The Electric Field in a Amazon Kindle Pixel

September 15, 2011

Points Awarded

1. Zero points: no work at all/not in class to participate
2. 1 point: attempted the problem
3. 2 points: solved the problem (correct units and number, but ignore significant figures in the answer)

Solution

A single pixel of e-Ink in an Amazon Kindle e-Book Reader (or similar device) contains a mixture of small particles that are either light and dark in color; these particles respond to electric fields and by moving they change the shade of the pixel and allow for "page turns" to occur. Each page turn on an Amazon Kindle requires about $0.50s$, which tells us that this is the time required for the light colored particles (Titanium-Oxide, each with electric charge $q = 16e$ and mass $m = 6.7 \times 10^{-15}$kg) to travel from the bottom of the cell to the top (or vice versa) in response to the applied electric field. If a single pixel has a depth of about 40.0μm, what is the strength of the applied electric field?

This is a question that asks you to perhaps relate the following things: time, charge, and distance. We know time and distance are related by acceleration and velocity, and we know that acceleration is related for force, and force to the charge and the strength of the applied electric field. These are the principles that need to be applied to attack this problem.

Let us relate charge and force:

$$F = qE$$

and then force and acceleration:

$$F = ma$$

and finally acceleration to time and displacement (distance):

$$x = x_0 + v_0 t + \frac{1}{2} a t^2.$$

If the droplet is initially at rest (before the page turn) then its initial velocity is zero, and $v_0 = 0\text{m/s}$. We can rewrite the above equation to relate displacement and acceleration and time:

$$x - x_0 \equiv \Delta x = \frac{1}{2} a t^2$$

and finally we can solve for acceleration:

$$a = \frac{2\Delta x}{t^2}.$$

We can then plug this into the force equation:

$$F = \frac{2m\Delta x}{t^2}$$

and then relating to electric field and charge:

$$qE = \frac{2m\Delta x}{t^2}$$

we can solve for the strength of the field:

$$E = \frac{2m\Delta x}{qt^2} = 0.84\text{N/C}$$