

Homework 3

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Torque Statics

1	Book	2
1.1	11.14	2
1.2	11.16	3
1.3	11.23	4
1.4	11.45	5
1.5	11.49	5
1.6	11.53	7
1.7	11.71	8
1.8	11.75	9
1.9	11.81	10
2	Lab Manual	11
2.1	370	11
2.2	372	11

1 Book

1.1 11.14

(a)

(b)

$$\begin{aligned}
 l_b &= 9.00 \text{ m} \\
 w_b &= 300 \text{ N} \\
 x_{B,A} &= 5.00 \text{ m} \\
 w_p &= 600 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 \sum \tau_{\star} &= 0 \\
 (F_A)(5 \text{ m}) &= (w_p)(5 \text{ m} - x) + (w_b)(2.5 \text{ m}) \\
 F_A &= (0.2 \text{ m}^{-1}) ((600 \text{ N})(5 \text{ m} - x) + (300 \text{ N})(2.5 \text{ m})) \\
 (0) &= 600 \text{ N} - (120 \text{ N m}^{-1})x + 150 \text{ N} \\
 (120 \text{ N m}^{-1})x &= 750 \text{ N} \\
 x &= 6.25 \text{ m}
 \end{aligned}$$

$$x = 6.25 \text{ m} - x_{B,A} = 1.25 \text{ m}$$

$$\boxed{1.25 \text{ m}}$$

(c)

$$x_{\text{p}} = 7.00 \text{ m}$$

$$w_{\text{p}} = 600 \text{ N}$$

$$x_{\text{b}} = 2.5 \text{ m}$$

$$w_{\text{b}} = 300 \text{ N}$$

$$x_{\text{B}} = ?$$

$$F_{\text{B}} = 900 \text{ N}$$

$$x_{\text{A}} = 0$$

$$F_{\text{A}} = 0$$

$$\sum \tau_{\star} = 0$$

$$(w_{\text{b}})(x_{\text{b}}) + (w_{\text{p}})(x_{\text{p}}) = (F_{\text{b}})(x_{\text{b}})$$

$$x_{\text{b}} = \frac{(300 \text{ N})(2.5 \text{ m}) + (600 \text{ N})(7.00 \text{ m})}{900 \text{ N}}$$

$$x_{\text{b}} = 1.5 \text{ m}$$

$$\boxed{x_{\text{b}} = 1.5 \text{ m}}$$

1.2 11.16

$$l_{(\text{b})\text{eam}} = 4.00 \text{ m}$$

$$l_{(\text{c})\text{able}} = 5.00 \text{ m}$$

$$l_{(\text{w})\text{all}} = 3.00 \text{ m}$$

$$w_{\text{b}} = 190 \text{ N}$$

$$w_{(\text{o})\text{bject}} = 300 \text{ N}$$

$$\theta_{\text{c,b}} = 36.87^\circ$$

(a)

$$T = ?$$

$$T_y = T \sin(\theta_{\text{c,b}})$$

$$\sum \tau_{\star} = 0$$

$$\left(\frac{l_{\text{b}}}{2}\right)(w_{\text{b}}) + (l_{\text{b}})(w_{\text{o}}) = (l_{\text{b}})(T_y)$$

$$T = \frac{\left(\frac{4.00 \text{ m}}{2}\right)(190 \text{ N}) + (4.00 \text{ m})(300 \text{ N})}{(4.00 \text{ m})(\sin(36.87^\circ))}$$

$$T = 658.3 \text{ N}$$

$$\boxed{T = 658.3 \text{ N}}$$

(b)

$$\begin{aligned}F_x &=? \\ \sum F_x &= 0 \\ F_x &= T_x \\ &= T \cos(\theta_{c,b}) \\ &= (658.3 \text{ N})(\cos(36.87^\circ)) \\ F_x &= 526.6 \text{ N}\end{aligned}$$

$$\begin{aligned}F_y &=? \\ \sum F_y &= 0 \\ F_y + T_y &= w_b + w_o \\ F_y + (658.3 \text{ N})(\sin(36.87^\circ)) &= 190 \text{ N} + 300 \text{ N} \\ F_y &= 190 \text{ N} + 300 \text{ N} - (658.3 \text{ N})(\sin(36.87^\circ)) \\ F_y &= 95.02 \text{ N}\end{aligned}$$

$$\boxed{F_x = 526.6 \text{ N}, F_y = 95.02 \text{ N}}$$

1.3 11.23

$$\begin{aligned}F_1 &= F_2 = 6.30 \text{ N} \\ l_{F_1,O} &= 3.00 \text{ m}\end{aligned}$$

(a)

$$\begin{aligned}l &=? \\ \sum \tau_\star &= 6.50 \text{ N m} \\ (F_2)(l_{F_1,O} + l) &= 6.50 \text{ N m} + (F_1)(l_{F_1,O}) \\ (6.30 \text{ N})(3.00 \text{ m} + l) &= 6.50 \text{ N m} + (6.30 \text{ N})(3.00 \text{ N}) \\ l &= 1.032 \text{ m}\end{aligned}$$

$$\boxed{l = 1.032 \text{ m}}$$

(b)

$$\boxed{\text{clockwise}}$$

(c)

$$l = ?$$

$$F_2 = 0$$

$$\sum \tau_{\star} = (6.50 \text{ N m})(3.00 \text{ m} + l)$$

$$-(F_1)(l) = (6.50 \text{ N m})$$

$$-(6.30 \text{ N})(l) = (6.50 \text{ N m})$$

$$l = -1.032 \text{ m}$$

$$\boxed{l = -1.032 \text{ m}}$$

1.4 11.45

$$h = 0.300 \text{ m}$$

$$x = 0.080 \text{ m}$$

$$\theta = 60^\circ$$

$$F_1 = ?$$

$$F_2 = ?$$

$$\sum \tau_{\star} = 0$$

$$(F_2)(h) - (F_1)_y(x) = 0$$

$$(F_2)(0.300 \text{ m}) = (F_1 \sin(60^\circ))(0.080 \text{ m})$$

$$F_1 = F_2(4.330)$$

$$\boxed{F_1 = F_2(4.330)}$$

1.5 11.49

$$\theta = 25.0^\circ$$

$$\phi = 35.0^\circ$$

$$l_{\text{cog}} = 1.1 \text{ m}$$

$$m_{\text{p}} = 82.0 \text{ kg}$$

$$l_{(\text{h})\text{ands}} = 1.40 \text{ m}$$

$$l_{(\text{p})\text{erson}} = 1.90 \text{ m}$$

(a)

$$\begin{aligned}\sum \tau_{\star} &= 0 \\ (T_y)(l_h) &= (w_p)(l_{\text{cog}})(\cos(\phi)) \\ T &= \left(\frac{m_p(10 \text{ m s}^{-2})(l_{\text{cog}})(\cos(\phi))}{(l_h)(\cos(\phi - \theta))} \right) \\ T &= \frac{(82.0 \text{ kg})(10 \text{ m s}^{-2})(1.1 \text{ m})(\cos(35.0^\circ))}{(1.40 \text{ m})(\cos(10^\circ))} \\ T &= 535.9 \text{ N}\end{aligned}$$

$$\boxed{T = 535.9 \text{ N}}$$

(b)

$$\begin{aligned}\sum F_x &= 0 \\ N &= T_x \\ N &= (535.9 \text{ N})(\sin(25.0^\circ)) \\ N &= 226.5 \text{ N}\end{aligned}$$
$$\begin{aligned}\sum F_y &= 0 \\ Ty + f &= w_p \\ (535.9 \text{ N})(\cos(25.0^\circ)) + f &= (82.0 \text{ kg})(10 \text{ m s}^{-2}) \\ f &= 334.3 \text{ N}\end{aligned}$$

$$\boxed{N = 226.5 \text{ N}, f = 334.3 \text{ N}}$$

(c)

$$\begin{aligned}f &= \mu N \\ \mu &= \frac{f}{N} \\ &= \frac{334.3 \text{ N}}{226.5 \text{ N}} \\ \mu &= 1.476\end{aligned}$$

$$\boxed{\mu = 1.476}$$

1.6 11.53

$$\begin{aligned}
 l_{(\text{b})\text{eam}} &= 1.50 \text{ m} \\
 m_{\text{b}} &= 19.0 \text{ kg} \\
 m_{(\text{s})\text{ign}} &= 35.0 \text{ kg} \\
 l_{\text{s}} &= 1.20 \text{ m} \\
 x_{w_b, w_a} &= 32.0 \text{ cm} \\
 l_{(\text{c})\text{able}} &= 2.20 \text{ m}
 \end{aligned}$$

(a)

$$\begin{aligned}
 \cos(\theta) &= \frac{1.5 \text{ m}}{2.2 \text{ m}} \\
 \theta &= 68.2^\circ \\
 T_{\text{w}} &= \frac{(m_{\text{s}})(10 \text{ m s}^{-2})}{2} \\
 &= \frac{(35.0 \text{ kg})(10 \text{ m s}^{-2})}{2} \\
 T_{\text{w}} &= 175 \text{ N} \\
 \sum \tau_{\star} &= 0 \\
 (T_y)(l_{\text{b}}) &= (w_{\text{b}}) \left(\frac{l_{\text{b}}}{2} \right) + (T_{\text{w}})(l_{\text{b}} + x_{w_b, w_a}) \\
 T &= \frac{(190.0 \text{ N})(0.75 \text{ m}) + (175 \text{ N})(1.50 \text{ m} + 0.32 \text{ m})}{(1.50 \text{ m})(\sin(68.2^\circ))} \\
 T &= 331.0 \text{ N} \\
 \boxed{T = 331.0 \text{ N}}
 \end{aligned}$$

(b)

$$\begin{aligned}
 \sum F_y &= 0 \\
 F_y + T_y &= w_{\text{b}} + 2T_{\text{w}} \\
 F_y &= (190.0 \text{ N}) + 2(175 \text{ N}) - (331.0 \text{ N})(\sin(68.2^\circ)) \\
 F_y &= 232.7 \text{ N} \\
 \boxed{F_y = 232.7 \text{ N}}
 \end{aligned}$$

1.7 11.71

$$m_{\text{crate}} = 200 \text{ kg}$$

$$l_{\text{crate}} = 1.25 \text{ m}$$

$$h_{\text{crate}} = 0.500 \text{ m}$$

$$\theta = 45.0^\circ$$

$$F_1 = ?$$

$$F_2 = ?$$

$$\cos(\theta) = \frac{x_{\text{cog}}}{\frac{1}{2}l_{\text{crate}}}$$

$$x_{\text{cog}} = (0.625 \text{ m})(\cos(45.0^\circ))$$

$$x_{\text{cog}} = 0.442 \text{ m}$$

$$\cos(\theta) = \frac{x_{F_2}}{1.25 \text{ m}}$$

$$x_{F_2} = 0.884 \text{ m}$$

$$\sum \tau_\star = 0$$

$$(F_2)(x_{F_2}) = (w_{\text{crate}})(x_{\text{cog}})$$

$$F_2 = \frac{(2000 \text{ N})(0.442 \text{ m})}{0.884 \text{ m}}$$

$$F_2 = 1000 \text{ N}$$

$$\sum F_y = 0$$

$$F_1 + F_2 = w_{\text{crate}}$$

$$F_1 = 2000 \text{ N} - 1000 \text{ N}$$

$$F_1 = 1000 \text{ N}$$

$$\boxed{F_1 = 1000 \text{ N}, F_2 = 1000 \text{ N}}$$

They share an equal upward force on the crate.

1.8 11.75

$$\begin{aligned}
 l_{\text{gate}} &= 4.00 \text{ m} \\
 h_{\text{gate}} &= 2.00 \text{ m} \\
 w_{\text{gate}} &= 550 \text{ N} \\
 \theta &= 30.0^\circ \\
 T &=? \\
 T_x &= T \cos(30^\circ) \\
 T_y &= T \sin(30^\circ) \\
 l_{\text{cog}} &= 2.00 \text{ m}
 \end{aligned}$$

(a)

$$\begin{aligned}
 \sum \tau_\star &= 0 \\
 (T_y)(l_{\text{gate}}) + (T_x)(h_{\text{gate}}) &= (w_{\text{gate}}) \left(\frac{1}{2} l_{\text{gate}} \right) \\
 T &= \frac{(550 \text{ N})(2.00 \text{ m})}{\sin(30^\circ)(4.00 \text{ m}) + (\cos(30^\circ))(2.00 \text{ m})} \\
 T &= 294.7 \text{ N} \\
 \boxed{T = 294.7 \text{ N}}
 \end{aligned}$$

(b)

$$\begin{aligned}
 \sum F_x &= 0 \\
 F_x &= T_x \\
 F_x &= (294.7 \text{ N})(\cos(30^\circ)) \\
 F_x &= 255.2 \text{ N} \\
 \boxed{F_x = 255.2 \text{ N}}
 \end{aligned}$$

(c)

$$\begin{aligned}
 \sum F_y &= 0 \\
 F_{y_B} + F_{y_A} + T_y &= w_{\text{gate}} \\
 F_{y_B} + F_{y_A} &= 550 \text{ N} - (294.7 \text{ N})(\sin(30^\circ)) \\
 F_{y_B} + F_{y_A} &= 401.5 \text{ N} \\
 \boxed{F_{y_B} + F_{y_A} = 401.5 \text{ N}}
 \end{aligned}$$

1.9 11.81

$$\begin{aligned}\mu &= 0.49 \\ l_{B,A} &= 2.00 \text{ m} \\ l_{(d)oor,(wh)eel} &= 0.50 \text{ m} \\ w_d &= 958 \text{ N} \\ \vec{F} &=? \\ h &=?\end{aligned}$$

(a)

$$h = 1.43 \text{ m}$$

$$\begin{aligned}\sum F_y &= 0 \\ N_A + N_B &= w_d \\ N_A + N_B &= 958 \text{ N}\end{aligned}$$

$$\begin{aligned}\sum F_x &= 0 \\ f_A + f_B &= F \\ \mu N_A + \mu N_B &= F \\ \mu(N_A + N_B) &= F \\ (0.49)(958 \text{ N}) &= F \\ F &= 469.4 \text{ N}\end{aligned}$$

$$\begin{aligned}\sum \tau_\star &= 0 \\ (w_d) \left(\frac{l_{B,A}}{2} \right) &= (l_{A,B})(N_A) + (F)(h) \\ N_A &= \frac{(w_d) \left(\frac{l_{B,A}}{2} \right) - (F)(h)}{l_{A,B}} \\ N_A &= \frac{(958 \text{ N})(1.00 \text{ m}) - (469.4 \text{ N})(1.43 \text{ m})}{2.00 \text{ m}} \\ N_A &= 143.4 \text{ N}\end{aligned}$$

$$\begin{aligned}N_A + N_B &= w_d \\ N_B &= 958 \text{ N} - 143.4 \text{ N} \\ N_B &= 814.6 \text{ N}\end{aligned}$$

$$\boxed{N_A = 143.4 \text{ N}, N_B = 814.6 \text{ N}}$$

(b) $N_A = 0$

$$\begin{aligned}\sum \tau_{\star} &= 0 \\ (w_d) \left(\frac{l_{B,A}}{2} \right) &= (l_{A,B})(N_A) + (F)(h) \\ h &= \frac{(w_d) \left(\frac{l_{B,A}}{2} \right) - (l_{A,B})(N_A)}{F} \\ h &= \frac{(958 \text{ N})(1.00 \text{ m}) - (0)}{469.4 \text{ N}} \\ h &= 2.041 \text{ m}\end{aligned}$$

$h = 2.041 \text{ m}$

2 Lab Manual

2.1 370

2.2 372