Solutions to the Extra Practice Problems for Chapter 3

1. The mass is 15.5 kg. Since the mass is not falling, the sum of the forces must be zero:

$$\mathbf{F}_{\text{net}} = \mathbf{F}_{\text{n}} + \mathbf{w} = \mathbf{0}$$

Defining up as positive:

$$\mathbf{F}_{\text{n}} - \text{m} \cdot \text{g} = 0$$

$$152 \text{ N} - \text{m} \cdot \left(9.81 \frac{\text{m}}{\text{s}^2}\right) = 0$$

$$\text{m} = \frac{152 \frac{\text{kg} \cdot \cancel{\text{m}}}{\cancel{\text{s}^2}}}{\left(9.81 \frac{\cancel{\text{m}}}{\cancel{\text{s}^2}}\right)} = 15.5 \text{ kg}$$

2. The acceleration is 1.1 m/s^2 up. We have what we need to calculate the man's actual weight, which will allow us to calculate the net force acting on him, since the scale reads the normal force. Defining up as positive:

$$\mathbf{F}_{\text{net}} = \mathbf{F}_{\text{n}} + \mathbf{w} = 851 \text{ N} - \text{m} \cdot \text{g} = 851 \text{ N} - (78.0 \text{ kg}) \cdot \left(9.81 \frac{\text{m}}{\text{s}^2}\right) = 851 \text{ N} - 765 \text{ N} = 86 \text{ N}$$

According to Newton's Second Law, that has to equal mass times acceleration:

$$\mathbf{F}_{\text{net}} = \text{m} \cdot \mathbf{a}$$

$$86 \text{ N} = (78.0 \text{ kg}) \cdot \mathbf{a}$$

$$\mathbf{a} = \frac{86 \text{ N}}{78.0 \text{ kg}} = \frac{86 \frac{\cancel{\text{kg}} \cdot \text{m}}{\text{s}^2}}{78.0 \cancel{\text{kg}}} = 1.1 \frac{\text{m}}{\text{s}^2}$$

Positive was defined as up, so the acceleration is up.

3. The coefficient of kinetic friction is 0.27. It doesn't matter what the constant velocity is. The fact that it is constant means the acceleration is zero, which means the net force is zero.

$$\mathbf{F}_{\text{net}} = \mathbf{F} + \mathbf{f} = 0$$

Defining the push as positive, and remembering that we must convert to kg:

$$\mathbf{F} - \mu \cdot \text{m} \cdot \text{g} = 0$$

$$1.0 \text{ N} - \mu \cdot (0.372 \text{ kg}) \cdot \left(9.81 \frac{\text{m}}{\text{s}^2}\right) = 0$$

$$\mu = \frac{1.0 \text{ N}}{(0.372 \text{ kg}) \cdot \left(9.81 \frac{\text{m}}{\text{s}^2}\right)} = \frac{1.0 \frac{\cancel{\text{kg}} \cdot \cancel{\text{m}}}{\cancel{\text{s}^2}}}{(0.372 \cancel{\text{kg}}) \cdot \left(9.81 \frac{\cancel{\text{m}}}{\cancel{\text{s}^2}}\right)} = 0.27$$

4. Yes, it will move, and its acceleration will be 1.8 m/s^2 north. To move the box, the force must be greater than static friction, which is:

$$\mathbf{f} = \mu \cdot \text{m} \cdot \text{g} = (0.45) \cdot (95 \text{ kg}) \cdot \left(9.81 \frac{\text{m}}{\text{s}^2}\right) = 420 \text{ N}$$

So it will move. To determine its acceleration while moving, we have to determine the net force, which is the applied force and kinetic friction. Defining north as positive:

$$\mathbf{F_{net}} = \mathbf{F} + \mathbf{f} = 439\ \text{N} - \mu \cdot \text{m} \cdot \text{g} = 439\ \text{N} - (0.29) \cdot (95\ \text{kg}) \cdot \left(9.81\ \frac{\text{m}}{\text{s}^2}\right) = 439\ \text{N} - 270\ \text{N} = 170\ \text{N}$$

That will equal the mass times the acceleration:

$$\mathbf{F_{net}} = \text{m} \cdot \mathbf{a}$$

$$170\ \text{N} = (95\ \text{kg}) \cdot \mathbf{a}$$

$$\mathbf{a} = \frac{170\ \text{N}}{95\ \text{kg}} = \frac{170\ \frac{\cancel{\text{kg}} \cdot \text{m}}{\text{s}^2}}{95\ \cancel{\text{kg}}} = 1.8 \frac{\text{m}}{\text{s}^2}$$

Positive was defined as north, so the acceleration is north.

5. <u>It will take 20 s</u>. We have enough information to calculate the net force. Defining south as positive:

$$\mathbf{F_{net}} = \mathbf{F} + \mathbf{f} = 57\ \text{N} - \mu \cdot \text{m} \cdot \text{g} = 57\ \text{N} - (0.22) \cdot (24.3\ \text{kg}) \cdot \left(9.81\ \frac{\text{m}}{\text{s}^2}\right) = 57\ \text{N} - 52\ \text{N} = 5\ \text{N}$$

That will equal the mass times the acceleration:

$$\mathbf{F_{net}} = \text{m} \cdot \mathbf{a}$$

$$5\ \text{N} = (24.3\ \text{kg}) \cdot \mathbf{a}$$

$$\mathbf{a} = \frac{5\ \text{N}}{24.3\ \text{kg}} = \frac{5\ \frac{\cancel{\text{kg}} \cdot \text{m}}{\text{s}^2}}{24.3\ \cancel{\text{kg}}} = 0.2 \frac{\text{m}}{\text{s}^2}$$

We now know the acceleration, that $\mathbf{v}_0 = 0$, and $\mathbf{v}_f = 3.4$ m/s south (which is positive).

$$\mathbf{v_f} = \mathbf{v_o} + \mathbf{a} \cdot \text{t}$$

$$3.4 \frac{\text{m}}{\text{s}} = 0 + \left(0.2 \frac{\text{m}}{\text{s}^2}\right) \cdot \text{t}$$

$$\text{t} = \frac{3.4 \frac{\cancel{\text{m}}}{\cancel{\text{s}}}}{0.2 \frac{\cancel{\text{m}}}{\cancel{\text{s}^2}}} = 20\ \text{s}$$

6. <u>It will slide 14 m</u>. We have enough information to calculate the net force. Defining north as positive:

$$\mathbf{F_{net}} = \mathbf{F} + \mathbf{f} = 390\ \text{N} - \mu \cdot \text{m} \cdot \text{g} = 390\ \text{N} - (0.19) \cdot (115\ \text{kg}) \cdot \left(9.81\ \frac{\text{m}}{\text{s}^2}\right) = 390\ \text{N} - 210\ \text{N} = 180\ \text{N}$$

That will equal the mass times the acceleration:

$$\mathbf{F_{net}} = \text{m} \cdot \mathbf{a}$$

$$180\ \text{N} = (115\ \text{kg}) \cdot \mathbf{a}$$

$$\mathbf{a} = \frac{180\ \text{N}}{115\ \text{kg}} = \frac{180\ \frac{\cancel{\text{kg}} \cdot \text{m}}{\text{s}^2}}{115\ \cancel{\text{kg}}} = 1.6 \frac{\text{m}}{\text{s}^2}$$

We know $\mathbf{v}_f = 0$, $\mathbf{v}_0 = 6.6$ m/s, and $\mathbf{a} = 1.6$ m/s^2. We can use Equation (2.11) to determine the distance:

$$\mathbf{v_f}^2 = \mathbf{v_0}^2 + 2\mathbf{a} \cdot \Delta\mathbf{x}$$

$$(6.6\frac{\text{m}}{\text{s}})^2 = (0)^2 + 2(1.6\frac{\text{m}}{\text{s}^2}) \cdot \Delta\mathbf{x}$$

$$\Delta\mathbf{x} = \frac{(6.6\frac{\text{m}}{\text{s}})^2}{2(1.6\frac{\text{m}}{\text{s}^2})} = \frac{43.56\frac{\text{m}^{\cancel{2}}}{\cancel{\text{s}^2}}}{2(1.6\frac{\cancel{\text{m}}}{\cancel{\text{s}^2}})} = 14\text{ m}$$

7. <u>It is being pushed with a force of 1.91 N west</u>. We need to figure out the net force, and we can get it from the acceleration. We know $\Delta\mathbf{x} = 9.1$ m west, t = 3.0 s, $\mathbf{v}_0 = 0$. We can use Equation (2.16) to get the acceleration. Defining west as positive:

$$\Delta\mathbf{x} = \mathbf{v}_0 t + \frac{1}{2}\mathbf{a}t^2$$

$$9.1\text{ m} = (0)\cdot(3.0\text{ s}) + \frac{1}{2}\cdot\mathbf{a}\cdot(3.0\text{ s})^2$$

$$\mathbf{a} = \frac{2\cdot 9.1\text{ m}}{(3.0\text{ s})^2} = 2.0\frac{\text{m}}{\text{s}^2}$$

This gives us the net force, once we convert grams to kg:

$$\mathbf{F}_{\text{net}} = \text{m}\cdot\mathbf{a} = (0.461\text{ kg})\cdot\left(2.0\frac{\text{m}}{\text{s}^2}\right) = 0.92\text{ N}$$

That is equal to the applied force and friction:

$$\mathbf{F}_{\text{net}} = \mathbf{F} + \mathbf{f}$$

$$0.92\text{ N} = \text{F} - \mu\cdot\text{m}\cdot\text{g}$$

$$0.92\text{ N} = \text{F} - (0.22)\cdot(0.461\text{ kg})\cdot\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)$$

$$\mathbf{F} = 0.92\text{ N} + 0.99\text{ N} = 1.91\text{ N}$$

Since west is positive, the force is west.

8. <u>The string must be able to withstand 147 N of tension</u>. The string has to hold the sign up, and it does that with tension. It must use that to fight the weight. Defining up as positive:

$$\mathbf{T} + \mathbf{w} = 0$$

$$\mathbf{T} - \text{m}\cdot\text{g} = 0$$

$$\mathbf{T} = \text{m}\cdot\text{g} = (15.0\text{ kg})\cdot\left(9.81\ \frac{\text{m}}{\text{s}^2}\right) = 147\ \frac{\text{kg}\cdot\text{m}}{\text{s}^2}$$

9. <u>The tension will be 7,500 N</u>. The rope uses its tension to pull. If the rock is moving at a constant velocity, then the sum of that force and friction is zero:

$$\mathbf{F}_{\text{net}} = \mathbf{T} + \mathbf{f} = 0$$

Defining the direction with which the tension pulls as positive:

$$\mathbf{T} - \mu \cdot \mathrm{m} \cdot \mathrm{g} = 0$$

$$\mathbf{T} = \mu \cdot \mathrm{m} \cdot \mathrm{g} = (0.77) \cdot (991 \text{ kg}) \cdot \left(9.81 \ \frac{\mathrm{m}}{\mathrm{s}^2}\right) = 7{,}500 \text{ N}$$

10. Each segment will have a tension of 3,800 N. Since there are two segments pulling the rope, they can share the tension, so each gets half of the answer to problem 9. Since we are limited to two significant figures, that makes it 3,800 N each.