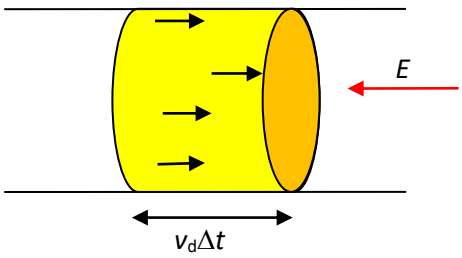
Teacher notes
Topic B

The missing equation

In the previous syllabus we had the formula for current $I = nAv_d e$ in terms of the electron drift speed. In the present Unit B, which is focused on the particulate nature of matter, it is very strange that this very useful formula, which shows the particulate nature of current, is missing! This is a derivation.

To establish a current, we need an electric field which will force electrons to move in the same direction. A very useful formula for current is $I = nAv_d e$ where v_d is the drift speed of the electrons, n is the number of electrons per unit volume and A is the cross-sectional area of the conductor. The drift speed is the average speed in the same direction that the electrons acquire because of the action of the electric field.

This can be derived very easily as follows: the shaded cylinder is part of a cylindrical conductor.



The length of the cylinder is $v_d \Delta t$ where v_d is the drift speed of electrons. In time Δt every electron in the shaded cylinder will pass through the cross-sectional area of the cylinder (shaded orange). The number of electrons in the shaded cylinder is $N = nV = nAv_d \Delta t$. The charge in the cylinder is then $\Delta Q = eN = enAv\Delta t$.

Therefore, the current is (charge through the cross-sectional area per unit time)

$$I = \frac{\Delta Q}{\Delta t} = \frac{enAv_d \Delta t}{\Delta t} = enAv_d .$$