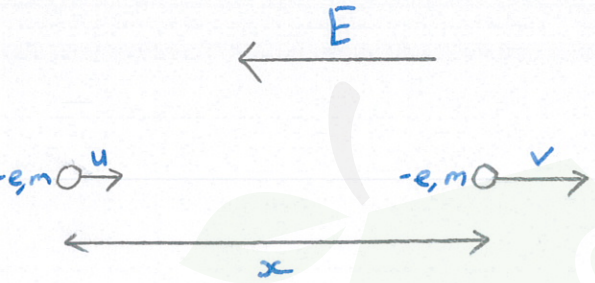
Worked Solutions

Electron in an E Field

Exercise 1: An electron of mass m, travelling with an initial speed u, enters a region containing an electric field of magnitude E. The electric field points in the opposite direction to the electron's motion. After the electron has moved a distance x within the field, it will have a speed v. Find an expression for the square of this speed in terms of u, x, e, E and m.



Taking to the right as positive,

force on electron

$\underline{F} = q\underline{E}$ where $\underline{F}$ & $\underline{E}$ are vectors

$F = (-e)(-E) = eE$ to the right

Using Newton's 2nd Law

$F_{res} = ma$

$eE = ma$

$a = \frac{eE}{m}$

Acceleration is constant within electric field. Using suvat equations of motion

$s = x$

$u = u$

$v = v = ?$

$a = eE/m$

$t = ?$

Use equation linking s, u, v and a

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

$v^2 = u^2 + 2as$

$= u^2 + 2\left(\frac{eE}{m}\right)x$

$$v^2 = u^2 + \frac{2eEx}{m}$$

Alternatively, work done by force on electron = gain in kinetic energy

Force and displament of electron are in the same direction so $W = Fx$

$W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$Fx = \frac{1}{2}m(v^2 - u^2)$

$\frac{2Fx}{m} = v^2 - u^2$

$v^2 = u^2 + \frac{2Fx}{m}$

$$v^2 = u^2 + \frac{2eEx}{m}$$