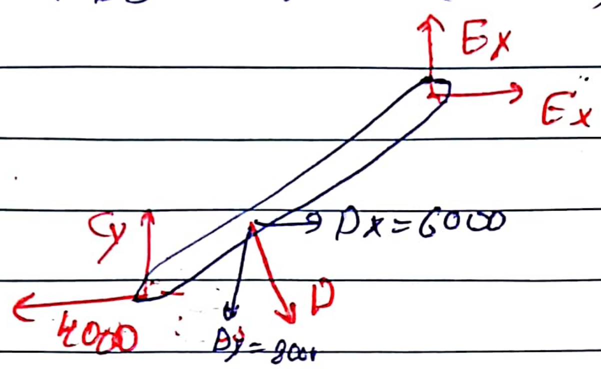
$\Sigma F_x = 0$

$4000 + A_x - 6000 = 0$

$A_x = 2000$ Ib ↑

by Gyometry I could find out the distance $\overline{CB}$ And $CD = 3$

FBD for (CDE)



نعكس اتجاه C_x الناتج من ماسبق لان C_x هناك هو من عمل (CDE) على العضو (ABC) نحن هنا العكس اي القوة المعاكسة حسب قانون نيوتن III

$E_x - 4000 + 6000 = 0$

$E_x = -2000 \uparrow lb$

~~$M_E = 0 \quad -10000 * 3 + E * 100 = 0$~~

~~$E = 3000$~~

~~$\sqrt{E_x^2 + E_y^2} = 3000$~~

~~$E_y =$~~

$D * 7 - 4000 * 6 - C_y * 8$

$70000 - 24000 - C_y * 8 = 0$

$C_y = 5750 \; lb$

$\Sigma F_y = 0 \quad C_y + E_y - D_y = 0$

$5750 + E_y - 8000 = 0$

$E_y = 2250 \; lb \uparrow$

Answers

(a) $E_x = -2000 \; lb \uparrow$

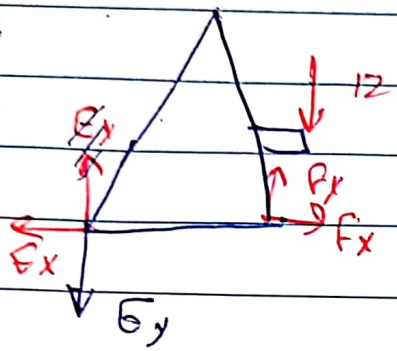
$E_y = 2250 \uparrow$

(b) $C_x = -4000 \uparrow$

$C_y = +5750 \; lb \uparrow$

P 101

FBD for entire frame



$M_E = 0$

$12 * 2.1 - Fy * 1.8 = 0$

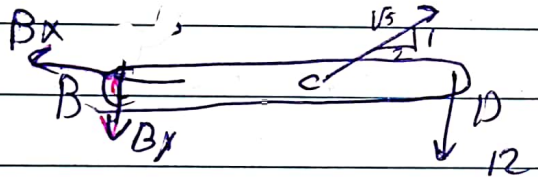
$Fy = 14\ KN \uparrow$

$M_F = 0$

$Ex * 1.8 = 12 * 0.3$

$Ex = -2\ KN \downarrow$

FBD for BCD



$M_B = 0$

$12 * 1.8 = Cy * 1.2$

$Cy = 18\ KN \downarrow$

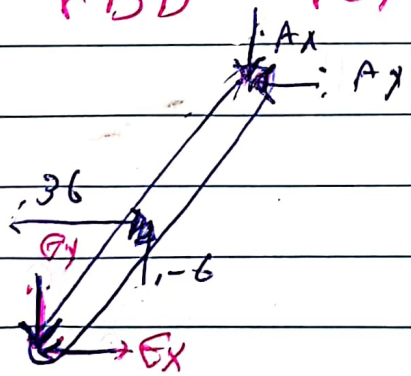
$Cx = 2Cy = 36\ KN \rightarrow$

$Bx = -36\ KN \uparrow$

$\Sigma Fy = 0 = 12 - 18 + By = 0$

$By = -6 \downarrow\ KN$

FBD for ABE



$M_A = 0$

$6 * 0.6 - 36 * 1.2 + Ex * 1.8 - 2 * 0.9 = 0$

$Ex = 23$

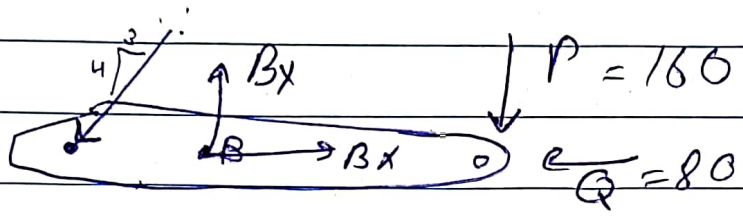
$Ex = -23\ KN \leftarrow$

$\Sigma Fx = 0 \rightarrow Ax = -13\ KN \uparrow$ $Bx = 36 \uparrow$ $Ex = -23 \uparrow$

$\Sigma Fx = 0 \rightarrow Ay = -4\ KN \uparrow$ $By = 6 \downarrow$ $Ex = -2kN \downarrow$

Prob 139

FBD for ABC



$\Sigma M_B = 0$

$\frac{4}{5} * EA * 160 = 600 * 160$

$EA = 800\ N$ Tension ✓

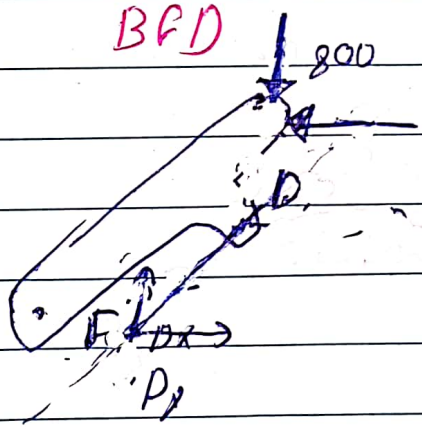
$\Sigma f_x = 0 \rightarrow 80 + 480 - B_x = 0$

$B_x = 560\ N \leftarrow$ ✓

$B_x = 160 + 640$

$B_y = 800\ N \uparrow$

FBD for BFD



$\Sigma M_F = 0$

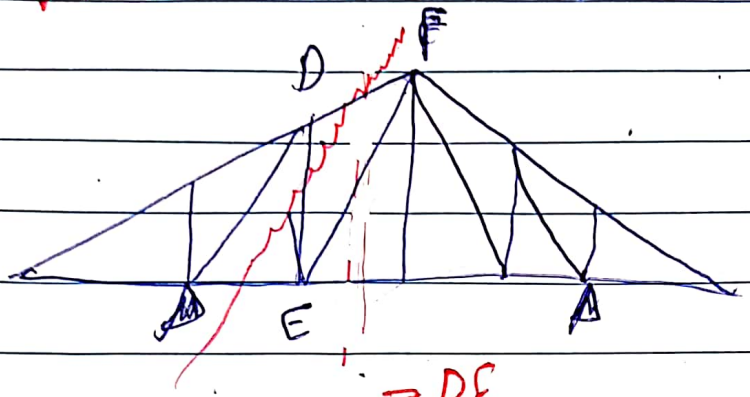
$560 * 400 + D_x * 200 - 800 * 300 = 0$

$D_y = 80$

$\rightarrow D = 100$ comp

Transibility

Prob 51 by method of section



$P * 6 = 180$ kips

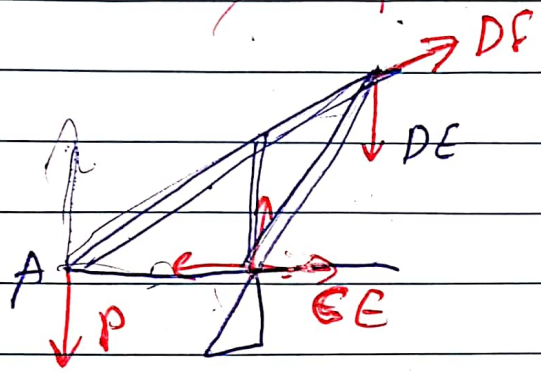
$M_C = P(30 + 18 + 12 + 6)$

$- P * 6 - K_y * 24$

$1200 = K_y * 24$

$K_y = 50$

$C_y = 50$ By Σf_x



$M_A = 0$

$50 * 6 = DE * 12$

$DE = 25$ T

$M_C = 0$

$20 * 6 + 25 * 6 - DF * \frac{7.5}{\sqrt{7.5^2 + 18^2}} * 6$

$(-5) = DF * 0.38$

$DF = -13 = 13$ com.