Physics 200 Name: Key

Practice - 18.7, 18.8

Equations and Helpful Information:

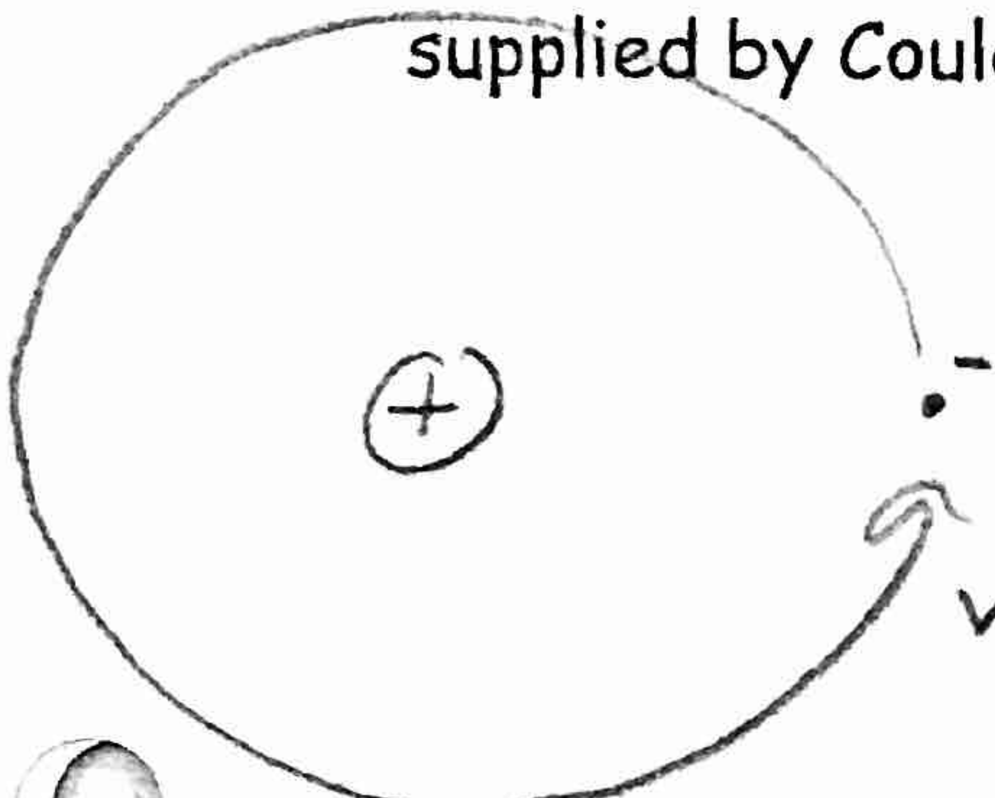
$q_{electron} = -1.6\text{x}10^{-19}\text{C}$ $F_e = \frac{k|q_1 q_2|}{r^2}$ $E = \frac{kQ}{r^2}$ $E = \frac{F}{q}$ $k = 8.99\text{x}10^9 \text{Nm}^2/\text{C}^2$

$\Sigma F = ma$ $\Sigma F = \text{sum of individual forces}$ $w = mg$

$v_f = v_0 + at$ $v_f^2 = v_0^2 + 2a\Delta x$ $F_{centripetal} = mv^2/r$

Practice - 18.7 Conductors and Electric Fields in Static Equilibrium

1. Calculate the linear velocity of an electron assuming it orbits a proton (even though technically it does not) in the hydrogen atom, given the radius of the orbit is 0.530 x 10^{-10} m. You may assume that the proton is stationary and the centripetal force is supplied by Coulomb attraction. $m_e = 9.11 \times 10^{-31}$ kg.



$$\Sigma F = \frac{mv^2}{r} = \frac{k q_1 q_2}{r^2} \Rightarrow mv^2 = \frac{k q_1 q_2}{r}$$

$$v = \sqrt{\frac{k q_1 q_2}{mr}}$$

$$v = \sqrt{\frac{8.99\times10^9 \frac{Nm^2}{C^2}(1.6\times10^{-19}C)^2}{(0.53\times10^{-10}m)(9.11\times10^{-31}kg)}}$$

$$= 2.18\times10^6 \text{ m/s}$$

2. An electron has an initial velocity of 5.00 x 10^6 m/s in a uniform 2.00 x 10^5 N/C strength electric field. The field accelerates the electron in the direction opposite to its initial velocity.

   A. What is the direction of the electric field?

   Rightward (positive direction), because rightward-moving electron is accelerated leftward. Electrons accelerate opposite to field direction

   B. How far does the electron travel before coming to rest?

   $v^2 = v_0^2 + 2a\Delta x$

   $a = \frac{Eq}{m} = \frac{(2\times10^5 N/C)(1.6\times10^{-19}C)}{9.11\times10^{-31}kg} = -0.35\times10^{17} m/s^2$

   opposite direction

   $0 = (5\times10^6 m/s)^2 + 2(-0.35\times10^{17} m/s^2)\Delta x$

   $\Delta x = 3.6\times10^{-4} m$

   C. How long does it take the electron to come to rest?

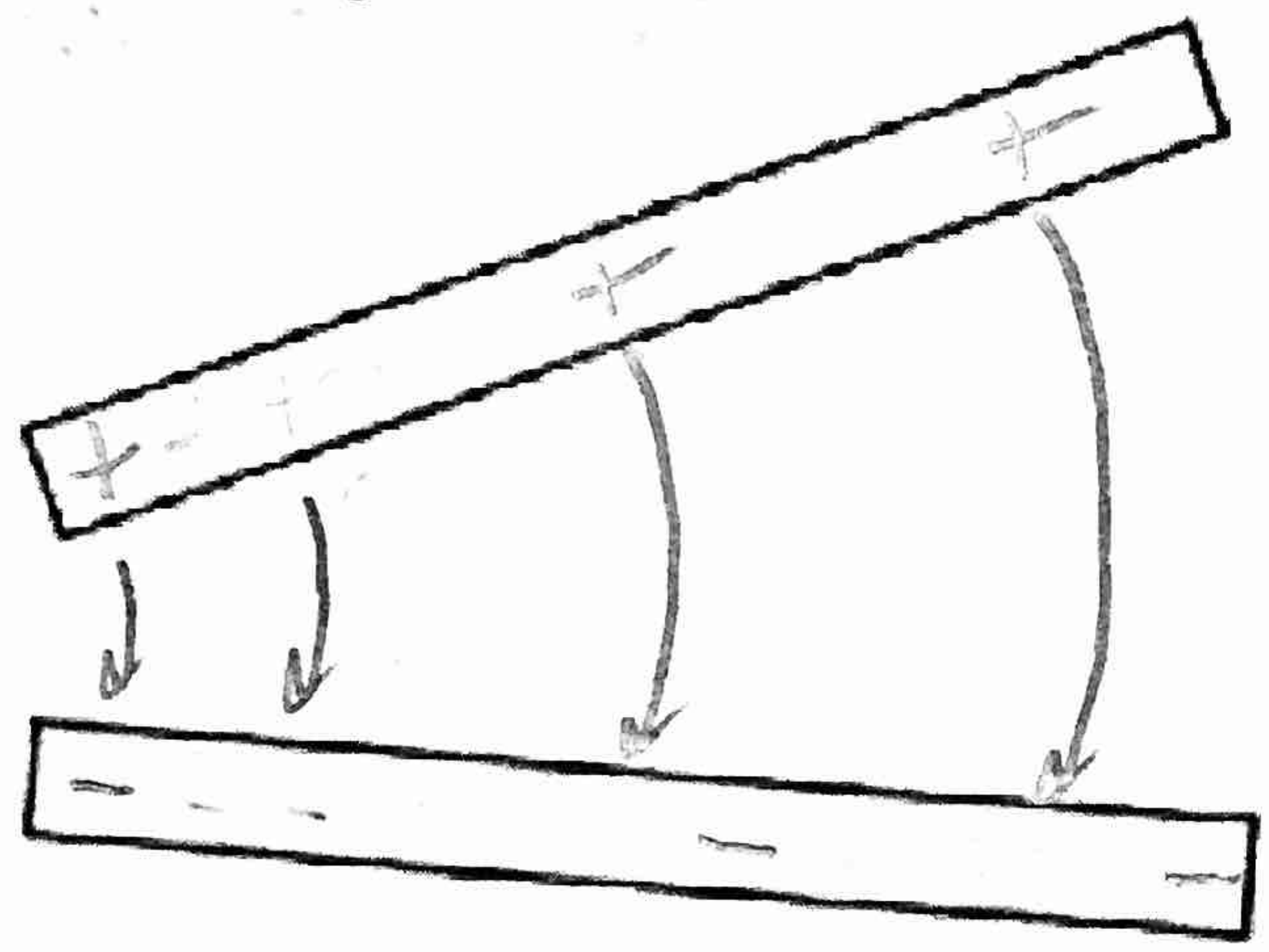
   $v = v_0 + at$

   $0 = 5\times10^6 m/s + (-0.35\times10^{17} m/s^2)t$

   $t = 1.42\times10^{-10} s$

Practice - 18.8 Electrostatic Applications

1. Sketch the electric field between the two conducting plates shown below using the principles of electric fields and charges in and around conductors. Assume the top plate is positive and an equal amount of negative charge is on the bottom plate. Also indicate the distribution of charge on the plates.



2. What is the direction and magnitude of an electric field that supports the weight of a free electron (m_e = 9.11 x 10^{-31} kg) near the surface of Earth? Discuss what the small value for this field implies regarding the relative strength of the gravitational and electrostatic forces.

$\uparrow F_{electrostatic} = Eq$

$\Sigma F = 0$

$q_e = 1.6 \times 10^{-19}\ C$

$\downarrow F_{gravity} = w = mg$

$Eq = mg$

$E(1.6 \times 10^{-19}\ C) = 9.11 \times 10^{-31}\ kg\ (9.8\ m/s^2)$

$E = 5.5 \times 10^{-11}\ N/C$

3. Earth has a net charge that produces an electric field of approximately 150 N/C downward at its surface.

   A. What is the magnitude and sign of the excess charge, noting the electric field of a conducting sphere is equivalent to a point charge at its center?
   R_{Earth} = 6371 km

$$E = \frac{kQ}{r^2} \Rightarrow Q = \frac{Er^2}{k}$$

$$Q = \frac{150\,N/C\,(6.371\times10^3\,m)^2}{8.99\times10^9\,\frac{Nm^2}{C^2}} = -6.77\times10^5\,C$$

Negative because fields point toward negative charge.

   B. What acceleration will the field produce on a free electron near Earth's surface?

$$a = \frac{Eq}{m} = \frac{150\,N/C\,(1.6\times10^{-19}\,C)}{9.11\times10^{-31}\,kg}$$

$$a = 2.63\times10^{13}\,m/s^2, \text{ upward}$$

   C. What mass object with a single extra electron will have its weight supported by this field?

$\uparrow F = Eq$

$\Sigma F = 0$ o $-q_e$

$\downarrow F = mg$

$$mg = Eq$$

$$m(9.8\,m/s^2) = 150\,N/C\,(1.6\times10^{-19}\,C)$$

$$m = 2.45\times10^{-18}\,kg$$

4. The practical limit to an electric field in air is about 3.00×10^6 N/C. Above this strength, sparking takes place because air begins to ionize and charges flow, reducing the field.

   A. Calculate the distance a free proton must travel in this field to reach 3.00% of the speed of light, starting from rest. $m_p = 1.67 \times 10^{27}$ kg, $c = 3.00 \times 10^8$ m/s

$$v^2 = v_0^2 + 2a\Delta x$$

$$F = Eq = ma \Rightarrow a = \frac{Eq}{m}$$

$$a = \frac{3\times10^6 \, N/C \, (1.6\times10^{-19} \, C)}{1.67\times10^{-27} \, kg}$$

$$a = 2.87\times10^{14} \, m/s^2$$

$$\boxed{[(0.03)(3\times10^8 \, m/s)]^2} = 0 + 2(2.87\times10^{14} \, m/s^2)\Delta x$$

$$\Delta x = 0.141 \, m$$

   ~~B. Is this practical in air, or must it occur in a vacuum?~~