F:(20 pts) Truck-Car Near Collision

This problem is about a truck and a car. Capital letters (A, V_0, V, X) refer to the truck, while small letters (a, v, x_0, x) refer to the car. The truck is travelling down a one-lane road with initial velocity $V_0 = 30m/s$ when the truck driver sees the car in the middle of the road, at rest. The truck driver immediately puts on the brakes, which causes the truck to decelerate, with constant acceleration $A = -8m/s^2$. Measuring all distances from the initial position of the truck, the car is initially at a distance $x_0 = 25m$ ahead of the truck. At the same moment, the car driver realizes the situation and "floors" the gas pedal, instantly achieving forward constant acceleration a. (There is no delay in getting the car started, etc.) The car driver wonders whether he can stay ahead of the truck...

$a =$______________

$t =$______________

$\Delta x =$______________

$v =$______________

•$(12pts)$ Find the minimum acceleration a needed if the car is just barely going to avoid being hit by the truck. For the rest of this problem, use this value of the acceleration. Also find the time t elapsed to the point of "near miss." Proceed as follows. First, write down two equations giving the position X and velocity V of the truck as functions of time. Second, write down two equations giving the position x and velocity v of the car as functions of time. Third, set $X = x$ and $V = v$ at the moment of "near miss;" this gives you two equations in the two unknowns a and t, in terms of known quantities A, V_0, and x_0. Finally, solve for a and t.

•$(6pts)$ Find the distance $\Delta x = x - x_0$ travelled by the car until the point of "near miss," and the velocity v of the car at that time.

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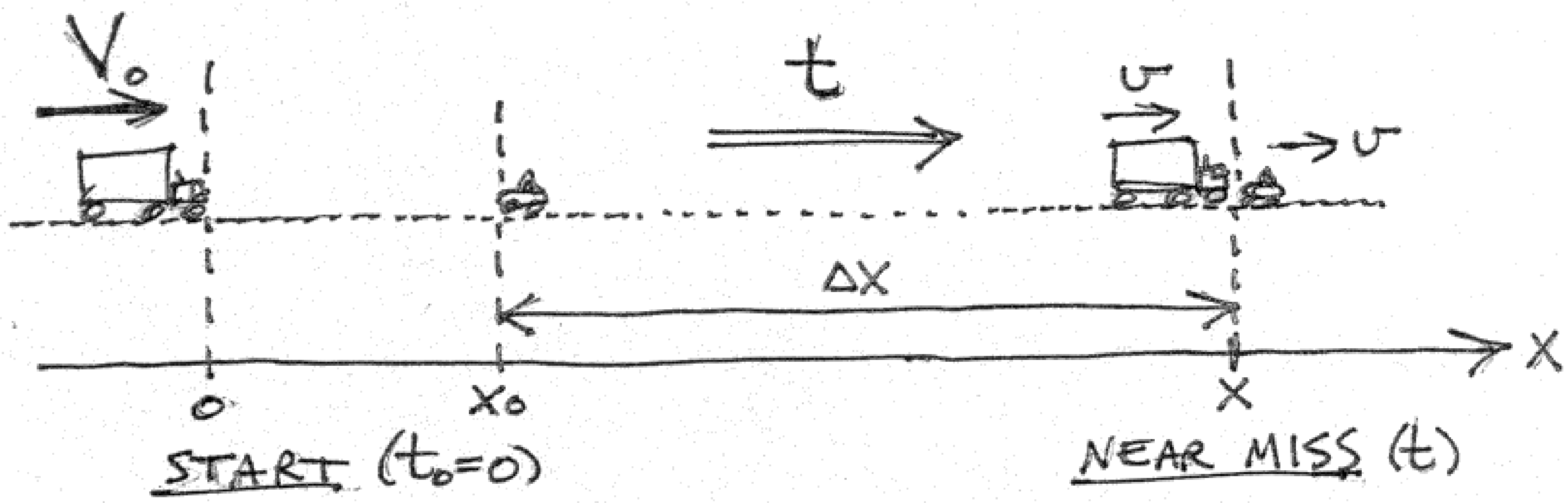
$a =$ 10 m/s²

$t =$ 1.67 s

$\Delta x =$ 13.9 m

$v =$ 16.7 m/s



•(12*pts*) Find the minimum acceleration a needed if the car is just barely going to avoid being hit by the truck. For the rest of this problem, use this value of the acceleration. Also find the time t elapsed to the point of "near miss." Proceed as follows. First, write down two equations giving the position X and velocity V of the truck as functions of time. Second, write down two equations giving the position x and velocity v of the car as functions of time. Third, set $X = x$ and $V = v$ at the moment of "near miss;" this gives you two equations in the two unknowns a and t, in terms of known quantities A, V_0, and x_0. Finally, solve for a and t.

•(6*pts*) Find the distance $\Delta x = x - x_0$ travelled by the car until the point of "near miss," and the velocity v of the car at that time.

$$X = \cancel{X_0} + V_0 t + \tfrac{1}{2}At^2 = V_0 t + \tfrac{1}{2}At^2$$

$$V = V_0 + At$$

$$x = x_0 + \cancel{v_0}t + \tfrac{1}{2}at^2 = x_0 + \tfrac{1}{2}at^2$$

$$v = \cancel{v_0} + at = at$$

$$X = x \Rightarrow \quad V_0 t + \tfrac{1}{2}At^2 = x_0 + \tfrac{1}{2}at^2$$

$$V = v \Rightarrow \quad V_0 + At = at$$

Solve...

$V_0 = 30\,m/s$
$X_0 = 25\,m$, $A = -8\,m/s^2$

F: Truck-Car Near Collision, Continued...

$$V_0 + At = at \Longrightarrow a = \frac{V_0 + At}{t}$$

then, $$V_0 t + \cancel{\tfrac{1}{2}At^2} = x_0 + \frac{1}{2}\left(\frac{V_0 + At}{t}\right)t^2$$

$$= x_0 + \frac{1}{2}(V_0 + At)t$$

$$= x_0 + \frac{1}{2}V_0 t + \cancel{\tfrac{1}{2}At^2}$$

$$V_0 t = x_0 + \frac{1}{2}V_0 t$$

$$\frac{1}{2}V_0 t = x_0, \quad \boxed{t = \frac{2X_0}{V_0}} = \boxed{1.66667\,s}$$

$$a = \frac{V_0}{2X_0}\left(V_0 + A \cdot \frac{2X_0}{V_0}\right) = \frac{V_0^2}{2X_0} + A$$

$$\boxed{a = A + \frac{V_0^2}{2X_0}} = \boxed{10\,m/s^2}$$

$$\Delta X = X - X_0 = \frac{1}{2}at^2 = \boxed{13.8889\,m}$$

$$v = at = \boxed{16.6667\,m/s}$$