1. Initially, the boot and snow have a downward velocity.

Finally, the boot stops abruptly. Inertia of snow carries it downward, off the boot.

2.

2.1. A
2.2. B
2.3. C
2.4. None
2.5. None
2.6. A, B, C (always!)
3. The force needed is \( F = W \cdot \frac{h}{d} \)

Where:
- \( W \) = weight of refrigerator
- \( h \) = height
- \( d \) = length of ramp

\[ W = mg \]
\[ F = mg \cdot \frac{h}{d} = 200(9.8) \cdot \frac{1}{4} \]

\[ F = 490 \text{ kg.m/s}^2 \]

\( F = 490 \text{ Newtons} \)

\( W = \text{force} \times \text{distance} \)

\[ W = 490\text{N} \times 4\text{m} \]

\[ = 1960 \text{ N.m} \]

\( W = 1960 \text{ Joules} \)

Gravitational Potential Energy: \( U = mgh \)

\[ U = (200 \text{ kg}) \cdot (9.8 \text{ m/s}^2) \cdot (1 \text{ m}) \]

\[ U = 1960 \text{ Joules} \]

4. The force of your foot on the ball is the same as the force of the ball on your foot. That is Newton's 3rd Law.

The soccer ball accelerates more because it has a smaller mass than your foot and leg.
5. To break the tree branch, it must rotate around the breaking point. This requires **torque**.

The larger the torque, the more likely it is that the branch will break.

Force = Your weight = F

\[ \tau = r \times F \quad \text{(Eq. 2.1.2)} \]

where \( \tau \) = torque  
\( r \) = distance from pivot, or trunk.

So, as \( r \) increases, \( \tau \) increases, and branch is more likely to break.

6. The muscles in your jaw are attached at fixed points to your jaw. The torque they exert is \( \tau = r \times F \) is set by the muscle force. \( \tau_{\text{jaw}} \) is a constant.

To chew an object, the torque is transferred to the teeth:

\[ \tau_{\text{jaw}} = r \times F, \quad F = \frac{\tau_{\text{jaw}}}{r} \]

As \( r \) increases, \( F \) decreases. Force is greater at back of mouth, where \( r \) is small.
Some suggested problems (not to be turned in):

**Practice 1:**
When applying brakes, or slowing down, the velocity and acceleration are in opposite directions. If the bike is going forward, the acceleration is **backwards**.

**Practice 2:**
\[ v = v_0 + at \]
Assuming the rock's initial velocity is zero, \( v_0 = 0 \).
\[ v = at \], downward
\[ v = 1.5 \text{ m} \left( \frac{3 \text{ s}}{\text{s}^2} \right) \]
\[ v = 4.5 \text{ m/s}, \text{ downward} \]

**Practice 3.1**
Weight = \( m \times g \)
Assume \( g = 10 \text{ m/s}^2 \), \( W = (80 \text{ kg}) (10 \text{ m/s}^2) \)
\[ W = 800 \text{ N} \]

**Practice 3.2**
Moon weight = \( m \times 1.5 \text{ m/s}^2 \)
\[ W = 120 \text{ N} \]
Practice 4:

Hand at side:

- Shoulder = pivot
- Force is parallel to the line between the force and pivot.
- Therefore, there is no torque on the shoulder.
- It is easy to carry.

Hand in front:

- Lever arm: Force is now perpendicular to the line between force & pivot.
- Force: This exerts a large torque on the shoulder, and makes the weight difficult to carry.
Practice 5

\[ r_1 = 5r_2 \]

Torque from handle is

\[ \tau_1 = r_1 \times F_1 \]

This must equal the magnitude of the torque on the nut, to keep the objects from rotating:

\[ \tau_2 = r_2 \times F_2 = r_1 \times F_1 \]

**Known:**

\[ F_2 = \text{force on nut} \]

\[ F_1 = 20N \]

\[ r_1 = 5r_2 \]

Solve for \( F_2 \):

\[ F_2 = \frac{r_1 \times F_1}{r_2} \]

\[ F_2 = \frac{5r_2 \times F_1}{r_2} \]

\( r_2 \)'s cancel:

\[ F_2 = 5 \times F_1 = 100N \]