Past-paper walk-through

Magnetic fields due to currents ▪ 20.4

eXercise

Questions in this set

- 9702/43 J23 Q6 ▪ 10 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 6

9702/43 J23 ▪ Q6 ▪ 10 marks

6

(a) State what is meant by a magnetic field. **[2]**

(b) A long, straight wire P carries a current into the page, as shown in Fig. 6.1.

On Fig. 6.1, draw four field lines to represent the magnetic field around wire P due to the current in the wire. **[3]**

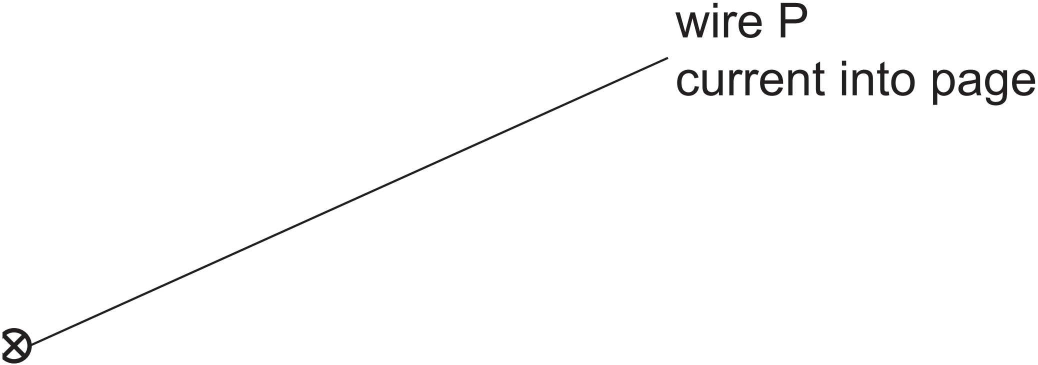
(c)(i) Calculate the magnetic force per unit length exerted on wire Q by wire P. **[2]**

(c)(ii) State the direction of the force exerted on wire Q by wire P. **[1]**

(c)(iii) The flux density of the magnetic field at wire P due to the current in wire Q is 1.5 mT.

Determine the magnitude of the current in wire P. Explain your reasoning. **[2]**

Question 6



Solution 6

(a)

Mark scheme

- a region where a force acts on
- a current-carrying conductor
- or
- a moving charge
- or
- a magnetic material / magnetic pole

Solution 6

(b) Worked steps

Know. The field around a long straight current-carrying wire is a set of **concentric circles** centred on the wire, and it gets weaker with distance.
Draw. Four circles centred on the wire, each larger than the last, with the **spacing between them increasing** as you move out — the field strength falls as $1/r$, and field lines are drawn further apart where the field is weaker.
Which way round? Grip the wire with the right hand, thumb pointing along the conventional current. Here the current goes **into the page**, so the fingers curl **clockwise**, and every circle carries a clockwise arrow.

Solution 6

Check. Three separate marks: the shape, the increasing spacing, and the arrows. Evenly spaced circles lose one; unarrowed circles lose another.

Mark scheme

- concentric circles around the wire
- spacing between circles increases with distance from wire
- arrows showing direction of field is clockwise

Solution 6

(c)(i) Worked steps

Know. A wire of length L carrying current I at right angles to a field B feels a force $F = BIL$. "Per unit length" means divide through by L.

Equation. $\frac{F}{L} = BI$.

Substitute. $\frac{F}{L} = 2.6 \times 10^{-3} \times 5.0$.

Answer. $\frac{F}{L} = 1.3 \times 10^{-2}$ N m^{-1}.

Solution 6

Check. The unit asked for is newtons per metre, so no length appears in the answer at all. If you have used a length, you have answered a different question.

Mark scheme

- $F = BIL$
- force per unit length $= BI$
- $= 2.6 \times 10^{-3} \times 5.0$
- $= 0.013$ N m^{-1}

Solution 6

(c)(ii)

Mark scheme

- to the right

Solution 6

(c)(iii) Worked steps

Know. The two wires exert forces on **each other**, and by Newton's third law those forces are equal in magnitude and opposite in direction — even though the two wires carry different currents and sit in different fields.

Reasoning. So the force per unit length on P due to Q equals the value found in (c)(i), 1.3×10^{-2} N m^{-1}, and that force is produced by Q's field acting on P's own current.

Equation. $\dfrac{F}{L} = B_{\mathrm{Q}} I_{\mathrm{P}}$, so $I_{\mathrm{P}} = \dfrac{F/L}{B_{\mathrm{Q}}}$.

Solution 6

Substitute. $I_\mathrm{P} = \dfrac{1.3 \times 10^{-2}}{1.5 \times 10^{-3}}$.

Answer. $I_\mathrm{P} = 8.7$ A.

Check. The third-law step is worth a mark on its own and must be **stated**, not assumed. Without it there is no route from Q's field to P's current.

Mark scheme

- force (per unit length) has the same magnitude due to Newton's 3rd law
- $0.013 = 1.5 \times 10^{-3} \times I$
- current $= 8.7$ A