



two axes now, resolve first, then it's two straight lines



## Displacement vs path length \*

### Displacement

- a vector, the change in position vector,  $s = x_2 - x_1$
- depends only on where you started and where you finished
- can be zero even after a long journey, as it is for one full circle

### Path length

- a scalar, the actual distance covered along the way
- never decreases, and never smaller than the magnitude of the displacement
- for one full circle it is the whole circumference

so average speed uses path length while average velocity uses displacement. They agree only while the motion never reverses

## Velocity and acceleration, average and instantaneous

- average velocity =  $\frac{\text{displacement}}{\text{time interval}}$ , average speed =  $\frac{\text{path length}}{\text{time interval}}$
- instantaneous velocity, the limit as the interval shrinks to zero:  $v = \frac{dx}{dt}$
- that's the slope of the  $x$ - $t$  tangent
- instantaneous speed equals the magnitude of instantaneous velocity: over a vanishing interval, path = displacement
- acceleration  $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$ , the slope of the  $v$ - $t$  tangent
- average and instantaneous values coincide for uniform motion, not for non-uniform

learn these

### Equations of motion for uniform acceleration

velocity after time  $t$   $v = u + at$

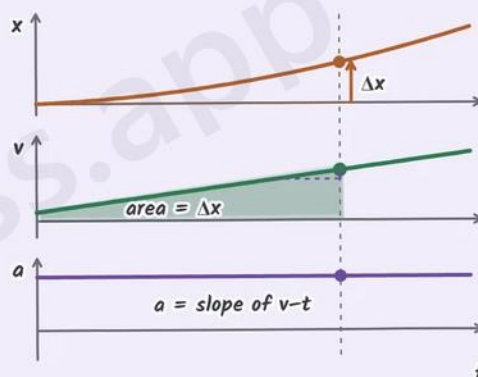
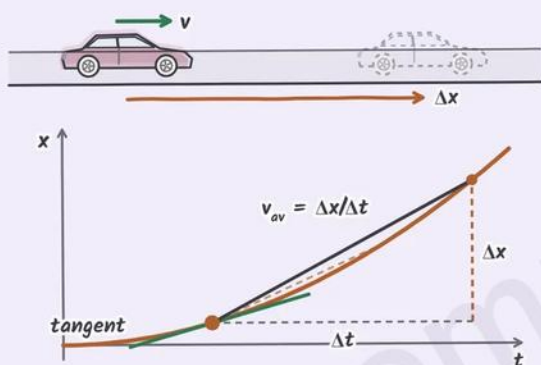
displacement  $s = ut + \frac{1}{2}at^2$

velocity against displacement  $v^2 = u^2 + 2as$

from the average velocity  $s = \frac{u+v}{2} t$

all four come straight off the  $v$  against  $t$  graph: the slope is  $a$  and the area under it is  $s$ . They hold only while  $a$  is constant

## Reading a motion graph



$x$  against  $t$ : the chord's slope is  $v_{av}$  the tangent's is  $v$   $v$  against  $t$ : slope  $a$ , the area beneath it the displacement  
a horizontal  $x$ - $t$  line is rest. a curved  $v$ - $t$  line means  $a$  itself is changing

