ME 205 – STATICS – FALL 2014
SECTION 04

HOMEWORK #4 SOLUTION

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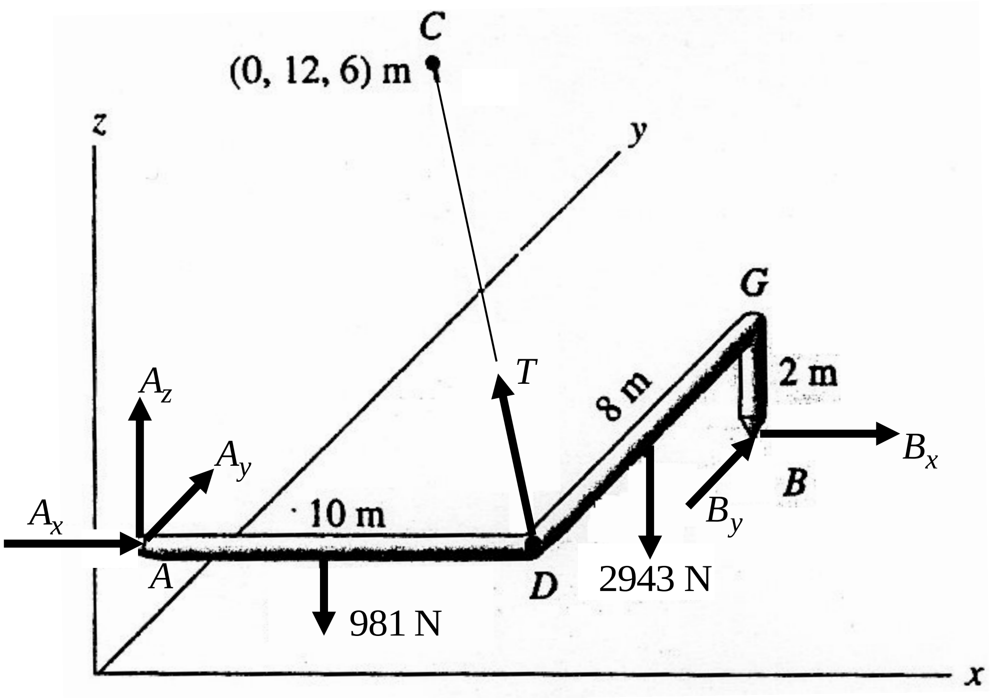
Solution:

The free-body diagram of the bent rod *ADGB* can be obtained as follows,



Note that, there are six unknown force magnitudes shown on the free-body diagram. Two different methods can be applied to solve this problem. But first, vector components of *T* should be found,

$$\vec{r}_{DC} = \{-10i + 11.5j + 4k\} \text{ m} \tag{1.1}$$

$$\vec{u}_{DC} = \frac{\vec{r}_{DC}}{\left|\vec{r}_{DC}\right|} = \{-0.634i + 0.729j + 0.254k\} \tag{1.2}$$

$$\vec{T} = \{-0.634T \cdot i + 0.729T \cdot j + 0.254T \cdot k\} \tag{1.3}$$

1. Method

Note that, sum of the moments about axis passing through points *A* to *B* should be zero,

$$\sum M_{AB} = \vec{u}_{AB} \cdot \sum\left(\vec{r} \times \vec{F}\right) = 0 \tag{1.4}$$

Here, $\vec{r}$ represents a position vector drawn from *any point* on the axis *DA* to any point on the line of action of the force $\vec{F}$. Therefore, taking moment about point *A*,

$$\begin{aligned}\sum\left(\vec{r} \times \vec{F}\right) = &\left[5i \times (-981k)\right] + \left[(10i + 4j) \times (-2943k)\right] \\ &+ \left[(10i) \times (-0.634T \cdot i + 0.729T \cdot j + 0.254T \cdot k\ )\right]\end{aligned} \tag{1.5}$$

$$\sum\left(\vec{r}\times\vec{F}\right)=\left\{-11772\cdot i+\left(34335-2.54T\right)\cdot j+7.29T\cdot k\right\} \tag{1.6}$$

Note that, forces at point *B* is not considered since these forces do not create any moments about axis passing through points *A* to *B*. Also,

$$\vec{r}_{AB}=10i+8j-2k \tag{1.7}$$

$$\vec{u}_{AB}=\frac{\vec{r}_{AB}}{\left|\vec{r}_{AB}\right|}=\left\{0.772i+0.617j-0.154k\right\} \tag{1.8}$$

Using Equations (1.8) and (1.6) in (1.4), *T* can be directly obtained.

$$\sum M_{AB}=\left\{0.772i+0.617j-0.154k\right\}\cdot\left\{-11772\cdot i+\left(34335-2.54T\right)\cdot j+7.29T\cdot k\right\}=0 \tag{1.9}$$

$$-9088+21185-1.567T-1.123T=0 \tag{1.10}$$

Therefore, tension in the cable is obtained as,

$$\underline{\underline{T=4497.4\text{ N}}} \tag{1.11}$$

2. Method

Six equations of equilibrium should be written to obtain the six unknown force magnitudes. Applying the force equation equilibrium,

$$\sum F_x=0\;\rightarrow\;A_x+B_x-0.634T=0 \tag{1.12}$$

$$\sum F_y=0\;\rightarrow\;A_y+B_y+0.729T=0 \tag{1.13}$$

$$\sum F_z=0\;\rightarrow\;A_z+0.254T-981N-2943N=0 \tag{1.14}$$

Summing the moments about point *A*,

$$\sum\vec{M}_A=0 \tag{1.15}$$

$$\sum M_x=0\;\rightarrow\;-2943\cdot 4+B_y\cdot 2=0 \tag{1.16}$$

$$\sum M_y=0\;\rightarrow\;981\cdot 5+2943\cdot 10-B_x\cdot 2-0.254T\cdot 10=0 \tag{1.17}$$

$$\sum M_z=0\;\rightarrow\;0.729T.10+B_y\cdot 10-B_x\cdot 8=0 \tag{1.18}$$

Using Equations (1.12)-(1.18), *T* can be obtained as,

$$\underline{\underline{T=4497.4\text{ N}}} \tag{1.19}$$