Unit 20 · Electric Field

HARDER PRACTICE QUESTIONS

Full marks 31

Write your answers on separate paper. Show your working. Take $k = 9.0 \times 10^9$ N m^2/C^2, $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(N m^2), $e = 1.6 \times 10^{-19}$ C, the mass of an electron 9.11×10^{-31} kg, the radius of the Earth 6.4×10^6 m and $g = 9.8$ m/s^2.

1 Spot the error [3]

Find the mistake in the working and correct it.

The field 10 cm from a long, straight charged wire is 6.0×10^4 N/C. Asmita worked out the field 30 cm from it:
"E $\propto 1/r^2$, so at three times the distance E = $6.0 \times 10^4 \div 9 =$ **6.7×10^3 N/C**."

2 Work backwards [3]

An electron passes between two plates 3.0 cm long and 1.5 cm apart, with 60 V between them, entering parallel to them. It leaves them deflected by 1.5 mm. How fast was it moving?

3 Check the readings [3]

A computer model gives the field of an insulating ball of radius 10 cm, charged evenly through its volume, at different distances r from its center:

r (cm)	2.5	5.0	10	15	20
E (10^5 N/C)	4.5	9.0	18	12	4.5

Check each value against Gauss's law. Which value is wrong, and what should it be?

4 Predict, then explain [3]

Write your prediction first, then explain it.

A proton and an alpha particle (charge +2e, about four times the proton's mass) enter the same field between two plates at the same speed, moving parallel to the plates. Predict which is deflected more, by how much, and in which direction. Then explain.

5 Estimate it [3]

On a fine day the electric field at the ground is about 130 N/C, pointing down, everywhere on the Earth.

i. Treating the Earth as a charged sphere, estimate its charge, using Gauss's law.
ii. What sign is it?

6 Design it [3]

Nirjala is designing deflecting plates 5.0 cm long and 1.5 cm apart for an electron beam moving at 2.0×10^7 m/s. She wants the beam to leave the plates deflected by 4.0 mm. What p.d. must she put across the plates? Would the beam clear the plates?

7 What if? [3]

A point charge +q sits at the center of a cube of side s. Say what happens to the total flux out of the cube, and why, if

i. the cube is made twice as large;
ii. the charge is moved off-center, still inside;
iii. a second charge −q is put just outside the cube.

8 Show that [3]

Show that the charge crossing between two parallel plates from rest gains kinetic energy $\frac{1}{2}mv^2 = qV$, and use it to find how fast an electron is moving after it is accelerated from rest through 2,000 V.

9 Correct the misconceptions [3]

The paragraph has three mistakes. Write each mistake and correct it.

Sanskar wrote: “A field line shows the path a charge follows. The field at a point depends on the size of the test charge put there. Inside a uniformly charged insulating sphere the field is zero everywhere.”

10 Think [2]

Two large parallel plates carry charges $+\sigma$ and $-\sigma$ per square meter. Using the field of one sheet, $\sigma/(2\varepsilon_0)$, explain why the field between them is σ/ε_0 but outside them is zero.

11 Make your own [2]

Choose a point charge and a distance of your own at which the field is 1.0×10^4 N/C. Then find the total flux through a sphere of any radius round your charge.