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<u>Problem 28.37 (RHK)</u>

An electron moving with a speed of $4.86\times10^{6}\ \mathrm{m\,s^{-1}}$ *is shot parallel to an electric field of strength* $1030\ \mathrm{NC^{-1}}$ *arranged so as to retard its motion. We have to find* (a) *the distance the electrons will travel in the field before coming* (momentarily) *to rest;* (b) *the time that will have lapsed.* (c) *If the electric field ends abruptly after* $7.88\ \mathrm{mm}$, *we have to calculate the fraction of initial kinetic energy that the electron will lose in traversing it.*

<u>Solution:</u>

We recall the following data:

$m_e = 9.11\times10^{-31}$ kg,

$|\mathrm{e}| = 1.60\times10^{-19}$ C.

(a)

Electrons will be decelerating in the retarding electric field with the acceleration

$$|a| = \frac{eE}{m} = \frac{1.60\times10^{-19}\times1030}{9.11\times10^{-31}} \text{ m s}^{-2}$$

$$= 1.81\times10^{14} \text{ m s}^{-2}.$$

The distance d the electrons entering the electric field with initial speed 4.86×10^{6} m s^{-1} will travel before momentarily coming to rest can be calculated using the kinematics. We have

$$d = \frac{u^2}{2|a|} = \frac{\left(4.86\times10^{6}\right)^2}{2\times1.81\times10^{14}} \text{ m} = 6.52\times10^{-2} \text{ m} = 6.52 \text{ cm.}$$

(b)

The time that will have lapsed between when the electrons enter the field and when they momentarily come to rest can be calculated using the relation

$$u = |a|t \ .$$

We find

$$t = \frac{4.86\times10^{6}}{1.81\times10^{14}} \text{ s} = 2.68\times10^{-8} \text{ s} = 26.8 \text{ ns.}$$

(c)

Fraction of kinetic energy that electrons will lose in traversing 7.88 mm in the field can be calculated using the kinematical relation

$$u_i^2 - u_f^2 = 2|a|d \ .$$

We find

$$f = \frac{\frac{1}{2}m\left(u_i^2 - u_f^2\right)}{\frac{1}{2}mu_i^2} = \frac{2|a|d}{u_i^2} = \frac{2\times1.81\times10^{14}\times7.88\times10^{-2}}{\left(4.86\times10^{6}\right)^2}$$

$$= 0.121 \text{ or } 12.1\% \, .$$