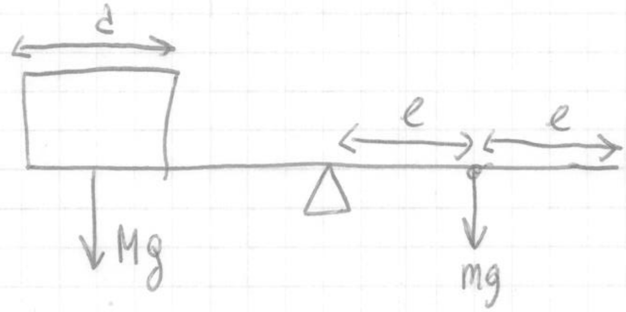
# PHYSICS 2 SUMMER 08
## HOMEWORK 2

### 11.3

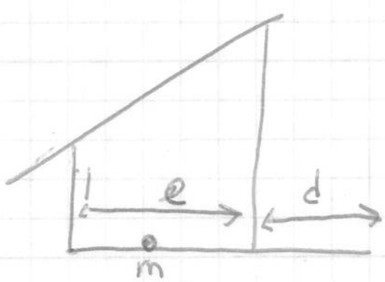



$d = 75$ cm
$l = 50$ cm
$m = 25$ kg
$M = ?$

Balance torques $\boxed{Mg(2l - d/2) = mgl}$

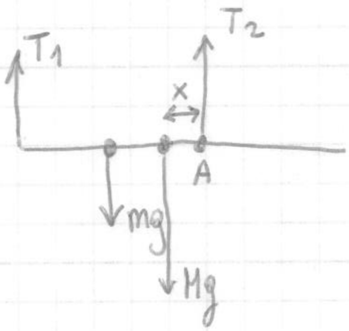
$$\boxed{M = m\frac{l}{2l - d/2}} \qquad M = 25\,kg\ \frac{50\,cm}{62.5\,cm} = \underline{\underline{20\,kg}}$$

### 11.8




$d = 20$ cm
$l = 40$ cm
$mg = 25$ N
$Mg = 50$ N

FBD




$\Sigma\vec{F} = 0 \Rightarrow \boxed{T_1 + T_2 = (m+M)g}$ (1)

$\Sigma\vec{\tau} = 0$ around point A

$\boxed{T_1 l = mg\frac{l}{2} + Mg x}$ (2)

Find $x$ $\quad d + x = l - x$ since $x$ is midpoint of shelf

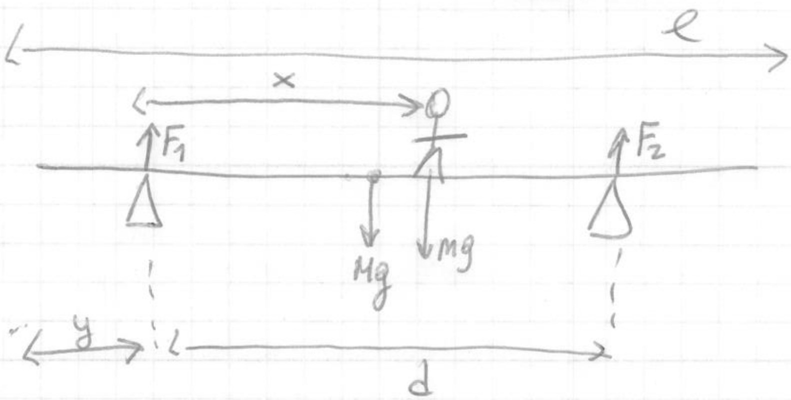
$$x = \frac{l - d}{2} = \underline{\underline{10\,cm}}$$

Eqtn (1) $\longrightarrow$ $T_1 = \frac{m}{2}g + Mg\underbrace{\frac{x}{l}}_{=1/4} = 12.5\,N + 12.5\,N = \underline{\underline{25\,N}}$

Then from equation (2), $T_2 = mg + Mg - T_1 = 25N + 50N - 25N$

$$\underline{\underline{T_2 = 50N}}$$

11.12




$mg = 600N$

$Mg = 300N$

$d = 5\ m$

$\ell = 9\ m$

$y = 2\ m$

$\Sigma \vec{F} = \vec{0} \qquad F_1 + F_2 = Mg + mg \quad (1)$

$\Sigma \vec{\tau} = \vec{0}$ - Take it from left support

$$F_2 d = Mg\frac{d}{2} + \underline{mg}\,x$$

$$\boxed{F_2(x) = \frac{1}{2}Mg + mg\frac{x}{d}}$$

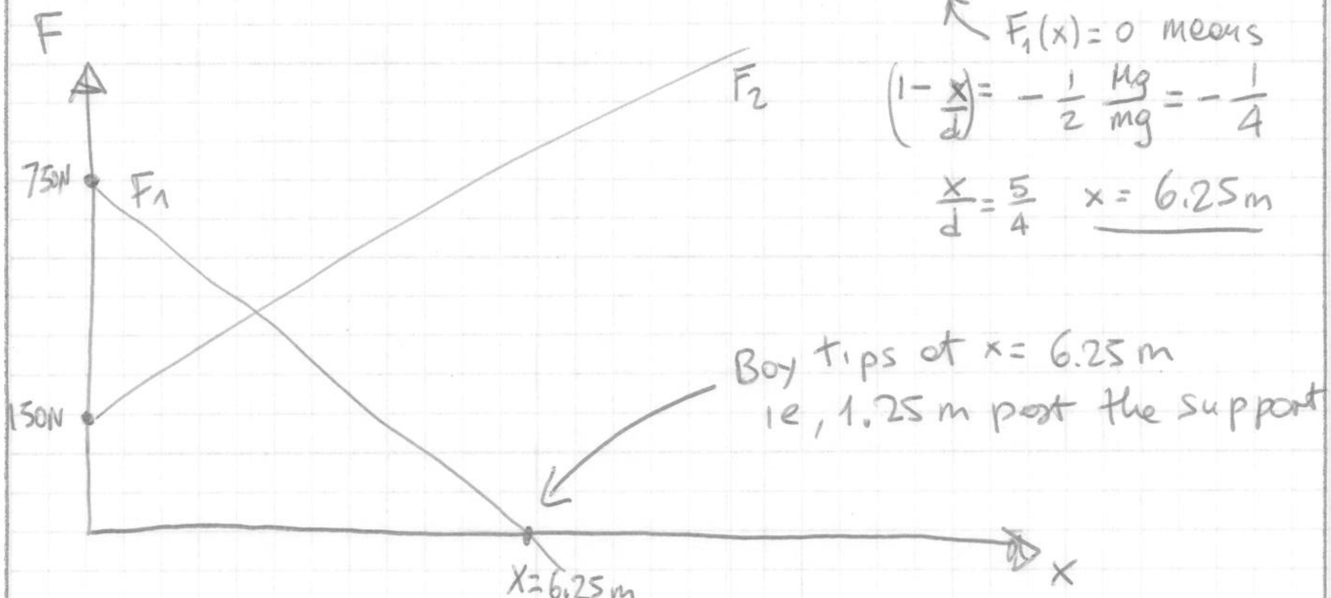
From eqtn (1) $\quad F_1(x) = Mg + mg - F_2(x)$

$$\boxed{F_1(x) = \frac{1}{2}Mg + mg\left(1 - \frac{x}{d}\right)}$$

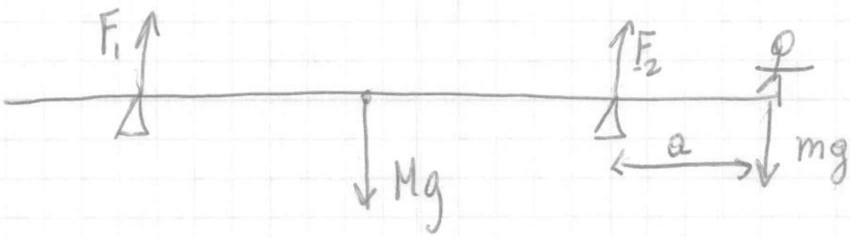
$F_1(x) = 0$ means

$$\left(1 - \frac{x}{d}\right) = -\frac{1}{2}\frac{Mg}{mg} = -\frac{1}{4}$$

$$\frac{x}{d} = \frac{5}{4} \qquad \underline{x = 6.25\,m}$$



(c) Take torque around right end



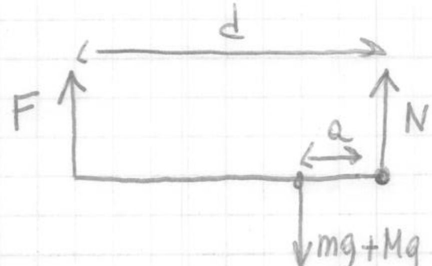

Just before tipping $F_1 = 0$

Then $F_2 = Mg + mg$ from $\Sigma \vec{F} = 0$

$$\Sigma \vec{\tau} = 0 \rightarrow \quad Mg \frac{l}{2} = F_2 a \qquad \boxed{a = l \, \frac{Mg/2}{Mg + mg}}$$

$$a = 9\text{ m}\ \frac{150}{900} = \underline{\underline{1.5\text{ m}}}$$

11.16 FBD




$d = 140$ cm
$F = 650$ N
$mg = 80$ N
$a = 50$ cm
$Mg = ?$

(a)

Take torques around rightmost point

$$Fd = mga + Mga \qquad \boxed{Mg = F\frac{d}{a} - mg}$$

$$Mg = 650\text{N}\ \frac{140}{50} - 80\text{N} = \underline{\underline{1740\text{ N}}}$$

(b) normal force (ground pushing up on wheel)

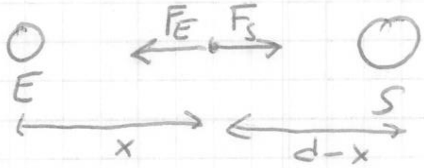
(11.23) $Y = \frac{F/A}{\Delta l / l} = \frac{l F}{A \Delta l} \rightarrow A = \frac{l F}{Y \Delta l}$

But $A = \pi r^2 = \pi \left(\frac{d}{2}\right)^2$ r = radius of wire
d = diameter of wire

$\frac{\pi}{4} d^2 = \frac{l F}{Y \Delta l}$ $\boxed{d = \sqrt{\frac{4 l F}{\pi Y \Delta l}}}$ Using $Y = 2 \cdot 10^{11}$ get

$\underline{d = 1.4 \text{ mm}}$

(12.5)



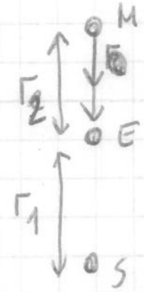

$d = 1.5\ 10^{11}$ m

$$\frac{G m M_E}{x^2} = \frac{G m M_S}{(d-x)^2} \Rightarrow (d-x)^2 = x^2 \left(\frac{M_S}{M_E}\right)$$

$$d - x = x \sqrt{\frac{M_S}{M_E}}$$

$\boxed{x = \frac{d}{1 + \sqrt{M_S/M_E}}}$ $M_S = 1.99\ 10^{30}$ kg
$M_E = 5.97\ 10^{24}$ kg $\Rightarrow \underline{x = 2.59\ 10^{8} \text{ m}}$

(12.9)
(a)



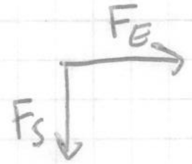

$F_E$ and $F_s$ point in same direction

$F = F_E + F_S = G\frac{M_m M_E}{r_2} + G\frac{M_m M_E}{r_1}$

$F = 6.3\ 10^{20}$ N $\left[\begin{array}{l} F_E = 1.99\ 10^{20} \text{ N} \\ F_S = 4.34\ 10^{20} \text{ N} \end{array}\right]$

(c) just like (a) but now a negative sign $\Rightarrow$ $F = 2.37\ 10^{20}$ N towards sun

(i) Since $r_1 \gg r_2$ can take forces to be (almost $\perp$)




Then $F = \sqrt{F_E^2 + F_S^2} = \underline{2.37\ 10^{20}\,N}$

(12.14) $M = 1.5\ 10^{22}\,kg$ and $R = 1.15\ 10^{6}\,m \Rightarrow g = \frac{GM}{R^2}$ gives

$\underline{g = 0.757\ m/s^2}$

(12.20) $g_E = \frac{G M_E}{R_E^2} \quad g_N = G\frac{M_N}{R_N^2}$

$$\Rightarrow \frac{W_E}{W_N} = \frac{g_E}{g_N} \Rightarrow W_N = W_E \frac{g_N}{g_E}$$

$$\boxed{W_N = W_E \frac{M_N R_E^2}{M_E R_N^2}}$$

Using $M_N = 1.99\ 10^{30}\,kg$

$M_E = 5.97\ 10^{24}\,kg$

$R_E = 6.38\ 10^{6}\,m$

$R_N = 10^4\,m$

$W_E = 675\,N$

$\hookrightarrow$ get $\underline{\underline{W_N = 9.2\ 10^{13}\,N}}$

12.22

$a = r\omega^2$ for circular motion $\quad r = 4.25\,m$

$$g = \frac{G M_E}{R_E^2} \qquad M_E = \text{Europa mass} = 4.8\,10^{22}\,kg$$
$$R_E = \text{Europa radius} = 1.569\,10^{6}\,m$$

$$r\omega^2 = \frac{G M_E}{R_E^2} \qquad \boxed{\omega = \sqrt{\frac{G M_E}{r R_E^2}}}$$ ← This is in $\frac{\text{radians}}{\text{sec}}$

If I want $\omega$ in rpm, ~~multiply by~~

$$1\ \text{rpm} = \frac{2\pi\ \text{rad}}{60\ \text{sec}} = \frac{\pi}{30}\ \frac{\text{rad}}{\text{sec}}$$

$$\Rightarrow 1\ \frac{\text{rad}}{\text{sec}} = \frac{30}{\pi}\ \text{rpm}$$

$$\boxed{\omega = \frac{30}{\pi}\sqrt{\frac{G M_E}{r R_E^2}}}\ (\text{in rpm})$$

Plugging numbers in $\underline{\underline{\omega = 5.28\ \text{rpm}}}$