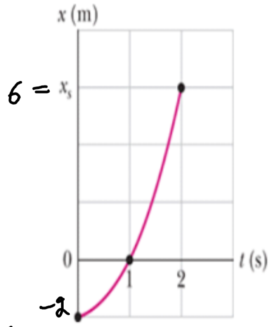
37 M Figure 2.14 depicts the motion of a particle moving along an x axis with a constant acceleration. The figure's vertical scaling is set by $x_s = 6.0$ m. What are the (a) magnitude and (b) direction of the particle's acceleration?



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

$$t=1 \rightarrow 0 = \frac{1}{2}a\times 1 + v_0 \times 1 - 2$$

$$t=2 \rightarrow 6 = \frac{1}{2}a\times 2^2 + v_0 \times 2 - 2$$

$$\xrightarrow{\times(-2)} \begin{cases} \frac{1}{2}a + v_0 = 2 \quad * \\ 2a + 2v_0 = 8 \end{cases} \rightarrow \begin{cases} -a - 2v_0 = -4 \\ 2a + 2v_0 = 8 \end{cases} \xrightarrow{+} a = 4.0 \ m/s^2$$

$$* : \frac{1}{2}\times 4 + v_0 = 2 \Rightarrow v_0 = 0$$

38 M (a) If the maximum acceleration that is tolerable for passengers in a subway train is 1.34 m/s^2 and subway stations are located 806 m apart, what is the maximum speed a subway train can attain between stations? (b) What is the travel time between stations? (c) If a subway train stops for 20 s at each station, what is the maximum average speed of the train, from one start-up to the next? (d) Graph x, v, and a versus t for the interval from one start-up to the next.

$a = +1.34$ m/s^2 $\quad a' = -1.34$ m/s^2

$v_0 = 0 \quad v_{max} \quad v = 0$

$x_0 = 0 \quad x = \frac{806}{2} = 403 \quad x = 806$ m

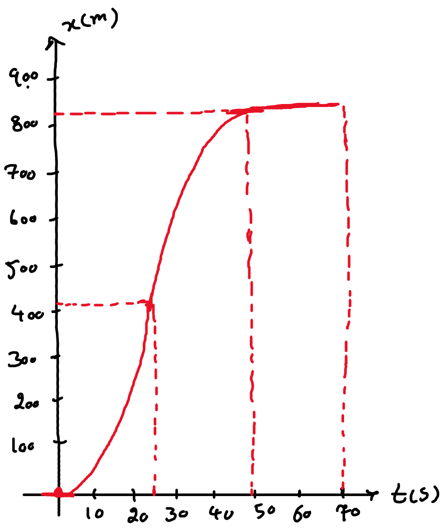
a) $v^2 - v_0^2 = 2ax \Rightarrow v_{max}^2 - 0 = 2\times 1.34 \times 403 = 1080.04 \Rightarrow v_{max} \simeq 32.86 = 32.9$ m/s

b) $a = \frac{\Delta v}{\Delta t} = \frac{v_{max} - v_0}{t} \Rightarrow t = \frac{32.86 - 0}{1.34} \simeq 24.52 \Rightarrow T = 2t \simeq 49.1$ s

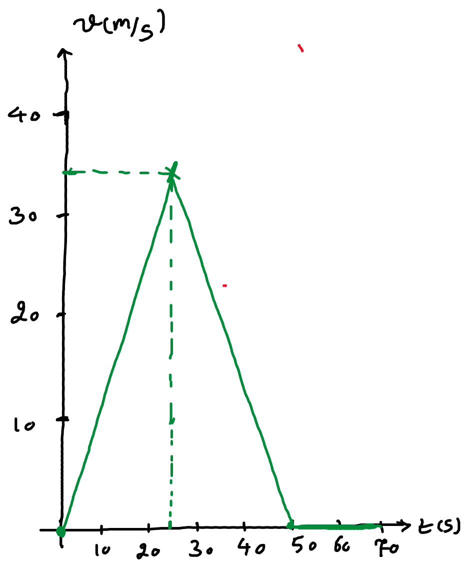
c) $t_{stop} = 20$ s $\rightarrow T' = 20 + 49.1 = 69.1$ s

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{806}{69.1} \simeq 11.66 = 11.7 \ m/s$$

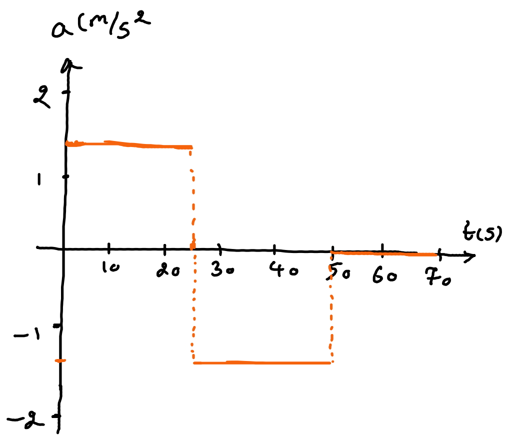
d)



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



$v = at + v_0$

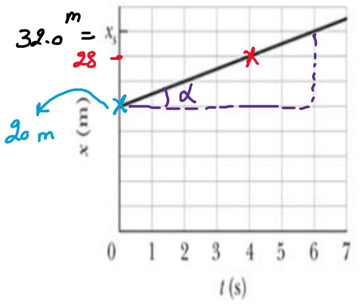


39 M Cars A and B move in the same direction in adjacent lanes. The position x of car A is given in Fig. 2.15, from time $t = 0$ to $t = 7.0$ s. The figure's vertical scaling is set by $x_s = 32.0$ m. At $t = 0$, car B is at $x = 0$, with a velocity of 12 m/s and a negative constant acceleration a_B. (a) What must a_B be such that the cars are (momentarily) side by side (momentarily at the same value of x) at $t = 4.0$ s? (b) For that value of a_B, how many times are the cars side by side? (c) Sketch the position x of car B versus time t on Fig. 2.15. How many times will the cars be side by side if the magnitude of acceleration a_B is (d) more than and (e) less than the answer to part (a)?

Car B: $t=0 \rightarrow x_{0B}=0$

$v_{0B} = 12$ m/s

$a_B < 0$



$v_A = \tan\alpha = \dfrac{32-20}{6} = 2.0$ m/s

$x_{0A} = 20$ m

a) $a_B = ?$

$x_A = x_B \quad (t=4.0)$

$x_B = \frac{1}{2}a_B t^2 + v_{0B}t + x_{0B} = \frac{1}{2}a_B \times 4^2 + 12\times 4 + 0 = 8a_B + 48$

$x_A = 28$

$\rightarrow 8a_B + 48 = 28 \Rightarrow 8a_B = 28 - 48 = -20 \Rightarrow a_B = -2.5$ m/s²

b) $x_A = x_B \quad (t=?)$

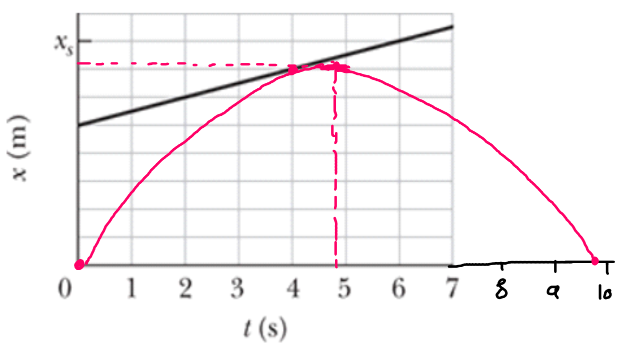
$x_A = v_A t + x_{0A} = 2t + 20$

$x_B = \frac{1}{2}a_B t^2 + v_{0B}t + x_{0B} = \frac{1}{2}\times(-2.5)t^2 + 12t + 0$

$\rightarrow 2t + 20 = \dfrac{\overset{-1.25}{-2.5}}{2}t^2 + 12t \Rightarrow 1.25t^2 - 10t + 20 = 0 \xRightarrow{\div(1.25)} t^2 - 8t + 16 = 0$

$\rightarrow (t-4)^2 = 0 \rightarrow t = 4.0$ s

c)



$x = \frac{1}{2}\times(-2.5)t^2 + 12t = -1.25t^2 + 12t$ *

$\dfrac{dx}{dt} = -1.25\times 2t + 12 = -2.5t + 12 = 0 \Rightarrow t = 4.8$ s

$x(t=4.8) = 28.8$ m

$\dfrac{d^2x}{dt^2} = -2.5 < 0 \rightarrow$ Concave down

* : $-1.25t^2 + 12t = 0 \rightarrow t(-1.25t + 12) = 0$

$\rightarrow t = 0 \;,\; t = \dfrac{12}{1.25} = 9.6$ s $(x=0)$

d, e) $x_A = x_B \rightarrow 2t + 20 = \frac{1}{2}a_B t^2 + 12t \rightarrow \frac{1}{2}a_B t^2 + 10t - 20 = 0 \Rightarrow a_B t^2 + 20t - 40 = 0$

$ax^2 + 2bx + c = 0 \Rightarrow x = \dfrac{-b \mp \sqrt{b^2 - ac}}{a}$; $a = a_B,\ b = 10,\ c = -40$

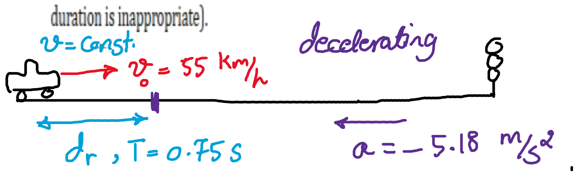
$\Rightarrow t = \dfrac{-10 \mp \sqrt{100 + 40a_B}}{\underset{a_B \neq 0}{a_B}} \rightarrow 100 + 40a_B \geq 0 \Rightarrow a_B \geq \dfrac{-100}{40} = -2.5$ m/s²

$|a_B| > 2.5 \rightarrow$ two different times

$|a_B| = 2.5 \rightarrow$ only one time

$|a_B| < 2.5 \rightarrow$ the cars are never side by side

40 M FCP You are driving toward a traffic signal when it turns yellow. Your speed is the legal speed limit of $v_0 = 55$ km/h; your best deceleration rate has the magnitude $a = 5.18$ m/s^2. Your best reaction time to begin braking is $T = 0.75$ s. To avoid having the front of your car enter the intersection after the light turns red, should you brake to a stop or continue to move at 55 km/h if the distance to the intersection and the duration of the yellow light are (a) 40 m and 2.8 s, and (b) 32 m and 1.8 s? Give an answer of brake, continue, either (if either strategy works), or neither (if neither strategy works and the yellow duration is inappropriate).



$v_0 = 55 \text{ km/h} \times \frac{10^3}{3600} \simeq 15.28$ m/s

a) $d = 40$ m , $t = 2.8$ s

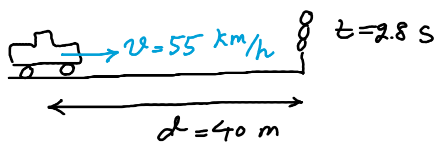
first option:

$T = 0.75$ s $\rightarrow v = \text{const.} = 15.28$ m/s $\Rightarrow d_r = vT = 15.28 \times 0.75 = 11.46$ m

$v = 0 \rightarrow v^2 - v_0^2 = 2a\,d_b \rightarrow 0 - (15.28)^2 = 2 \times (-5.18) \times d_b \Rightarrow d_b \simeq 22.54$ m

$d' = d_b + d_r = 22.54 + 11.46 \simeq 34.0$ m $< d$ $\rightarrow$ The driver is able to stop the car

second option:



$v = \frac{d}{t'} \Rightarrow t' = \frac{40}{15.28} \simeq 2.6$ s < 2.8 $\rightarrow$ The driver is able to cross the intersection.

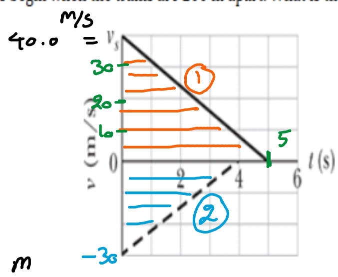
b) $d = 32$ m , $t = 1.8$ s

$d' = 34.0$ m > 32 m $\rightarrow$ The driver can't stop the car before the traffic light

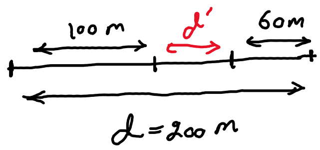
$v = \frac{d}{t'} \rightarrow t' = \frac{32}{15.28} \simeq 2.09 \simeq 2.1$ s > 1.8 $\rightarrow$ The driver can't cross the intersection.

41 M GO As two trains move along a track, their conductors suddenly notice that they are headed toward each other. Figure 2.16 gives their velocities v as functions of time t as the conductors slow the trains. The figure's vertical scaling is set by $v_s = 40.0$ m/s. The slowing processes begin when the trains are 200 m apart. What is their separation when both trains have stopped?

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



$S_1 = \frac{40 \times 5}{2} = 100 \rightarrow d_1 = 100$ m



$S_2 = \frac{30 \times 4}{2} = 60 \Rightarrow d_2 = 60$ m

$\Rightarrow d' = 200 - (100 + 60) = 40$ m