B7 · Extra practice, worked solutions

Fields between plates | Diploma-style set of 8

Easy · B7-X01. Two parallel plates are 0.0300 m apart and connected to a 450 V battery. Find the field strength between the plates in V/m.

1. Givens: $\Delta d = 0.0300$ m; $\Delta V = 450$ V. Question: E.

2. $E = \Delta V/\Delta d$.

3. $= 450 \div 0.0300 = 1.50 \times 10^{4}$ V/m.

4. Answer: 1.50×10^{4} V/m

Easy · B7-X02. A charge of 2.00×10^{-6} C is in a uniform field of 3600 N/C. Find the size of the electric force on it in newtons.

1. Givens: $q = 2.00 \times 10^{-6}$ C; $E = 3600$ N/C. Question: F.

2. $F = qE$.

3. $= (2.00 \times 10^{-6})(3600) = 7.20 \times 10^{-3}$ N.

4. Answer: 7.20×10^{-3} N

Easy · B7-X03. Two parallel plates stay connected to the same battery. The plates are moved so the gap doubles. What happens to the field strength between them?

A. It doubles.
B. It stays the same.
C. It becomes four times larger.
D. It is cut in half.

1. Givens: ΔV stays the same; Δd doubles. Question: what happens to E.

2. $E = \Delta V/\Delta d$. Doubling the denominator halves E.

3. Answer: D. It is cut in half.

Medium · B7-X04. An electron is in a uniform field of 6000 N/C. Use e = 1.60×10^{-19} C and electron mass $m_e = 9.11 \times 10^{-31}$ kg. Find its acceleration in m/s².

1. Givens: E = 6000 N/C; q = 1.60×10^{-19} C; m = 9.11×10^{-31} kg. Question: a.

2. F = qE = $(1.60 \times 10^{-19})(6000) = 9.60 \times 10^{-16}$ N.

3. a = F/m = $9.60 \times 10^{-16} \div (9.11 \times 10^{-31}) = 1.05 \times 10^{15}$ m/s².

4. Answer: 1.05×10^{15} m/s²

Medium · B7-X05. A proton starts from rest at the positive plate of a pair of plates 0.0250 m apart with a potential difference of 900 V. Use e = 1.60×10^{-19} C and proton mass mp = 1.67×10^{-27} kg. Find its speed at the negative plate in m/s.

1. Givens: starts from rest (so $v_i = 0$ m/s); Δd = 0.0250 m; ΔV = 900 V; q = 1.60×10^{-19} C; m = 1.67×10^{-27} kg. Question: v.

2. The energy gained is kinetic: $q\Delta V = \frac{1}{2}mv^2$. The gap length is not needed for the speed.

3. $v = \sqrt{(2q\Delta V \div m)} = \sqrt{(2 \times (1.60 \times 10^{-19})(900) \div (1.67 \times 10^{-27}))} = 4.15 \times 10^5$ m/s.

4. Answer: 4.15×10^5 m/s

Medium · B7-X06. A charge is released from rest in a uniform electric field. Which description of its motion is correct?

A. A straight line with constant acceleration
B. A straight line at constant speed
C. A circle at constant speed
D. A curve with changing acceleration

1. Givens: uniform field, charge starts from rest. Question: the motion.

2. In a uniform field, the force F = qE is constant, so the acceleration is constant.

3. Starting from rest, the charge moves in a straight line along the field.

4. Answer: A. A straight line with constant acceleration

Challenging · B7-X07. An electron is released from rest at the negative plate. The plates are 0.0150 m apart with 240 V across them. Use $e = 1.60 \times 10^{-19}$ C and electron mass $m_e = 9.11 \times 10^{-31}$ kg. Find the time it takes to cross the gap, in seconds.

1. Givens: starts from rest; $\Delta d = 0.0150$ m; $\Delta V = 240$ V; $q = 1.60 \times 10^{-19}$ C; $m = 9.11 \times 10^{-31}$ kg. Question: t.

2. $E = \Delta V/\Delta d = 240 \div 0.0150 = 1.60 \times 10^{4}$ V/m.

3. $a = qE/m = (1.60 \times 10^{-19})(1.60 \times 10^{4}) \div (9.11 \times 10^{-31}) = 2.81 \times 10^{15}$ m/s².

4. From rest, $\Delta d = \frac{1}{2}at^2$, so $t = \sqrt{(2\Delta d/a)} = \sqrt{(2 \times 0.0150 \div (2.81 \times 10^{15}))} = 3.27 \times 10^{-9}$ s.

5. Answer: 3.27×10^{-9} s

Challenging · B7-X08. A small charged ball of mass 1.60×10^{-14} kg and charge 4.80×10^{-19} C hangs motionless between horizontal parallel plates 0.0200 m apart. Use $g = 9.81$ m/s². Find the potential difference across the plates, in volts.

1. Givens: at rest, so the net force is zero; $m = 1.60 \times 10^{-14}$ kg; $q = 4.80 \times 10^{-19}$ C; $\Delta d = 0.0200$ m; $g = 9.81$ m/s². Question: ΔV.

2. The upward electric force balances the weight: $qE = mg$.

3. $E = mg/q = (1.60 \times 10^{-14})(9.81) \div (4.80 \times 10^{-19}) = 3.27 \times 10^{5}$ V/m.

4. $\Delta V = E\Delta d = (3.27 \times 10^{5})(0.0200) = 6540$ V.

5. Answer: 6540 V