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ANSWER BOOK

Magnetic flux density and the force on a wire

Magnetic fields · Year 13

AQA 3.7.5.1 · CIE 20.1.1, 20.1.2, 20.2.1, 20.2.2, 20.2.3, 20.4.1, 20.4.2, 20.4.3
OCR A 6.3.1(a), 6.3.1(b), 6.3.1(c), 6.3.1(d), 6.3.1(e)(i), 6.3.1(e)(ii), 6.3.1(f)

18 questions · 47 marks

NAVY EDITION

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SECTION A · Warm-up

A1 $F = BIl$, where B is the flux density, I the current and l the length of wire in the field (1); valid when the wire is perpendicular to the field (1). [2]

A2 $F = BIl = 0.20 \times 3.0 \times 0.15$ (1)
$F = 0.09$ N (1) [2]

A3 The force per unit current per unit length on a wire carrying a current at right angles to the field, $B = F/Il$ (1); 1 T = 1 N A^{-1} m^{-1} (1). [2]

A4 A circled cross represents a field directed into the page and a circled dot a field directed out of the page (1). [1]

A5 $F = BIl = 0.090 \times 2.5 \times 0.045$ (1)
$F = 0.010$ N (1) [2]

SECTION B · Standard

B1 $B = F/(Il) = 0.50/(4.0 \times 0.25)$ (1)
$B = 0.50$ T (1) [2]

B2 $F = BIl \sin\theta = 0.30 \times 2.0 \times 0.10 \times \sin 30°$ (1)
$F = 0.030$ N (1) [2]

B3 $I = F/(Bl) = 0.18/(0.45 \times 0.080)$ (1)
$I = 5.0$ A (1) [2]

B4 The force depends on the angle θ between the wire and the field through $F = BIl \sin\theta$ (1). At 90°, $\sin\theta = 1$, giving the maximum force (1); when the wire is parallel to the field, $\theta = 0$ and $\sin\theta = 0$, so there is no force (1). [3]

B5 They repel (1). Each wire lies in the circular field of the other and so feels a force $F = BIl$; applying Fleming's left hand rule to either wire, using the field of its neighbour, gives a force directed away from the neighbour (1). [2]

B6 Weight $= mg = 0.40 \times 10^{-3} \times 9.81 = 3.9 \times 10^{-3}$ N (1)
For support, $BIl = mg$, so $I = mg/(Bl) = 3.9 \times 10^{-3}/(0.15 \times 0.060)$ (1)
$I = 0.44$ A (1) [3]

B7 [3]

$B = F/(Il \sin\theta)$ (1)
$= (8.4 \times 10^{-3})/(3.2 \times 0.070 \times \sin 25^\circ)$ (1)
$B = 0.089$ T (1)

SECTION C · Stretch

C1 [4]

$F = BIl = 0.60 \times 8.0 \times 0.050$ (1)
$F = 0.24$ N (1)
$m = F/g = 0.24/9.81$ (1)
$m = 24.5$ g (1)

C2 [4]

Perpendicular: $F = BIl = 0.25 \times 6.0 \times 0.12$ (1)
$F = 0.18$ N (1)
At 45°: $F = BIl \sin 45^\circ = 0.18 \times \sin 45^\circ$ (1)
$F = 0.127$ N (1)

C3 [3]

Clamp a horizontal wire between the poles of a magnet standing on a top-pan balance, with the wire perpendicular to the field; zero the balance, then pass a known current (1). The wire exerts an equal and opposite force on the magnet (Newton's third law), changing the balance reading (1). Force = change in mass reading (in kg) × g; repeat for a range of currents (1).

C4 [3]

$F = BIl$, so with B and l constant the graph of F against I is a straight line through the origin with gradient Bl (1)
$B = \text{gradient}/l = 0.048/0.120$ (1)
$B = 0.40$ T (1)

C5 [4]

Use of $F = BIl$ with each length in metres at the maximum current (1)
W: $F = 0.101$ N and Y: $F = 0.119$ N (1)
X: $F = 0.168$ N and Z: $F = 0.176$ N (1)
Only X and Z reach 0.15 N, so either is suitable; W and Y are not (1)

C6 [3]

By Newton's third law the force on the magnet equals the force on the wire: $F = \Delta m\, g = 0.65 \times 10^{-3} \times 9.81 = 6.4 \times 10^{-3}$ N (1)
$B = F/(Il) = 6.4 \times 10^{-3}/(3.5 \times 0.050)$ (1)
$B = 0.036$ T (1)