NAME Fall 2010 - Q1 Solution Key

COURSE CIVE 310 - Mechanics of Materials

CLASS OF SECTION DATE

FACULTY OF ENGINEERING & ARCHITECTURE
AMERICAN UNIVERSITY OF BEIRUT

CLOSED BOOK EXAMINATION

THIS BOOK MUST BE RETURNED COMPLETE

COURSE No.	
QUESTION No.	SCORE
1	
2	
3	
4	
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9	
10	
11	
12	
TOTAL SCORE OUT OF 100	

ON MY HONOR, I WILL NOT GIVE OR RECEIVE ANY ASSISTANCE ON THIS QUIZ OR EXAM.

Signature: ________

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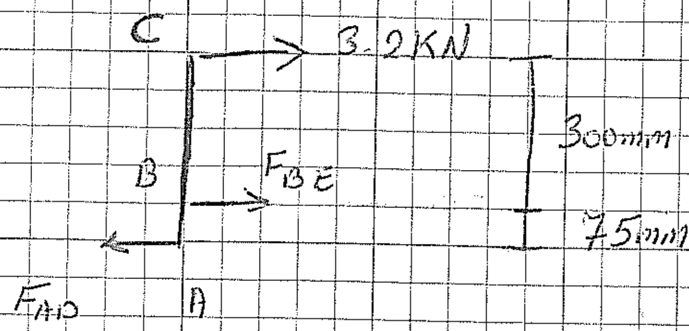
Problem 1



$\Sigma M_A = 0 \Rightarrow F_{BE}(75) + 3.2(375) = 0$

$\Rightarrow \boxed{F_{BE} = -16\ KN}$

$\Sigma \vec{F} = 0 \Rightarrow 3.2 + F_{BE} - F_{AD} = 0$

$\Rightarrow \boxed{F_{AD} = -12.8\ KN}$

$\Rightarrow$ both members BE & AD are in tension

$\delta_{BE} = \frac{F_{BE} L}{AE} = \frac{16\ KN \times 400mm}{6mm \times 18mm \times 200\ KN/mm^2} = \boxed{0.296mm \rightarrow}$

$\delta_{AD} = \frac{F_{AD} L}{AE} = \frac{12.8 \times 400}{6 \times 18 \times 200} = \boxed{0.237mm \leftarrow}$

Rigid Beam A, B, C

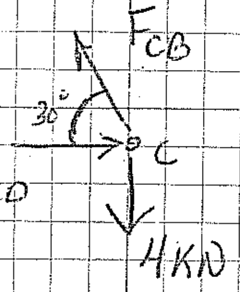
$\Rightarrow \frac{\delta_B - \delta_A}{75} = \frac{\delta_C - \delta_B}{300}$

$\frac{0.296 + 0.237}{75} = \frac{\delta_C - 0.296}{300}$

$\Rightarrow \boxed{\vec{\delta_C} = 2.428mm}$

Problem 2

(a) **Joint C:**

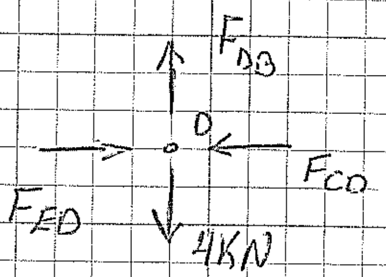


$\Sigma F_y \uparrow = 0$

$\Rightarrow$ $\boxed{F_{CB} = 8\,KN}$

$\overrightarrow{\Sigma F} = 0 \quad \Rightarrow \quad \boxed{F_{CD} = 6.93\,KN}$

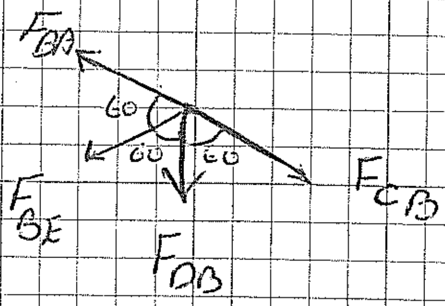
Joint D:



$\Rightarrow$ $\boxed{F_{DB} = 4KN}$

$\boxed{F_{ED} = 6.93\,KN}$

Joint B:



ΣF_y (30°) $= 0$

$\Rightarrow$ $\boxed{F_{BE} = -4KN}$

ΣF_x (30°) $= 0$

$\Rightarrow F_{CB} - F_{BA} + F_{BE}\cos 60 + F_{DB}\cos 60 = 0$

$\Rightarrow 8 + 4/2 + 4/2 - F_{BA} = 0$

$\Rightarrow$ $\boxed{F_{BA} = 12\,KN}$

$\Rightarrow$ Member AB in Tension

Member ED in Compression

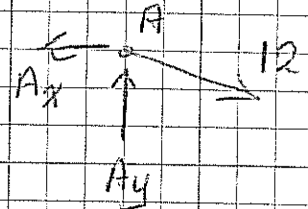
$\sigma_{all} = \frac{\sigma_{ult}}{F.S} = 200\ MPa$

$A_{AB} = \frac{F_{AB}}{\sigma_{AB_{all}}} = \frac{12000\ N}{200\ N/mm^2} = \boxed{60\ mm^2}$

$A_{ED} = \frac{F_{ED}}{\sigma_{ED_{all}}} = \frac{6930\ N}{200\ N/mm^2} = \boxed{34.65\ mm^2}$

(b)

Joint A



$A_x = 12 \cos 30$

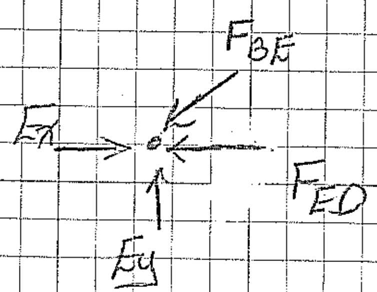
$= 10.39\ KN$

$A_y = 6KN$

$F_A = 12KN$

Double Shear $\Rightarrow$ $\boxed{\tau_A = 0.119\ KN/mm^2}$

Joint E



$\Sigma \vec{F_x} = 0$

$\Rightarrow E_x - F_{ED} - F_{BE} \cos 30 = 0$

$\Rightarrow E_x = 10.39KN$

$E_y = 2KN$

$F_E = \sqrt{(2)^2 + (10.39)^2}$

$= 10.58KN$

Double Shear $\boxed{\tau_E = 0.105\ KN/mm^2}$

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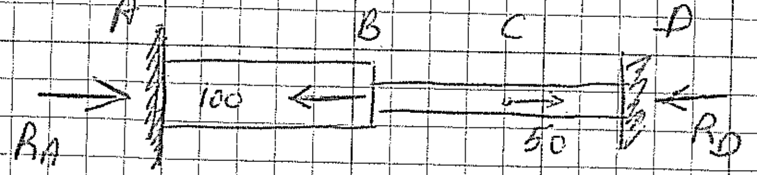
Problem 3



$\sum \vec{F_x} = 0$

$\Rightarrow R_A - 100 + 50 - R_D = 0$

$\Rightarrow \boxed{R_A - R_D = 50}$ Statically Ind.

Principle of Superposition

Step ① Release D

$\sum \vec{F_x} = 0 \Rightarrow R_{A_0} + 50 - 100 = 0 \Rightarrow \boxed{R_{A_0} = 50\ KN}$

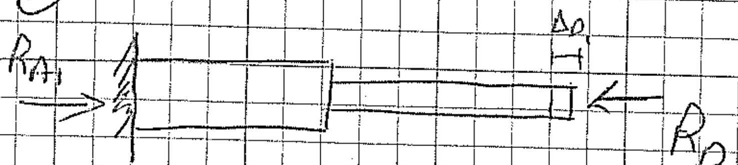
$\Delta D_0 = \Delta_{D/C} + \Delta_{C/B} + \Delta_{B/A}$

$= 0 + \frac{50\times10^3 N \times 5m}{2\times10^{-6} m^2 \times 70\times10^9 N/m^2} - \frac{50\times10^3 \times 5}{6\times10^{-6}\times 70\times10^9}$

$= 1.7857 + (-0.5952)$

$\boxed{\Delta_{D_0} = 1.1905\ mm}$

Step ②



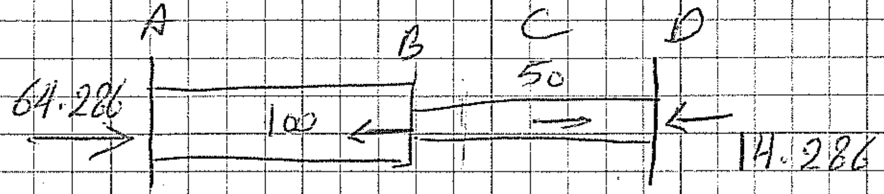
$\Delta_{D_1} = \frac{-R_D(10)}{2\times10^{-6}\times70\times10^9} - \frac{R_D(5)}{6\times10^{-6}\times70\times10^9} = -8.33\times10^{-5}\ R_D$

Compatibility: $\Delta_{D_0} + \Delta_{D_1} = 0$

$\Rightarrow$ $R_D = 14.286 KN$

$R_{A_1} = +R_D = +14.286 KN$

$\Rightarrow$ $R_A = R_{A_0} + R_{A_1} = 64.286 KN$

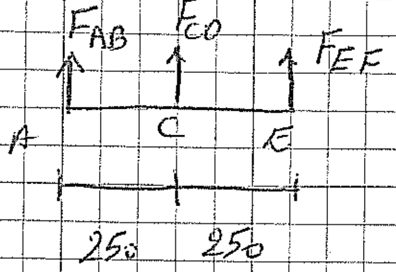


	AB	BC	CD
P (KN)	64.286	35.714	14.286
(+/-)	(-)	(+)	(-)
A	6 mm²	2 mm²	2 mm²
σ	10.71 KN/mm²	17.857	7.143

$\Rightarrow$ Max Normal Stress

$\sigma_{BC} = 17.86 KN/mm^2$

Problem 4



$\Sigma M_C \circlearrowright = 0 \Rightarrow \boxed{F_{EF} = F_{AB}} = F$

$\Sigma F_y \uparrow = 0 \Rightarrow 2F + F_{CD} = 0$

$\Rightarrow \boxed{F_{CD} = -2F}$

Rigid Beam

$\Rightarrow \delta_C - \delta_A = \delta_E - \delta_C$

$2\delta_C = \delta_A + \delta_E$

$2\left(\delta_{C(T)} + \delta_{C(F)}\right) = \left(\delta_{A(T)} + \delta_{A(F)} + \delta_{E(T)} + \delta_{E(F)}\right)$

$2\left[12\times10^{-6}/°C \times 60°C \times 500mm + \frac{(-2F)(500)}{25\times200\times10^3}\right] =$

$12\times10^{-6}/°C \times 60 \times 500 + \frac{F(500)}{(25)(200\times10^3)} + 21\times10^{-6}\times60\times500$

$+ \frac{F(500)}{(25)(120\times10^3)}$

$\Rightarrow 2(0.36 - 2\times10^{-4}F) = 0.99 + 2.67\times10^{-4}F$

$0.72 - .99 = 6.67\times10^{-4}F \Rightarrow \boxed{F = -404.8N}$

$\Rightarrow$ AB & EF are in compression

$$\sigma_{AB} = \sigma_{EF} = F/A = \frac{404.8\,N}{25\,mm^2} = \boxed{16.19\ MPa}$$

CD is in tension

$$\sigma_{CD} = \frac{2F}{A} = \boxed{32.38\ MPa}$$

(b)
$$\delta_A = \overset{(T)}{0.36} - \overset{(F)}{0.0408}$$
$$= 0.3192\ mm \downarrow$$

$$\delta_E = \overset{(T)}{0.63} - \overset{(F)}{0.0675}$$
$$= 0.5625 \downarrow$$

$$\theta = \frac{\delta_E - \delta_A}{2d} = \boxed{4.866 \times 10^{-4}\ radians}$$