InkPhysics

QUESTION WORKBOOK

Force on a moving charge

Magnetic fields · Year 13

AQA 3.7.5.2 · CIE 20.3.1, 20.3.2, 20.3.3, 20.3.4, 20.3.5, 20.3.6 · OCR A 6.3.2(a), 6.3.2(b), 6.3.2(c)

19 questions · 52 marks

NAVY SCREEN EDITION

SECTION A · Warm-up

A1 State the equation for the magnetic force on a charge moving through a magnetic field and the condition under which it applies. [2]

A2 A particle of charge 1.6×10^{-19} C moves at 2.0×10^{6} m s^{-1} at right angles to a magnetic field of flux density 0.40 T. Calculate the force on the particle. [2]

A3 Explain why a charged particle moving at right angles to a uniform magnetic field moves in a circle. [2]

A4 State two situations in which a charged particle in a magnetic field experiences no magnetic force. [2]

A5 An electron travels horizontally due north through a region where the magnetic field is directed vertically downwards. Determine the direction of the magnetic force on the electron. [2]

A6 The speed of a charged particle moving at right angles to a uniform magnetic field is doubled. State and explain the effect on the magnetic force on the particle and on the radius of its path. [2]

SECTION B · Standard

B1 An electron moves at 3.0×10^{6} m s^{-1} perpendicular to a magnetic field of flux density 0.50 T. Calculate the radius of its circular path.
$m_e = 9.11 \times 10^{-31}$ kg, $e = 1.60 \times 10^{-19}$ C [3]

B2 A proton moves at 5.0×10^{5} m s^{-1} perpendicular to a magnetic field of flux density 0.80 T. Calculate the magnetic force on the proton. [2]

B3 Calculate the radius of the circular path of the proton in the previous question.
$m_p = 1.67 \times 10^{-27}$ kg [2]

B4 Explain why the magnetic force on a moving charged particle does no work on the particle. [3]

B5 An alpha particle of charge $+3.2 \times 10^{-19}$ C and mass 6.64×10^{-27} kg travels at 1.5×10^{7} m s^{-1} at right angles to a magnetic field of flux density 250 mT. Calculate the radius of its circular path. [3]

B6 In a velocity selector, an electric field of strength 4.5×10^4 V m^{-1} is perpendicular to a magnetic field of flux density 0.30 T. State the condition for a charged particle to pass through undeflected and calculate the speed at which this occurs. [3]

B7 In a particle detector, a particle of charge 1.60×10^{-19} C leaves a circular track of radius 45 mm in a magnetic field of flux density 1.2 T. Calculate the momentum of the particle. [2]

SECTION C · Stretch

C1 An electron is accelerated from rest through a potential difference of 500 V and then enters a magnetic field of flux density 0.30 T at right angles to the field. Calculate the speed of the electron and the radius of its circular path.
$e = 1.60 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ kg [4]

C2 Show that the period of the circular motion of a charged particle in a magnetic field is $T = 2\pi m/BQ$, for speeds well below the speed of light. Calculate the period and the frequency of this motion for an electron in a field of flux density 0.50 T.

[4]

C3 Describe how a cyclotron uses magnetic and electric fields to accelerate charged particles. [3]

C4 A particle of charge $+1.60 \times 10^{-19}$ C enters a detector at 3.0×10^{6} m s^{-1}, at right angles to a magnetic field of flux density 0.85 T, and follows a circular arc of radius 24 mm. Deduce whether the particle could be a proton.

$m_p = 1.67 \times 10^{-27}$ kg [4]

C5 In a cyclotron, protons reach their maximum speed at the outer edge of the dees, where the radius of their path is 0.60 m and the flux density is 1.5 T. Calculate the maximum speed of the protons and their maximum kinetic energy.
$e = 1.60 \times 10^{-19}$ C, $m_p = 1.67 \times 10^{-27}$ kg [4]

C6 A Hall probe is used to measure magnetic flux density. Explain how a steady pd, proportional to the flux density, appears across a current-carrying slice of semiconductor placed in the field. [3]