Problem 1  22 points

6 pts  a) Highest point when \( v = 0 \)
\[
 v = v_0 - gt
\]
\[
 0 = +20 - 10t \Rightarrow t = 2 \text{ sec}
\]
\[
y = y_0 + v_0 t - \frac{1}{2}gt^2 = 20t - 5t^2 \Rightarrow \text{at 2 sec, } y = 20 \text{ m}
\]

6 pts  b) \( t = 2 \text{ sec} \) : 1\(^{st}\) stone is at 
\[
y = y_0 + v_0 t - \frac{1}{2}gt^2 = -20 - 2 - 5 \cdot 4 = +20 \text{ m}
\]
This happens to be the highest point.

10 pts  c) Hit should occur when 1\(^{st}\) stone is 3 sec on its way. Its height is then
\[
y = +20 \cdot 3 - 5 \cdot 3^2 = +15 \text{ m}
\]
We want the 2\(^{nd}\) stone to also be at +15 m at 1 second in its flight:
\[
15 = 0 + v_0 t - 5t^2 \quad t = 1
\]
\[
15 = v_0 - 5 \Rightarrow v_0 = +20 \text{ m/sec}
\]
which is the same speed as the 1\(^{st}\) stone when it started.

There is another way of finding the speed without making any calculations. At \( t = 3 \),
the 1\(^{st}\) stone is at the same height as it was at \( t = 1 \) sec. Since the stones have to collide
at this height exactly 1 sec after the 2\(^{nd}\) stone is thrown, the 2\(^{nd}\) stone should also begin
with a speed of 20 m/sec.
**Problem 2** 34 points

6 pts  a) \( \ddot{v} = \frac{dv}{dt} = 4\dot{y} - (2 - 2t)\ddot{z} \)

at \( t = 3, \ddot{v} = 4\dot{y} + 4\ddot{z} \)

6 pts  b) \( |\ddot{v}| = \sqrt{16 + 16} = 4\sqrt{2} \text{ m/sec} \)

6 pts  c) \( \ddot{a} = 2\ddot{z}, |\ddot{a}| = 2 \text{ m/sec} \)

6 pts  d) \( v = (2t - 2)\ddot{z} \Rightarrow v = 0 \) when \( t = 1 \text{ sec} \)

10 pts  e) \( z = \ell^2 - 2\ell - 3, \) at \( t = 0, z = -3 \)

\[ z = 0 \Rightarrow t = \frac{-2\pm\sqrt{4+12}}{2} = 1 \pm 2 \Rightarrow t = -1 \text{ and } t = +3 \]

\( v = 0 \) at \( t = 1 \Rightarrow z = 1 - 2 - 3 = -4 \)

at \( t = -2, z = 4 + 4 - 3 = +5 \)
Problem 3  44 points

6 pts  a) \( x = x_0 + v_0 t = 3t + 3t = +3m \)

6 pts  b) \( a = \frac{dv}{dt} \) and \( a \) is constant between \( t = 1 \) and \( t = 3 \). The velocity goes down by 6 m/sec in 2 sec. Thus, \( a = -3 \text{ m/sec}^2 \).

6 pts  c) At the beginning of the 2nd sec, \( x = +3 \) and \( v = +3 \). During the next 2 sec (up to \( t = +3 \)), \( a = -3 \). Thus \( x \) at \( t = 3 \) becomes \( x = +3 + 3t - \frac{3}{2}t^2 \). But \( t \) is now 2 sec so \( x = +3 \text{ m} \).

6 pts  d) \( v_{t=0,t=3} = \frac{x_0 - x_0}{3} = \frac{+3 - 0}{3} = +1 \text{ m/sec} \)

10 pts  e) Between \( t = 1 \) sec and \( t = 2 \) sec, the position of \( x \) keeps increasing as the velocity is positive. \( x \) reaches a maximum at \( t = 2 \) sec, at which time its position is \( x = +4.5 \text{ m} \). During the third second (between \( t = 2 \) sec and \( t = 3 \) sec), the velocity becomes negative and at \( t = 3 \) sec the object is back at \( x = +3 \). Thus, it has traveled \( 4.5 + 1.5 = 6 \text{ m} \) during the first 3 sec. Thus its average speed is \( 2 \text{ m/sec} \).

10 pts  f) The plot: