UNIVERSITY OF TORONTO
Faculty of Applied Science and Engineering

TERM TEST, OCTOBER 23, 2012, 12:10-1:40 p.m.
First Year - Programs 1,2,3,4,6,7, 8 and 9

CIV 100F - MECHANICS
Examiner: Staff in Civil Engineering

FAMILY NAME: SOLUTIONS **GIVEN NAMES:** 2012.

(Please **print clearly**)

STUDENT NUMBER: ______________________

CIRCLE THE NAME OF YOUR LECTURER AND YOUR GROUP LETTER

A	**Kuhn**, Eva	**D**	**El-Diraby**, Tamer	**G**	**Guner**, Serhan
B	**Mercan**, Oya	**E**	**Johnson**, David	**H**	**Seica**, Michael
C	**Panesar**, Daman	**F**	**Kamaleddine**, Fouad	**J**	**Packer**, Jeff

CIRCLE MODEL NUMBER OF CALCULATOR

CASIO 260 SHARP 520 TI 30

NOTES:

1. Be sure you have all 4 sheets of this examination paper. If you need more space for a question please use the back of the preceding question. In all cases indicate clearly where your calculations are continued.
2. Answer all 3 (three) equal-valued questions.
3. No other paper will be accepted for marking nor allowed on the desk.
4. The permissible calculators are listed above.

DO NOT WRITE IN THIS SPACE.

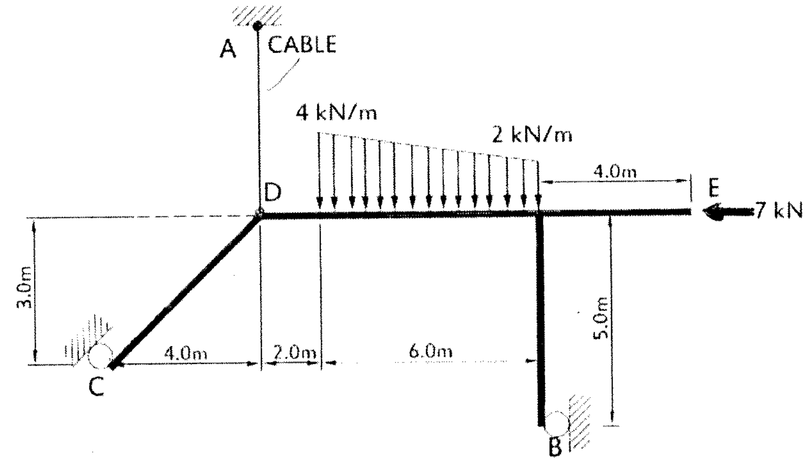
1.	/10
2.	/10
3.	/10
TOTAL	/30

Name DTJ 2012

1.) The member shown is supported by a **vertical cable AD** and **rollers at both locations C and B.** For the given loading and if the system is in equilibrium:

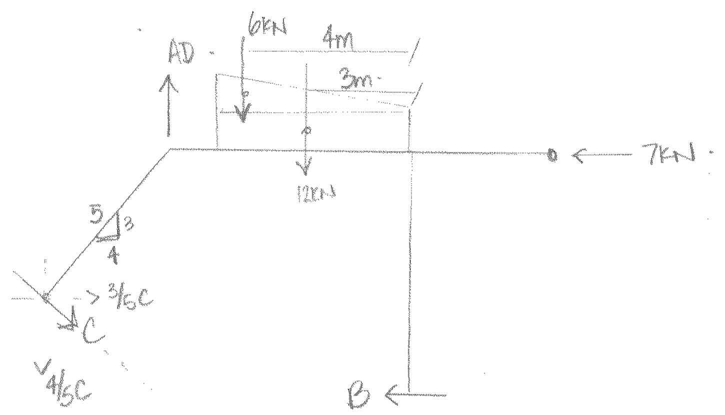
a) Draw a separate free body diagram of the entire body showing all forces

b) Determine the reaction forces at C and B, and the tension in cable AD.



* For this problem there are at least 4 different solutions

FREE BODY DIAGRAM



1ST SOLUTION

$\circlearrowright^{+} \Sigma M_D = 0 \quad -5(C) + 6(4) + 12(5) - 5(B) = 0$ simplify: $5B - 5C + 84 = 0$

$\therefore B - C + 16.8 = 0$ (EQ 1)

$\overset{+}{\rightarrow} \Sigma F_x = 0 \quad \frac{3}{5}C - 7 - B = 0. \quad \therefore B = \frac{3}{5}C - 7$ (EQ 2)

SUB EQ 2 INTO 1.

IN 1. $B - C + 16.8 = 0 \rightarrow (\frac{3}{5}C - 7) - C + 16.8 = 0 \quad \therefore -\frac{2}{5}C + 9.8 = 0.$

SOLVING $\underline{C = 24.5\ \text{kN} \searrow}$. → in 2 $\frac{3}{5}(24.5) - 7 - B = 0$; SOLVING $\underline{B = 7.70\ \text{kN} \leftarrow}$

$+\uparrow \Sigma F_y = 0 \quad -\frac{4}{5}C + AD - 6 - 12 = 0$. SUB $C = 24.5\ \text{kN}$; SOLVE $\underline{AD = 37.6\ \text{kN} \uparrow = 37.6\ \text{kN (T)}}$

2ND SOLUTION

$\circlearrowright^{+} \Sigma M_C = 0 \quad -AD(4) + 6(8) + 12(9) - 7(3) + 2B = 0$; $-4AD + 2B + 135 = 0$ (EQ 1)

$\overset{+}{\rightarrow} \Sigma F_x = 0 \quad \frac{3}{5}C + 0(AD) - B = 7$; $\frac{3}{5}C - B = 7$ (EQ 2)

$+\uparrow \Sigma F_y = 0 \quad -\frac{4}{5}C + AD = 18$; $-\frac{4}{5}C + AD = 18$ (EQ 3)

· SOLVE THE 3X SYSTEM OF EQUATIONS.

SOLVING $\underline{AD = 37.6\ \text{kN (T)}\ ;\ C = 24.5\ \text{kN} \searrow\ ;\ B = 7.70\ \text{kN} \leftarrow}$

3RD SOLUTION

$\circlearrowright^{+} \Sigma M_B = 0 \quad \frac{3}{5}C(2) - \frac{4}{5}C(12) + 8AD - 24 - 36 - 35 = 0$; $-\frac{42}{5}C + 8AD - 95 = 0$ (EQ 1)

$+\uparrow \Sigma F_y = 0 \quad -\frac{4}{5}C + AD - 12 - 6 = 0.$; $-\frac{4}{5}C + AD = 18$; $AD = 18 + \frac{4}{5}C$ (EQ 2)

SUB 2 INTO 1 $\quad -\frac{42}{5}C + 8(18 + \frac{4}{5}C) - 95 = 0$; $-2C + 144 - 95 = 0.$

SOLVING $\underline{C = 49/2 = 24.5\ \text{kN} \searrow}$ in EQ 2 $\underline{AD = 18 + \frac{4}{5}(24.5) = 37.6\ \text{kN (T)}}$.

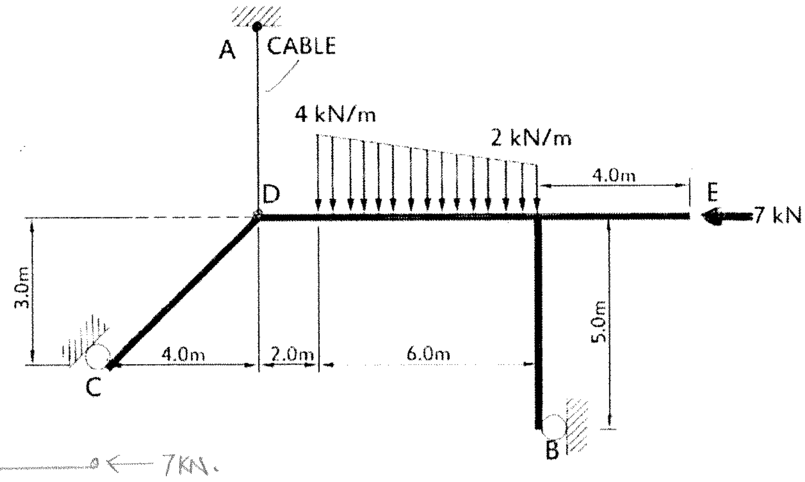
$\overset{+}{\rightarrow} \Sigma F_x = 0 \quad \frac{3}{5}C - B - 7 = 0 \quad \therefore \frac{3}{5}(24.5) - B - 7 = 0 \quad \therefore \underline{B = 7.70\ \text{kN} \leftarrow}$

 Name DTJ 2012

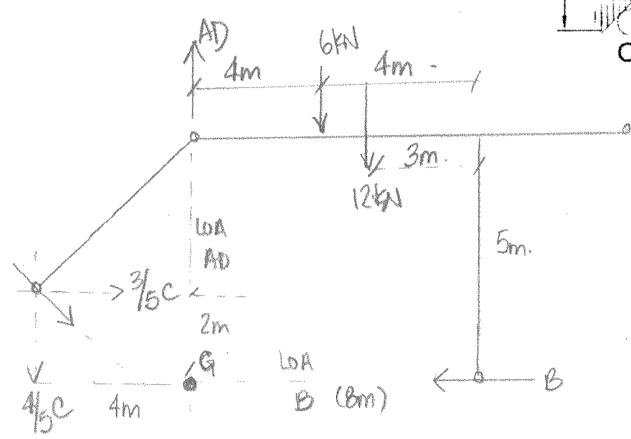
1.) The member shown is supported by a **vertical cable AD** and **rollers at both locations C and B.** For the given loading and if the system is in equilibrium:

a) Draw a separate free body diagram of the entire body showing all forces

b) Determine the reaction forces at C and B, and the tension in cable AD.



4TH SOLUTION



• In this case You CAN TAKE $\Sigma M_G = 0$.
• this way we can get C w/ one equation.

$\overset{\curvearrowright}{+} \Sigma M_G = 0$ $\quad -7(5) + 6(4) + 12(5) + \frac{3}{5}C(2) - \frac{4}{5}(4)C = 0.$

$-35 + 24 + 60 + \frac{6}{5}C - \frac{16}{5}C = 0.$

$\therefore -\frac{10}{5}C = -49 \quad \therefore 2C = 49 \; ; \; \underline{C = 24.5 \text{ KN.}}$

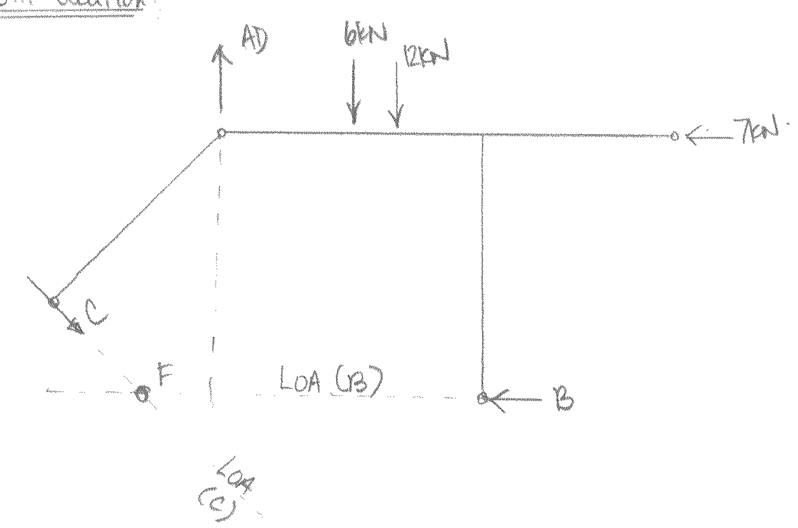
$\overset{+}{\rightarrow} \Sigma F_x = 0 \quad \frac{3}{5}(24.5) - 7 - B = 0.$

$\therefore \underline{B = 7.70 \text{ KN} \leftarrow}$

$+\uparrow \Sigma F_y = 0 \quad -\frac{4}{5}C + AD - 6 - 12 = 0.$

$-\frac{4}{5}(24.5) + AD - 18 = 0 \quad ; \quad \underline{AD = 37.6 \text{ KN} \uparrow}$

5TH SOLUTION



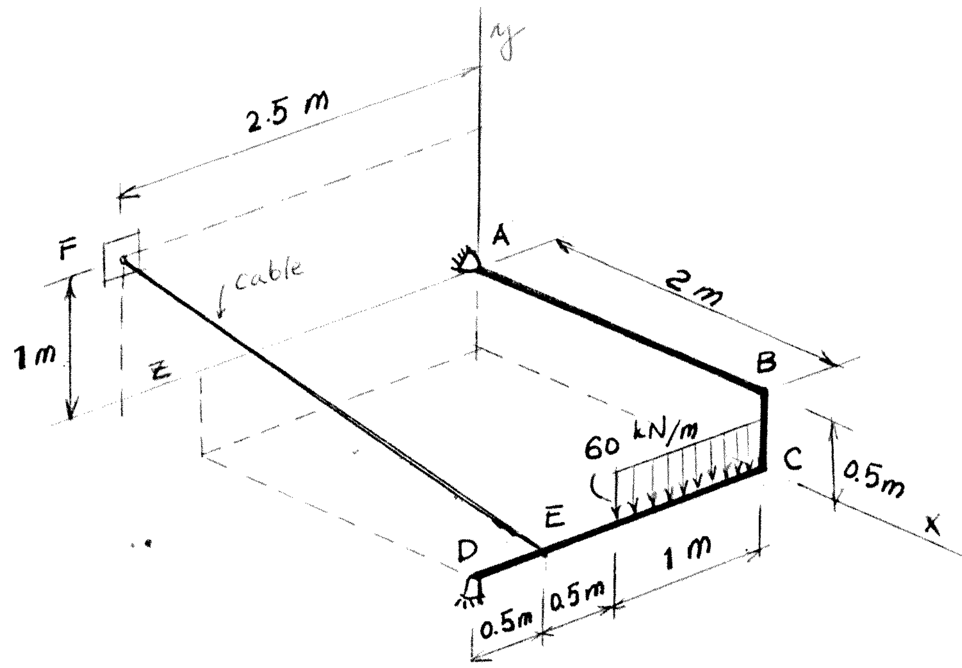
ALTERNATIVELY
AS BEFORE YOU CAN
LOCATE POINT F WHERE
TWO LINE OF ACTIONS
INTERSECT & SOLVE (F).
YOU CAN SOLVE THIS IN A SIMILAR
MANNER TO SOLUTION 4 ABOVE.

Name DTJ 2012.

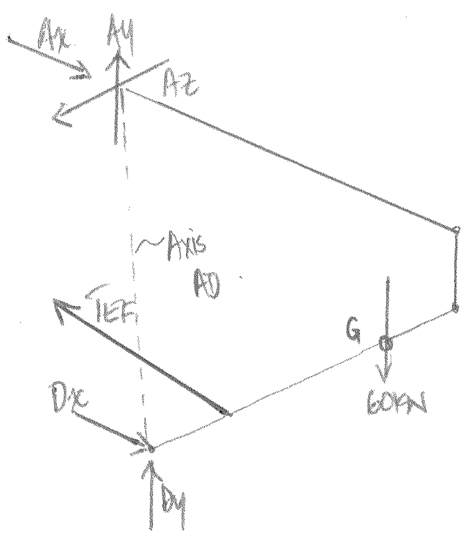
2. The member **ABCD (AB** is parallel to **x**, **BC** is parallel to **y** and **CD** is parallel to **z** axis), has negligible weight and is supported by a ball-and socket at **A**, by a ball-and socket at **D** which has been modified to provide reactions only in the **x** and **y** direction, and by **cable EF**.

a) Draw the Free Body Diagram of **ABCD**.

b) Determine the tension in **cable EF**.



a.) FBD



THERE ARE 2 SOLUTIONS : MOMENT ABOUT AN AXIS AD ; MOMENT ABOUT POINT A.

AXIS SOLUTION

$$u_{AD} = \frac{2\vec{i} - 0.5j + 2k}{\sqrt{2^2 + 0.5^2 + 2^2}} = \frac{2i - 0.5j + 2k}{\sqrt{8.25}} = 0.696i - 0.174j + 0.696k.$$

$$\vec{T}_{EF} = T_{EF} \cdot u_{EF} = T_{EF}\left(\frac{-2i + 1.5j + 1k}{\sqrt{2^2+1.5^2+1^2}}\right) = T_{EF}\left(\frac{-2i+1.5j+k}{\sqrt{7.25}}\right) = T_{EF}\left(-0.7428i + 0.557j + 0.3714k\right)$$

$\vec{W} = -60j$; $r_{DG} = -1.5K$, $r_{DE} = -0.5k$ * Using point D on axis AD is simpler

$$\Sigma M_{AD} = \begin{vmatrix} 0.696 & -0.174 & 0.696 \\ 0 & 0 & -1.5 \\ 0 & -60 & 0 \end{vmatrix} + T_{EF}\begin{vmatrix} 0.696 & -0.174 & 0.696 \\ 0 & 0 & -0.5 \\ -0.743 & 0.557 & 0.371 \end{vmatrix} = 0$$

$$\therefore 0 = -0.696(-60)(-1.5) + T_{EF}\left[(-0.696)(0.557)(-0.5) + (-0.174)(-0.5)(-0.743)\right] = 0.$$

$$0 = -62.64 + T_{EF}(0.1292) \; ; \; \therefore T_{EF} = 484.8 \text{ kN (T)} \approx \underline{\underline{485 \text{ kN (T)}}}$$

POINT SOLUTION

$\Sigma M_A = 0$; $r_{AG} = 2i - 0.5j + 0.5k$; $r_{AE} = 2i - 0.5j + 1.5k$; $r_{AD} = 2i - 0.5j + 2k$.

$$\Sigma M_A = 0 = \begin{vmatrix} i & j & k \\ 2 & -0.5 & 0.5 \\ 0 & -60 & 0 \end{vmatrix} + T_{EF}\begin{vmatrix} i & j & k \\ 2 & -0.5 & 1.5 \\ -0.743 & 0.557 & 0.371 \end{vmatrix} + \begin{vmatrix} i & j & k \\ 2 & -0.5 & 2 \\ Dx & Dy & 0 \end{vmatrix} = 0$$

$$0 = i(60)(0.5) + k(-120) + T_{EF}\Big[i\big((-0.5)(0.371) - (0.557)(1.5)\big) - j\big(2(0.371) - 1.5(-0.743)\big) + k\big(2(0.557) - (-0.5)(-0.743)\big)\Big]$$
$$+ i(-2Dy) - j(-2Dx) + k(2Dy + 0.5Dx) = 0.$$

* Very Complex Solution.

$\Sigma M_x = 0$ i : $30 - 1.021 T_{EF} - 2Dy = 0$. ①

$\Sigma M_y = 0$ j : $-1.8565(T_{EF}) + 2Dx = 0$ ②

$\Sigma M_z = 0$ K : $-120 + 0.7425 T_{EF} + 2Dy + 0.5Dx = 0$. ③

3 EQUATIONS } SOLVE THIS 3X3 MATRIX } YIELDS

$T_{EF} = 484.8 = 485$ kN.

$Dx = 450$ kN

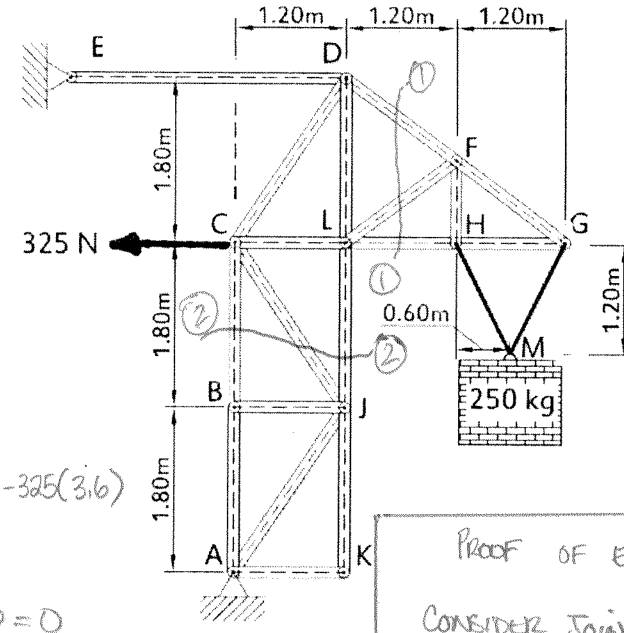
$Dy = -232.5 = 233$ kN

Name DTJ 2012

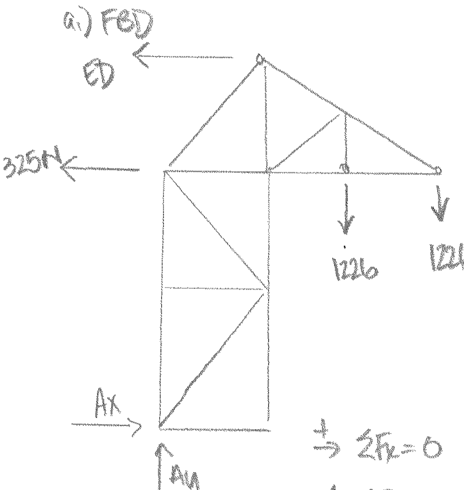
3. Shown is a truss supported by a **pin at A** and **pin-connected member ED**. All truss connections are pins. The truss is carrying a load of 250 kg by two cables **MH** and **MG,** and the truss is also carrying a force of 325 N **at C**. The truss is in equilibrium and the weight of the truss members is negligible.

a) Draw a free body diagram of the truss and determine the reactions at the two supports.

b) Using the ***method of sections***, determine the forces in the following members of the truss: **FD, FL, HL and CJ**. Please ensure that for every step of your analysis you have an accompanying free body diagram drawn. Also indicate if the forces are in tension or compression.



a.) FBD



REACTIONS

$\circlearrowright \Sigma M_A = 0$

$0 = 1226(2.4) + 1226(3.6) - 325(3.6) - ED(5.4) = 0$

$0 = 7356 - 1170 - 5.4ED = 0$

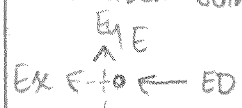
$ED = 1146 \text{ N} \leftarrow$

$\xrightarrow{+} \Sigma F_x = 0 \quad Ax - 1146 - 325 = 0 \quad \therefore Ax = 1471 \text{ N} \rightarrow$

$+\uparrow \Sigma F_y = 0 \quad Ay - 1226 \times 2 = 0 \quad \therefore Ay = 2452 \text{ N} \uparrow$

PROOF OF ED

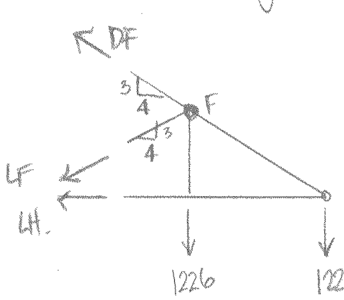
CONSIDER JOINT (E)



$\xrightarrow{+} \Sigma F_x = 0 \quad Ex = ED$

$+\uparrow \Sigma F_y = 0 \quad Ey = 0$

b.) Use Cut ① - ① (right side)



$\circlearrowright \Sigma M_F = 0 \quad 1226(1.2) + LH(0.9) = 0$

$\therefore LH = 1635 \text{ N (C)}$

$\uparrow \Sigma F_y = 0 \quad 1635 - \frac{4}{5}DF - \frac{4}{5}FL = 0$

$\therefore DF + FL = 2043.75 \text{ N} \quad$ EQ ①

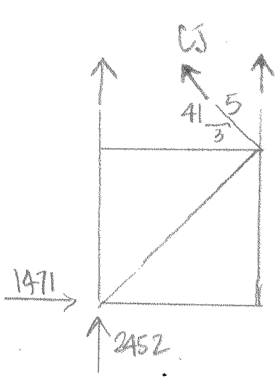
$\xrightarrow{+} \Sigma F_x = 0 \quad -2452 + \frac{3}{5}DF - \frac{3}{5}FL = 0$

$\therefore DF - FL = 4087 \quad$ EQ ②

SOLVE ① ; ② WHICH YIELDS $DF = 3095 \text{ N (T)}$; $FL = -1022 \text{ N} = 1022 \text{ N (C)}$

$\therefore LH = 1.635 \text{ kN (C)}$; $DF = 3.10 \text{ kN (T)}$; $FL = 1.022 \text{ kN (C)}$

Use Cut ② - ② Bottom to solve CJ.



$\xrightarrow{+} \Sigma F_x = 0 \quad 1471 - \frac{3}{5}CJ = 0$

$\therefore CJ = 2452 \text{ N (T)} = 2.45 \text{ kN (T)}$