Electric Charges and Fields

Standard difficulty · 20 questions · 40 marks · Time: 36 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer 8 × 1 = 8 marks

1. Two point charges of 2 μC and 6 μC are 15 cm apart in air. The force between them is: ($k = 9 \times 10^9$ N m^2/C^2)

(a) 0.048 N **(b)** 48 N **(c)** 72 N **(d)** 4.8 N

2. Two charges attract each other with a force F. If each charge is made 3 times as large and the distance between them is made 4 times as large, the force becomes:

(a) (16/9)F **(b)** (3/4)F **(c)** (9/16)F **(d)** (9/8)F

3. The number of electrons removed from a body that has a charge of +6 μC is: ($e = 1.6 \times 10^{-19}$ C)

(a) 3.75×10^{14} **(b)** 9.6×10^{-25} **(c)** 3.75×10^{12} **(d)** 3.75×10^{13}

4. The electric field 20 cm from a point charge of 8 μC is: ($k = 9 \times 10^9$ N m^2/C^2)

(a) 1.8×10^8 N/C **(b)** 3.6×10^7 N/C **(c)** 1.8×10^6 N/C **(d)** 1.8×10^4 N/C

5. The SI unit of electric charge is the:

(a) coulomb **(b)** farad **(c)** ampere **(d)** volt

6. A charge of 7 μC is at the centre of a cube. The electric flux through the whole surface of the cube is: ($k = 9 \times 10^9$ N m^2/C^2)

(a) $2.52\pi \times 10^{11}$ N m^2/C **(b)** $4.2\pi \times 10^4$ N m^2/C

(c) $6.3\pi \times 10^4$ N m^2/C **(d)** $2.52\pi \times 10^5$ N m^2/C

7. A dipole made of charges ±2 μC, 9 cm apart, makes 90° with a uniform field of 9×10^4 N/C. The torque on it is:

(a) 1.62×10^{-4} N m **(b)** 0.0162 N m

(c) 1.62 N m **(d)** 0.0324 N m

8. Assertion (A): The field 3 cm from a 5 μC point charge is 5×10^7 N/C. ($k = 9 \times 10^9$ N m^2/C^2)
Reason (R): The field of a point charge is E = kq/r.

(a) Both A and R are true, and R is the correct explanation of A.

(b) Both A and R are true, but R is not the correct explanation of A.

(c) A is true, but R is false.

(d) A is false, but R is true.

Section B — Short answer 8 × 2 = 16 marks

9. Charges of −7 μC and −9 μC are at x = 0 and x = 18 cm. Find the net force on a charge of +1 μC at x = 15 cm. ($k = 9 \times 10^9$ N m^2/C^2)

10. Charges of 3 μC and 48 μC are 40 cm apart. Where between them is the electric field zero?

11. A glass rod rubbed with silk loses 8×10^{13} electrons. Find the charge on the rod and its sign. ($e = 1.6 \times 10^{-19}$ C)

12. A long straight wire carries a uniform charge of 9 μC/m. Find the electric field 5 cm from it. ($k = 9 \times 10^9$ N m^2/C^2)

13. A uniform field of 700 N/C passes through a flat surface of area 37 cm^2. Find the flux if the field makes 60° with the normal to the surface.

14. A short dipole has dipole moment 9×10^{-9} C m. Find the field 2 cm from its centre (a) on its axis, (b) on its equatorial line. ($k = 9 \times 10^9$ N m^2/C^2)

15. A thin spherical shell of radius 7 cm carries 4 μC. Find the electric field at 1 cm and at 15 cm from its centre. ($k = 9 \times 10^9$ N m^2/C^2)

16. Can a body carry a charge of 24×10^{-19} C? Explain. ($e = 1.6 \times 10^{-19}$ C)

Section C — Word problems — 4 × 4 = 16 marks

17. Charges of 3 μC and 4 μC are placed at A and B, each 3 cm from a point C, with CA ⊥ CB. Find the magnitude of the net force on a charge of +4 μC at C. ($k = 9 \times 10^9$ N m^2/C^2)

18. A dipole has charges ±8 nC separated by 4 mm. Find (a) its dipole moment, (b) the field 30 cm away on its axis, (c) the greatest torque on it in a field of 9×10^4 N/C. ($k = 9 \times 10^9$ N m^2/C^2)

19. An oil drop of mass 1.04×10^{-13} kg stays still between two plates where the field is 500,000 N/C, directed upwards. Find the charge on the drop and how many electrons it has lost. ($g = 10$ m/s^2; $e = 1.6 \times 10^{-19}$ C)

20. A long wire carries 9 μC/m. Find the field at 5 cm and at 30 cm from it, and the force on a charge of 4 μC placed 5 cm away. ($k = 9 \times 10^9$ N m^2/C^2)

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Answer key

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Q	Answer	Working
1	**(d) 4.8 N**	$F = kq_1q_2/r^2 = 9 \times 10^9 \times 2 \times 10^{-6} \times 6 \times 10^{-6} \div (15 \times 10^{-2})^2$
2	**(c) (9/16)F**	$F \propto q_1q_2/r^2$: × 9 ÷ 16
3	**(d) 3.75×10^{13}**	$n = q/e = 6 \times 10^{-6} \div (1.6 \times 10^{-19})$
4	**(c) 1.8×10^6 N/C**	$E = kq/r^2$
5	**(a) coulomb**	—
6	**(d) $2.52\pi \times 10^5$ N m²/C**	$\Phi = q/\varepsilon_0 = 4\pi kq$
7	**(b) 0.0162 N m**	$\tau = pE \sin\theta$; $p = 2 \times 10^{-6} \times 9 \times 10^{-2}$ C m
8	**(c) A is true, but R is false.**	A is true: $kq/r^2 = 9 \times 10^9 \times 5 \times 10^{-6} \div (3 \times 10^{-2})^2 = 5 \times 10^7$ N/C. R is false.
9	**87.2 N towards x = 18 cm**	from the first: −2.8 N; from the second: 90 N (positive means towards x = 18 cm)
10	**8 cm from the 3 μC charge**	$q_1/x^2 = q_2/(40 - x)^2 \Rightarrow x/(40 - x) = 1/4$
11	**$+1.28 \times 10^{-5}$ C**	$q = ne = 8 \times 10^{13} \times 1.6 \times 10^{-19}$; losing electrons leaves it positive
12	**3.24×10^6 N/C**	$E = 2k\lambda/r = 2 \times 9 \times 10^9 \times 9 \times 10^{-6} \div (5 \times 10^{-2})$
13	**1.295 N m²/C**	$\Phi = EA\cos\theta = 700 \times 37 \times 10^{-4} \times \cos 60°$
14	**(a) 2.025×10^7 N/C; (b) 1.0125×10^7 N/C**	$E(\text{axis}) = 2kp/r^3$; $E(\text{equator}) = kp/r^3$
15	**0 at 1 cm (inside); 1.6×10^6 N/C at 15 cm**	Gauss: no charge is enclosed inside; outside, the shell acts like a point charge
16	**Yes: it is 15e**	q = ne with n a whole number
17	**200 N, at $\tan^{-1}(4/3)$ to the line AC**	forces 120 N and 160 N at right angles; $\sqrt{(3^2 + 4^2)} = 5$
18	**(a) 3.2×10^{-11} C m; (b) 21.3 N/C; (c) 2.88×10^{-6} N m**	$p = q \times 2a$; $E = 2kp/r^3$; $\tau_{max} = pE$
19	**$q = mg/E = 2.08 \times 10^{-18}$ C (positive, since the force is upwards along the field); it has lost 13 electrons**	$qE = mg \Rightarrow q = 1.04 \times 10^{-12} \div 500{,}000$
20	**3.24×10^6 N/C; 5.4×10^5 N/C; 12.96 N**	$E = 2k\lambda/r$; $F = qE$

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