Homework 6 - Force Dynamics

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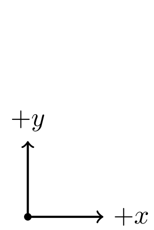
Contents

1 Book

1.1 5.12

$$
\begin{aligned}
m &= 125\,\mathrm{kg} \\
F_{\text{thrust}} &= 1720\,\mathrm{N} \\
F_{\text{ps}} &= 15.5\,\mathrm{N}
\end{aligned}
$$

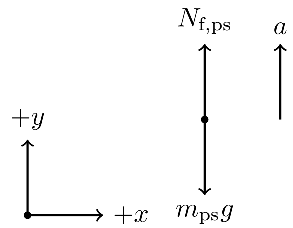
(a)



$$
\begin{aligned}
\sum F_y &= ma \\
F_{\text{thrust}} &= ma + mg \\
a &= \frac{F_{\text{thrust}} - mg}{m} \\
a &= \frac{1720\,\mathrm{N} - (125\,\mathrm{kg})(10\,\mathrm{m\,s^{-2}})}{125\,\mathrm{kg}} \\
a &= 3.76\,\mathrm{m\,s^{-2}}
\end{aligned}
$$

$$\boxed{a = 3.76\,\mathrm{m\,s^{-2}}}$$

(b)



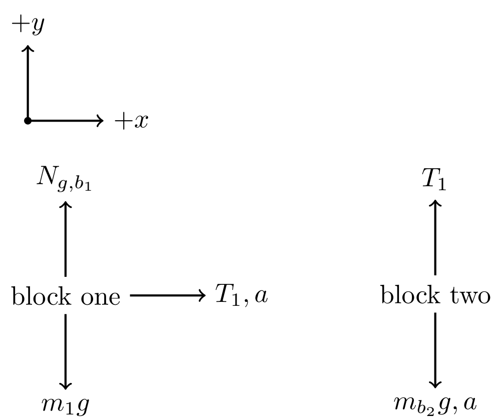
$$
\begin{aligned}
\sum F_y &= m_{\mathrm{ps}}a \\
N_{\mathrm{f,ps}} - m_{\mathrm{ps}}g &= m_{\mathrm{ps}}a \\
N_{\mathrm{f,ps}} &= m_{\mathrm{ps}}(g+a) \\
N_{\mathrm{f,ps}} &= \left(\frac{F_{\mathrm{ps}}}{g}\right)(g+a) \\
N_{\mathrm{f,ps}} &= \left(\frac{15.5\,\mathrm{N}}{10\,\mathrm{m\,s^{-2}}}\right)(10\,\mathrm{m\,s^{-2}} + 3.76\,\mathrm{m\,s^{-2}}) \\
N_{\mathrm{f,ps}} &= 21.33\,\mathrm{N}
\end{aligned}
$$

$$\boxed{N_{\mathrm{f,ps}} = 21.33\,\mathrm{N}}$$

1.2 5.17

$$
\begin{aligned}
m_1 &= 4.70\,\mathrm{kg} \\
\mu &= 0 \\
m_2 &=? \\
T &= 13.6\,\mathrm{N}
\end{aligned}
$$

(a)



(b)

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

$$\boxed{a = 2.89\,\mathrm{m\,s^{-2}}}$$

(c)

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

$$\boxed{m_{b_2} = 1.91\,\mathrm{kg}}$$

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

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

solved as so:

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

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

1.3 5.21

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

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

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

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

Find t when the velocity is 0.

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

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

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

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

$$\boxed{x = 13.2\,\mathrm{m}}$$

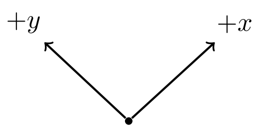
(b) Find v at time $t = 3.00\,\mathrm{s}$.

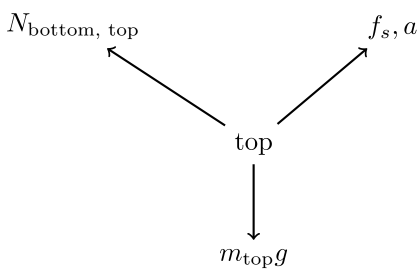
$$
\begin{aligned}
v(3.00\,\mathrm{s}) &= (-0.953\,\mathrm{m\,s^{-4}})(3.00\,\mathrm{s})^3 + 8.50\,\mathrm{m\,s^{-1}} \\
v(3.00\,\mathrm{s}) &= -17.2\,\mathrm{m\,s^{-1}}
\end{aligned}
$$

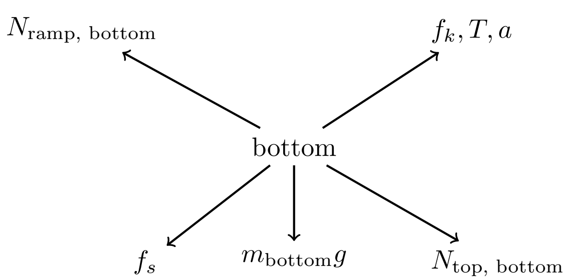
$$\boxed{v = -17.2\,\mathrm{m\,s^{-1}}}$$

1.4 5.33

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







(a)

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

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

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

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

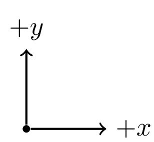
(b)

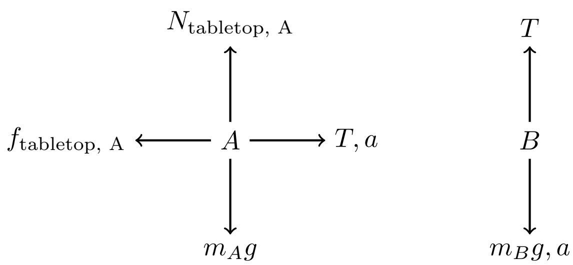
$$
\begin{aligned}
\sum F_x^{(\text{top})} &= 0 \\
f_s &= m_{\text{top}} g \sin(27.8^\circ) \\
f_s &= (32.0\,\text{kg})(10.0\,\text{m}\,\text{s}^{-2}) \sin(27.8^\circ) \\
f_s &= 149.2\,\text{N}
\end{aligned}
$$

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

1.5 5.34

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





(a)

$$
\begin{aligned}
w_A &= m_A g \\
m_A &= \frac{w_A}{g} \\
m_A &= \frac{45.0\,\mathrm{N}}{10\,\mathrm{m\,s^{-2}}} \\
m_A &= 4.5\,\mathrm{kg}
\end{aligned}
$$

$$
\begin{aligned}
w_B &= m_B g \\
m_B &= \frac{w_B}{g} \\
m_B &= \frac{25.0\,\mathrm{N}}{10\,\mathrm{m\,s^{-2}}} \\
m_B &= 2.5\,\mathrm{kg}
\end{aligned}
$$

$$
\begin{aligned}
\sum F_y^{(B)} &= -m_B a \\
T - m_B g &= (-m_B)(0) \\
T &= m_B g \\
T &= 25.0\,\mathrm{N}
\end{aligned}
$$

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

$$
\begin{aligned}
\sum F_x^{(A)} &= m_A a \\
T - \mu N_{\text{t, A}} &= (m_A)(0) \\
\mu &= \frac{T}{N_{\text{t, A}}} \\
\mu &= \frac{25.0\,\mathrm{N}}{45.0\,\mathrm{N}} \\
\mu &= 0.556
\end{aligned}
$$

$$\boxed{\mu = 0.556}$$

(b)

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

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

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

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

$$\boxed{a = -2.18\,\mathrm{m\,s^{-2}}}$$

2 Lab Manual

2.1 571

$T, f_{\text{slant, block}}$

block

2.2 575

2.3 577

2.4 578