Topic Test: OxfordAQA International A level Physics

Magnetic Fields

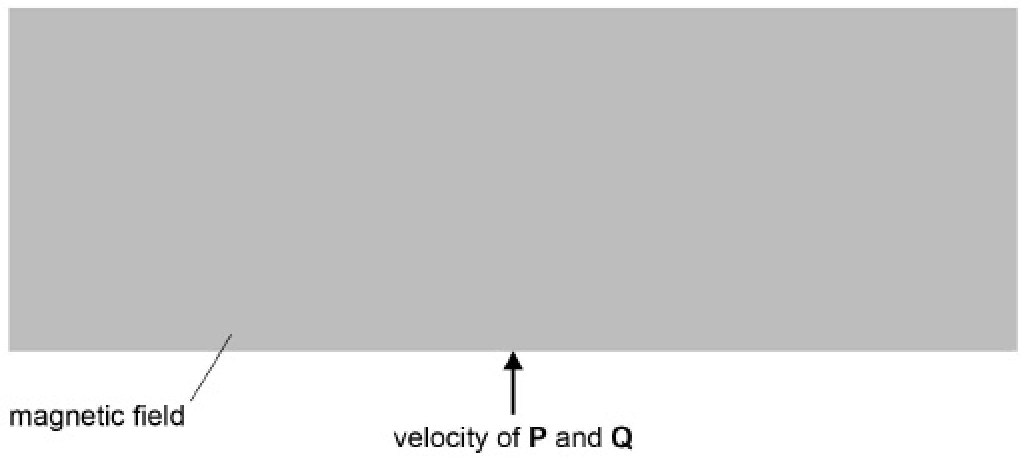
Name: ______________________

Class: ______________________

Date: ______________________

Time:	**58 minutes**
Marks:	**39 marks**
Comments:	

1 The diagram below shows where two equally charged oxygen ions **P** and **Q** enter a uniform magnetic field at 90° to the field. The ions each have a velocity of 4.1×10^6 m s^{-1}



charge on **P** and **Q**	=	$+3.2 \times 10^{-19}$ C
magnetic flux density	=	0.93 T
direction of magnetic field	=	out of page
mass of **P**	=	2.66×10^{-26} kg
mass of **Q**	=	2.83×10^{-26} kg

(a) Sketch and label the paths of **P** and **Q** on the diagram.

(2)

(b) Calculate the difference between the diameters of the paths followed by **P** and **Q** while in the magnetic field.
Ignore any forces acting between the ions.

difference = ____________________ m

(4)

(c) The ions are subject to a magnetic force when they are in the field.
Explain why their speed does not change.

____

____

____

(1)

(Total 7 marks)

2 (a) The equation $F = BIl$, where the symbols have their usual meanings, gives the magnetic force that acts on a conductor in a magnetic field.

Given the unit of each of the quantities in the equation.

F ______________________ *B* ______________________

I ______________________ l ______________________

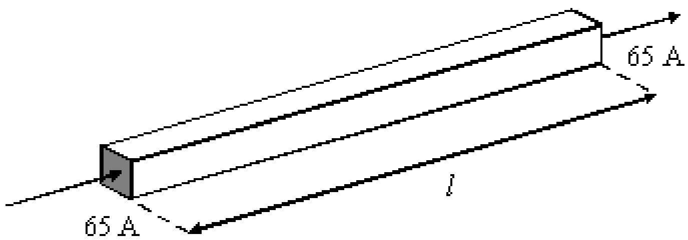
State the condition under which the equation applies.

____

____

(2)

(b) The diagram shows a horizontal copper bar of 25 mm × 25 mm square cross-section and length l carrying a current of 65 A.



(i) Calculate the minimum value of the flux density of the magnetic field in which it should be placed if its weight is to be supported by the magnetic force that acts upon it.

density of copper = 8.9×10^3 kg m^{-3}

____

____

____

____

____

(ii) Draw an arrow on the diagram above to show the direction in which the magnetic field should be applied if your calculation in part (i) is to be valid. Label this arrow M.

(5)

(Total 7 marks)

3

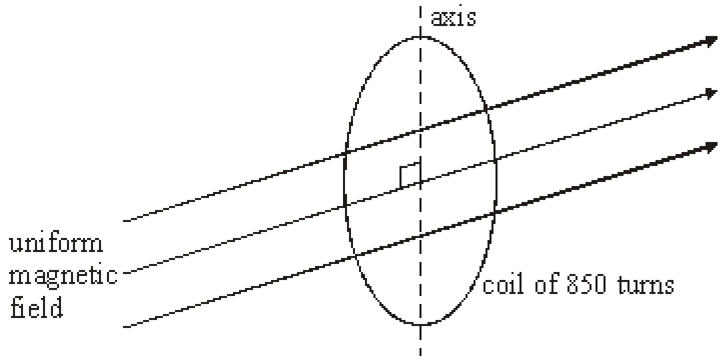


Figure 1

A circular coil of diameter 140 mm has 850 turns. It is placed so that its plane is perpendicular to a horizontal magnetic field of uniform flux density 45 mT, as shown in **Figure 1**.

(a) Calculate the magnetic flux passing through the coil when in this position.

____

____

(2)

(b) The coil is rotated through 90° about a vertical axis in a time of 120 ms.

Calculate

(i) the change of magnetic flux linkage produced by this rotation,

____

____

(ii) the average emf induced in the coil when it is rotated.

____

____

____

(4)

(Total 6 marks)

4

A low voltage supply is needed for a battery charger.
An engineer designs a transformer to convert an alternating input voltage of 230 V_{rms} to the low voltage needed for the battery charger.
The transformer has 800 turns on the primary coil and 28 turns on the secondary coil.

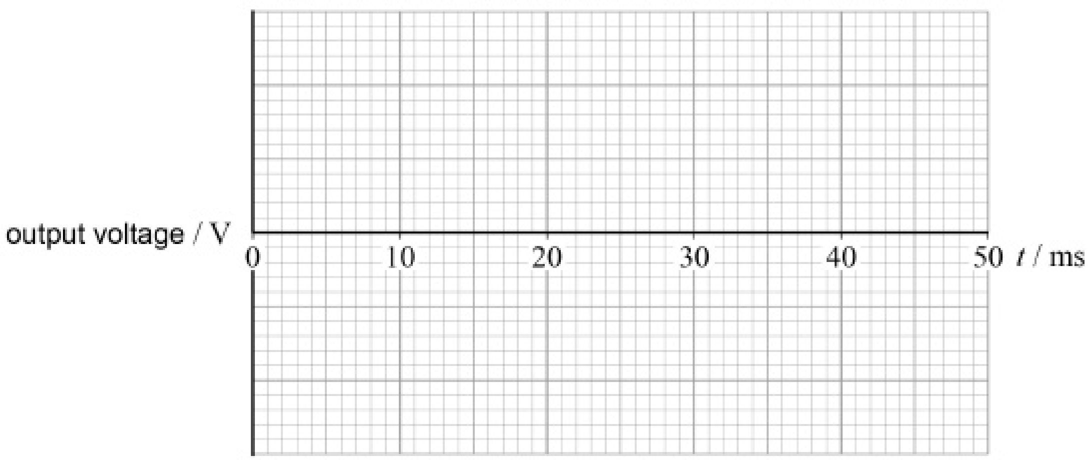
(a) Calculate V_s the rms output voltage from the secondary coil.
For this calculation, assume that the transformer is ideal.

V_s = ____________________ V

(2)

(b) The frequency of the input voltage is 50 Hz.

Sketch on the axes below a graph of the variation of the output voltage with time *t*.
The graph should show the voltage variation over a period of 50 ms.
Add an appropriate scale to the voltage axis.



(4)

(c) In practice, the transformer is 90% efficient. The rms current in the secondary coil is 2.4 A.

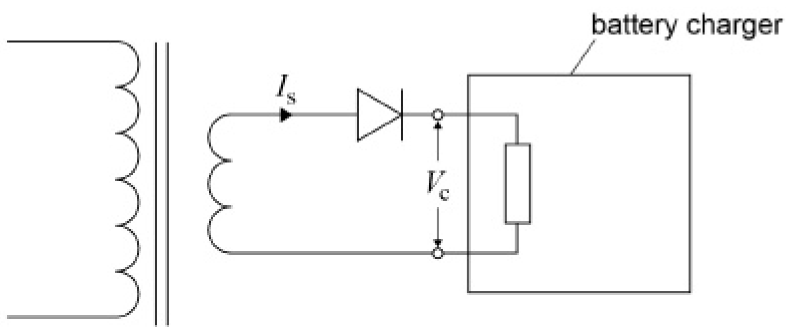
Calculate in mA the rms current in the primary coil of the transformer.

rms current = ____________________ mA

(2)

(d) The engineer now connects the output of the transformer in series with a semiconductor diode and the battery charger.

The diagram below shows the circuit. The battery charger behaves as an ohmic conductor.



Deduce how the magnitude and waveform of the voltage V_c across the battery charger are different from the magnitude and waveform of the output from the transformer.

magnitude ____

____

____

waveform ____

____

____

(2)

(e) One inefficiency of the transformer arises from eddy current losses.

Explain how eddy current losses occur in a transformer and go on to suggest how good transformer design minimises eddy current losses.

(4)

(Total 14 marks)

5 An aircraft, of wing span 60 m, flies horizontally at a speed of 150 m s^{-1}. If the vertical component of the Earth's magnetic field in the region of the plane is 1.0×10^{-5} T, what is the magnitude of the magnetic flux cut by the wings in 10 s?

A 1.0×10^{-5} Wb

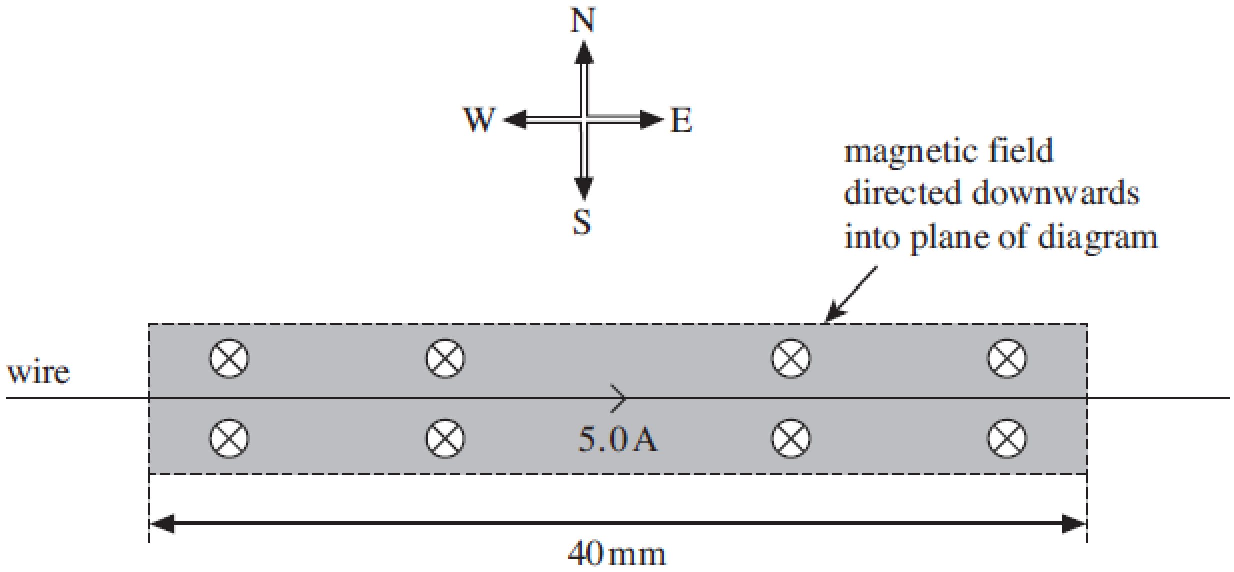
B 1.0×10^{-4} Wb

C 9.0×10^{-2} Wb

D 9.0×10^{-1} Wb

(Total 1 mark)

6 A horizontal straight wire of length 40 mm is in an east-west direction as shown in the diagram. A uniform magnetic field of flux density 50 mT is directed downwards into the plane of the diagram.



When a current of 5.0 A passes through the wire from west to east, a horizontal force acts on the wire. Which line, **A** to **D**, in the table gives the magnitude and direction of this force?

	magnitude / mN	**direction**
A	2.0	north
B	10.0	north
C	2.0	south
D	10.0	south

(Total 1 mark)

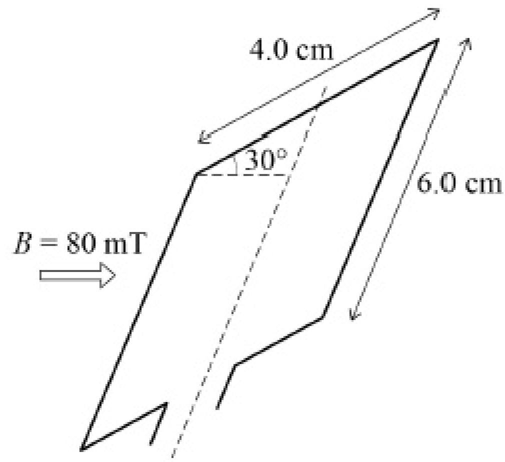
7 Which line, **A** to **D**, in the table correctly describes the trajectory of charged particles which enter separately, at right angles, a uniform electric field, and a uniform magnetic field?

	uniform electric field	**uniform magnetic field**
A	parabolic	circular
B	circular	parabolic
C	circular	circular
D	parabolic	parabolic

(Total 1 mark)

8 A rectangular coil with 50 turns has a length of 6.0 cm and a width of 4.0 cm. The plane of the coil is at 30° to a magnetic field of flux density 80 mT.

What is the flux linkage of the coil?



A 9.6×10^{-5} Wb

B 4.8×10^{-3} Wb

C 8.3×10^{-3} Wb

D 4.8×10^{0} Wb

(Total 1 mark)

9 A transformer has 400 turns on the primary coil and 5000 turns on the secondary coil. The transformer is 93% efficient. The primary voltage is 12 V and the primary current is 4.8 A.

What is the magnitude of the secondary current?

A 0.36 A

B 0.41 A

C 56 A

D 65 A

(Total 1 mark)

Mark schemes

1 (a) Both curve to the right − apparently circular arcs ✓

P has smaller radius than **Q** ✓

2

(b) Equates Bqv and $\frac{mv^2}{r}$ ✓

Correct substitution of data for one calculation ✓

Look for $r = \frac{2.66 \times 10^{-26} \times 4.1 \times 10^{6}}{0.93 \times 3.2 \times 10^{-19}}$ *but accept in other arrangements*

Either radius correct: **P** is 0.366 m; **Q** is 0.390 m ✓

0.047 (m) ✓

4

(c) Force acting is always at right angles to velocity **or** circular motion so direction changes but speed stays the same ✓

1

[7]

2 (a) units: F - newton (N), B - tesla (T) or weber metre^{-2} (Wb m^{-2}), I - ampere (A), l - metre (m) **(1)**
condition: I must be perpendicular to B **(1)**

2

(b) (i) mass of bar, $m = (25 \times 10^{-3})^2 \times 8900 \times l$ **(1)**
(= 5.56l) weight of bar (= mg) = 54.6l **(1)**
$mg = BIl$ or weight = magnetic force **(1)**
$54.6l = B \times 65 \times l$ gives $B = 0.840$ T **(1)**

(ii) arrow in correct direction (at right angles to I, in plane of bar) **(1)**

5

[7]

3 (a) Φ (= BA) = $45 \times 10^{-3} \times \pi \times (70 \times 10^{-3})^2$ **(1)**
= 6.9×10^{-4} Wb **(1)** (6.93×10^{-4} Wb)

2

(b) (i) $N\Delta\Phi$ (= NBA – 0) = $850 \times 6.93 \times 10^{-4}$ **(1)**

= 0.59 (Wb turns) **(1)** (0.589 (Wb turns))

(if $\Phi = 6.9 \times 10^{-4}$, then 0.587 (Wb turns))

(allow C.E. for value of Φ from (a))

(ii) induced emf ($= N \frac{\Delta\Phi}{\Delta t}$) $= \frac{0.589}{0.12}$ **(1)**

= 4.9 V **(1)** (4.91 V)

(allow C.E. for value of Wb turns from (ii)

4

[6]

4 (a) Use of $\frac{N_s}{N_p} = \frac{V_s}{V_p}$ ✓

8.1 or 8.05 (V) ✓

Either correct substitution or rearrangement

2

(b) At least 2 cycles of ac shown with or without scales on axis ✓

Must be even and with consistent peak values.

Evidence of the use of $\sqrt{2}$ **or** $t = \frac{1}{f}$ ✓

Students who get either V_{max} or T correct get this mark also.

Peaks at 11.3 (V) ✓

Accept even if value of T on graph contradicts the calculated value

Time period 20 ms shown on graph or calculated ✓

4

(c) $V_s I_s = 0.9 V_p I_p$ seen in some form ✓

For ecf answer should be 11.6 × their (a)

93(.3) (mA) ✓ ecf from (a) ✓

2

(d) Magnitude of (peak) pd is **less** (because of pd dropped across diode) ✓

Only positive “humps” remain **or** negative is blocked
Or the output is (half wave) rectified ✓

2

(e) Eddy currents or emf induced in the core… ✓
… because of varying magnetic field or flux✓
Eddy currents dissipate energy wtte ✓
Core is laminated…✓
…to reduce (magnitude of) eddy currents✓
ANY 4

4

[11]

5 D

[1]

6 B

[1]

7 A

[1]

8 B

[1]

9 A

[1]