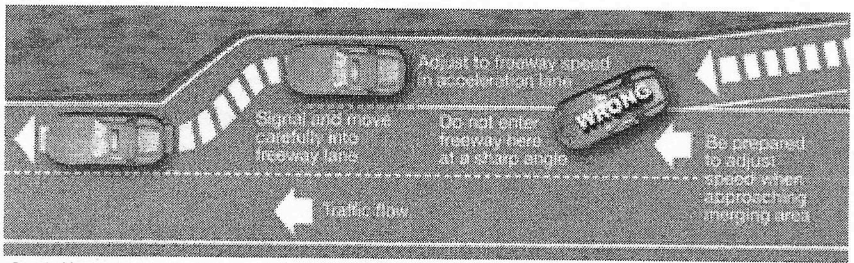
1.6 Calculating Displacement During Accelerated Motion

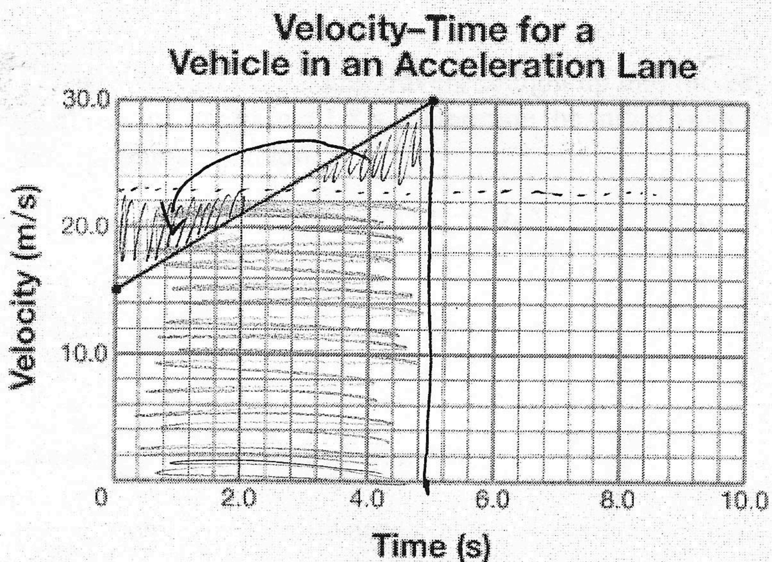
Merging requires that you time your approach and smoothly blend in with the other traffic. This may require adjusting your speed so that when you reach the end of the acceleration lane, you have a gap in the traffic, which will permit you to enter the flow of traffic safely. Your entry into that flow should be at, or near, the speed of the other traffic.



Why is the first lane you enter on a highway called the acceleration lane?

-space designated for vehicles to accelerate up to highway speed.

The following graph represents typical data for a vehicle in an acceleration lane.



$$\Delta \vec{d} = \left(\frac{\vec{v}_i + \vec{v}_f}{2} \right) \Delta T$$

a. Determine the initial velocity and the final velocity of the vehicle in metres per second and kilometres per hour.

$v_i = 15.0 \text{ m/s}$ $v_i = 54.0 \text{ km/h}$

$v_f = 30.0 \text{ m/s}$ $v_f = 108 \text{ km/h}$

b. Using the data on the graph, calculate the magnitude of the acceleration of this vehicle in m/s^2.

$a = \frac{v_f - v_i}{t}$ $a = \frac{30 - 15}{5.0 s}$ $a = 3.0 m/s^2$

Determining the minimum length of an acceleration lane: – find displacement during acceleration

- Find area under curve

$a^{rea} = \cancel{l} \times w$

$a^{rea} =$ average velocity x time

$d = \left(\frac{v_1 + v_2}{2}\right)t$

Displacement Equation:

$$\Delta\vec{d} = \left(\frac{\vec{v}_i + \vec{v}_f}{2}\right)\Delta t$$

d = displacement
t = time

v_f = final v
v_i = inital v

Example 1:
A car enters the acceleration lane with an initial velocity of 65.0 km/h[E]. The car reaches a final velocity of 100.0 km/h[E] in just 4.00 s. Calculate the displacement of the car in metres. $\frac{65\,km}{h} \times \frac{1000\,m}{1\,km} \times \frac{1\,h}{3600\,s}$

$v_i = 65.0$ km/h $= 18.05$ m/s
$v_f = 100.0$ km/h $= 27.7$ m/s
$t = 4.00$ s

$\vec{d} = \left(\frac{v_i + v_f}{2}\right)t$

$= \left(\frac{18.5 + 27.7}{2}\right)(4)$

$= 91.7$ m [E]

Example 2:
A baseball leaves a bat and travels straight up into the air, reaching its highest point 15.9 m above the bat in just 1.8 s. Determine the initial velocity of the ball using the displacement equation.

$d = 15.9$ m
$t = 1.8$ s
$v_i = ?$
$v_f = 0$

$\vec{d} = \left(\frac{v_i + v_f}{2}\right)t$

$\vec{d} = \left(\frac{v_i}{2}\right)t$

$2\left(\frac{d}{t}\right) = \left(\frac{v_i}{\cancel{2}}\right)\cancel{2}$

$v_i = \frac{2d}{t}$

$v_i = \frac{2(15.9)}{1.8}$

$v_i = 18$ m/s

Another Displacement Equation

Change in speed → not ~~average~~ uniform

A car travelling 90 km/h accelerates at 0.50 m/s^2 while passing another vehicle. If it takes 5.0 s to pass the vehicle, determine the distance travelled by the vehicle during this time.

$v_i = 90$ km/h $= 25$ m/s
$a = 0.50$ m/s^2
$t = 5.0$ s
$d = ?$
$v_f = ?$

step1

$a = \frac{v_f - v_i}{t}$

$v_f = at + v_i$
$= (0.5)(5) + 25$
$= 27.5$ m/s

step2

$\vec{d} = \left(\frac{v_i + v_f}{2}\right)(t)$

$d = \left(\frac{25 + 27.5}{2}\right)(5.0)$

$d = 131$ m $= 1.3 \times 10^2$ m