

D.2 Electric and magnetic fields

Practice Worksheet — name: _____ date: _____

FORMULAS FOR THIS TOPIC

COULOMB'S LAW $F = k \frac{q_1 q_2}{r^2}$ COULOMB CONSTANT $k = \frac{1}{4\pi\epsilon_0}$ ELECTRIC FIELD STRENGTH $E = \frac{F}{q}$ UNIFORM FIELD (PLATES) $E = \frac{V}{d}$ ELECTRIC PE (HL) $E_p = k \frac{q_1 q_2}{r}$ ELECTRIC POTENTIAL (HL) $V_e = \frac{kQ}{r}$ POTENTIAL GRADIENT (HL) $E = -\frac{\Delta V_e}{\Delta r}$ WORK DONE (HL) $W = q\Delta V_e$

SECTION A — MULTIPLE CHOICE

A1. Two point charges attract with force F . If both charges are doubled and the separation halved, the force becomes:

- A $2F$
- B $4F$
- C $8F$
- D $16F$

A2. In Millikan's experiment, every measured droplet charge was found to be:

- A Exactly equal to e
- B An integer multiple of e
- C Randomly distributed
- D Proportional to the droplet mass

A3. A proton is released from rest in a uniform electric field. It moves:

- A Along a field line, from high to low potential
- B Along a field line, from low to high potential
- C Perpendicular to the field lines
- D Along an equipotential surface

SECTION B — SHORT ANSWER

B1. Two parallel plates 5.0 mm apart have a potential difference of 200 V. Calculate the electric field between them, and the force on an electron in this field. [3 marks]

B2. Explain how a charged balloon sticks to a neutral wall. [3 marks]

B3. Compare gravitational and electric fields: give two similarities and two differences. [4 marks]

ANSWER KEY

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Section A

A1: $16F$ — Doubling each charge gives $\times 4$; halving r gives another $\times 4$ from the inverse square. Net: $16F$.

A2: An integer multiple of e — Droplets carried different numbers of surplus electrons, but every charge was ne with integer n — no fractional values. That is the experimental meaning of charge quantisation.

A3: Along a field line, from high to low potential — Positive charges feel force in the field direction, and field lines point from high to low potential (field is the negative potential gradient). Electrons do the reverse. Nothing accelerates along an equipotential.

Section B

B1: $E = V/d = 200/(5.0 \times 10^{-3}) = 4.0 \times 10^4 \text{ V m}^{-1}$. Force: $F = eE = 1.6 \times 10^{-19} \times 4.0 \times 10^4 = 6.4 \times 10^{-15} \text{ N}$, directed towards the positive plate.

B2: The balloon's charge induces a redistribution in the wall: opposite charges are attracted towards the surface and like charges repelled deeper. The opposite induced charge is nearer than the like charge, and since the electric force falls with distance, attraction wins — a net force despite the wall's overall neutrality.

B3: Similarities: both obey inverse-square force laws; both are described by field strength, potential and equipotential surfaces with the same mathematics. Differences: electric forces can attract or repel (two signs of charge) while gravity only attracts; electric forces between elementary particles are enormously stronger; and electric fields can be shielded, gravity cannot.