Université d'Ottawa
Faculté de génie

University of Ottawa
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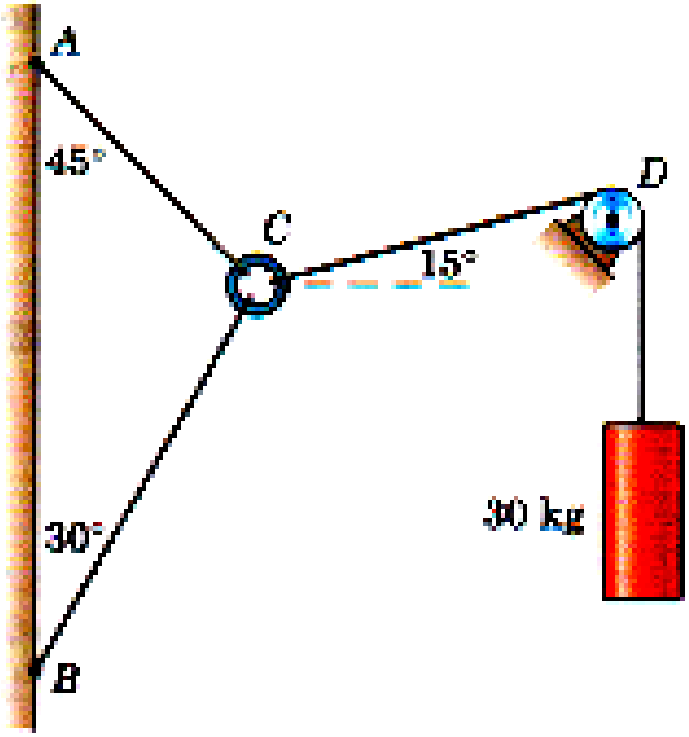
GNG 1105 B- Engineering Mechanics

Mid-Term Exam — 03 November 2016
Professor A. Skaff — Time: 80 min.

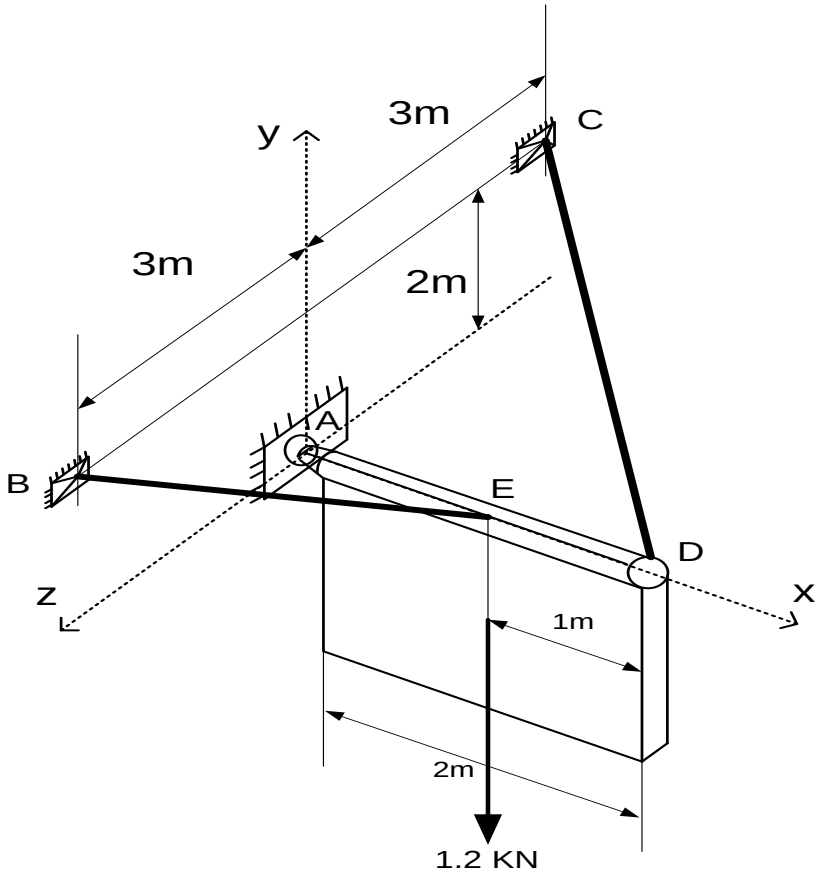
Closed Book. Non programmable calculators are allowed. Free-body diagrams must be drawn wherever appropriate.

1. **(15 marks)** Three cables are joined at the junction ring *C*. Determine the tensions in cables *AC* and *BC* caused by the weight of the 30 kg cylinder.



2. (15 marks) A 1m×2m sign of uniform density weighs 1.2 kN is held in place by a ball-and-socket support at point *A* and by two cables *EB* and *DC*.

a) Write the tensions in cables *EB* and *DC* in vector form.
b) Determine the tensions in cables *EB* and *DC*.



Good luck,

GNG 1105 B

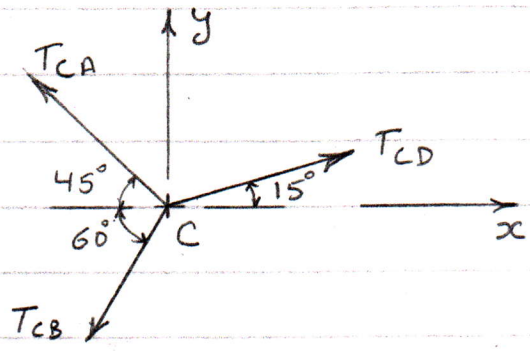
ENGINEERING MECHANICS

MID-TERM EXAM — NOV. 3, 2016

SOLUTIONS

1.

FBD - Point C



$30\,kg \times 9.81 = 294.3\,N$

$T_{CD} = 294.3\,N$

$\pm \rightarrow \Sigma F_x = 0$

$T_{CD} \times \cos 15^\circ - T_{CA} \times \cos 45^\circ - T_{CB} \times \cos 60^\circ = 0$

$0.966\,T_{CD} - 0.707\,T_{CA} - 0.500\,T_{CB} = 0$

$0.966 \times 294.3 - 0.707\,T_{CA} - 0.500\,T_{CB} = 0$

$284.294 - 0.707\,T_{CA} - 0.500\,T_{CB} = 0$ ——— (1)

$+\uparrow \Sigma F_y = 0$

$T_{CD} \times \sin 15^\circ + T_{CA} \times \sin 45^\circ - T_{CB} \times \sin 60^\circ = 0$

$294.3 \times 0.259 + 0.707\,T_{CA} - 0.866\,T_{CB} = 0$

$76.224 + 0.707\,T_{CA} - 0.866\,T_{CB} = 0$ ——— (2)

Solve eqs (1) & (2) simultaneously:

Add the 2 equations

$360.518 - 1.366\,T_{CB} = 0$

i.e. $1.366\,T_{CB} = 360.518$

$\therefore T_{CB} = \frac{360.518}{1.366} = \underline{263.922\,N}$ ANS.

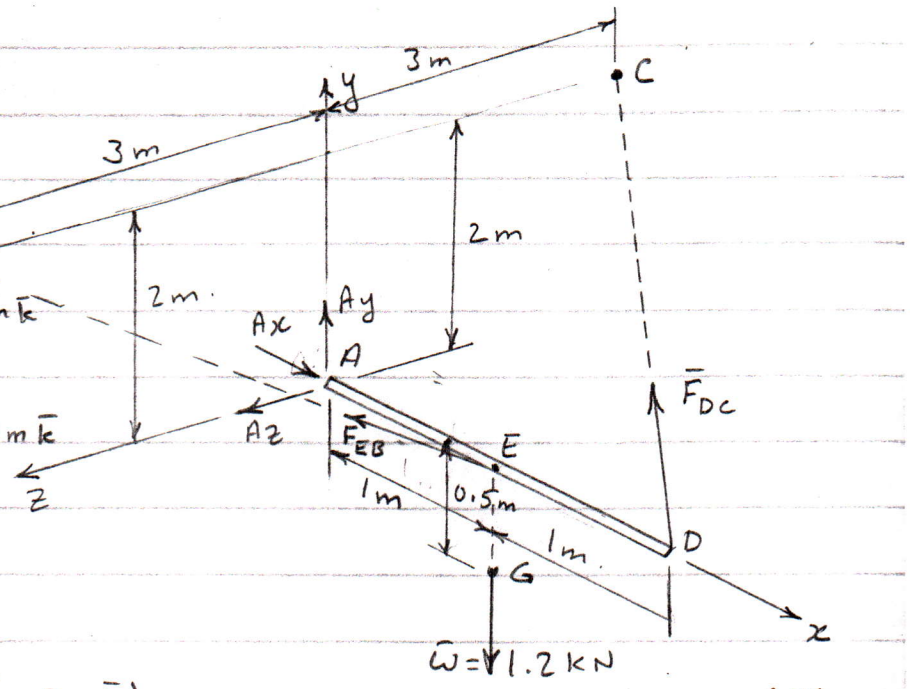
Insert in eq. (1): $284.294 - 0.707\,T_{CA} - 0.500 \times 263.922 = 0$

$0.707\,T_{CA} = 284.294 - 131.961 = 152.333$

$\therefore T_{CA} = \frac{152.333}{0.707} = \underline{215.464\,N}$ ANS.

2.

a) FBD - Rod AD



$\bar{EB} = -1.0m\,\bar{i} + 2.0m\,\bar{j} + 3.0m\,\bar{k}$

$EB = \sqrt{14} = 3.74m.$

$\bar{DC} = -2.0m\,\bar{i} + 2.0m\,\bar{j} - 3.0m\,\bar{k}$

$DC = \sqrt{17} = 4.12m.$

$$\bar{F}_{EB} = F_{EB}\,\bar{\lambda}_{EB} = F_{EB}\frac{\bar{EB}}{EB}$$

$$= \frac{F_{EB}}{3.74}(-1.0\,\bar{i} + 2.0\,\bar{j} + 3.0\,\bar{k}) \quad \text{ANS.}$$

$$\bar{F}_{DC} = F_{DC}\,\bar{\lambda}_{DC} = F_{DC}\frac{\bar{DC}}{DC}$$

$$= \frac{F_{DC}}{4.12}(-2.0\,\bar{i} + 2.0\,\bar{j} - 3.0\,\bar{k}) \quad \text{ANS.}$$

b) $\Sigma \bar{M}_A = \bar{r}_{E/A}\,\bar{F}_{EB} + \bar{r}_{D/A}\,F_{DC} + \bar{r}_{E/A}\,\bar{W} = 0$

where $\bar{r}_{E/A} = +1.0m\,\bar{i}$ $\bar{r}_{D/A} = 2.0m\,\bar{i}$

$\bar{k}\ \bar{j}\ \bar{i}$

$$\therefore \Sigma \bar{M}_A = 1.0\,\bar{i} \times \frac{F_{EB}}{3.74}(-1.0\,\bar{i} + 2.0\,\bar{j} + 3.0\,\bar{k})$$

$$+ 2.0\,\bar{i} \times \frac{F_{DC}}{4.12}(-2.0\,\bar{i} + 2.0\,\bar{j} - 3.0\,\bar{k}) + 1.0\,\bar{i}\,(-1.2\,\text{kN}\,\bar{j}) = 0$$

$$\Sigma M_A = 0.53\,F_{EB}\,\bar{k} - 0.80\,F_{EB}\,\bar{j} + 0.97\,F_{DC}\,\bar{k} + 1.46\,F_{DC}\,\bar{j} - 1.2\,\bar{k} = 0$$

Equate coefficients of $\bar{j}$ and $\bar{k}$ to zero.

$\bar{j}$: $-0.80\,F_{EB} + 1.46\,F_{DC} = 0$ ——— (1)

$\bar{k}$: $0.53\,F_{EB} + 0.97\,F_{DC} - 1.2 = 0$ ——— (2)

Solve (1) and (2) simultaneously:

Multiply (1) by 0.53 and (2) by 0.80 and add:

$0.774\,F_{DC} + 0.776\,F_{DC} - 0.96 = 0$; $1.55\,F_{DC} = 0.96$; $\therefore F_{DC} = \frac{0.96}{1.55} = \underline{0.62\,\text{kN}}$ ANS.

Insert in (1): $-0.80\,F_{EB} + 1.46 \times 0.62 = 0$

$0.80\,F_{EB} = 0.91$; $\therefore F_{EB} = \frac{0.91}{0.80} = \underline{1.14\,\text{kN}}$ ANS.