일반물리I. Chapter. 12

10.

(a). $\vec{F}_1+\vec{F}_2+\vec{F}_3 = (1-2+1)\hat{i} + (2-5+3)\hat{j}$

$= 0\hat{i}+0\hat{j}\ N$

(b). $\vec{\tau}_1+\vec{\tau}_2+\vec{\tau}_3$

$= \vec{r}_1\times\vec{F}_1+\vec{r}_2\times\vec{F}_2+\vec{r}_3\times\vec{F}_3$

$= (2m\hat{i}+0\hat{j})\times(1\hat{i}+2\hat{j})N$

$+(-1m\hat{i}+1m\hat{j})\times(-2\hat{i}-5\hat{j})N$

$+(-2m\hat{i}+3m\hat{j})\times(1\hat{i}+3\hat{j})N$

$= (4\hat{k}+5\hat{k}+2\hat{k}-6\hat{k}-5\hat{k})N\cdot m$

$= (0\hat{k})N\cdot m$

15.

맨 오른쪽을 영점으로 두고, 통나무의 질량 중심은 x_{cm}

$x_{cm} : (23-4) = 6.2 : 7.5$

$$x_{cm} = \frac{6.2\times19}{7.5} = 약\ 16m$$

혹은, 맨 왼쪽을 영점으로 두었을 때,

$$\Sigma F_i = -7.5\,\text{kN} + 6.2\,\text{kN} + F' = 0$$

$$F' = 1.3\,\text{kN}$$

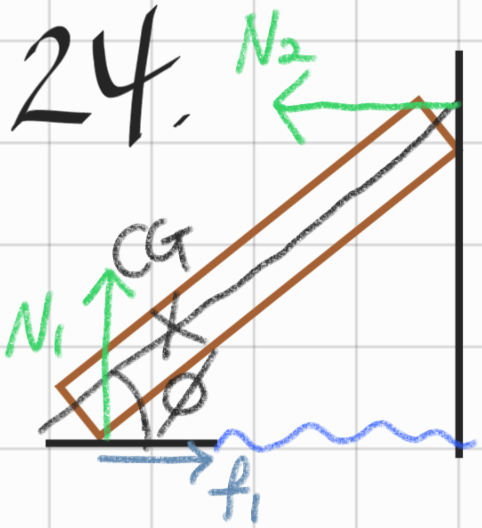
$$(23 - x_{cm})1.3 = (x_{cm} - 4)6.2$$

$$29.9 - 1.3x_{cm} = 6.2x_{cm} - 24.8$$

$$7.5x_{cm} = 54.7$$

$$x_{cm} = \text{약 } 7\,\text{m}$$

24.



$M = 224\,kg$, $m = 77.3\,kg$

좌표 중심을 통나무가 땅 바닥에 닿는곳으로 설정

$\mu_s = 0.982$.

$\vec{f}_1 = \mu_s N_1 \hat{i}$,

$\Sigma \vec{F}_i = 0$ 이므로,

$$\vec{f}_1 + \vec{N}_1 + M\vec{g} + m\vec{g} + \vec{N}_2 = 0$$

$$\Rightarrow (\mu_s N_1 - N_2)\hat{i} + (N_1 - Mg - mg)\hat{j} = 0$$

$$\therefore N_2 = \mu_s N_1 , \quad (M+m)g = N_1$$

마찬가지로 $\Sigma \vec{\tau}_i = 0$.

$$\Rightarrow \frac{LM}{3} g\cos\phi (\hat{i} \times -\hat{j}) + \frac{Lm}{2} g\cos\phi (\hat{i} \times -\hat{j}) + L N_2 \sin\phi (\hat{j} \times -\hat{i}) = 0$$

$$\therefore (L N_2 \sin\phi)\hat{k} - \left(\frac{LM}{3} g\cos\phi + \frac{Lm}{2} g\cos\phi\right)\hat{k} = 0$$

$$LN_2 \sin\phi = \left(\frac{LM}{3}g + \frac{Lm}{2}g\right)\cos\phi$$

$$\tan\phi = \frac{\frac{LM}{3}g + \frac{Lm}{2}g}{LN_2}$$

$$= \frac{2Mg + 3mg}{6N_2}$$

$$2(M+m)g = 2N_1 , \quad N_2 = \mu_s N_1$$

$$\tan\phi = \frac{2N_1 + mg}{6\mu_s N_1} = \frac{1}{3\mu_s} + \frac{mg}{6\mu_s N_1}$$

f_1은 정지 마찰력이므로, $f_1 \le \mu_s N_1$

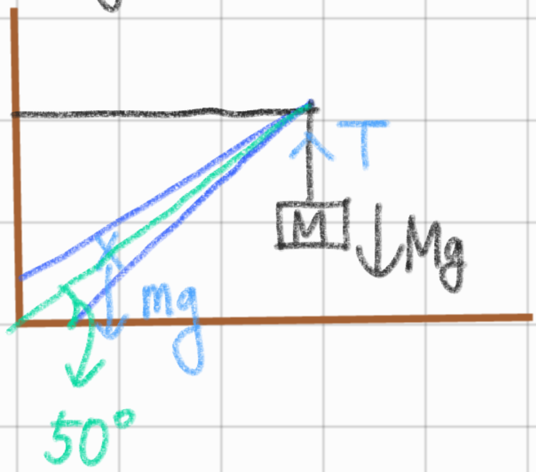
$\rightarrow f_1 = \mu_s N_1$ 일 때 $\tan\phi$이 최소,

$$\tan\phi = \frac{1}{3\mu_s} + \frac{mg}{6\mu_s (M+m)g}$$

$$\tan^{-1}\left\{\frac{1}{3\mu_s} + \frac{m}{6\mu_s (M+m)}\right\} = \phi$$

$$\boxed{\therefore \phi_{min} = \text{약 } 21^\circ}$$

42. $M=2500\,kg \quad m=830\,kg$



기중기 팔의 길이를 L,

$\Sigma \vec{\tau}_i = 0$

$\Rightarrow \vec{L}\times\vec{T} + \frac{1}{3}\vec{L}\times m\vec{g} + \vec{L}\times M\vec{g}$

$50° = \theta$로 두고 전개

$L\{\sin(\pi-\theta)\hat{i} + \cos(\pi-\theta)\hat{j}\} \times T\hat{j}$

$+ \frac{1}{3}L(\cos\theta\,\hat{i} + \sin\theta\,\hat{j}) \times mg(-\hat{j})$

$+ L\{\sin(\pi - \frac{\pi}{2} - \theta)\hat{i} + \cos(\pi - \frac{\pi}{2} - \theta)\hat{j}\} \times Mg(-\hat{j})$

$= LT\sin(\pi-\theta)\hat{k} - \frac{1}{3}Lmg\cos\theta\,\hat{k} - LMg\sin(\frac{\pi}{2}-\theta)\hat{k}$

$= LT\sin\theta\,\hat{k} - \frac{1}{3}Lmg\cos\theta\,\hat{k} - LMg\cos\theta\,\hat{k} = 0$

$\therefore LT\sin\theta = Lg\cos\theta\left(\frac{1}{3}m + M\right)$

$T = g\cot\theta\left(\frac{1}{3}m + M\right) = g\cot 50°\left(\frac{1}{3}m + M\right)$

$\boxed{T = \text{약 } 22833\,N \approx 23\,kN}$

58.

책들의 질량중심의 합이 책상의 가장자리를 넘어서는 안 된다.
가장자리를 $x=0$ 라고 하고, 맨 아래 책의 질량 중심이 a에 위치해 있다고 가정하자. ?$=x$라 하면,

$$x_{cm} = \frac{1}{M}\Sigma x_i m_i = \frac{1}{M}\left\{am + \left(a+\frac{1}{4}L\right)m + \left(a+\frac{3}{4}L\right)m\right\}$$

$M=3m$.

$$x_{cm} = \frac{1}{3}\left(3a+L\right)=0$$

$$\Rightarrow a = -\frac{L}{3}$$

따라서 $\frac{L}{2} - \frac{L}{3} = \boxed{\frac{L}{3}}$ 만큼 밖으로 나올 수 있다.