Q.2.

Resultant force at O

$$\vec{R} = T(\hat{i}+\hat{j})$$

Resultant Moment at O.

$$\vec{M}_0 = -6aT\,\hat{i} + 3aT\,\hat{j}$$
$$= 3aT(-2\hat{i}+\hat{j})$$

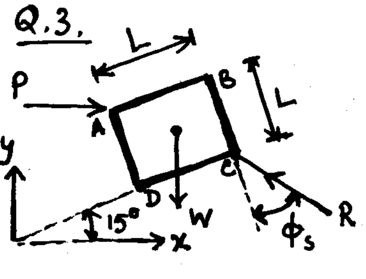
Pitch of wrench $= p = \dfrac{(\vec{R}\cdot\vec{M}_0)}{R^2}$

$$p = \frac{-3aT^2}{2T^2} = -\frac{3a}{2}$$

Wrench axis intersection with y-z plane

$$p\vec{R} + (y\hat{j}+z\hat{k})\times(\vec{R}) = \vec{M}_0$$
$$p\cancel{T}(\hat{i}+\hat{j}) + (y\hat{j}+z\hat{k})\times\cancel{T}(\hat{i}+\hat{j}) = 3a\cancel{T}(-2\hat{i}+\hat{j})$$
$$(p-z)\hat{i} + (p+z)\hat{j} - y\hat{k} = -6a\hat{i} + 3a\hat{j}$$
$$y = 0, \quad z = \frac{9a}{2}$$

Q.3.



F.B.D

Motion is impending, tipping is just prevented

ϕ_s: angle of limiting static friction

Unknowns : P, R, ϕ_s

$$\Sigma F_x = -R\sin(15+\phi_s) + P = 0 \quad \text{— (1)}$$
$$\Sigma F_y = R\cos(15+\phi_s) - W = 0 \quad \text{— (2)}$$
$$\Sigma M_c = (-P\cos 15^\circ)L + (P\sin 15^\circ)L + W\cos 15^\circ \frac{L}{2} + W\sin 15^\circ \frac{L}{2} = 0 \quad \text{— (3)}$$

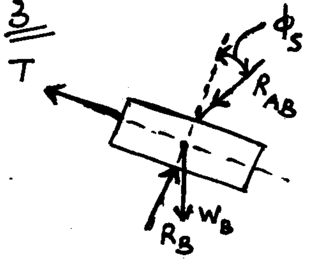
From (3)

$$P = \frac{W}{2}\left[\frac{\sin 15 + \cos 15}{\cos 15 - \sin 15}\right]$$
$$= \frac{W}{2}\left[\frac{1+\tan 15}{1-\tan 15}\right] = \frac{W}{2}\tan 60^\circ$$
$$= \underline{\underline{254.61\ N}}$$

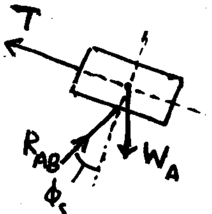
From (1) & (2)

$$\tan(15+\phi_s) = \frac{P}{W} = \frac{\tan 60}{2}$$
$$\Rightarrow \phi_s = 25.89, \quad \mu_s = \tan\phi_s = \underline{\underline{0.485}}$$

3'



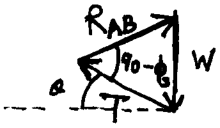
Block B F.B.D.



Block A F.B.D

From force triangle for A

$$R_{AB} = \frac{\cos\theta}{\cos\phi_s} W_A$$
$$T = \frac{\sin(\theta+\phi_s)}{\cos\phi_s} W_A$$



Force triangle

Equilibrium of Block B

$$T + R_{AB}\sin\phi_s - W_B\sin\theta = 0$$
$$\frac{\cos\theta}{\cos\phi_s}W_A + \frac{\sin(\theta+\phi_s)}{\cos\phi_s}\sin\phi_s W_A - W_B\sin\theta = 0$$

On simplification we get

$$\tan\theta = \frac{2\mu_s}{(W_B/W_A - 1)}$$

4

$B \equiv (0,0,10)$
$C \equiv (-5,0,0)$
$D \equiv (4,4,2)$

$$\Rightarrow \vec{\lambda}_{BC} = \frac{\vec{r}_C - \vec{r}_B}{|\vec{r}_C - \vec{r}_B|} = \frac{-\hat{i} - 2\hat{k}}{\sqrt{5}}$$
$$\vec{\lambda}_{BD} = \frac{\vec{r}_D - \vec{r}_B}{|\vec{r}_D - \vec{r}_B|} = \frac{\hat{i}+\hat{j} - 2\hat{k}}{\sqrt{6}}$$

$$T_1 = T_1\vec{\lambda}_{BD}, \quad T_2 = T_2\vec{\lambda}_{BC}$$

Equilibrium of Pole AB

Taking moments about x and y axes passing through O,

$$\Sigma M_x = 0 : \frac{T_1}{\sqrt{6}}\cdot 10 - 4\times 5 = 0 \Rightarrow T_1 = \underline{\underline{4.899\,kN}}$$
$$\Sigma M_y = 0 : -\frac{T_2}{\sqrt{5}}\cdot 10 + \frac{T_1}{\sqrt{6}}\cdot 10 = 0 \Rightarrow T_2 = 4.472\ kN$$