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ANSWER BOOK

Force on a moving charge

Magnetic fields · Year 13

AQA 3.7.5.2 · CIE 20.3 · OCR A 6.3.2

10 questions · 30 marks

NAVY EDITION

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SECTION A · Warm-up

A1 F = BQv, where Q is the charge and v its speed. It applies when the velocity is perpendicular to the field. [2]

A2 $F = BQv = 0.40 \times 1.6 \times 10^{-19} \times 2.0 \times 10^{6} = 1.28 \times 10^{-13}$ N. [2]

A3 The magnetic force is always perpendicular to the velocity, so it changes the direction of motion but not the speed. A constant-magnitude force always at right angles to the velocity provides a centripetal force, giving circular motion. [2]

SECTION B · Standard

B1 $BQv = mv^2/r$, so $r = mv/BQ = (9.11 \times 10^{-31} \times 3.0 \times 10^{6})/(0.50 \times 1.60 \times 10^{-19}) = 3.42 \times 10^{-5}$ m. [4]

B2 $F = BQv = 0.80 \times 1.60 \times 10^{-19} \times 5.0 \times 10^{5} = 6.40 \times 10^{-14}$ N. [3]

B3 $r = mv/BQ = (1.67 \times 10^{-27} \times 5.0 \times 10^{5})/(0.80 \times 1.60 \times 10^{-19}) = 6.52 \times 10^{-3}$ m. [3]

B4 The magnetic force is always perpendicular to the velocity, and work done is force times displacement in the direction of the force. With no component of force along the motion, no work is done, so the particle's speed and kinetic energy stay constant. [3]

SECTION C · Stretch

C1 $E_k = eV = 8.00 \times 10^{-17}$ J, so $v = \sqrt{(2E_k/m)} = 1.33 \times 10^{7}$ m s^{-1}. Then $r = mv/BQ = 2.52 \times 10^{-4}$ m. [4]

C2 Since $v = 2\pi r/T$ and $r = mv/BQ$, substituting gives $T = 2\pi m/BQ$ (independent of v). $T = (2\pi \times 9.11 \times 10^{-31})/(0.50 \times 1.60 \times 10^{-19}) = 7.15 \times 10^{-11}$ s, and $f = 1/T = 1.40 \times 10^{10}$ Hz. [4]

C3 A uniform magnetic field bends the particles into semicircles inside two hollow 'dees'. Each time a particle crosses the gap between the dees, an alternating electric field accelerates it. As it speeds up the radius grows, spiralling outward, until it leaves at high energy. [3]