Electric Fields Problems

You will need the data below to answer the following questions.

	charge	mass
electron	-1.6×10^{-19} C	9.11×10^{-31} kg
proton	$+1.6 \times 10^{-19}$ C	1.67×10^{-27} kg

$$F = \frac{qQ}{4\pi\varepsilon_0 d^2} \qquad E = \frac{Q}{4\pi\varepsilon_0 d^2} \qquad \varepsilon_0 = 8.85 \times 10^{-12}\ \text{Fm}^{-1}$$

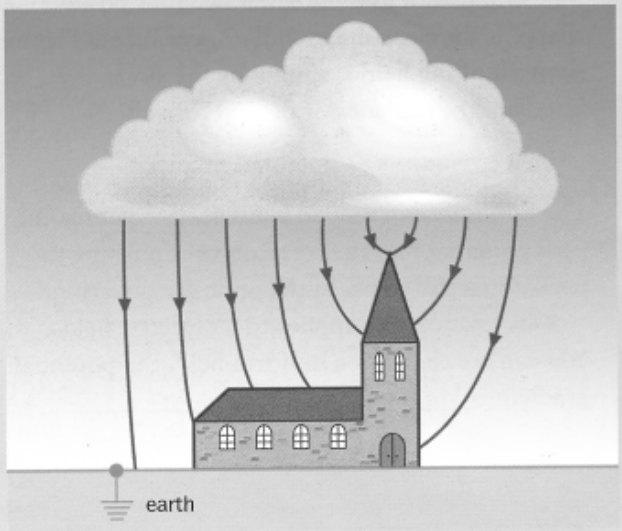
1. Two protons in the nucleus of an atom are separated by 10^{-15}m. Calculate the force of electrostatic repulsion between them, and the force of gravitational attraction between them. Is gravity enough to balance the electric repulsion tending to separate them? What does this suggest to you about the forces between protons in a nucleus?
2. An iron atom has a nucleus that contains 26 protons (and a lot of neutrons). Its electrons orbit at a typical distance of 10^{-10}m. Calculate the attractive force exerted by the nucleus on a singe electron at this distance.
   The nucleus of an iron atom has a diameter of 4.9×10^{-15}m. Calculate the field strength where the electrons are, and at the surface of the nucleus.
3. A Van de Graff generator produces sparks when the field strength at its surface is 40 000 V cm^{-1}. If the diameter of the sphere is 40 cm, what is the charge on it?

Comprehension

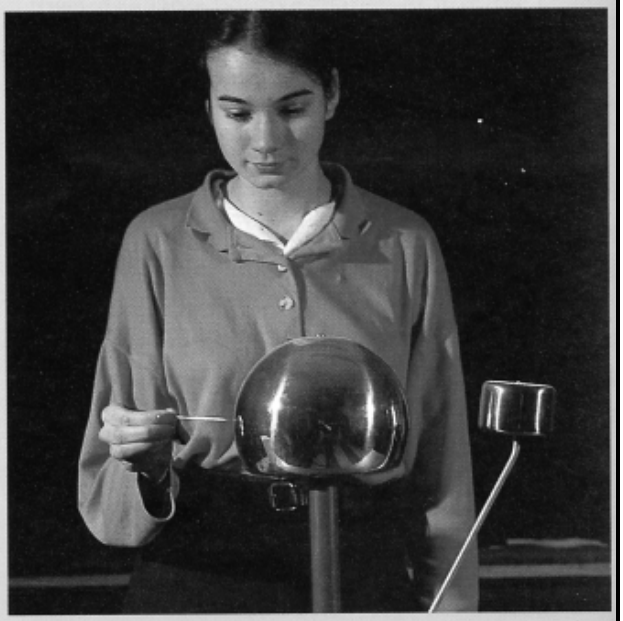
The drawing in *figure 7.27* shows a thunder-cloud above the Earth. The electric field it creates is shown by the lines of force.

Many tall buildings have lightning conductors. These help to conduct away any lightning that strikes the building. They also help to discharge thunder-clouds without lightning striking.

If you have a Van de Graaff generator running so that sparks ('lightning') are jumping to a nearby earthed sphere, you can simulate the effect of a lightning conductor. Bring up the sharp point of a pin towards the dome of the generator *(figure 7.28)*; the sparks will stop. A very small current is flowing through the air to the pin and through you to earth. Remove the pin and the sparks start again.



● ***Figure 7.27*** The electric field below a thunder-cloud.



● ***Figure 7.28*** The effect of a sharp point in an electric field.

A Copy the diagram of the thunder-cloud, and add equipotential lines. (Remember that they are always at right-angles to the field lines.)
B Where is the electric field strongest? Explain your answer by referring to the field lines, and by referring to the equipotential lines.
C Where is lightning more likely to strike?
D Draw a diagram to show why the sharp pin prevents the generator from sparking.