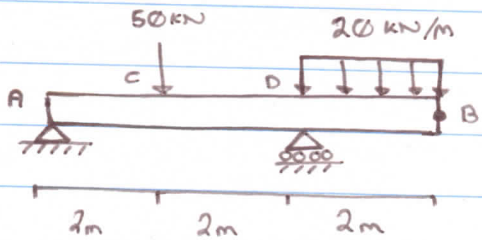
Nov. 28/16

(Q1)



$\Sigma M_A = 0$

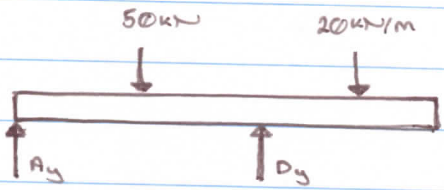
$\Rightarrow (-50)(2) + D_y(4) + (-20)(2)(5)$

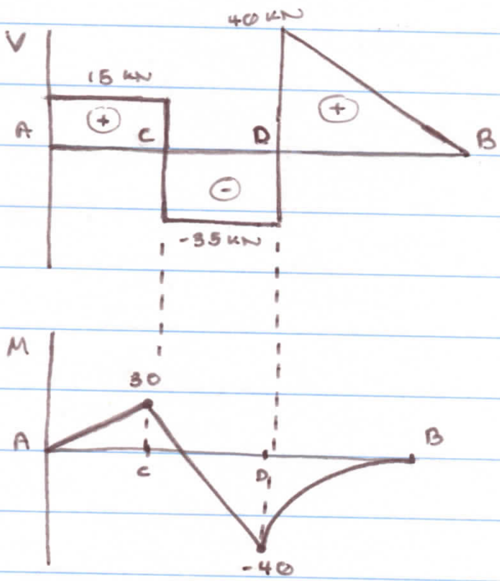
$\Rightarrow D_y = 75 \text{ kN}$ ↺+

$\Sigma F_y = 0$

$\Rightarrow 75 - 50 - 40 + A$

$\Rightarrow A = 15 \text{ kN}$ ↑+



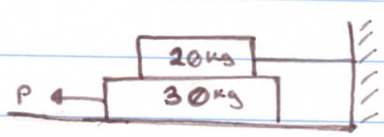


(From week 10 Tutorial)

(Q2) The coefficient of friction are $\mu_s = 0.40$ and $\mu_k = 0.30$ between all surfaces of contact. Determine the smallest force P required to start the 30 kg moving if cable AB

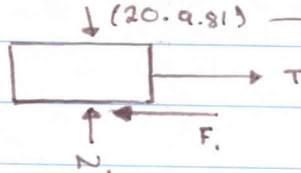
(a) is attached as shown

(b) is removed



a) Free-body diagram for the 20 kg block

$(20 \cdot 9.81) \longrightarrow 196.2 \text{ N} = W_1$



$\Sigma F_y = 0$

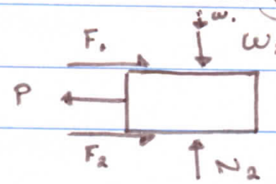
$N_1 = 196.2 \text{ N}$

$\Sigma F_x = 0$

$T - F_1 = 0 \Rightarrow T = 78.48 \text{ N}$

$F_1 = \mu_s(N_1) \Rightarrow 78.48 \text{ N}$

Free-body diagram for the 30 kg block:



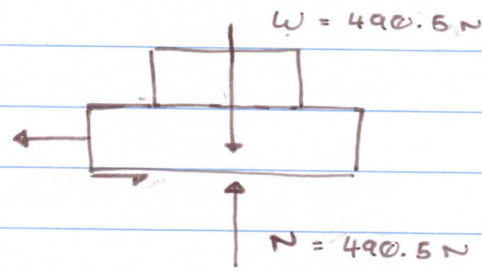
$\Sigma F_y = 0$

$W_2 = (30\ kg)(9.81\ m/s) = 294.3\ N$

$N = 196.2 + 294.3 = 490.5\ N$

$F_P = 0.4((490.5) = \boxed{196.2\ N}$

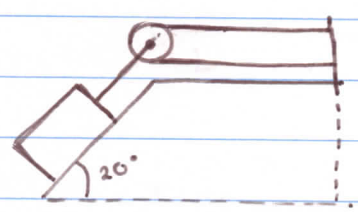
b) Free-body diagram of both blocks:



$\overset{+}{\leftarrow} \Sigma F = 0$

$P = \mu_s N = -0.4(490.5) = \boxed{196.2\ N}$

Q3 The arrangement exerts a horizontal force on the stationary crate. The crate weighs 800 N, and the coefficient of static friction between the crate and the ramp is $\mu_s = 0.4$



What is the largest force the rope can exert on the crate without causing it to move up the ramp?

a) If the rope exerts a 400 N force on the crate what is the friction force exerted on the crate by the ramp?

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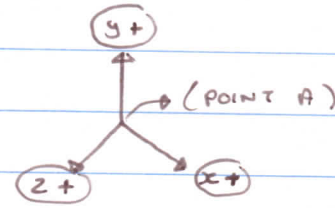
Review Problem 1



$\Sigma F_A = 0 \Rightarrow \vec{T}_{AB} + \vec{T}_{AC} + \vec{T}_{AD} + P + Q = 0$

$\Rightarrow T\vec{e}_{AB} + T\vec{e}_{AC} + T\vec{e}_{AD} + P\vec{e}_P + \emptyset = 0$

$\vec{AB} = (-960\ mm)i - (240\ mm)j + (380\ mm)k$

$AB = 1060\ mm$ (by $\sqrt{i^2+j^2+k^2}$)

$\vec{AC} = (-960mm)i - (240mm)j - (320\ mm)k$

$AC = 1040mm$

$\vec{AD}$ $(-960mm)i + (720mm)j - (220\ mm)k$

$AD = 1220mm$

$T_{AB} = T_{AB}e_{AB} = T_{AB}\left(-48/53\,i - 12/53\,j + 19/53\,k\right)$

$T_{AC} = T_{AC}e_{AC} = T_{AC}\left(-12/13\,i - 3/13\,j - 4/13\,k\right)$

$T_{AD} = T_{AD}e_{AD} = \left(305/1220\right)\left[(-960\ mm)i + (720\ mm)j - (220\ mm)k\right]$

$= -(240\ N)i + (180\ N)j - (55\ N)k$

$\vec{P} = P\vec{i}$

Substituting into $\Sigma F_A = 0$

$\vec{i}$: $P = 48/53\ T_{AB} + 12/13\ T_{AC} + 240N$

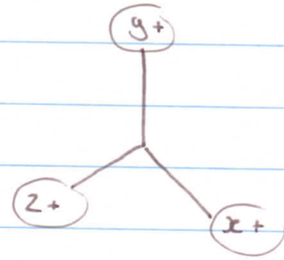
$\vec{j}$: $12/53\ T_{AB} + 3/13\ T_{AC} = 180N$

$\vec{k}$: $19/53\ T_{AB} - 4/13\ T_{AC} = 55N$

Solving: $T_{AB} = 446.7\ N$

$T_{AC} = 341.7\ N$

$P = 960\ N$



Review Problem 2

$\vec{M} = \vec{M}_1 + \vec{M}_2$; $F_1 = 16\ lb$; $F_2 = 40\ lb$

$\vec{M}_1 = \vec{r}_c \times \vec{F}_1 = (30\ in)\vec{i} \times [-16\ lb]\vec{j}$

$= -(480\ lb \cdot in)\ k$

$\vec{M}_2 = \vec{r}_{E/B} \times \vec{F}_2 = (-15\ in)\vec{i} - (5\ in)\vec{j}$

$d_{DE} = \sqrt{(0)^2 + (5)^2 + (10)^2} = 5\sqrt{5}\ in$

$\vec{F}_2 = 40\,lb/5\sqrt{5}\ (5j - 10k)$

$\vec{F}_2 = 8\sqrt{5}\ [(1\ lb)\vec{j} - (2\ lb)\vec{k}]$

$$M_2 = 8\sqrt{5} \begin{vmatrix} i & j & k \\ 15 & -5 & 0 \\ 0 & 1 & -2 \end{vmatrix}$$

$= 8\sqrt{5}\ [(10\ lb \cdot in)\vec{i} + (30\ lb \cdot in)\vec{j} + (15\ lb \cdot in)\vec{k}]$

$\vec{M} = (178.885\ lb \cdot in)\vec{i} + (536.66\ lb \cdot in)\vec{j} - (211.67\ lb \cdot in)\vec{k}$

$M = \sqrt{(178.885)^2 + (536.66)^2 + (211.67)^2}$

$M = 603.99\ lb \cdot in$

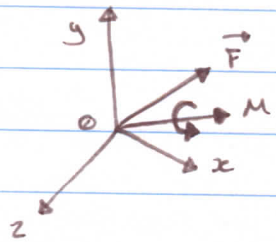
$\vec{e}_{axis} = \vec{M}/M = 0.29617\,i + 0.8885\,j - 0.3504\,k$

$\cos\theta_x = 0.29617 \rightarrow 72.8°$

$\cos\theta_y = 0.8885 \rightarrow 27.3°$

$\cos\theta_z = -0.3504 \rightarrow 110.5°$

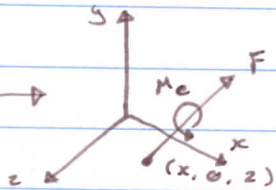
Solution copied directly from textbook. Check math.



The system consists of the Force and couple $\vec{F} = 3\vec{i} + 6\vec{j} + 2\vec{k}$

$\vec{M} = 12\vec{i} + 4\vec{j} + 6\vec{k}$

Represent it by a wrench, and determine where the line of action of the wrench's Force intersects the $x - z$ plane.



Dividing $\vec{F}$ by its magnitude to obtain a unit vector $\vec{e}$ with the same direction as $\vec{F}$

$$\vec{e} = \vec{F}/F' = \frac{3i + 6j + 2k}{\sqrt{(3)^2 + (6)^2 + (2)^2}} = 0.429\vec{i} + 0.857\vec{j} + 0.286\vec{k}$$

$$M_p = (\vec{e} \cdot \vec{M})\,\vec{e}$$

$$\Rightarrow [(0.429)(12) + (0.857)(4) + (0.286)(6)]\,\vec{e}$$

$$= 4.408\vec{i} + 8.816\vec{j} + 2.939\vec{k} \text{ N.m.}$$

The component of M normal to $\vec{F}$ is $\vec{M}_A = \vec{M} - \vec{M}_p$

$$\vec{M}_A = (7.592\vec{i} - 4.816\vec{j} + 3.061\vec{k}) \text{ N.m}$$

The wrench is shown in this Figure.

$$\vec{r}_{op} \times F = \begin{vmatrix} i & j & k \\ x & 0 & z \\ 3 & 6 & 2 \end{vmatrix} = -6z\,\vec{i} - (2x - 3z)\vec{j} + 6x\,\vec{k}$$

By equating this moment to M_A

$$-6z\,\vec{i} - (2x - 3z)\vec{j} + 6x\,\vec{k} = 7.592\vec{i} - 4.816\vec{j} + 3.061\vec{k}$$

We obtain the equations

$$-6z = 7.592\vec{i}$$

$$2x - 3z = -4.816\vec{j}$$

$$6x = 3.061$$

$$P(0.510,\ 0,\ -1.265)$$