# TEST 2
## Spring 2013-14
(6th May, 2014)
## CIE200 – STATICS
## CLOSED BOOK, 75 MINUTES

**Name:** F. El Meski **ID#:** 9014 xxxx **Section: 11**

***NOTES***

- 3 problems (12 pages).
- All your answers should be provided on the question sheets.
- Two extra sheets are provided at the end.
- Ask for additional sheets if you need more space.
- Some answers may require much less than the space provided.
- *Do not* use the back of the sheets for answers.
- ***Every FBD needed for the solution of a problem should be clearly shown.***
- ***Points will be deducted for any missing/ incomplete/incorrect FBD.***
- ***Points will be deducted for answers not supported by proper calculations.***

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***YOUR COMMENT(S)***

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DO NOT WRITE IN THE SPACE BELOW

***MY COMMENT(S)***

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***YOUR GRADE***

| | |
|---|---|
| *Problem I:* | 30 /30 |
| *Problem II:* | 35 /35 |
| *Problem III* | 35 /35 |
| ***TOTAL:*** | 100 /100 |

**Problem I:** *(30 points)*

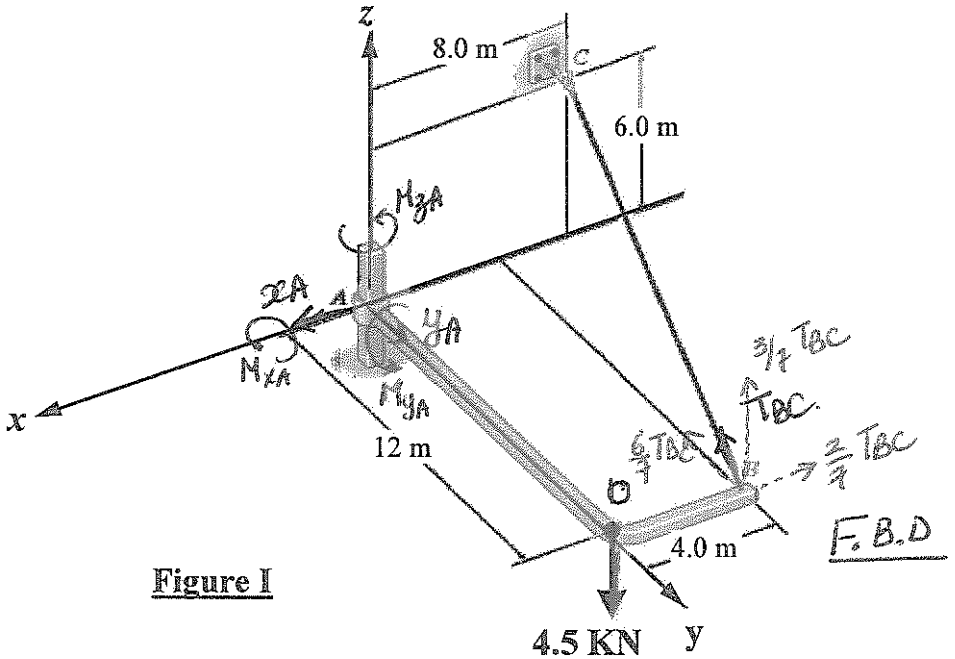



**Figure I**

Member AB shown in Figure I is supported at B by a cable and at A by a smooth fixed square rod (*fixed support that allows translation along z-axis*).

1- Determine the tension in cable BC and the support reactions at A, if the member is subjected to a force of 4.5 kN. *(30 points)*

*Note: FBD must be included*

Calculations and/or Diagrams:

Support at A is a fixed support that allows translation along z-axis (i.e. support A has the following reactions: $x_A, y_A, M_{xA}, M_{yA}, M_{zA}$)

Coordinates: A(0,0,0) D(0,12,0) B(-4,12,0) C(-8,0,6)

Express forces in cartesian vector

$\vec{F}_D = 0\vec{i} + 0\vec{j} - 4.5\vec{k}$

$\vec{u}_{BC} = \dfrac{(-8-(-4))\vec{i} + (0-12)\vec{j} + (6-0)\vec{k}}{\sqrt{(-4)^2+(-12)^2+(6)^2}} = \dfrac{-4}{14}\vec{i} - \dfrac{12}{14}\vec{j} + \dfrac{6}{14}\vec{k}$

$\therefore \vec{u}_{BC} = -\dfrac{2}{7}\vec{i} - \dfrac{6}{7}\vec{j} + \dfrac{3}{7}\vec{k}$

$\vec{T}_{BC} = T_{BC}\vec{u}_{BC} = T_{BC}\left(-\dfrac{2}{7}\vec{i} - \dfrac{6}{7}\vec{j} + \dfrac{3}{7}\vec{k}\right) = -\dfrac{2}{7}T_{BC}\vec{i} - \dfrac{6}{7}T_{BC}\vec{j} + \dfrac{3}{7}T_{BC}\vec{k}$

## Scalar Approach:

$\Sigma F_x = 0 \Rightarrow x_A - \frac{2}{7} T_{BC} = 0$ ... Eq. (1) $\Rightarrow \boxed{x_A = \frac{2}{7}(10.5) = 3\ KN}$

$\Sigma F_y = 0 \Rightarrow y_A - \frac{6}{7} T_{BC} = 0$ ... Eq. (2) $\Rightarrow \boxed{y_A = \frac{6}{7}(10.5) = 9\ KN}$

$\Sigma F_z = 0 \Rightarrow -4.5 + \frac{3}{7} T_{BC} = 0 \Rightarrow \boxed{T_{BC} = 10.5\ KN}$ ... Eq. (3)

substitute $T_{BC} = 10.5\ KN$ in Eq. (1) and (2) to solve for $x_A$ & $y_A$

$\Sigma M_x = 0 \Rightarrow M_{xA} - 4.5(12) + \frac{3}{7} T_{BC}(12) = 0$ ... Eq. (4)

$\Rightarrow M_{xA} - 4.5(12) + \frac{3}{7}(10.5)(12) = 0 \Rightarrow \boxed{M_{xA} = 0}$

$\Sigma M_y = 0 \Rightarrow M_{yA} + \frac{3}{7} T_{BC}(4) = 0 \Rightarrow M_{yA} + \frac{3}{7}(10.5)(4) = 0$ ... Eq (5)

$\Rightarrow \boxed{M_{yA} = -18\ KN.m = 18\ KN.m \circlearrowleft}$

$\Sigma M_z = 0 \Rightarrow M_{zA} + \frac{6}{7} T_{BC}(4) + \frac{2}{7} T_{BC}(12) = 0$ ... Eq. (6)

$\Rightarrow M_{zA} + \frac{8}{7}(10.5)(4) + \frac{2}{7}(10.5)(12) = 0 \Rightarrow M_{zA} = -72\ KN.m$

$\boxed{M_{zA} = 72\ KN.m \circlearrowleft}$

$\vec{T}_{BC} = \{-3\vec{i} - 9\vec{j} + 4.5\vec{k}\}^{KN}$ ; $\vec{R}_A = \{3\vec{i} + 9\vec{j} + 0\vec{k}\}^{KN}$

$\vec{M}_A = \{0\vec{i} - 18\vec{j} + 72\vec{k}\}^{KN.m}$

## Vector Approach:

Equations (1), (2) and (3) remain the same

$\vec{M} = \vec{r} \times \vec{F} = \vec{r}_{AD} \times \vec{F}_D + \vec{r}_{AB} \times \vec{T}_{BC}$

where $\vec{r}_{AD} = 0\vec{i} + 12\vec{j} + 0\vec{k}$ ; $\vec{r}_{AB} = -4\vec{i} + 12\vec{j} + 0\vec{k}$

$$\vec{M} = \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ 0 & 12 & 0 \\ 0 & 0 & -4.5 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ -4 & 12 & 0 \\ -\frac{2}{7}T_{BC} & -\frac{6}{7}T_{BC} & \frac{3}{7}T_{BC} \end{vmatrix}$$

$\vec{M} = \{(-12 \times 4.5)\vec{i} - 0\vec{j} + 0\vec{k}\} + \{(12 \times \frac{3}{7}T_{BC})\vec{i} - (-4 \times \frac{3}{7}T_{BC})\vec{j} + (4 \times \frac{6}{7}T_{BC} + 12 \times \frac{2}{7}T_{BC})\vec{k}\}$

$\vec{M} = -54\vec{i} + \frac{36}{7}T_{BC}\vec{i} + \frac{12}{7}T_{BC}\vec{j} + \frac{48}{7}T_{BC}\vec{k}$

$\Rightarrow \vec{M} = \underbrace{\left(-54 + \frac{36}{7}T_{BC}\right)}_{M_x}\vec{i} + \underbrace{\frac{12}{7}T_{BC}}_{M_y}\vec{j} + \underbrace{\frac{48}{7}T_{BC}}_{M_z}\vec{k}$

Calculations and/or Diagrams:

$\therefore \Sigma M_x = 0 \Rightarrow M_{xA} - 54 + \frac{36}{7} T_{BC} = 0$

substitute $T_{BC} = 10.5$ kN $\Rightarrow M_{xA} - 54 + \frac{36}{7}(10.5) = 0$

$\Rightarrow \boxed{M_{xA} = 0}$

$\Sigma M_y = 0 \Rightarrow M_{yA} + \frac{12}{7} T_{BC} = 0 \Rightarrow M_{yA} + \frac{12}{7}(10.5) = 0$

$\Rightarrow \boxed{M_{yA} = -18 \text{ kN.m}}$

$\Sigma M_z = 0 \Rightarrow M_{zA} + \frac{48}{7} T_{BC} = 0 \Rightarrow M_{zA} = -\frac{48}{7}(10.5) = -72$ kN.m

$\boxed{M_{zA} = -72 \text{ kN.m}}$

P.S: the negative sign indicates that the assumed direction is wrong.

Express results in Cartesian vector:

$\vec{T_{BC}} = \{ -3\vec{i} - 9\vec{j} + 4.5\vec{k} \}$ kN

$\vec{R_A} = \{ 3\vec{i} + 9\vec{j} + 0\vec{k} \}$ kN

$\vec{M_A} = \{ 0\vec{i} - 18\vec{j} + 72\vec{k} \}$ kN.m

**Problem II:** *(35 points)*

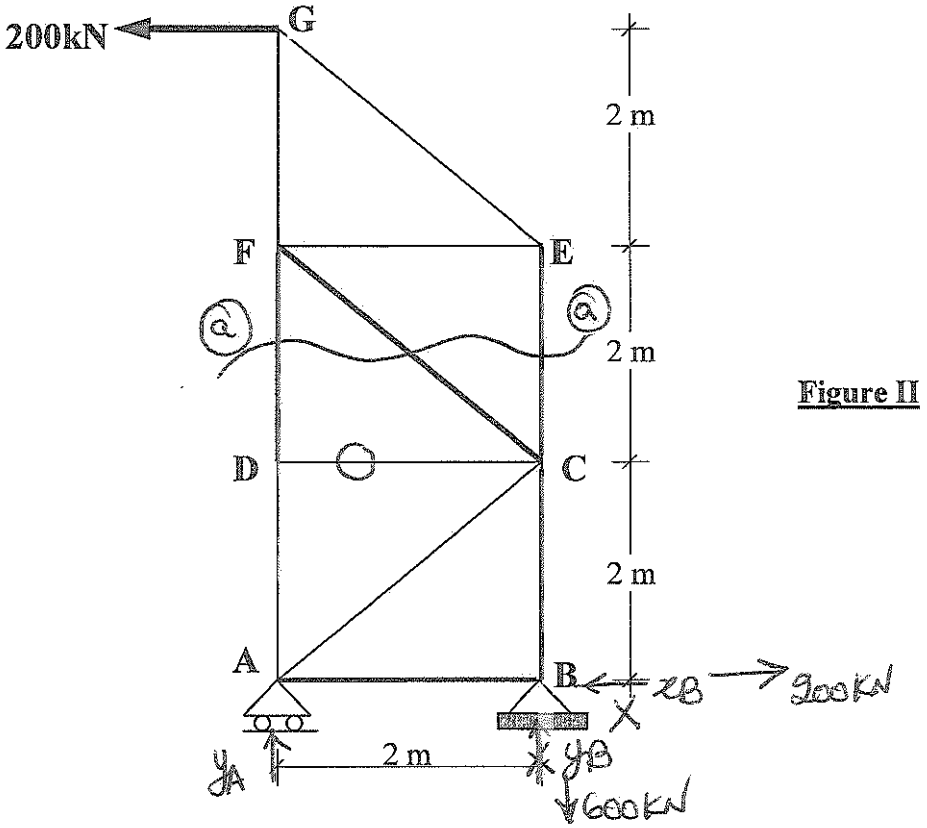



**Figure II**

The truss shown in Figure II is subjected to a force of 200 kN at G:

1- Determine the external reactions at the roller support A and the pin at B. *(5 points)*

2- Determine the force in members DF, FC, EC ***using the section method.*** Also solve for the force in members AB, and BC using the appropriate method of analysis. *(25 points)*

3- Indicate zero-force members. (5 points)

Calculations and/or Diagrams:

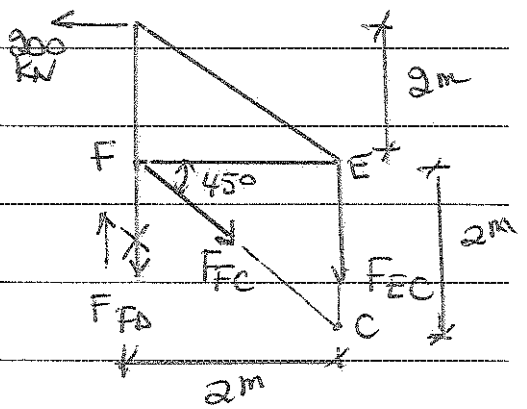
1- Reactions.

$\stackrel{+}{\rightarrow} \Sigma F_x = 0 \Rightarrow -900 - x_B = 0 \Rightarrow x_B = 900\,kN \rightarrow$

$+\circlearrowleft \Sigma M_A = 0 \Rightarrow +y_B(2) + 900(6) = 0 \Rightarrow y_B = -600\,kN$ — $600\,kN \downarrow$

$+\uparrow \Sigma F_y = 0 \Rightarrow y_A - 600 = 0 \Rightarrow y_A = 600\,kN \uparrow$

2- (Sec - a - a) (upper part is considered)




$\stackrel{+}{\rightarrow} \Sigma F_x = 0 \Rightarrow -900 + F_{FC}\cos 45 = 0$

$\Rightarrow F_{FC} = 989.84\,KN\,(T)$

Calculations and/or Diagrams (cont'd):

$+\circlearrowleft \Sigma M_F = 0 \Rightarrow -F_{EC}(2) + 200(2) = 0 \Rightarrow \boxed{F_{EC} = 200\,KN\,(T)}$

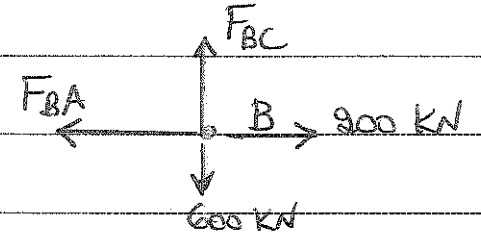
$+\circlearrowleft \Sigma M_C = 0 \Rightarrow F_{FD}(2) + 200(4) = 0 \Rightarrow F_{FD} = -400\,KN$

$\therefore \boxed{F_{FD} = 400\,KN\,(C)}$

CHECK!

$+\uparrow \Sigma F_y \stackrel{?}{=} 0 \Rightarrow 400 - 282.84 \sin 45 - 200 = 0 \therefore$ O.K ✓

Equilibrium at joint B




$\stackrel{+}{\rightarrow} \Sigma F_x = 0 \Rightarrow -F_{BA} + 200 = 0 \Rightarrow \boxed{F_{BA} = 200\,KN\,(T)}$

$+\uparrow \Sigma F_y = 0 \Rightarrow F_{BC} - 600 = 0 \Rightarrow \boxed{F_{BC} = 600\,KN\,(T)}$

3- Zero force member is DC

Calculations and/or Diagrams (cont'd):

**Problem III:** *(35 points)*

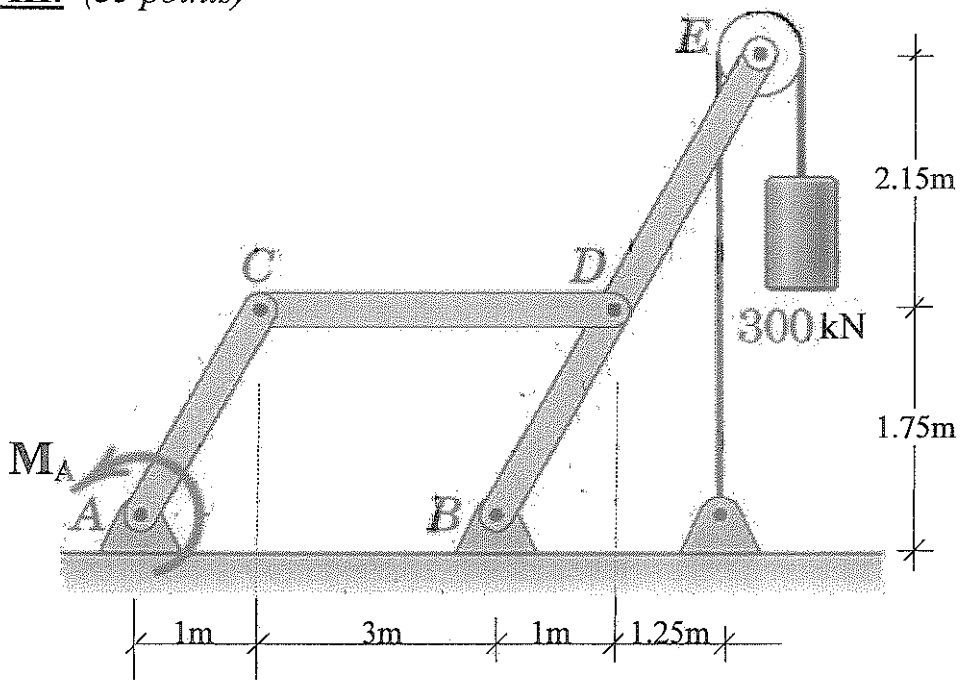


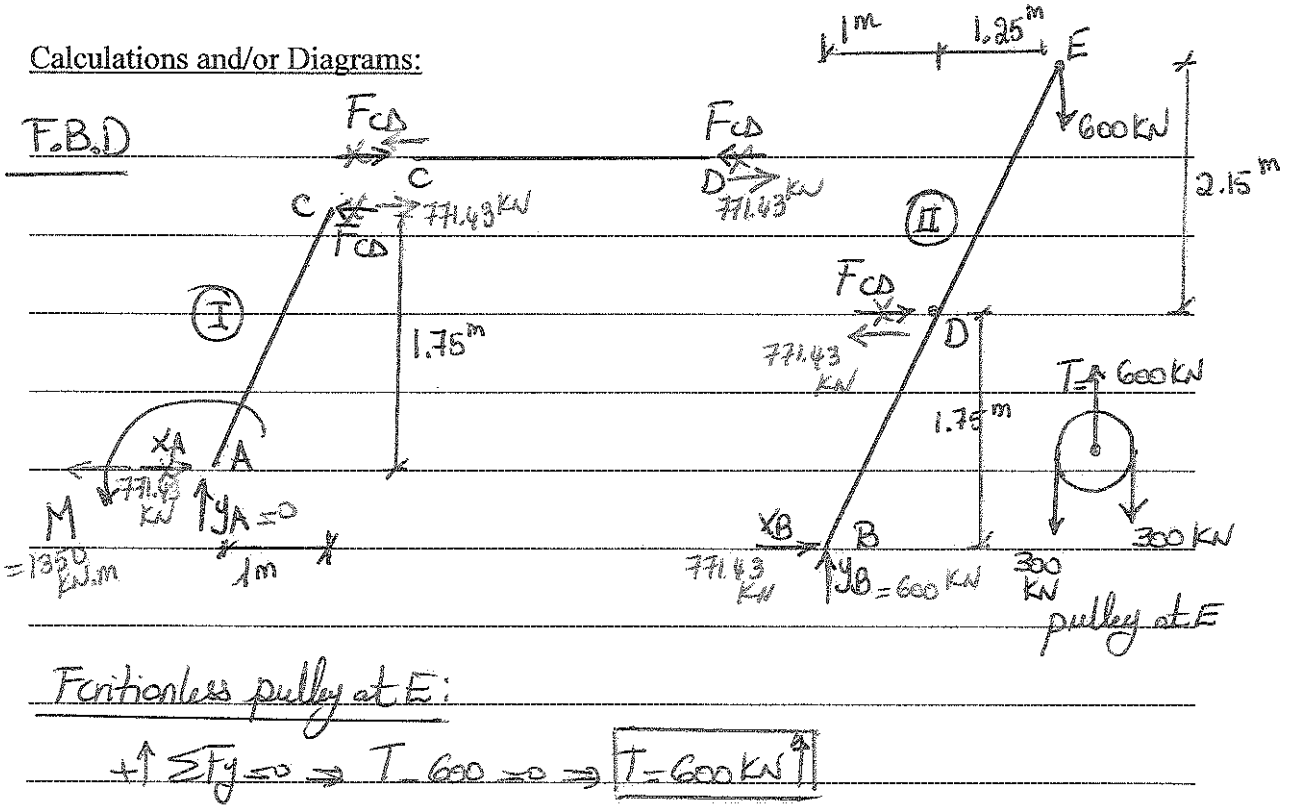

**Figure III**

The frame shown in Figure III is composed of three members **AC**, **CD** and **BE**, connected by pins at **C**, and **D**. A frictionless pulley is attached to the member **BE** with a pin at **E**.

1. Determine the external reactions at pins A and D and the moment at A, and the internal forces of the frame at points C, D and E. *(35 points)*

*Note: FBD must be included*

Calculations and/or Diagrams:




Frictionless pulley at E:

$+\uparrow \Sigma F_y = 0 \Rightarrow T - 600 = 0 \Rightarrow \boxed{T = 600\ kN\uparrow}$

Calculations and/or Diagrams (cont'd):

Part II:

$+\circlearrowleft \Sigma M_B = 0 \Rightarrow -F_{CD}(1.75) - 600(2.25) = 0 \Rightarrow F_{CD} = -771.43\ KN$

$\therefore \boxed{F_{CD} = 771.43\ KN \leftarrow}$

$+\rightarrow \Sigma F_x = 0 \Rightarrow x_B - 771.43 = 0 \Rightarrow \boxed{x_B = 771.43\ KN \rightarrow}$

$+\uparrow \Sigma F_y = 0 \Rightarrow y_B - 600 = 0 \Rightarrow \boxed{y_B = 600\ KN \uparrow}$

Part I:

$+\rightarrow \Sigma F_x = 0 \Rightarrow x_A + 771.43 = 0 \Rightarrow x_A = -771.43\ KN$

$\therefore \boxed{x_A = 771.43\ KN \leftarrow}$

$+\uparrow \Sigma F_y = 0 \Rightarrow \boxed{y_A = 0}$

$+\circlearrowleft \Sigma M_A = 0 \Rightarrow M - 771.43(1.75) = 0 \Rightarrow \boxed{M = 1350\ KN.m \curvearrowright}$

Calculations and/or Diagrams (cont'd):

## EXTRA SHEET 1: Continued from page ____

**Name:** _____ **ID#:** _____

Calculations and/or Diagrams:

## EXTRA SHEET 2: Continued from page _____

**Name:** _____ **ID#:** _____

Calculations and/or Diagrams: