A parachutist after bailing out falls 50 m without friction. When the parachute opens, he decelerates at 2.0 m/s². He reaches the ground with a speed of 30 m/s.

(a) How long is the parachutist in the air?
(b) At what height did he bail out?

\[ \begin{align*}
\text{Let the height at which he bailed out be } h. \\
\text{For the first 50 m he falls with acceleration } g, \text{ so} \\
y - y_0 &= v_0t + \frac{1}{2}gt^2 = \frac{1}{2}gt^2, \text{ since the initial velocity is zero} \\
t &= \sqrt{\frac{2(y - y_0)}{g}} = \sqrt{\frac{2(-50 m)}{9.8 \text{ m/s}^2}} = 10.2 \text{ s} \\
\text{(t = -10.2 s is obviously unphysical.)} \\
\text{The velocity of the parachutist at the moment the parachute opens is thus} \\
v &= v_0 + gt = 0 - (9.8 \text{ m/s}^2)(3.2 \text{ s}) = -31 \text{ m/s}. \\
\text{For the remainder of the trip we have} \\
v_f^2 - v^2 &= 2a(0 - [h - 50]) \quad \text{where } v_f = -30 \text{ m/s}, \\
&= 2a[h - 50] \\
&= 2 \times 20 \text{ m/s}^2 \\
&= 40 \text{ m/s}^2. \\
\text{Thus} \\
h - 50 &= \frac{v_f^2 - v^2}{2a} \\
h &= 50 + \frac{(-31 \text{ m/s})^2 - (30 \text{ m/s})^2}{2(20 \text{ m/s}^2)} = 70 \text{ m} \\
\text{The second part of the trip covers a time } t_2 \text{, with} \\
v_f - v &= at_2 \quad \text{or} \quad t_2 = \frac{v_f - v}{a} = \frac{-30 \text{ m/s} - (-31 \text{ m/s})}{20 \text{ m/s}^2} = 0.65 \text{ s}. \\
a) \text{ The total time is } t + t_2 = 3.2 \text{ s} + 0.65 \text{ s} = 3.8 \text{ s} \\
\end{align*} \]