Free Fall on the Moon

1. A boy on Earth jumps straight upward with an initial velocity of 4.9 m/s.
   a. How long does it take for him to reach maximum height?
   
   \[ \begin{align*}
   \text{at max height } v &= 0 \text{ m/s} \\
   \frac{v_f}{v_i} &= \frac{t}{0} + at \\
   0 &= 4.9 + (-9.8t) \\
   t &= \frac{-4.9}{-9.8} = 0.5 \text{ s}
   \end{align*} \]
   
   b. At maximum height, what is his velocity?
   \[ 0 \text{ m/s} \]
   
   c. At maximum height, what is his acceleration? Explain your answer.
   \[ -9.8 \text{ m/s}^2 \]

2. An astronaut wearing a 20-kg spacesuit jumps on the Moon with an initial velocity of 16 m/s. On the Moon, the acceleration due to gravity is 1.62 m/s². (Assume that downward is the positive direction.)
   a. How long does it take him to reach maximum height?
   
   \[ \begin{align*}
   \frac{v_f}{v_i} &= \frac{t}{0} + at \\
   0 &= 16 - 1.62t \\
   t &= \frac{-16}{-1.62} = 9.85 \text{ s}
   \end{align*} \]
   
   b. What is the maximum height he reaches?
   \[ \Delta d = \frac{v_i t}{2} + \frac{1}{2} at^2 \]
   \[ \Delta d = 16(9.85) - \frac{1}{2}(1.62)(9.85^2) = 158.08 - 79.07 = 18.55 \text{ m} \]
   
   c. If you drew a velocity-time graph for the motion of the astronaut, what would be the slope of the line?
   \[ -1.62 \text{ m/s}^2 \]
   
   d. Are the vectors for acceleration and initial velocity pointed in the same or different directions? Explain your answer.
   Opposite
5. A toy rocket is shot straight up into the air with an initial speed of 45.0 m/s.

a. How long does it take for the rocket to reach its highest point?

\[
\begin{align*}
V_i &= 45 \text{ m/s} \\
V_f &= 0 \text{ m/s} \\
a &= -9.8 \text{ m/s}^2 \\
t &= ? \\
0 &= V_i + at \\
0 &= 45 - 9.8t \\
t &= \frac{-45}{-9.8} = 4.59 \text{s}
\end{align*}
\]

b. How high does the rocket rise above the ground?

\[
\begin{align*}
V_f^2 &= V_i^2 + 2ad \\
0^2 &= 45^2 + 2(-9.8)d \\
-2025 &= -19.6d \\
d &= \frac{-2025}{-19.6} = 103.3 \text{ m}
\end{align*}
\]
6. A squirrel drops an acorn from a tree branch that is 8.00 m from the ground.

a. How long is the acorn in the air?

\[
\begin{align*}
\Delta d &= -8 \text{ m} \\
V_i &= 0 \text{ m/s} \\
a &= -9.8 \text{ m/s}^2
\end{align*}
\]

\[
\Delta d = V_i t + \frac{1}{2} at^2 \\
-8 = 0(t) + \frac{1}{2}(-9.8)t^2 \\
t = 1.77
\]

b. What is the acorn's velocity when it reaches the ground?

\[
V_f^2 = V_i^2 + 2ad \\
V_f^2 = 0^2 + 2(-9.8)(-8) \\
V_f^2 = 156.8 \\
V_f = \sqrt{156.8} = -12.52 \text{ m/s}
\]

c. Draw a velocity-time graph. Shade the area that shows the acorn's displacement.