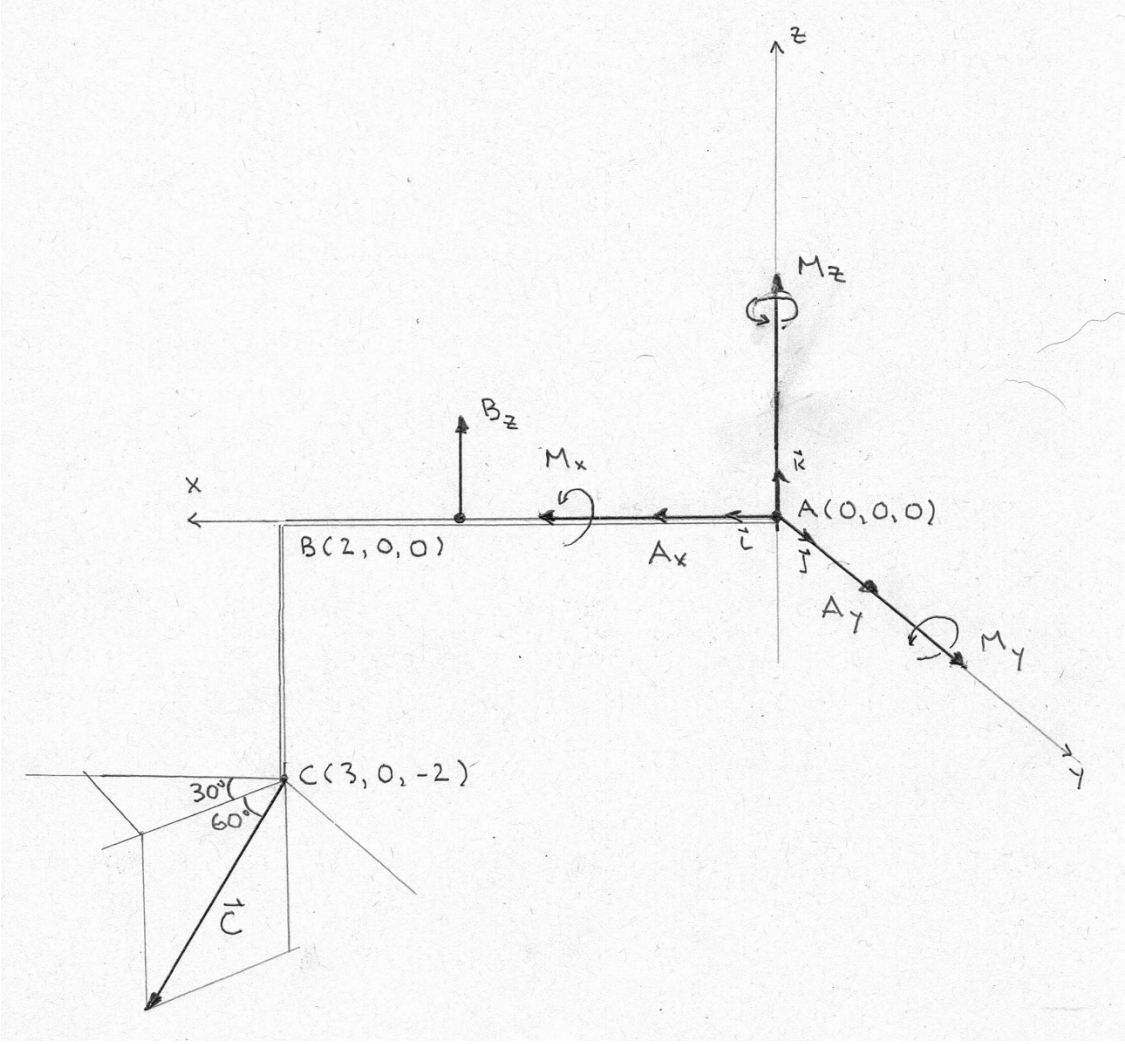
SOLUTION TO QUESTION 1 (15 MARKS) page 1

a) Free-Body Diagram (4 marks)



Coordinates:

$$A = (0,0,0) \text{ m}$$
$$B = (2,0,0) \text{ m}$$
$$C = (3,0,-2) \text{ m}$$

SOLUTION TO QUESTION 1 (15 MARKS) page 2

b) Cartesian component force equations of equilibrium (4 marks)

Forces:

$$\vec{A} = A_x\vec{i} + A_y\vec{j}$$
$$\vec{B} = B_z\vec{k}$$
$$\vec{C} = 800(\cos 60^\circ \cos 30^\circ \vec{i} + \cos 60^\circ \sin 30^\circ \vec{j} - \sin 60^\circ \vec{k})$$

$$\sum F_x = 0: \qquad A_x + 800\cos 60^\circ \cos 30^\circ = 0 \qquad (1)$$
$$\sum F_y = 0: \qquad A_y + 800\cos 60^\circ \sin 30^\circ = 0 \qquad (2)$$
$$\sum F_z = 0: \qquad B_z - 800\sin 60^\circ = 0 \qquad (3)$$

c) Vector moment equation of equilibrium at point *C* (3 marks)

$$\vec{r}_{CA} = \vec{r}_A - \vec{r}_C = -3\vec{i} + 2\vec{k}$$
$$\vec{r}_{CB} = \vec{r}_B - \vec{r}_C = -\vec{i} + 2\vec{k}$$

Couple Moment:

$$\vec{M}_A = M_x\vec{i} + M_y\vec{j} + M_z\vec{k}$$

$$(\vec{M}_R)_C = \sum \vec{M} + \sum(\vec{r}\times\vec{F}) = M_x\vec{i} + M_y\vec{j} + M_z\vec{k} + \vec{r}_{CA}\times\vec{A} + \vec{r}_{CB}\times\vec{B} =$$
$$M_x\vec{i} + M_y\vec{j} + M_z\vec{k} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ -3 & 0 & 2 \\ A_x & A_y & 0 \end{vmatrix} + \begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ -1 & 0 & 2 \\ 0 & 0 & B_z \end{vmatrix} = 0$$

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d) Cartesian component moment equations of equilibrium: (2 marks)

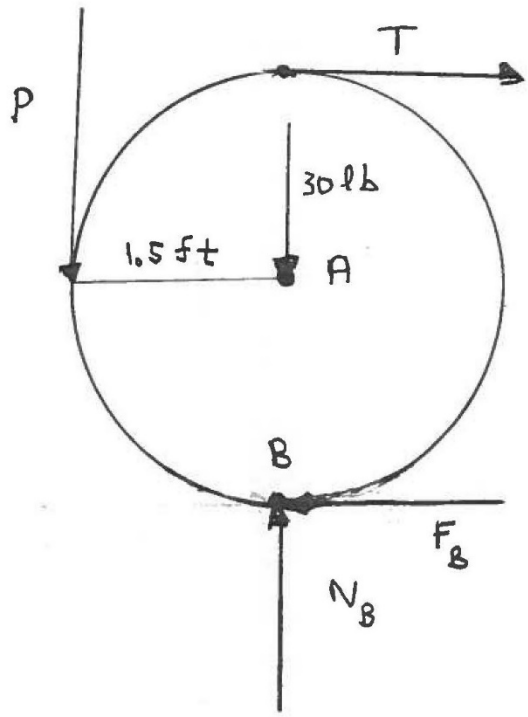
$$M_x - 2A_y = 0 \quad (4)$$
$$M_y + 2A_x + B_z = 0 \quad (5)$$
$$M_z - 3A_y = 0 \quad (6)$$

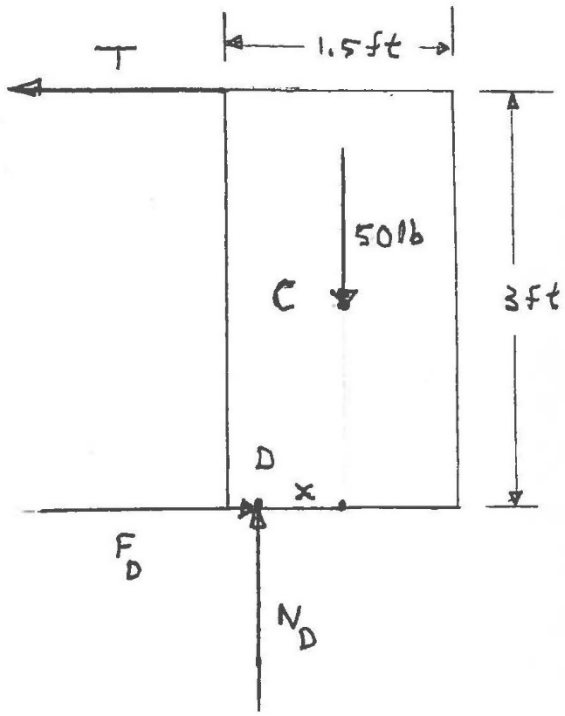
e) Solution to the equations of equilibrium: (2 marks)

$$A_x = -346 \text{ N} \qquad A_y = -200 \text{ N} \qquad B_z = 693 \text{ N}$$
$$M_x = -400 \text{ Nm} \qquad M_y = 0.00 \text{ Nm} \qquad M_z = -600 \text{ Nm}$$

The negative signs indicate that the reaction components are directed along the negative coordinate axes.

SOLUTION TO QUESTION 2 (15 MARKS) page 1





b) Equations of equilibrium for the wheel and for the block (6 marks)

Wheel:

$$\sum F_x = 0: \quad T = F_B = \mu_B N_B = 0.2 N_B \qquad (1)$$

$$\sum F_y = 0: \quad N_B = P + 30 \qquad (2)$$

$$\sum (M_z)_B = 0: \quad 1.5P = 3T \qquad (3)$$

Block:

$$\sum F_x = 0: \quad F_D = T \qquad (4)$$

$$\sum F_y = 0: \quad N_D = 50 \qquad (5)$$

$$\sum (M_z)_D = 0: \quad 50x = 3T \qquad (6)$$

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c) Solution to equations (1) to (5) (3 marks)

$P = 20.0$ lb $\quad T = F_B = F_D = 10.0$ lb

$N_B = 50.0$ lb $\quad N_D = 50.0$ lb

d) No impending sliding or impending tipping (2 marks)

$F_D = 10 < \mu_D N_D = 0.4(50) = 20 \Rightarrow$ no impending sliding

From equation (6): $x = 0.600$ ft < 0.750 ft $\Rightarrow$ no impending tipping