

Homework 6 - Force Dynamics

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20 April 2023

Contents

1	Book	2
1.1	5.12	2
1.2	5.17	3
1.3	5.21	4
1.4	5.33	6
1.5	5.34	7
2	Lab Manual	9
2.1	571	9
2.2	575	10
2.3	577	10
2.4	578	10

1 Book

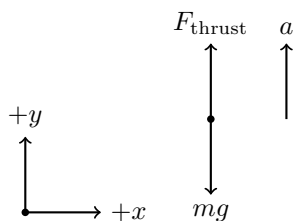
1.1 5.12

$$m = 125 \text{ kg}$$

$$F_{\text{thrust}} = 1720 \text{ N}$$

$$F_{\text{ps}} = 15.5 \text{ N}$$

(a)



$$\sum F_y = ma$$

$$F_{\text{thrust}} = ma + mg$$

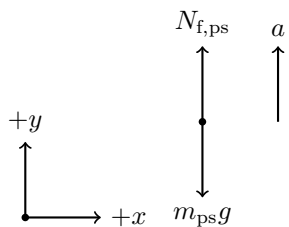
$$a = \frac{F_{\text{thrust}} - mg}{m}$$

$$a = \frac{1720 \text{ N} - (125 \text{ kg})(10 \text{ m s}^{-2})}{125 \text{ kg}}$$

$$a = 3.76 \text{ m s}^{-2}$$

$a = 3.76 \text{ m s}^{-2}$

(b)



$$\sum F_y = m_{ps}a$$

$$N_{f,ps} - m_{ps}g = m_{ps}a$$

$$N_{f,ps} = m_{ps}(g + a)$$

$$N_{f,ps} = \left(\frac{F_{ps}}{g} \right) (g + a)$$

$$N_{f,ps} = \left(\frac{15.5 \text{ N}}{10 \text{ m s}^{-2}} \right) (10 \text{ m s}^{-2} + 3.76 \text{ m s}^{-2})$$

$$N_{f,ps} = 21.33 \text{ N}$$

$N_{f,ps} = 21.33 \text{ N}$

1.2 5.17

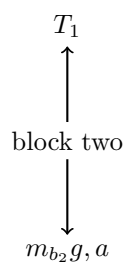
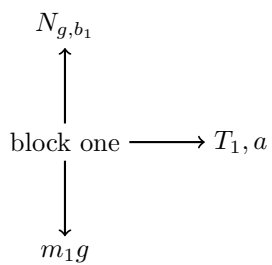
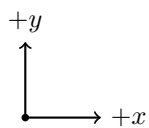
$$m_1 = 4.70 \text{ kg}$$

$$\mu = 0$$

$$m_2 = ?$$

$$T = 13.6 \text{ N}$$

(a)



(b)

$$\begin{aligned}\sum F_x^{(b_1)} &= m_{b_1} a \\ T_1 &= m_{b_1} a \\ a &= \frac{T_1}{m_{b_1}} \\ a &= \frac{13.6 \text{ N}}{4.70 \text{ kg}} \\ a &= 2.89 \text{ m s}^{-2} \\ \boxed{a &= 2.89 \text{ m s}^{-2}}\end{aligned}$$

(c)

$$\begin{aligned}\sum F_y^{(b_2)} &= -m_{b_2} a \\ T_1 - m_{b_2} g &= -m_{b_2} a \\ m_{b_2} (-a + g) &= T_1 \\ m_{b_2} &= \frac{T_1}{-a + g} \\ m_{b_2} &= \frac{13.6 \text{ N}}{-(2.89 \text{ m s}^{-2}) + 10 \text{ m s}^{-2}} \\ m_{b_2} &= 1.91 \text{ kg} \\ \boxed{m_{b_2} &= 1.91 \text{ kg}}\end{aligned}$$

(d) The weight of the hanging block (w_{b_2}) can be calculated using

$$w_{b_2} = m_{b_2} g,$$

solved as so:

$$\begin{aligned}w_{b_2} &= m_{b_2} g \\ &= (1.91 \text{ kg})(10 \text{ m s}^{-2}) \\ w_{b_2} &= 19.1 \text{ N}\end{aligned}$$

$$\boxed{\therefore \text{ it can be shown that } w_{b_2} > T_1}$$

1.3 5.21

$$\begin{aligned}m &= 2.10 \text{ kg} \\ v &= 8.50 \text{ m s}^{-1} \\ t &= 0 \\ F(t) &= (6.00 \text{ N s}^{-2})t^2\end{aligned}$$

- (a) Using the force function and NSL, solve for the acceleration function and integrate to get the velocity function.

$$\begin{aligned}
 F(t) &= ma \\
 a(t) &= \frac{F}{m} \\
 a(t) &= \frac{-6.00 \text{ N s}^{-2}}{2.10 \text{ kg}} t^2 \\
 a(t) &= (-2.86 \text{ m s}^{-4}) t^2
 \end{aligned}$$

$$\begin{aligned}
 v(t) &= \int a(t) dt = \int (-2.86 \text{ m s}^{-4}) t^2 dt \\
 v(t) &= (-0.953 \text{ m s}^{-4}) t^3 + v \\
 v(t) &= (-0.953 \text{ m s}^{-4}) t^3 + 8.50 \text{ m s}^{-1}
 \end{aligned}$$

Find t when the velocity is 0.

$$\begin{aligned}
 v(t) &= (-0.953 \text{ m s}^{-4}) t^3 + 8.50 \text{ m s}^{-1} = 0 \\
 (0.953 \text{ m s}^{-4}) t^3 &= 8.50 \text{ m s}^{-1} \\
 t &= 2.07 \text{ s}
 \end{aligned}$$

Integrate and find the distance at time, $t = 2.07 \text{ s}$.

$$\begin{aligned}
 x(t) &= \int v(t) dt = \int (-0.953 \text{ m s}^{-4}) t^3 + 8.50 \text{ m s}^{-1} dt \\
 x(t) &= (-0.238 \text{ m s}^{-2}) t^4 + (8.50 \text{ m s}^{-1}) t + 0
 \end{aligned}$$

$$\begin{aligned}
 x(2.07 \text{ s}) &= (-0.238 \text{ m s}^{-2})(2.07 \text{ s})^4 + (8.50 \text{ m s}^{-1})(2.07 \text{ s}) \\
 x(2.07 \text{ s}) &= 13.2 \text{ m}
 \end{aligned}$$

$$\boxed{x = 13.2 \text{ m}}$$

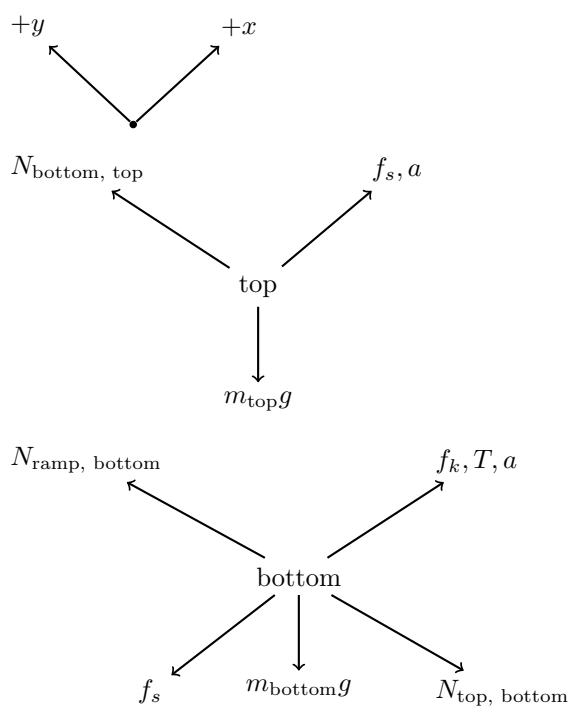
- (b) Find v at time $t = 3.00 \text{ s}$.

$$\begin{aligned}
 v(3.00 \text{ s}) &= (-0.953 \text{ m s}^{-4})(3.00 \text{ s})^3 + 8.50 \text{ m s}^{-1} \\
 v(3.00 \text{ s}) &= -17.2 \text{ m s}^{-1}
 \end{aligned}$$

$$\boxed{v = -17.2 \text{ m s}^{-1}}$$

1.4 5.33

$$\begin{aligned}
 m_{\text{top}} &= 32.0 \text{ kg} \\
 m_{\text{bottom}} &= 48.0 \text{ kg} \\
 \Delta y &= 2.50 \text{ m} \\
 \Delta x &= 4.75 \text{ m} \\
 v &= 15.0 \text{ cm s}^{-1} \\
 \mu_k &= 0.444 \\
 \mu_s &= 0.800 \\
 a_x &= 0 \text{ (constant)}
 \end{aligned}$$



(a)

$$\begin{aligned}
 \tan(\theta) &= \frac{y}{x} \\
 \theta &= \arctan\left(\frac{y}{x}\right) \\
 \theta &= \arctan\left(\frac{2.50 \text{ m}}{4.75 \text{ m}}\right) \\
 \theta &= 27.8^\circ
 \end{aligned}$$

$$\begin{aligned}
\sum F_y^{(\text{t, b})} &= m_{\text{t, b}} g \cos(27.8^\circ) \\
N_{\text{b, t}} - N_{\text{t, b}} + N_{\text{r, b}} &= m_{\text{t, b}} g \cos(27.8^\circ) \\
N_{\text{r, b}} &= m_{\text{t, b}} g \cos(27.8^\circ) \\
N_{\text{r, b}} &= (32.0 \text{ kg} + 48.0 \text{ kg})(10 \text{ m s}^{-2}) \cos(27.8^\circ) \\
N_{\text{r, b}} &= 707.7 \text{ N}
\end{aligned}$$

$$\begin{aligned}
\sum F_x^{(\text{t, b})} &= m_{\text{t, b}} a \\
f_s - f_s + f_k + T - m_{\text{t, b}} g \sin(27.8^\circ) &= (m_{\text{t, b}})(0) \\
\mu_k N_{\text{r, b}} + T - m_{\text{t, b}} g \sin(27.8^\circ) &= 0 \\
T &= m_{\text{t, b}} g \sin(27.8^\circ) - \mu_k N_{\text{r, b}} \\
T &= (32.0 \text{ kg} + 48.0 \text{ kg})(10 \text{ m s}^{-2}) \sin(27.8^\circ) - (0.444)(707.7 \text{ N}) \\
T &= 58.9 \text{ N}
\end{aligned}$$

$$\boxed{T = 58.9 \text{ N}}$$

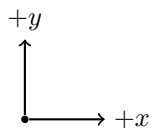
(b)

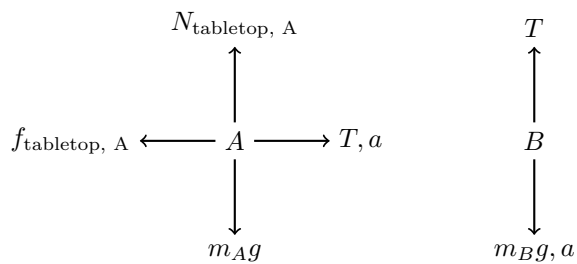
$$\begin{aligned}
\sum F_x^{(\text{top})} &= 0 \\
f_s &= m_{\text{top}} g \sin(27.8^\circ) \\
f_s &= (32.0 \text{ kg})(10.0 \text{ m s}^{-2}) \sin(27.8^\circ) \\
f_s &= 149.2 \text{ N}
\end{aligned}$$

$$\boxed{f_s = 149.2 \text{ N at } \theta = 27.8^\circ}$$

1.5 5.34

$$\begin{aligned}
w_A &= 45.0 \text{ N} \\
w_B &= 25.0 \text{ N} \\
a_B &= 0
\end{aligned}$$





(a)

$$w_A = m_A g$$

$$m_A = \frac{w_A}{g}$$

$$m_A = \frac{45.0 \text{ N}}{10 \text{ m s}^{-2}}$$

$$m_A = 4.5 \text{ kg}$$

$$w_B = m_B g$$

$$m_B = \frac{w_B}{g}$$

$$m_B = \frac{25.0 \text{ N}}{10 \text{ m s}^{-2}}$$

$$m_B = 2.5 \text{ kg}$$

$$\sum F_y^{(B)} = -m_B a$$

$$T - m_B g = (-m_B)(0)$$

$$T = m_B g$$

$$T = 25.0 \text{ N}$$

$$\sum F_y^{(A)} = 0$$

$$N_{\text{t, A}} = m_A g$$

$$N_{\text{t, A}} = 45.0 \text{ N}$$

$$\sum F_x^{(A)} = m_A a$$

$$T - \mu N_{\text{t, A}} = (m_A)(0)$$

$$\mu = \frac{T}{N_{\text{t, A}}}$$

$$\mu = \frac{25.0 \text{ N}}{45.0 \text{ N}}$$

$$\mu = 0.556$$

$$\mu = 0.556$$

(b)

$$\begin{aligned}\sum F_y^{(A)} &= 0 \\ N_{t, A} - m_A g &= 0 \\ N_{t, A} &= m_A g \\ N_{t, A} &= 2(45.0 \text{ N}) \\ N_{t, A} &= 90.0 \text{ N}\end{aligned}$$

$$\begin{aligned}\sum F_x^{(A)} &= m_A a \\ T - f_{t, A} &= m_A a \\ T &= \mu N_{t, A} + m_A a\end{aligned}$$

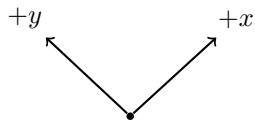
$$\begin{aligned}w_A &= m_A g \\ m_A &= \frac{90.0 \text{ N}}{10.0 \text{ m s}^{-2}} \\ m_A &= 9.00 \text{ kg}\end{aligned}$$

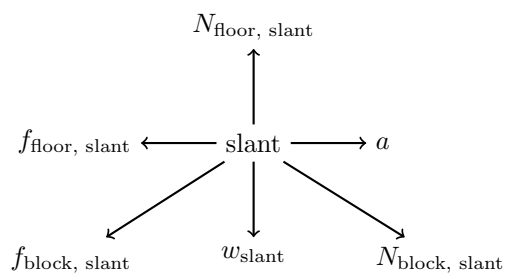
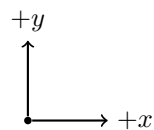
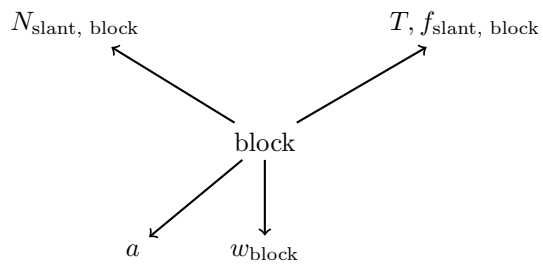
$$\begin{aligned}\sum F_y^{(B)} &= -m_B a \\ T - m_B g &= -m_B a \\ (\mu N_{t, A} + m_A a) - m_B g &= -m_B a \\ -m_A a - m_B a &= \mu N_{t, A} - m_B g \\ a &= \frac{\mu N_{t, A} - m_B g}{-m_A - m_B} \\ a &= \frac{(0.556)(90.0 \text{ N}) - 25.0 \text{ N}}{-(9.00 \text{ kg}) - 2.5 \text{ kg}} \\ a &= -2.18 \text{ m s}^{-2}\end{aligned}$$

$$a = -2.18 \text{ m s}^{-2}$$

2 Lab Manual

2.1 571





$$\begin{aligned}\sum F_y^{(b)} &= 0 \\ N_{s,b} - w_b &= 0 \\ N_{s,b} &= w_b\end{aligned}$$

$$\begin{aligned}\sum F_x^{(b)} &= -m_b a \\ T + f_{s,b} &= -m_b a \\ T + \mu N_{s,b} &= -m_b a \\ a &= -\frac{T + \mu N_{s,b}}{m_b}\end{aligned}$$

2.2 575

2.3 577

2.4 578