

Substituting v from equation 1 gives:

$$s = \left(\frac{u+u+at}{2} \right) \times t$$

$$= \frac{2ut}{2} + \frac{at^2}{2}$$

So

$$s = ut + \frac{1}{2}at^2 \quad (\text{equation 3})$$

Looking at Figure 2.18, you can see that the two terms on the right of the equation correspond to the *areas* of the rectangle and the triangle which make up the area under the graph. Of course, this is the same area as the rectangle in Figure 2.19.

Equation 4

Equation 4 is also derived from equations 1 and 2.

$$v = u + at \quad (\text{equation 1})$$

$$s = \frac{(u+v)}{2} \times t \quad (\text{equation 2})$$

Substituting for time t from equation 1 gives:

$$s = \frac{(u+v)}{2} \times \frac{(v-u)}{a}$$

Rearranging this gives:

$$2as = (u+v)(v-u)$$

$$= v^2 - u^2$$

Or simply:

$$v^2 = u^2 + 2as \quad (\text{equation 4})$$

Extension

Investigating road traffic accidents

The police frequently have to investigate road traffic accidents. They make use of many aspects of Physics, including the equations of motion. The next two questions will help you to apply what you have learned to situations where police investigators have used evidence from skid marks on the road.

SAQ

13 Trials on the surface of a new road show that, when a car skids to a halt, its acceleration is -7.0 m s^{-2} . Estimate the skid-to-stop distance of a car travelling at the speed limit of 30 m s^{-1} (approx. 110 km h^{-1} or 70 mph).

64.3 m \approx 64 m
Answer

14 At the scene of an accident on a French country road, police find skid marks stretching for 50 m . Tests on the road surface show that a skidding car decelerates at 6.5 m s^{-2} . Was the car which skidded exceeding the speed limit of 25 m s^{-1} (90 km h^{-1}) on this stretch of road?

25.5 m s^{-1}
Answer

Uniform and non-uniform acceleration

It is important to note that the equations of motion only apply to an object which is moving with a constant acceleration. If the acceleration a was changing, you wouldn't know what value to put in the equations. Constant acceleration is often referred to as **uniform acceleration**.

The velocity against time graph in Figure 2.20 shows *non-uniform* acceleration. It is not a straight line; its gradient is changing (in this case, decreasing). Clearly we could not derive such simple equations from this graph.

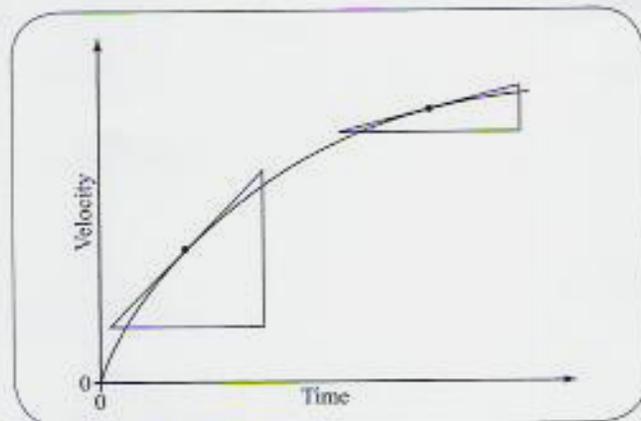


Figure 2.20 This curved velocity against time graph might show how a car accelerates until it reaches its top speed. A graph like this cannot be analysed using the equations of motion.