General Physics I
Homework Chapter 5

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Homework: Chapter 5

Problem (1)

A 520 kg rocket sled can be accelerated at a constant rate from rest to 1300 km/h in 2.7 s. What is the magnitude of the required net force?

R:

$$\begin{aligned}1300\ km/h &= 1300\ km/h \times \left(\frac{1000\ m}{1\ km}\right) \times \left(\frac{1\ h}{60\ min}\right) \times \left(\frac{1\ min}{60\ s}\right)\\ &= 361.\bar{1}\ m/s\end{aligned}$$

$$\begin{aligned}F &= ma\\ F &= (520\ kg)\frac{\Delta v}{\Delta t}\\ F &= (520\ kg)\frac{361.\bar{1}\ m/s}{2.7\ s}\\ F &= 69\ 547.3\ kg \times m/s^2 = 69\ 547.3\ N \qquad (1)\end{aligned}$$

Problem (2)

Let the mass of the block be 1.7 sl and the angle θ be 31^o.

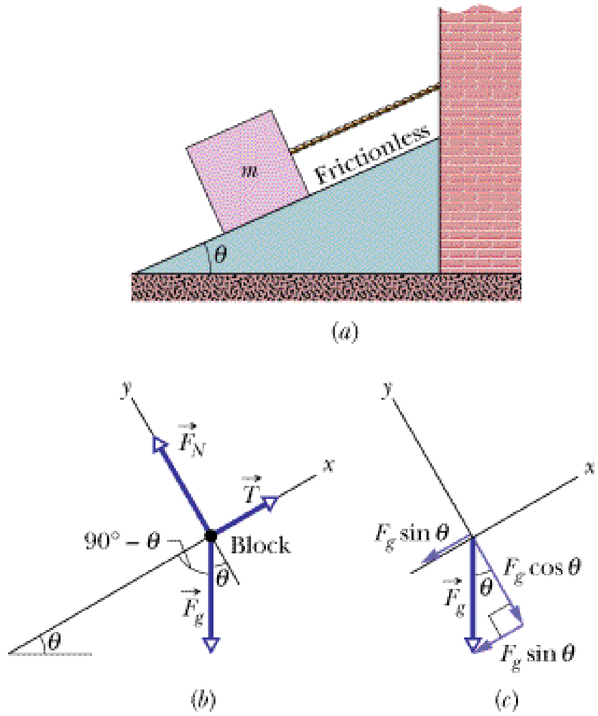

Figure 1: Illustration of Problem 2

Question (a)

Find the tension in the cord:

R:

Newton's 2^{nd} Law:

$$\begin{aligned}\sum F_x &= ma_x \\ T - F_{g_x} &= m(0) \\ T &= F_g \sin 31^o \\ &= (1.7\ sl)\left(32.2\ ft/s^2\right)(0.515) \\ &= 28.2\ sl \times ft/s^2 = 28.2\ lb \end{aligned} \tag{2}$$

Question (b)

Find the normal force acting on the block:

R:

Newton's 2^{nd} Law:

$$\begin{aligned} \sum F_y &= ma_y \\ F_N - F_{g_y} &= m(0) \\ F_N &= F_g \cos 31^o \\ &= (1.7\ sl)\left(32.2\ ft/s^2\right)(0.857) \\ &= 46.9\ sl \times ft/s^2 = 46.9\ lb \end{aligned} \tag{3}$$

Question (c)

If the cord is cut, find the magnitude of the block's acceleration:

R:

$$\begin{aligned} F_{g_x} &= 28.2\ lb = ma \\ a &= \frac{28.2\ lb}{1.7\ sl} = 16.6\ ft/s^2 \end{aligned} \tag{4}$$

Problem (3)

Sunjamming. A "sun yacht" is a spacecraft with a large sail that is pushed by sunlight. Although such a push is tiny in everyday circumstances, it can be large enough to send the spacecraft outward from the Sun on a cost-free but slow trip. Suppose that the spacecraft has a mass of 41 *sl* and receives a push of 3.6 *lb*.

Question (a)

What is the magnitude of the resulting acceleration?

R:

$$\begin{aligned} a &= \frac{F}{m} \\ &= \frac{3.6\ lb}{41\ sl} \\ &= 147.6\ ft/s^2 \end{aligned} \tag{5}$$

Question (b)

How far will it travel in 1 day?

R:

$$1\ day = 1\ day \times \left(\frac{24\ h}{1\ day}\right) \times \left(\frac{60\ min}{1\ h}\right) \times \left(\frac{60\ s}{1\ min}\right) \quad = 86\ 400\ s$$

$$s = s_0 + v_0 t + \frac{1}{2} a t^2$$

Suppose $v_0 = 0\ ft/s$ and $s_0 = 0\ ft$:

$$\begin{aligned} s &= \frac{1}{2}\left(147.6\ ft/s^2\right)(86400\ s)^2 \\ &= 550\ 914\ 048\ 000\ ft = 5.5 \times 10^{11}\ ft \end{aligned} \tag{6}$$

Question (c)

How fast will it then be moving?

R:

$$\begin{aligned} v &= v_0 + at \\ &= 0 + \left(147.6\ ft/s^2\right)(86\ 400\ s) \\ &= 12\ 752\ 640\ ft/s = 1.3 \times 10^7\ ft/s \end{aligned} \tag{7}$$

Problem (4)

A sphere of weight 0.084 N is suspended from a cord. A steady horizontal breeze pushes the sphere so that the cord makes a constant angle of 11^o with the vertical.

Question (a)

Find the magnitude of that push:

R:

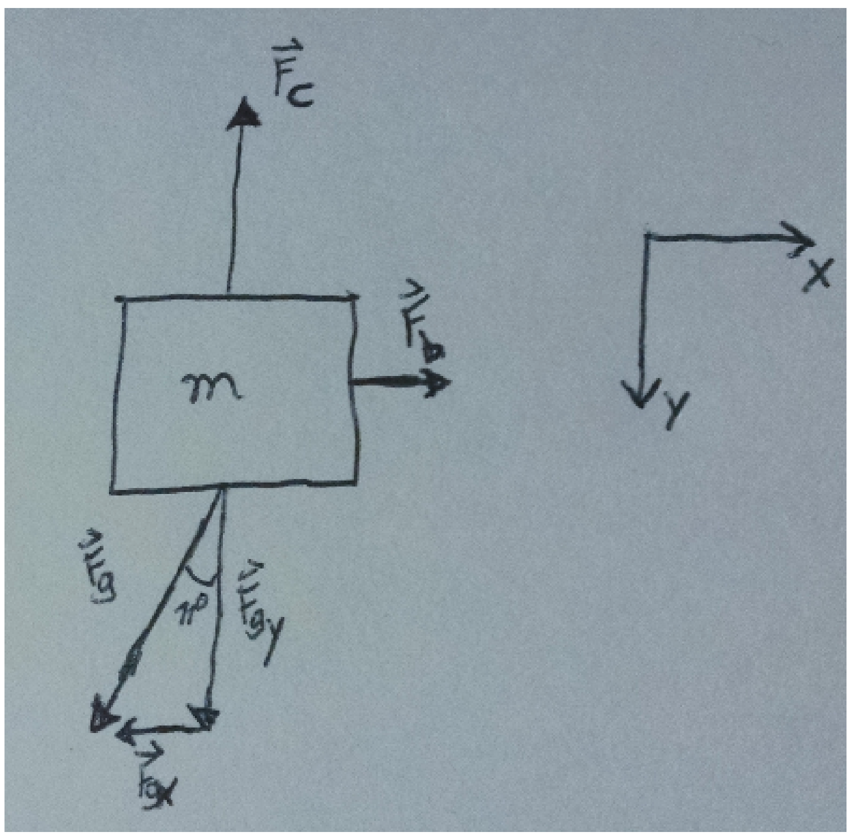

Figure 2: Free-Body Diagram (Problem 4)

Newton's 2^{nd} Law:

$$\begin{aligned}
\sum F_x &= ma_x \\
F_b - F_{g_x} &= m(0) \\
F_b &= F_{g_x} \\
&= F_g \sin 11^o \\
&= (0.084\ N)(0.191) \\
&= 0.016\ N
\end{aligned} \tag{8}$$

Question (b)

Find the tension in the cord:

R:

Newton's 2^{nd} Law:

$$\begin{aligned}
\sum F_y &= ma_y \\
F_c - F_{g_y} &= m(0) \\
F_c &= F_{g_y} \\
&= F_g \cos 11^o \\
&= (0.084\ N)(0.982) \\
&= 0.082\ N
\end{aligned} \tag{9}$$

Problem (5)

A elevator cab that weighs 8800 lb moves upward. What is the tension in the cable if the cab's speed is:

Question (a)

Increasing at a rate of 3.8 ft/s^2?

R:

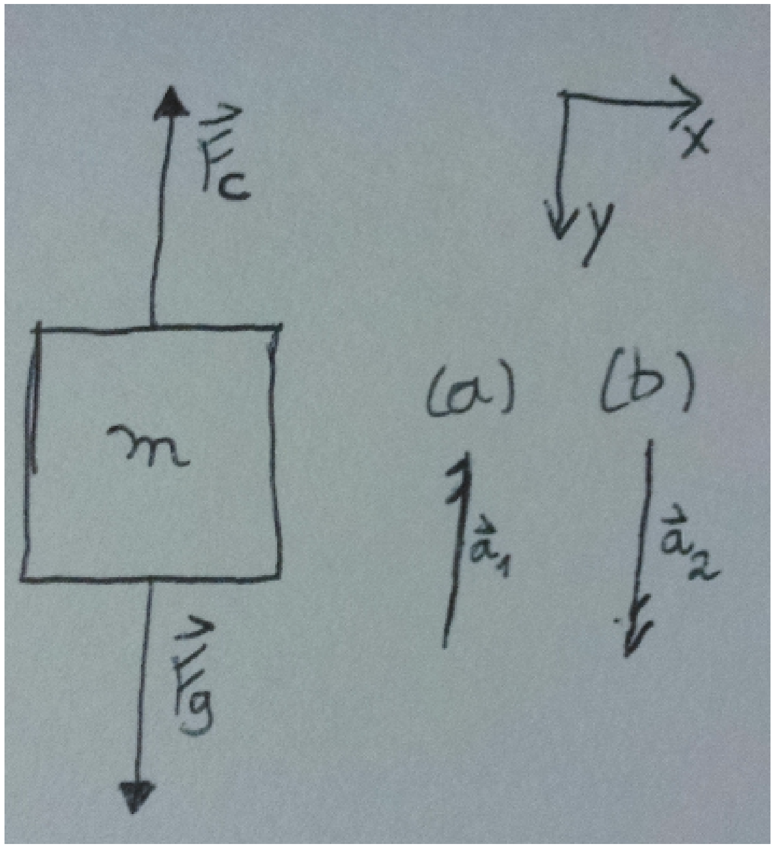

Figure 3: Free-Body Diagram (Problem 5)

$$m = \frac{8800\ lb}{32.2\ ft/s^2} = 273.2\ sl$$

Newton's 2^{nd} Law:

$$\begin{aligned}
\sum F_y &= ma_y \\
F_c - F_g &= (273.2\ sl)\left(3.8\ ft/s^2\right) \\
F_c &= (273.2\ sl)\left(3.8\ ft/s^2\right) + (8800\ lb) \\
F_c &= (1038.2\ lb) + (8800\ lb) = 9838.2\ lb
\end{aligned} \tag{10}$$

Question (b)

Decreasing at a rate of 2.9 ft/s^2?

R:

Newton's 2^{nd} Law:

$$\begin{aligned}
\sum F_y &= ma_y \\
F_c - F_g &= (273.2\ sl)\left(-2.9\ ft/s^2\right) \\
F_c &= (273.2\ sl)\left(-2.9\ ft/s^2\right) + (8800\ lb) \\
F_c &= (8800\ lb) - (792.3\ lb) = 8007.7\ lb
\end{aligned} \tag{11}$$

Problem (6)

Three connected blocks are pulled to the right on a horizontal frictionless table by a force of magnitude $T_3 = 58\ N$. If $m_1 = 13\ kg$, $m_2 = 26\ kg$, and $m_3 = 34\ kg$.

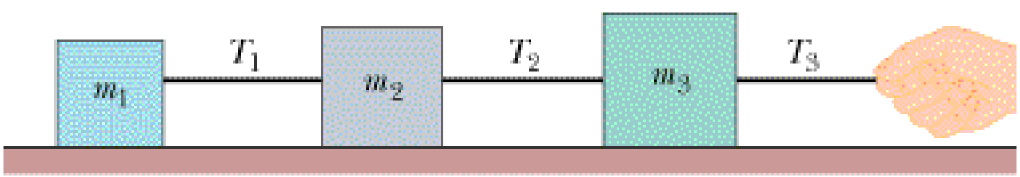

Figure 4: Illustration of Problem 6

Question (a)

Calculate the magnitude of the system's acceleration:

R:

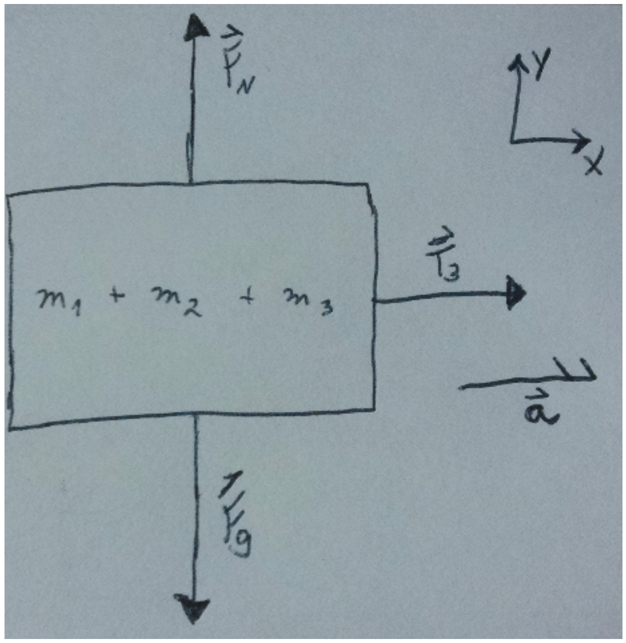

Figure 5: Free-Body Diagram (Problem 6 (a))

$$\begin{aligned} m &= m_1 + m_2 + m_3 \\ &= 73\ kg \end{aligned}$$

Newton's 2^{nd} Law on Block 3:

$$\begin{aligned} \sum F_x &= ma_x \\ T_3 &= (73\ kg)a_x \\ a_x &= \frac{58\ N}{73\ kg} \\ a &= 0.8\ m/s^2 \end{aligned} \tag{12}$$

Question (b)

Calculate the tension T_1:

R:

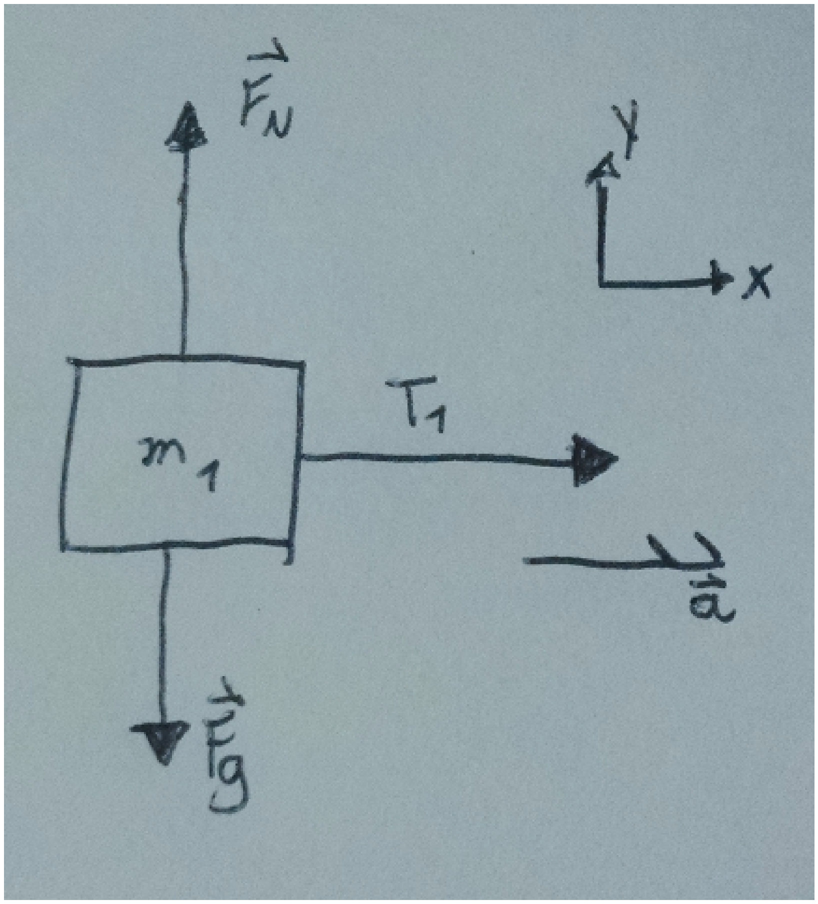

Figure 6: Free-Body Diagram (Problem 6 (b))

Newton's 2^{nd} Law on Block 1:

$$\begin{aligned}\sum F_x &= ma_x \\ T_1 &= (13\ kg)(0.8\ m/s^2) \\ &= 10.4\ N \end{aligned} \tag{13}$$

Question (c)

Calculate the tension T_2:

R:

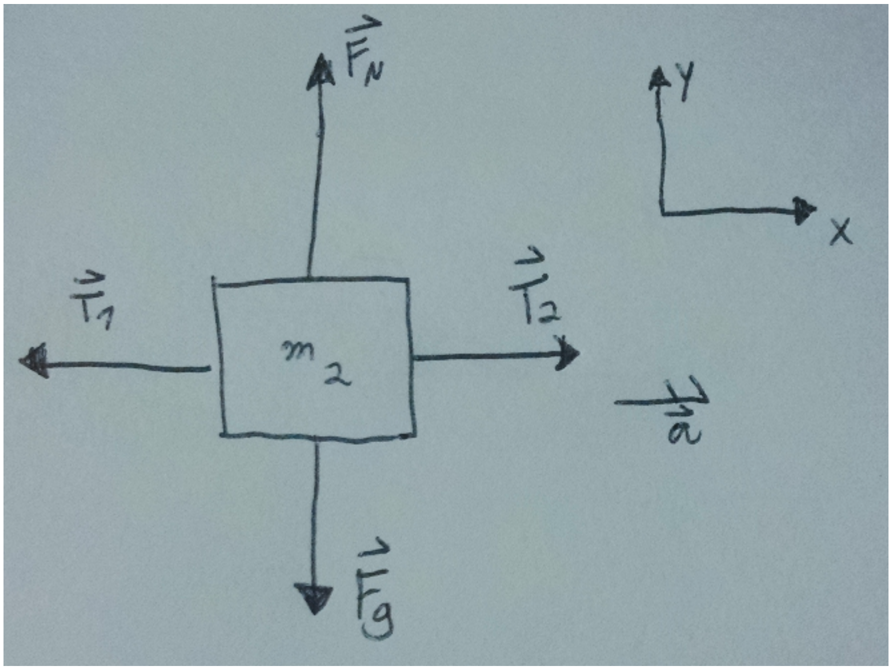

Figure 7: Free-Body Diagram (Problem 6 (c))

Newton's 2^{nd} Law on Block 2:

$$\begin{aligned}
\sum F_x &= ma_x \\
T_2 - T_1 &= (26\ kg)(0.8\ m/s^2) \\
T_2 &= (20.8\ N) + (10.4\ N) \\
&= 31.2\ N
\end{aligned} \tag{14}$$

Problem (7)

The figure shows two blocks connected by a cord (of negligible mass) that passes over a frictionless pulley (also of negligible mass). The arrangement is known as Atwood's machine. Block 1 has mass $m_1 = 0.89\ kg$; block 2 has mass $m_2 = 1.44\ kg$. What is the tension in the cord? Assume a y axis has its positive direction upward.

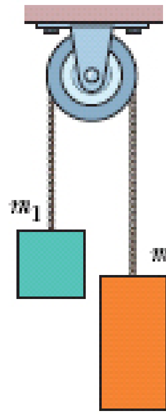

Figure 8: Illustration of Problem 7

R:

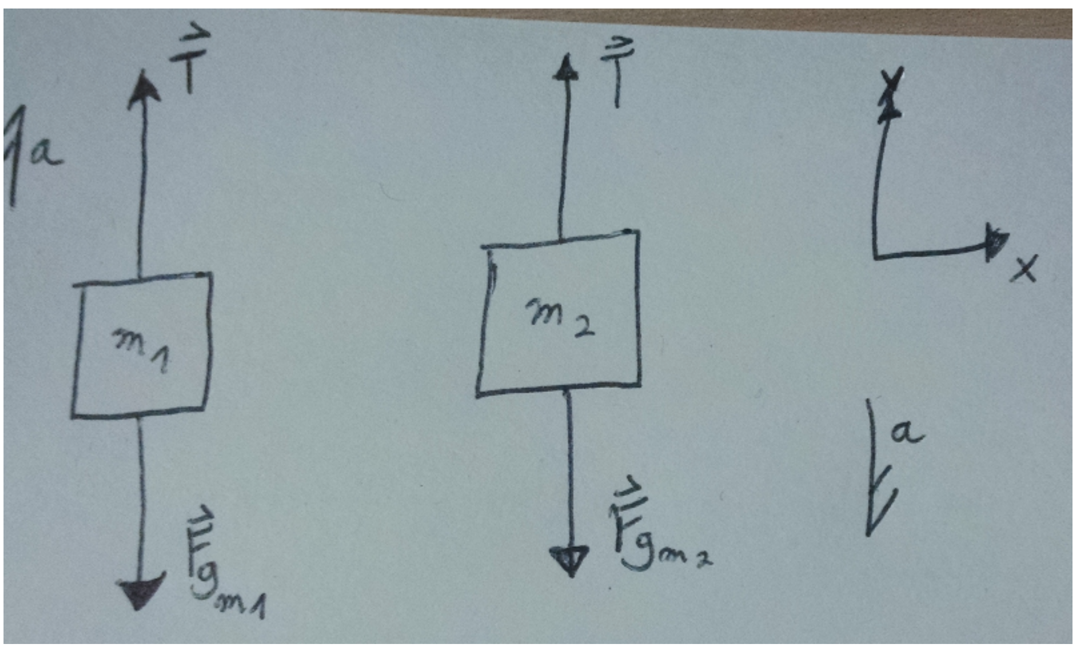

Figure 9: Free-Body Diagram (Problem 7)

For this problem, we can assume:

- The tensions in both blocks are equals
- The aceleration in both blocks have the same magnitude

Newton's 2^{nd} Law on Block 1:

$$\begin{aligned}
\sum F_y &= m_1 a_y \\
T - F_{g_{y_{m_1}}} &= (0.89\ kg)a \\
T &= (0.89\ kg)a + (0.89\ kg)\left(9.8\ m/s^2\right) \\
T &= (0.89\ kg)a + (8.72\ N)
\end{aligned}$$

Newton's 2^{nd} Law on Block 2:

$$\begin{aligned}
\sum F_y &= m_2 a_y \\
T - F_{g_{y_{m_2}}} &= (1.44\ kg)(-a) \\
T &= -(1.44\ kg)a + (1.44\ kg)\left(9.8\ m/s^2\right) \\
T &= -(1.44\ kg)a + (14.112\ N)
\end{aligned}$$

$$\begin{aligned}
(0.89\ kg)a + (8.72\ N) &= -(1.44\ kg)a + (14.112\ N) \\
(0.89\ kg)a + (1.44\ kg)a &= (14.112\ N) - (8.72\ N) \\
(2.33\ kg)a &= 5.392\ N \\
a &= \frac{5.392\ N}{2.33\ kg} = 2.314\ m/s^2 \\
T &= (0.89\ kg)(2.314\ m/s^2) + (8.72\ N) \\
&= (2.06\ N) + (8.72\ N) \\
&= 10.78\ N
\end{aligned} \tag{15}$$

Problem (8)

A block of mass $m_1 = 0.45\ sl$ on a frictionless plane inclined at angle $\theta = 34^o$ is connected by a cord over a massless, frictionless pulley to a second block of mass $m_2 = 0.15\ sl$ hanging vertically.

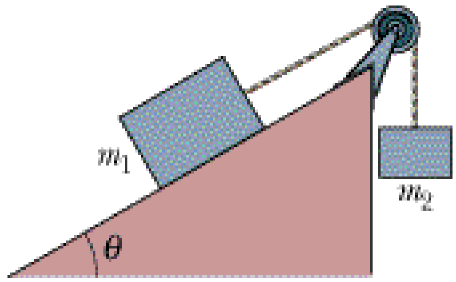

Figure 10: Illustration of Problem 8

Question (a)

What is the acceleration of the hanging block (choose the positive direction up)?

R:

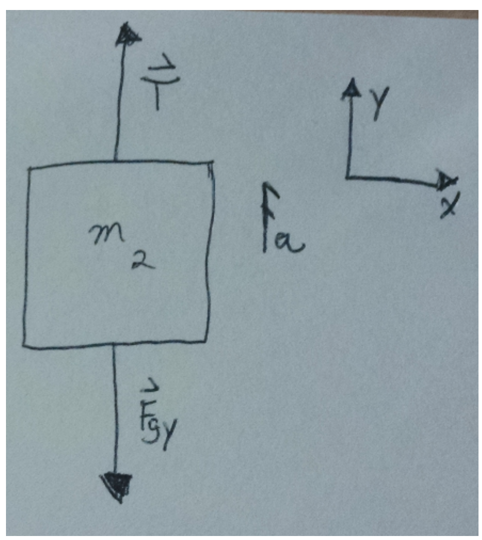

Figure 11: Free-Body Diagram (Problem 8 - Block 1)

For this problem, we can assume:

- The tensions in both blocks are equals

- The aceleration in both blocks have the same magnitude

Newton's 2^{nd} Law on Block 1:

$$\begin{aligned}\sum F_x &= m_1 a_x \\ T - F_{g_x} &= (0.45\ sl)a \\ T &= (0.45\ sl)a + F_g \sin 34^o \\ T &= (0.45\ sl)a + (0.45\ sl)\left(32.2\ ft/s^2\right)(0.559) \\ T &= (0.45\ sl)a + 8.1\ lb\end{aligned}$$

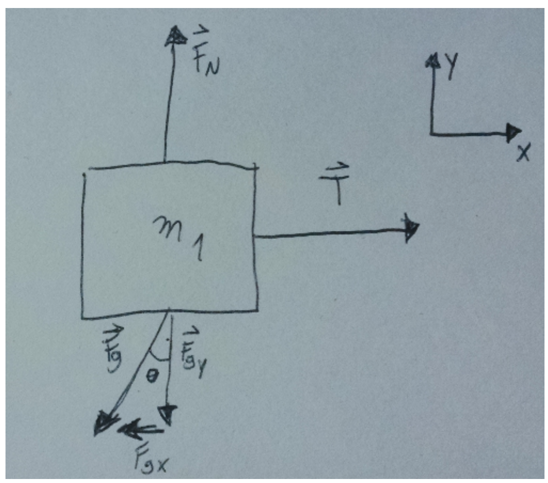

Figure 12: Free-Body Diagram (Problem 8 - Block 2)

Newton's 2^{nd} Law on Block 2:

$$\begin{aligned}\sum F_y &= m_2 a_y \\ T - F_{g_y} &= (0.15\ sl)a \\ T &= (0.15\ sl)a + (0.15\ sl)\left(32.2\ ft/s^2\right) \\ T &= (0.15\ sl)a + 14.49\ lb\end{aligned}$$

$$\begin{aligned}(0.15\ sl)a + (14.49\ lb) &= (0.45\ sl)a + (8.1\ lb)\\(0.15\ sl)a - (0.45\ sl)a &= (8.1\ lb) - (14.49\ lb)\\-(0.3\ sl)a &= -6.39\ lb\\a &= \frac{-6.39\ lb}{-0.3\ sl} = 21.3\ ft/s^2\end{aligned} \tag{16}$$

Question (b)

What is the tension in the cord?

R:

$$\begin{aligned}T &= (0.15\ sl)\left(21.3\ ft/s^2\right) + 14.49\ lb\\&= (3.19\ lb) + (14.49\ lb)\\&= 17.68\ lb\end{aligned} \tag{17}$$