

Forces on currents and moving charges in magnetic fields

Physics grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Award marks for method as well as for the final answer. Accept answers within rounding and follow through an earlier slip. A missing or wrong unit loses one mark only once in each question.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB D.3

Question 1 Defining the tesla (2 marks)

One tesla is the flux density that gives a force of **1 N on a 1 m length of wire carrying 1 A** perpendicular to the field.

Marking: 1 mark for force, current and length; 1 mark for perpendicular to the field.

Question 2 Force on a rail wire (3 marks)

a) $F = BIL = 0.30 \times 5.0 \times 0.60 = \mathbf{0.90\ N}$.

b) **Zero:** no moving charges, no magnetic force.

Marking: a) 1 mark for substitution, 1 mark for answer with unit. b) 1 mark.

Question 3 Direction of a path (3 marks)

a) The force on a positive charge is $F = qv \times B$. With v to the right and B out of the page, the force points **down the page**, perpendicular to v , so the path bends downwards.

b) The speed is **unchanged**.

Marking: a) 1 mark for the direction rule, 1 mark for force perpendicular to velocity. b) 1 mark.

Question 4 Radius of a proton (3 marks)

$r = mv/(qB) = 1.67 \times 10^{-27} \times 2.5 \times 10^6 / (1.60 \times 10^{-19} \times 0.35) = \mathbf{7.5\ cm}$.

Marking: 1 mark for formula, 1 mark for substitution, 1 mark for answer.

Question 5 Why circular? (2 marks)

The force is perpendicular to the velocity, so it provides a **centripetal force** of constant size

and the speed is constant. A constant-size force that always acts at right angles to the motion gives a circular path.

Marking: 1 mark for perpendicular force and centripetal role, 1 mark for constant size giving a circle.

Question 6 Velocity selector (3 marks)

a) $v = E/B = 6.0 \times 10^3 / 0.025 = \mathbf{2.4 \times 10^5 \text{ m/s}}$.

b) **No**: q cancels from $qE = qvB$.

Marking: a) 1 mark for formula, 1 mark for answer. b) 1 mark.

Question 7 Comparing proton and electron (2 marks)

The **proton** has the larger radius. $r = mv/(qB)$, the charges are equal in size, and the proton's mass is about 1800 times the electron's.

Marking: 1 mark for proton, 1 mark for the mass argument.

Question 8 Force on a wire at an angle (2 marks)

$$F = BIL \sin \theta = 0.15 \times 8.0 \times 0.30 \times \sin 40^\circ = \mathbf{0.23 \text{ N}}.$$

Marking: 1 mark for the sine, 1 mark for the answer.