10. \( F_N = 6.4 \text{N} \)
\( F_H = 12 \text{N} \)

Here's the trick: The net force is only in the y-direction. So, the x-components cancel out so the \( F_{net x} = 0 \).

\[-F_w + F_H = 0\]

\[-F_w \sin 25^\circ + F_H \sin \theta = 0\]

\[\sin \theta = \frac{F_w \sin 25^\circ}{12 \text{N}} = \frac{6.4 \text{N} \sin 25^\circ}{12 \text{N}}\]

\[\theta = 13^\circ \text{ from vertical}\]

17. This problem should have asked for the frictional force. (There isn't information to solve for the contact force.)

\[F_{net x} = M a_x\]

\[-f + (5.0 \text{N} \cos 60^\circ) = 0\]

\[f = 2.5 \text{N}\]
\[ T = 33600 \text{N} \]

\[ F_{\text{net}} = ma \]

\[ \frac{F_{\text{net}}}{T} - \frac{m}{m} = ma \]

\[ a = \frac{T - mg}{m} = \frac{33600 - (2530 \times 9.8)}{2530} \]

\[ a = 3.48 \frac{\text{m}}{\text{s}^2} \]

b.) use part a's acceleration...

\[ v = v_i + at = 1.20 \frac{\text{m}}{\text{s}} + (3.48 \frac{\text{m}}{\text{s}^2})(4.00 \text{s}) \]

\[ v = 15.1 \frac{\text{m}}{\text{s}} \]

30.

\[ F_P = 620 \text{N} \]

\[ F_a = ? \]

There must be air resistance from the skydiver, in addition to the parachute, in order for acceleration to be zero (constant velocity):

\[ F_{\text{net}} = ma = 0 \]

\[ F_P + F_a - W = 0 \]

\[ F_a = W - F_P = 650 - 620 = 30 \text{N} \]

b. Interaction Pairs: The parachute pulls the skydiver, so the skydiver pulls the parachute (620N). The air pushes on the skydiver, so the skydiver pushes on the air (30N). The earth pulls on the skydiver, so the skydiver pulls the earth (650N).

c. The parachute pulls on the diver and vice versa (620N) and the parachute and air must also be an interaction pair.
Assuming everything is in equilibrium, or $a = 0$.

Then,

a. The scale pushes up on Margie to counter her weight and make $F_T = 0$. So, $N = 543 \text{ N}$ upward.

b. The interaction partner is the force that the scale experiences due to Margie, also 543 N but downward.

c. The earth must push up on the scale with an upward force of $45 \text{ N} + 543 \text{ N} = 588 \text{ N}$. This is because of the scale's own weight plus the reaction force it must experience due to pushing on Margie.

39 a. We know it's going to fall to the Moon, since astronauts have actually done this... and the astronauts themselves are stuck to the moon - they don't fall to Earth. The rest of this problem shows why this is so.

b. $F_M = \frac{GM_m M}{r^2} = \left(\frac{6.67 \times 10^{-11} \text{ Nm}^2}{\text{kg}^2}\right) \left(\frac{7.35 \times 10^{22} \text{ kg}}{1.0 \text{ kg}}\right) \left(\frac{1.73 \times 10^6 \text{ m}}{2}\right)^2 = 1.6 \text{ N}$

c. $F_E = \frac{GM_m M}{r_E^2} = \left(\frac{6.67 \times 10^{-11} \text{ Nm}^2}{\text{kg}^2}\right) \left(\frac{5.97 \times 10^{24} \text{ kg}}{1.0 \text{ kg}}\right) \left(\frac{3.84 \times 10^8 \text{ m}}{2.7 \times 10^{-3}}\right)^2 
= 2.7 \times 10^{-3} \text{ N}$

This is really small!

d. The net force is $1.6 \text{ N} - 0.0027 \text{ N}$, so still 1.6 N towards the Moon.
Your weight: \( F = \frac{GMm}{r^2} \) where \( M = \) your mass \( M = 5.97 \times 10^{24} \text{ kg} \)
\( r = 6.37 \times 10^{6} \text{ m} \) (radius of Earth)

The question is, when is your altitude such that a new weight, \( F_2 \) is half of \( F_1 \)?

\[
\frac{F_1}{F_2} = 2 \quad \text{so} \quad F_2 = \frac{GMm}{r_2^2} = \frac{1}{2} \frac{GMm}{r_1^2} \Rightarrow \frac{1}{r_2^2} = \frac{1}{2} \frac{1}{r_1^2} \Rightarrow r_2^2 = \sqrt{2} r_1^2
\]

\( \frac{GMm}{r_2^2} \) hooray!

\[
\frac{GMm}{r_2^2} = 2 \Rightarrow \frac{1}{r_2^2} = \frac{1}{2} \frac{1}{r_1^2} \Rightarrow r_2 = \frac{r_1}{\sqrt{2}}
\]

but we wanted “altitude,” some \( h \) where \( h + r_1 = r_2 \), so:

\[
r_2 = h + r_1 = \frac{r_1}{\sqrt{2}}
\]

\[
h = \frac{r_1}{\sqrt{2}} - r_1 = r_1\left(\sqrt{2} - 1\right) = 2.64 \times 10^6 \text{ m above Earth's surface}
\]

[Diagram]

50°

Funny... I just so happen to have a book on a table on Earth right here in front of me!

The force of the table up on the book must be equal to the force of the Earth on the book. These act on the same object, so they are not interaction pairs. But they need to balance.
54a. \[ F_{\text{net}} = ma \]
\[ F_p - f > 0 \] for acceleration to begin
\[ F_p > f \]
\[ F_p > \mu_s N \]
\[ F_p > \mu_s (mg) \]
\[ \mu_s < \frac{F_p}{mg} = \frac{12 N}{(3.0 \, \text{kg})(9.8 \, \text{m/s}^2)} = 4/1 \]

I drew the same forces, with one addition force from the new block. The new block has to be pushed up by the old block, so the same force \( (Mg) \) must be acting on the bottom block.

in \( y \)-dir
\[ F_{\text{net}} = ma \]
\[ N - mg - Mg = 0 \]
\[ N = (m+M)g \]
What you'd expect: the table needs to support both blocks

b. \[ F_{\text{net}} = ma \]
\[ F_p - f > 0 \]
\[ F_p > \mu_s N = \mu_s (m+M)g \]
\[ F_p > 40 N \]
Great! No numbers!

\[ \text{in } y-\text{direction:} \]
\[ F_{\text{net}y} = M_2g \]
\[ T_y + T_{\text{act}} - W = 0 \]
\[ 2T \sin \theta - W = 0 \]
\[ T = \frac{W}{2 \sin \theta} \]

74.

No friction!

\[ T_i \text{ is the tension in this rope. It pulls } m_1 \text{ and } m_2 \text{, equal magnitude and oppositely directed, just as Newton would have it.} \]

Look at each block separately:

\[ m_1, \text{ x-direction} \]
\[ \frac{F_{\text{net}}}{m} = a \]
\[ T_1 = ma \]

\[ \text{um, ok, great!} \]

Now remember that “a” should be the same for both blocks, since they move together... \[ a = \frac{T_i}{m} \] substitute...

\[ m_2, \text{ x-direction} \]
\[ T_2 - T_1 = M_2a \]
\[ T_2 - T_1 = M_2 \cdot \frac{T_1}{m_1} \]
\[ T_2 = T_1 + \frac{m_2}{m_1} \cdot T_1 = T_i \left( 1 + \frac{m_2}{m_1} \right) \]

\[ \frac{T_2}{T_1} = 1 + \frac{m_2}{m_1} \]

GREAT! What does this mean?
To find acceleration consider forces on each block. Let's call the direction of motion (to right of $m_1$ and down for $m_2$) the positive and make it one dimensional.

For $m_1$:
$$T = m_1a$$

For $m_2$:
$$m_2g - T = m_2a$$

Oh, right, you want numbers!
$$a = \frac{(2.0 \text{ kg})(9.8 \text{ m/s}^2)}{(2.0 \text{ kg}) + (3.0 \text{ kg})} = 3.9 \text{ m/s}^2$$

(Both blocks accelerate at this rate.)

b. $N = x_i^0 + at = \left(3.9 \text{ m/s}^2\right)(1.2 \text{ s}) = 4.7 \text{ m/s}$ to right

c. $v^2 - x_i^0 = 2a \Delta x$
$$\Delta x = \frac{v^2}{2a} = \frac{(4.7 \text{ m/s})^2}{2 \left(3.9 \text{ m/s}^2\right)} = 2.8 \text{ m to right}$$

d. $\Delta x = x_i^0 + \frac{1}{2}at^2 = \frac{1}{2} \left(3.9 \text{ m/s}^2\right) (.48 \text{ s})^2 = .31 \text{ m right/down}$

Wow! Thanks, Adam, for such a fun review of chapter 2!
\[ \text{Net} = ma \\
N - mg = ma \\
a = \frac{N - mg}{m} = \frac{550 \text{N} - 600 \text{N}}{61.2 \text{ kg}} \\
= -81 \frac{\text{m}}{\text{s}^2} \text{ downward} \]

105. Only electromagnetic and gravitational have unlimited range. Sure, they get weaker with distance \( \left( F \propto \frac{1}{r^2} \right) \), but they never go to zero. Creepy!

The "strong force" only works for distances limited to the atomic nucleus. A contact force only works with contact, so, well... yeah... that doesn't work for anything except zero range, the definition of "in contact".

123. First of all, notice that photo. It was taken at the 2002 Olympics from right here on campus! We're famous!
Second of all, I think they meant “Canada and Scotland” (rather than Ireland). The sport was invented by the Scots and the stones themselves come from there. But, I digress.

a. “at rest”

\[
\begin{align*}
N & \downarrow \\
W & \downarrow \\
mg & \\
\end{align*}
\]

b. sliding:

\[
\begin{align*}
f & \leftarrow \\
m & \\
\text{friction (very small)} & \downarrow \\
N & \downarrow \\
mg & \\
\end{align*}
\]

(sliding to the right)

c. colliding:

\[
\begin{align*}
f & \leftarrow \\
m & \\
F & \downarrow \\
\text{due to collision with stone here} & \downarrow \\
mg & \\
\end{align*}
\]
\[ \frac{128}{m} \]

\[ m = 50.0 \text{ kg} \]

\[ 120 \text{ N} = T_2 - mg \]

\[ T_1 - T_2 - mg = 0 \]

\[ T_1 = T_2 + mg \]

\[ T_1 = 120 \text{ N} + \left( 50.0 \text{ kg} \right) \left( 9.8 \text{ m/s}^2 \right) \]

\[ T_1 = 610 \text{ N} \]