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Lebanese American University

LAU
School of Engineering

EXAMINATION BOOKLET

Date: / / (dd mm yyyy)

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Subject: Exam 2 - 10th November 2016 Section: CIE200

Instructor: Box No.: Email:

CLOSED-BOOK

Question:	1	2	3	4	5	6	7	8	9	10	Total:

Grade:

Problem (I)

(i) $\vec{F_R} = F_{Rx}\vec{i} + F_{Ry}\vec{j}$

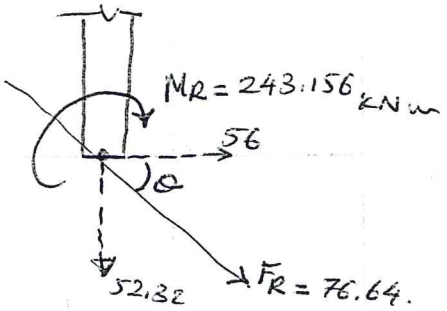
$F_{Rx} = 30\cos 30 - 20\sin 30 + 40 = 56$ kN.

$F_{Ry} = -30\sin 30 - 20 - 20\cos 30 = -52.32$ kN.

$\vec{F_R} = 56\vec{i} - 52.32\vec{j}$

$F_R = \sqrt{56^2 + 52.32^2} = 76.64$ kN.

$\theta = \tan^{-1}\frac{52.32}{56} = 48.05^\circ$



(+) M_R at "A" $= -40(3.5) - 30\cos 30\,(7)$.

$+ 20\sin 30(7) + 30\sin 30(2)$

$- 20\cos 30(2) + 20(2 - 4/3)$

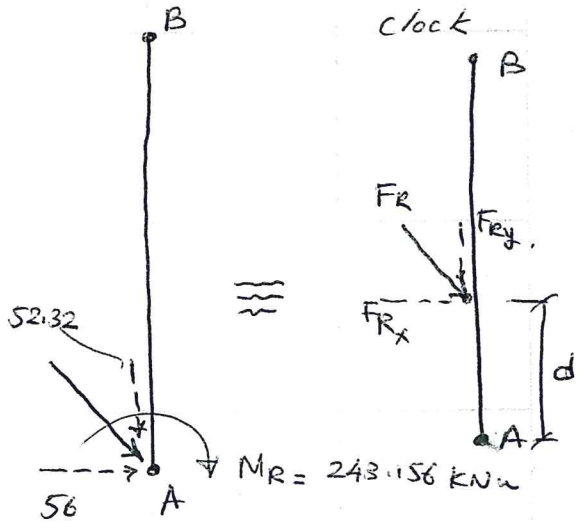
$= -140 - 181.86 + 70 + 30 - 34.64$

$+ 13.33 = -243.16$ kN.m

(ii)

(+) $-F_{Rx}(d) = -243.16$

$d = \frac{243.16}{56} = 4.34$ m



Problem (II)

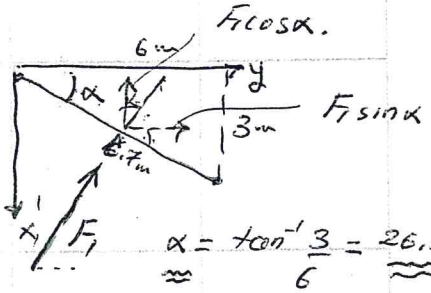
$$\vec{F} = 100\cos 30\,\vec{j} + 100\sin 30\,\vec{k}$$

$$\vec{F} = 86.6\,\vec{j} + 50\,\vec{k} \quad (N)$$

$$F_1 = 100 \times \left(\sqrt{6^2 + 3^2}\right) = 670.8\,N.$$

$$\vec{F_1} = -670.8\cos\alpha\,\vec{i} + 670.8\sin\alpha\,\vec{j}$$

$$\vec{F_1} = -600\,\vec{i} + 300\,\vec{j}$$



$$\alpha = \tan^{-1}\frac{3}{6} = 26.56°$$

at A $\quad \vec{F_R} = (-600)\vec{i} + \vec{j}(300 + 86.6) + \vec{k}(50)$

$$\vec{F_R} = -600\,\vec{i} + 386.6\,\vec{j} + 50\,\vec{k}$$

$$F_R = \sqrt{600^2 + 386.6^2 + 50^2} = 715.5\,N.$$

$$\alpha = \cos^{-1}\frac{-600}{715.5} = 146.9°$$

$$\beta = \cos^{-1}\frac{386.6}{715.5} = 57.29°$$

$$\gamma = \cos^{-1}\frac{50}{715.5} = 86°$$

at 'A' Moment

Using Scalar approach:

$F \rightarrow F_y = 86.6$

$M_x = +86.6 \times 3 = 260$ ✓

$M_z = +86.6 \times 3 = 260$ ✓

F_z

$M_x = +50 \times 6 = 300$ ✓

$M_y = -50 \times 3 = -150$ ✓

$$\vec{M_R} = \vec{i}(260 + 300) + \vec{j}(-150) + \vec{k}(260 + 1800 + 450)$$

$$\vec{M_R} = 560\,\vec{i} - 150\,\vec{j} + 2510\,\vec{k}$$

$$M_R = 2576.08\ Nm.$$

$F_1 \rightarrow F_x = 600$

$M_y = 0$

$M_z = +600 \times 3 = 1800\ Nm$

$F_y = 300$

$M_x = 0$

$M_z = +300 \times 1.5 = 450\ Nm.$

For M_R

$$\alpha = \cos^{-1}\frac{560}{2576.08} = 77.4$$

$$\beta = \cos^{-1}\frac{-150}{2576.08} = 93.3^\circ$$

$$\gamma = \cos^{-1}\frac{2510}{2576.08} = 13^\circ$$

(ii) M_R along AC. → need $\vec{U}_{AC}$

A(0, 0, 0) → C(3, 6, −3)

$$\vec{U}_{AC} = \frac{3\vec{i} + 6\vec{j} - 3\vec{k}}{\sqrt{3^2+6^2+3^2}} = \frac{3\vec{i} + 6\vec{j} - 3\vec{k}}{7.35}$$

$$\vec{U}_{AC} = 0.408\vec{i} + 0.816\vec{j} - 0.408\vec{k}$$

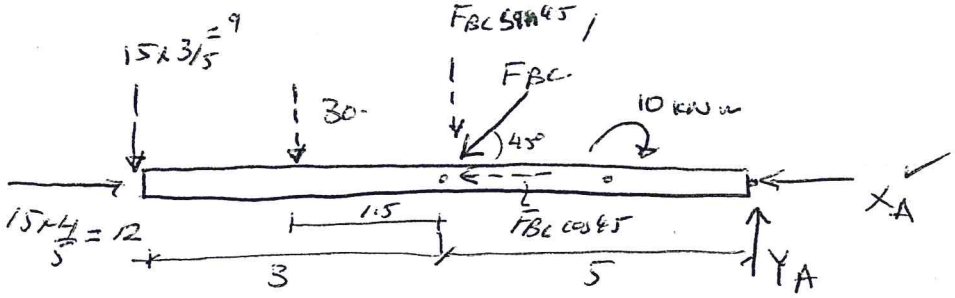
$|\vec{M}_R$ along AC$| = \vec{M}_R \cdot \vec{U}_{AC}$ (dot product) $= 560(0.408) + 0.816(-150) - 0.408 \times 2570$

$= -918$ N m.

$$\vec{M}_{R\text{ along AC}} = -918 \cdot \vec{U}_{AC} = -374.5\vec{i} - 749\vec{j} + 374.5\vec{k}$$

(III)

BC two force element



(↻) $\Sigma M_{@A} = 0$

$+9(8) + 30(5+1.5) + F_{BC}\sin 45\,(5) - 10 = 0$

$F_{BC} = -72.7\ kN$ .....

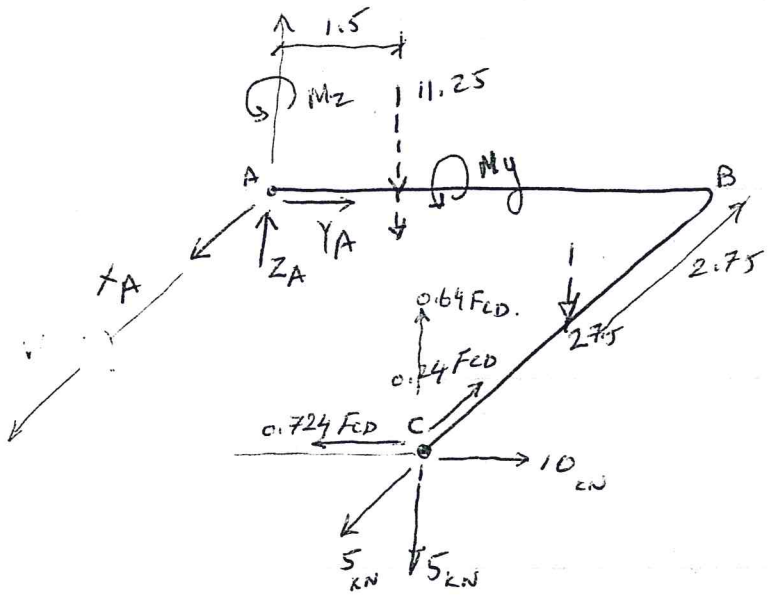
$\rightarrow \Sigma F_x = 0$ $\quad +12 - (F_{BC})\cos 45 - X_A = 0$ ($F_{BC} = -72.7$)

$X_A = +63.4\ kN$

$+\uparrow \Sigma F_y = 0$ $\quad Y_A - 9 - 30 - F_{BC}\sin 45 = 0$

$Y_A = -12.4\ kN$

Problem IV



A(0, 0, 0)

B(0, 4.5, 0)

C(5.5, 4.5, 0)

D(4, 0, 4)

$$\vec{U}_{CD} = \frac{(4-5.5)\vec{i} + (0-4.5)\vec{j} + 4\vec{k}}{\sqrt{(1.5^2 + 4.5^2 + 4^2)}} = -0.24\vec{i} - 0.725\vec{j} + 0.64\vec{k}$$

$\sqrt{(1.5^2 + 4.5^2 + 4^2)} \rightarrow 6.2$

Cable force $\vec{F}_{CD} = -0.24 F_{CD}\,\vec{i} - 0.725 F_{CD}\,\vec{j} + 0.64 F_{CD}\,\vec{k}$.

$\vec{F} = 5\vec{i} + 10\vec{j} - 5\vec{k}$.

$\Sigma F_x = 0 \quad X_A - 0.24 F_{CD} + 5 = 0 \quad -(1)$

$\Sigma F_y = 0 \quad Y_A - 0.725 F_{CD} + 10 = 0 \quad -(2)$

$\Sigma F_z = 0 \quad Z_A + 0.64 F_{CD} - 5 - 27.5 - 11.25 = 0 \quad -(3)$.

ΣM @ X axis $= 0 \quad -27.5(4.5) + 0.64 F_{CD}(4.5) - 5(4.5) = 11.25(1.5)$ ✓

$F_{CD} = +56.6$ kN (Tension) ✓

Substitute in (1) $\rightarrow X_A = 8.6$ kN.

in (2) $\rightarrow Y_A = 31.0$ kN

in (3) $\rightarrow Z_A = 7.5$ kN

ΣM @ Y axis passing thru A = 0

$-0.64 F_{CD}(5.5) + 5(5.5) + 27.5(2.75) + M_y = 0$

$M_y = +96.1$ kN.m

ΣM @ z axis passing thru A = 0

$$M_z \quad -5(4.5) \quad +10(5.5) \quad -0.724\,F_{CD}(5.5)$$
$$+0.24\,F_{CD}(4.5) \quad = 0.$$

$$M_z = 131.7 \text{ kNm.}$$