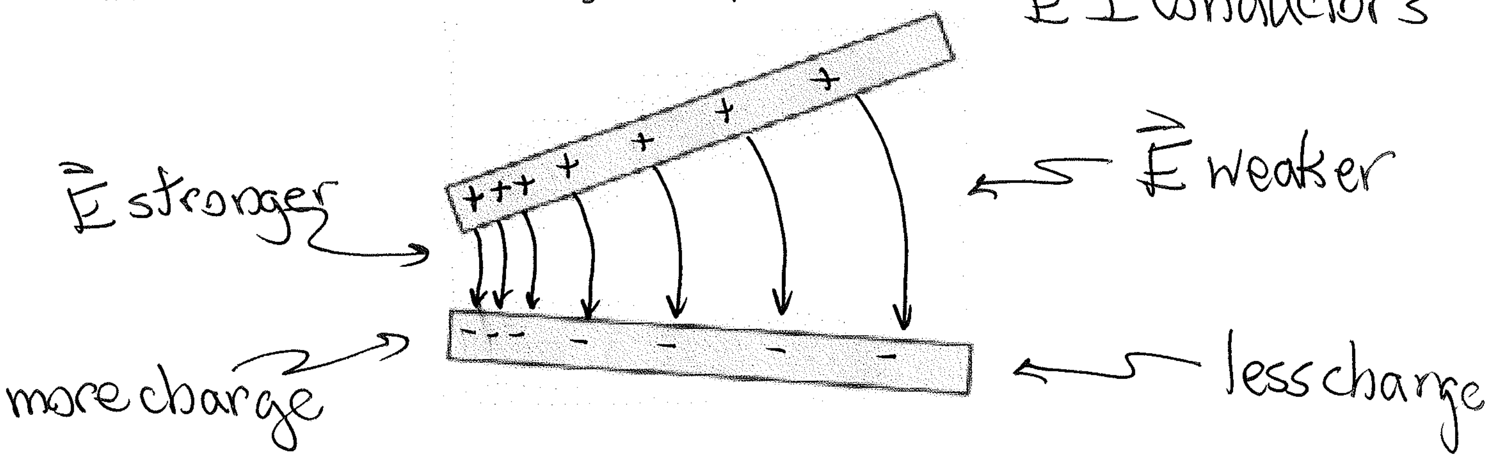
Name: Key

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.



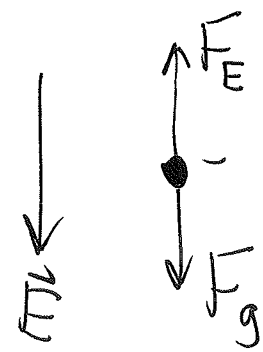
2. What is the direction and magnitude of an electric field that supports the weight of a free electron ($m_e = 9.11 \times 10^{-31}$ kg) near the surface of Earth? Discuss what the small value for this field implies regarding the relative strength of the gravitational and electrostatic forces.

$$F_E = F_g$$

$$qE = mg$$

$$E = \frac{mg}{q} = \frac{(9.11 \times 10^{-31}\,\text{kg})(9.80\,\frac{\text{m}}{\text{s}^2})}{1.60 \times 10^{-19}\,\text{C}}$$

$$= 5.58 \times 10^{-11}\,\frac{\text{N}}{\text{C}}$$ toward the surface of the Earth



It take only a very small electric field to overcome gravity $F_E >> F_g$

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

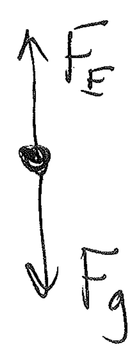
$$E = \frac{kQ}{R^2} \Rightarrow Q = \frac{ER^2}{k} = \frac{\left(150\frac{N}{C}\right)\left(6371\times10^{3}m\right)^2}{8.99\times10^{9}\frac{Nm^2}{C^2}}$$

$$= \boxed{6.77\times10^{5}\,C} \quad \boxed{\text{negative charge}}$$

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

$$a = \frac{F_E}{m} = \frac{qE}{m} = \frac{\left(1.60\times10^{-19}C\right)\left(150\frac{N}{C}\right)}{9.11\times10^{-31}kg} = \boxed{2.63\times10^{13}\frac{m}{s^2}} \quad \boxed{\text{upwards}}$$

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



$$F_E = F_g$$

$$qE = mg \Rightarrow m = \frac{qE}{g}$$

$$m = \frac{\left(1.60\times10^{-19}C\right)\left(150\frac{N}{C}\right)}{9.80\frac{m}{s^2}} = \boxed{2.45\times10^{-18}kg}$$

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 $c = 3.00 \times 10^{8} \frac{m}{s}$

$$V_f^2 = V_0^2 + 2ax \qquad a = \frac{qE}{m}$$

$$x = \frac{V_f^2}{2a} = \frac{mV_f^2}{2qE} = \frac{(1.67 \times 10^{-27} \text{ kg})(0.0300 \times 3.00 \times 10^{8} \frac{m}{s})^2}{2(1.60 \times 10^{-19} C)(3.00 \times 10^{6} \frac{N}{C})}$$

$$= \boxed{0.141 \text{ m}}$$

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

No The proton will collide with many air molecules.