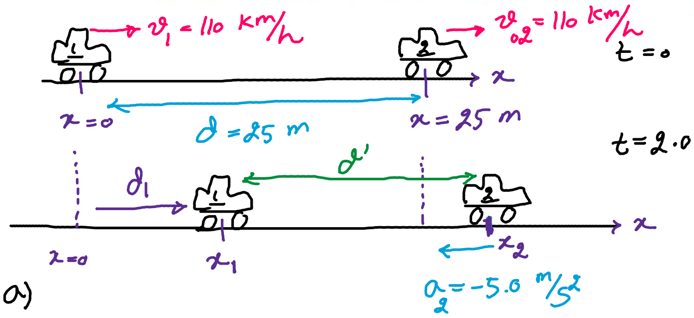
42 H GO You are arguing over a cell phone while trailing an unmarked police car by 25 m; both your car and the police car are traveling at 110 km/h. Your argument diverts your attention from the police car for 2.0 s (long enough for you to look at the phone and yell, "I won't do that!"). At the beginning of that 2.0 s, the police officer begins braking suddenly at 5.0 m/s². (a) What is the separation between the two cars when your attention finally returns? Suppose that you take another 0.40 s to realize your danger and begin braking. (b) If you too brake at 5.0 m/s², what is your speed when you hit the police car?



$$v_1 = 110\ km/h \times \frac{10^3}{3600} = 30.5\bar{5} \simeq 30.56\ m/s$$

a)

$t = 0$: Car 1 : $x_{01} = 0$, Car 2 : $x_{02} = 25\ m$

$t = 2.0\ s$: Car 1 : $\longrightarrow v = \text{const.} \Rightarrow x_1 = v_1 t + x_{01} = 30.56 \times 2 + 0 \simeq 61.11\ m = d_1$

Car 2 : $\longrightarrow a = \text{const.} \Rightarrow x_2 = \frac{1}{2} a_2 t^2 + v_{02} t + x_0 = \underbrace{\frac{1}{2} \times (-5) \times 2^2}_{-10} + \underbrace{30.56 \times 2}_{61.11} + 25$

$\longrightarrow x_2 = 76.11\ m$

$\Rightarrow d' = x_2 - d_1 = 76.11 - 61.11 = \boxed{15\ m}$

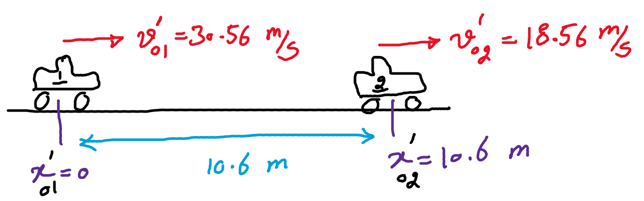
b)

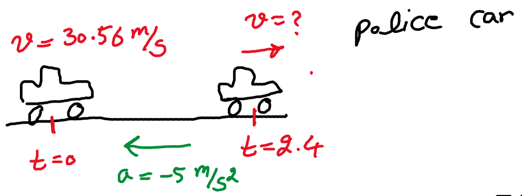
$t' = 2.4\ s$: Car 1 $\Rightarrow x_1' = v_1 t' + x_{01} = 30.56 \times 2.4 + 0 \simeq 73.33\ m$

Car 2 $\Rightarrow x_2' = \frac{1}{2} a_2 t' + v_{02} t' + x_0 = \underbrace{\frac{1}{2} \times (-5) \times (2.4)^2}_{-14.4} + 30.56 \times 2.4 + 25$

$\longrightarrow x_2' \simeq 83.94\ m$

$\longrightarrow d'' = x_2' - x_1' = 83.94 - 73.33 = 10.61\ m$





$v = at + v_0 = -5 \times 2.4 + 30.56 \simeq 18.56\ m/s$

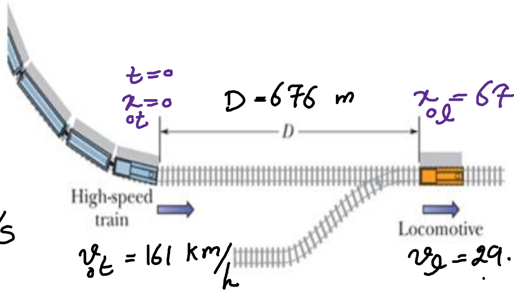
$x_1 = x_2 \Rightarrow \frac{1}{2} a_1 t^2 + v_{01}' t + x_{01}' = \frac{1}{2} a_2 t^2 + v_{02}' t + x_{02}'$

$\frac{1}{2}\cancel{(-5)} t^2 + 30.56 t + 0 = \frac{1}{2}\cancel{(-5)} t^2 + 18.56 t + 10.6$

$\longrightarrow 30.56 t - 18.56 t = 10.6 \longrightarrow t = \frac{10.6}{12} \simeq 0.883\ s$

$v = a_1 t + v_{01}' \Rightarrow v = -5 \times 0.883 + 30.56 = 26.14\ m/s \simeq \boxed{94\ km/h}$

43 H GO When a high-speed passenger train traveling at 161 km/h rounds a bend, the engineer is shocked to see that a locomotive has improperly entered onto the track from a siding and is a distance D = 676 m ahead (Fig. 2.17). The locomotive is moving at 29.0 km/h. The engineer of the high-speed train immediately applies the brakes. (a) What must be the magnitude of the resulting constant deceleration if a collision is to be just avoided? (b) Assume that the engineer is at $x = 0$ when, at $t = 0$, he first spots the locomotive. Sketch $x(t)$ curves for the locomotive and high-speed train for the cases in which a collision is just avoided and is not quite avoided.



$v_l = 29.0\ \frac{km}{h} \times \frac{10^3}{36} \simeq 8.05\ \frac{m}{s}$

$v_{0t} = 161\ \frac{km}{h} \times \frac{10^3}{36} \simeq 44.72\ \frac{m}{s}$

a)

locomotive : $v = \text{Const.} \Rightarrow x_l = v_l t + x_{0l}$

train : $a = \text{Const.} \Rightarrow x_t = \frac{1}{2}at^2 + v_{0t}t + x_{0t}$

$x_l = x_t \Rightarrow 8.05t + 676 = \frac{1}{2}at^2 + 44.72t + 0$

$\Rightarrow \frac{1}{2}at^2 + \underbrace{44.72t - 8.05t}_{36.67t} - 676 = 0$

$ax^2 + 2bx + c = 0$

$x = \frac{-b \mp \sqrt{b^2 - ac}}{a}$

$\xrightarrow{\times 2} at^2 + 73.34t - 1352 = 0$

$a = a$; $b = 36.67$; $c = -1352$

$\Rightarrow t = \frac{-36.67 \mp \sqrt{(36.67)^2 + 1352a}}{a} \Rightarrow (36.67)^2 + 1352a = 0 \Rightarrow a = \frac{-(36.67)^2}{1352}$

$\Rightarrow a \simeq -0.994\ m/s^2$

$t_{collision} = \frac{-36.67}{-0.994} = 36.45\ s$

b) locomotive : $x = 8.05t + 676$

$t = 0 \rightarrow x(t=0) = 676\ m$

$t = 10 \rightarrow x(t=10) = 756.5\ m$

train : $x = \frac{1}{2} \times (-0.994)t^2 + 44.72t$

$x = -0.497t^2 + 44.72t$

$t = 0 \rightarrow x(t=0) = 0$

$\frac{dx}{dt} = 0 \Rightarrow -0.497 \times 2t + 44.72 = 0$

$\Rightarrow t = \frac{44.72}{0.994} = 44.99 \simeq 45\ s$

$x(t = 44.99) \simeq 1006\ m$