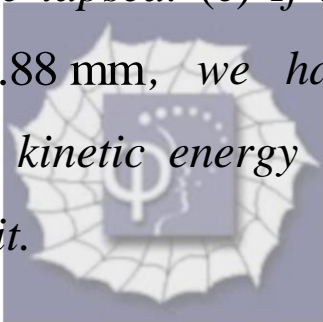


303.

Problem 28.37 (RHK)

An electron moving with a speed of $4.86 \times 10^6 \text{ m s}^{-1}$ is shot parallel to an electric field of strength 1030 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 mm, we have to calculate the fraction of initial kinetic energy that the electron will lose in traversing it.



Solution:

We recall the following data:

$$m_e = 9.11 \times 10^{-31} \text{ kg},$$

$$|e| = 1.60 \times 10^{-19} \text{ C}.$$

(a)

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

$$|a| = \frac{eE}{m} = \frac{1.60 \times 10^{-19} \times 1030}{9.11 \times 10^{-31}} \text{ m s}^{-2}$$

$$= 1.81 \times 10^{14} \text{ m s}^{-2}.$$

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

$$d = \frac{u^2}{2|a|} = \frac{(4.86 \times 10^6)^2}{2 \times 1.81 \times 10^{14}} \text{ m} = 6.52 \times 10^{-2} \text{ m} = 6.52 \text{ cm}.$$

(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

$$t = \frac{4.86 \times 10^6}{1.81 \times 10^{14}} \text{ s} = 2.68 \times 10^{-8} \text{ s} = 26.8 \text{ ns}.$$

(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

$$f = \frac{\frac{1}{2}m(u_i^2 - u_f^2)}{\frac{1}{2}mu_i^2} = \frac{2|a|d}{u_i^2} = \frac{2 \times 1.81 \times 10^{14} \times 7.88 \times 10^{-2}}{(4.86 \times 10^6)^2} \\ = 0.121 \text{ or } 12.1\% .$$

