32 E BIO FCP A world's land speed record was set by Colonel John P. Stapp when in March 1954 he rode a rocket-propelled sled that moved along a track at 1020 km/h. He and the sled were brought to a stop in 1.4 s. (See Fig. 2.3.1.) In terms of g, what acceleration did he experience while stopping?

$v_0 = 1020 \text{ km/h} = 1020 \times \frac{10^3 \text{ m}}{3600 \text{ s}} \simeq 283.3 \text{ m/s}$

$t = 1.4 \text{ s}$

$v = 0$

$a = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t - t_0} = \frac{0 - 283.3}{1.4} \simeq -202.4 \text{ m/s}^2$

$g = 9.8 \text{ m/s}^2 \Rightarrow a = \frac{-202.4}{9.8} g \simeq -20.65 g \simeq 21 g$

33 E SSM A car traveling 56.0 km/h is 24.0 m from a barrier when the driver slams on the brakes. The car hits the barrier 2.00 s later. (a) What is the magnitude of the car's constant acceleration before impact? (b) How fast is the car traveling at impact?

$x_0 = 0$ — $d = 24$ m — $x = d$

$v_0 = 56$ km/h, $t = 2$ s, $v = ?$

$v_0 = 56 \text{ km/h} = 56 \times \frac{10^3 \text{ m}}{3600 \text{ s}} \simeq 15.55 \text{ m/s}$

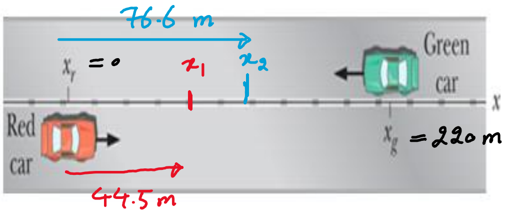
a) $x = \frac{1}{2} a t^2 + v_0 t + x_0 \rightarrow 24 = \frac{1}{2} \times a \times 2^2 + 15.55 \times 2 + 0 \Rightarrow a = \frac{24 - 31.1}{2} = -3.56 \text{ m/s}^2$

b) $v = at + v_0 \rightarrow v = -3.56 \times 2 + 15.55 \simeq 8.43 \text{ m/s} \simeq 30.3 \text{ km/h}$

34 M GO In Fig. 2.12, a red car and a green car, identical except for the color, move toward each other in adjacent lanes and parallel to an x axis. At time $t = 0$, the red car is at $x_r = 0$ and the green car is at $x_g = 220$ m. If the red car has a constant velocity of 20 km/h, the cars pass each other at $x = 44.5$ m, and if it has a constant velocity of 40 km/h, they pass each other at $x = 76.6$ m. What are (a) the initial velocity and (b) the constant acceleration of the green car?

$v_1 = 20 \text{ km/h} = 50/9 \text{ m/s}$; $x_1 = 44.5$ m

$v_2 = 40 \text{ km/h} = 100/9 \text{ m/s}$; $x_2 = 76.6$ m



$t = 0$

red car : $v = $ Const. $\rightarrow x = vt + x_0 \Rightarrow$

$44.5 = \frac{50}{9} t_1 + 0 \rightarrow t_1 = \frac{9 \times 44.5}{50} = 8.01 \text{ s}$

$76.6 = \frac{100}{9} t_2 + 0 \rightarrow t_2 = \frac{76.6 \times 9}{100} = 6.894 \text{ s}$

green car : $a = $ Const. $\rightarrow x = \frac{1}{2} a t^2 + v_0 t + x_0$

① : $x_1 = \frac{1}{2} a t_1^2 + v_0 t_1 + x_0^g \rightarrow 44.5 = \frac{1}{2} a \times (8.01)^2 + v_0 \times 8.01 + 220$

② : $x_2 = \frac{1}{2} a t_2^2 + v_0 t_2 + x_0^g \rightarrow 76.6 = \frac{1}{2} a \times (6.894)^2 + v_0 \times 6.894 + 220$

$\rightarrow$ $32.08 a + 8.01 v_0 = 44.5 - 220 = -175.5$ ← $\times 6.894$

$23.76 a + 6.894 v_0 = 76.6 - 220 = -143.4$ ← $\times 8.01$

$$221.16$$

$$\rightarrow \begin{cases} 32.08 \times 6.894 a + 8.01 \times 6.894 v_0 = -175.5 \times 6.894 \\ 23.76 \times 8.01 a + 8.01 \times 6.894 v_0 = -143.4 \times 8.01 \end{cases}$$

$$190.32$$

$\ominus$: $30.84 a = -61.263 \rightarrow a \simeq -1.986 \simeq -2.0 \ m/s^2$

$*$: $32.08 \times (-1.986) + 8.01 v_0 = -175.5 \rightarrow v_0 \simeq -13.96 \ m/s \times 3.6 \simeq -50 \ km/h$

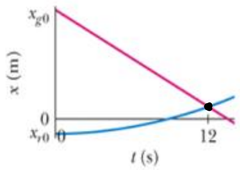
$-35.0^m = x_r^0$ $\quad x = 0$ $\quad x_g^0 = 270 \, m$ $\quad \rightarrow +$ $\quad v_0 = 0$

Figure 2.12 Problems 34 and 35.

35 **M** Figure 2.12 shows a red car and a green car that move toward each other. Figure 2.13 is a graph of their motion, showing the positions $x_{g0} = 270$ m and $x_{r0} = -35.0$ m at time $t = 0$. The green car has a constant speed of 20.0 m/s and the red car begins from rest. What is the acceleration magnitude of the red car?

green car : $v = const. = -20 \ m/s$

red car : $a = const. = ?$



$x_r = x_g$: $t = 12$ s

$$\left. \begin{aligned} x_g &= vt + x_g^0 \\ x_r &= \tfrac{1}{2} a t^2 + v_0 t + x_r^0 \end{aligned} \right\} \rightarrow vt + x_g^0 = \tfrac{1}{2} a t^2 + v_0 t + x_r^0 \quad (v_0 = 0)$$

$$\underbrace{(-20) \times 12 + 270}_{30} = \tfrac{1}{2} a \times \underbrace{(12)^2}_{144} + (-35) \rightarrow a = \frac{65}{72} \simeq 0.90 \ m/s^2$$

36 **M** A car moves along an x axis through a distance of 900 m, starting at rest (at $x = 0$) and ending at rest (at $x = 900$ m). Through the first $\frac{1}{4}$ of that distance, its acceleration is $+2.25$ m/s². Through the rest of that distance, its acceleration is -0.750 m/s². What are (a) its travel time through the 900 m and (b) its maximum speed? (c) Graph position x, velocity v, and acceleration a versus time t for the trip.

$v_0 = 0$ $\quad v_{max}$ $\quad a_2 = -0.750 \ m/s^2$ $\quad v = 0$

$x_0 = 0$ $\quad x = \frac{900}{4} = 225 m$ $\quad x = 900 \ m$

$a_1 = +2.25 \ m/s^2$

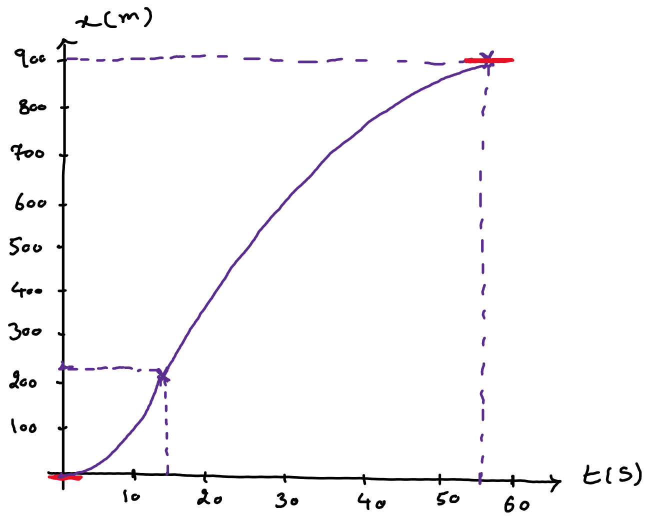
$$x_1 = \tfrac{1}{2} a t_1^2 + v_0 t + x_0 \quad (v_0 = 0,\ x_0 = 0) \rightarrow 225 = \tfrac{1}{2} \times 2.25 \, t_1^2 \rightarrow t_1^2 = \frac{2 \times 225}{2.25} = 200 \rightarrow t_1 = \sqrt{200} \simeq 14.14 \ s$$

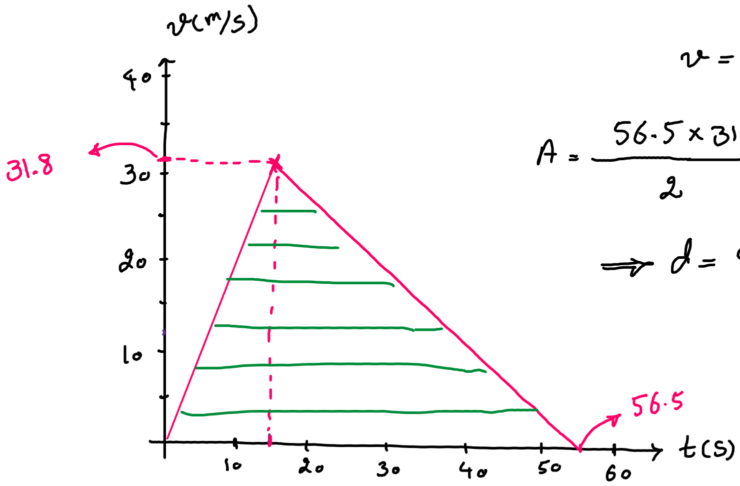
$$v = at + v_0 \quad (v_0 = 0) \rightarrow v_{max} = a_1 t_1 = 2.25 \times 14.14 \simeq 31.8 \ m/s \quad \leftarrow \text{part b}$$

$$a_2 = \frac{\Delta v}{\Delta t} = \frac{v - v_{max}}{t_2} \quad (v = 0) \rightarrow t_2 = \frac{-v_{max}}{a_2} = \frac{-31.8}{-0.75} \simeq 42.4 \ s$$

$$\rightarrow t = t_1 + t_2 = 14.14 + 42.4 = 56.54 \simeq 56.5 \ s$$

c)





$$v = \frac{dx}{dt} \longrightarrow x = \int v\,dt$$

$$A = \frac{56.5 \times 31.8}{2} \simeq 900$$

$$\Rightarrow d = 900 \text{ m}$$