At $t_0 = 0$ the front of a car is even with the back end of the train. The car travels with a constant velocity of 24.0 m/s in the direction shown. The train starts from rest and proceeds with an acceleration of 1.40 m/s².

A. **[10 pts.]** At what earliest instant after $t_0 = 0$ is the front of the car even with the front end of the train?

At this instant $x_c = x_T + L$

\[ v_{oc} \cdot t = \frac{1}{2} a_T \cdot t^2 + L \]

\[ (24 \text{ m/s})^2 - (24 \text{ m/s}) \cdot t + 92 = 0 \]

\[ t = \frac{24 \pm \sqrt{(24)^2 - (4)(1.4)(92)}}{1.4} \]

\[ t = \frac{24 \pm 17.8}{1.4} \]

\[ t = 4.40s, \ 29.95s \]

B. **[10 pts.]** At what location (position) does this occur?

\[ v_{oc} \cdot t = (24 \text{ m/s}) \cdot (4.40s) \]

\[ x_c = 107 \text{ m} \]

C. **[10 pts.]** After how many seconds past $t_0 = 0$ will the front of the car once again be even with the rear end of the train? At the second instant

\[ x_c = x_T \]

\[ v_{oc} \cdot t = \frac{1}{2} a_T \cdot t^2 \]

\[ t = \frac{2v_{oc}}{a_T} = \frac{(2)(24 \text{ m/s})}{1.4 \text{ m/s}^2} = 34.3 \text{ s} \]

D. **[10 pts.]** What is the distance between the front of the car and the front of the train at the instant the car and train have identical velocities? When $v_{oc} = v_T = 24.0 \text{ m/s} = a_T \cdot t$

The time taken is thus

\[ t = \frac{v_{oc}}{a_T} = \frac{24 \text{ m/s}}{1.4 \text{ m/s}^2} \]

\[ x_c - x_T = v_{oc} \cdot t - (L + \frac{1}{2} a_T \cdot t^2) \]

\[ = (24 \text{ m/s})(17.15s) - (92m + (1.7 \text{ m/s}^2)(17.15s)^2) \]

\[ \Delta x = 1.3 \text{ m} \]