A-Level Physics

Magnetic Fields

Mark Scheme

Time available: 74 minutes
Marks available: 50 marks

1. (a) Core – links the magnetic flux/field from the primary coil to the secondary coil ✓$_1$ owtte

Secondary coil – (a conductor) has a varying magnetic flux/field passing through/linking with it ✓$_2$ owtte

to induce an emf determined by the number of turns in the primary and secondary coils ✓$_3$ owtte

✓$_1$ The word 'links' can be replaced with channels/directs /concentrates/focuses.

✓$_2$ 'varying' is important for this mark.

✓$_3$ induction and reference to turns ratio both must be mentioned.

3

(b) The sheets of material **M** are made from insulator/high resistivity material which prevents/limits eddy currents from flowing in the core. ✓$_1$

(soft) iron is used because it efficiently links the magnetic field or it magnetises and demagnetises easily ✓$_2$

thin sheets of iron are used so smaller emfs are induced in the core (which increases the efficiency) ✓$_3$

thin sheets of iron are used so resistance is high causing lower currents (which increases the efficiency) ✓$_4$

✓$_2$ A reference to the benefit of using iron must be made (repeating the function of the core is not enough)

Any 3 points gain the marks; however, if ✓$_3$ and ✓$_4$ are both used one must refer to the resulting increase in efficiency

3 Max

(c) If the voltage is lower/33 kV then power is transmitted at high current. So energy is wasted/lost in the cable by I^2r heating. ✓$_1$ owtte

If the voltage is made too high this will create major insulation/isolation difficulties. ✓$_2$ owtte

✓$_2$ higher pylons, transformers that have better insulation against spark over, more costly equipment

2

(d) Use of efficiency $\eta = \frac{\text{power}_{out}}{\text{power}_{in}}$ once ✓^{1}

Use of $I = P/V$ once at any point ✓$_2$

I = 3200 (A) (correct answer only, no ecf) ✓$_3$

✓$_1$ examples could be:

power at 132 kV = 72 / 0.98 = 73.5 MW

Or

at transmission line start = 73.5 / 0.94 = 78.2 MW

Or

at 25 kV = 78.2 / 0.98 = 79.8 MW

Or in single stage

Power at 25 kV = 72 / (0.94 × 0.98^2) = 79.8 MW)

✓$_2$ expect I = 79.8 × 10^6 / 25 × 10^3 = 3200 A

3

[11]

2. (a) Magnetic flux density at 0.070 m = 0.07 ± 0.005 T ✓

(use of flux linkage $N\Phi = BAN$
= 0.07 × 3.5 × 10^{-5} × 200)

Flux linkage = 4.9 ± 0.2 × 10^{-4} (Wb-turns) ✓

shown calculated to at least 2 sig figs

2

(b) (As the coil moves) there is a rate of change of flux through the coil ✓$_1$ (owtte)

The induced emf is proportional to the rate of change of flux (linkage) so the (magnitude) of the emf decreases ✓$_2$ (owtte)

✓$_1$ The first part ie the induced emf is proportional to the rate of change of flux linkage may be given in a number of ways eg emf = $N\frac{\Delta\Phi}{\Delta t}$ or $N\frac{\Delta(BA)}{\Delta t}$ or simply saying 'because of Faraday's law'.

Ignore the sign of the emf

✓$_2$ It's not enough to say the emf decreases

Connection between rate of change of flux and change of flux with distance must be made

2

(c) Finding a gradient from a tangent ✓$_1$

Attempting to use Faraday's law

emf = $N\frac{\Delta(BA)}{\Delta t}$

OR incorporating velocity into Faraday's law $NA\left(\frac{\Delta B}{\Delta x}\right)v$

emf = (200 × 3.5 × 10^{-5}(0.693) × 0.80)
emf = 3.6 to 4.2 × 10^{-3} (V) ✓$_3$

The maximum emf (in the range considered) is the greatest at x = 0.10 m (as the gradient is the greatest)
So No ✓$_4$ owtte

✓$_1$ This can be calculated at any x
eg at x = 0.10 m gives $\frac{\Delta B}{\Delta x} = \left(\frac{0.095}{0.137}\right)$ = 0.69(3) (T m^{-1})

✓$_2$ The mark is given for an attempt to use Faraday's law. Allow errors provided the form of the equation remains correct.

✓$_3$ The expected value is 3.8(8) × 10^{-3} V {range to be decided at standardisation}

✓$_4$ No and an indication that the emf at x = 0.10 m is the maximum available. This could come earlier in the answer and can be inferred by a reference to the maximum gradient in the range considered.
No ecf.

If no marks are awarded allow 1 mark if candidate states that the largest emf is expected at x = 0.10 m

If only the second mark is awarded allow a mark for finding $\frac{\Delta B}{\Delta t}$ or $N\frac{\Delta \phi}{\Delta t}$ between x = 0.07 and 0.10 m (e.g. $\frac{200\times3.5\times10^{-5}(0.07-0.024)}{0.0375}$)

4

[8]

3. (a) $N = \frac{\Phi}{AB}$ Or $N = \frac{1.5\times10^{-3}}{2.5\times10^{-2}\times5.0\times10^{-4}}$

N = 120 (turns) ✓$_2$

✓$_1$ N must be the subject of the equation for the mark.

✓$_2$ A correct answer gains both marks.

If no mark is awarded a single mark can be given for Φ = BAN cos 30° being used to find
N = 139.

2

(b) Φ(= NAB cosθ = 1.5 × 10^{-3} cos 30°)

Flux linkage = 1.3 × 10^{-3} (Wb turns) ✓

1

(c) $f = \frac{1}{T} = \frac{1}{0.25}$ = 4.0 (Hz) or ω = 25.1 or 8π (rad s^{-1}) ✓$_1$

Peak emf (= $BAN\frac{2\pi}{T}$ = $1.5 \times 10^{-3} \times \frac{2\pi}{0.25}$)

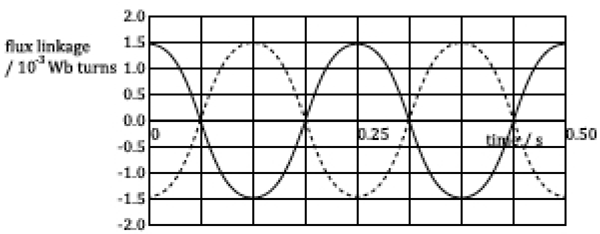
✓$_1$ Condone using 1 sig fig for f but not ω or T.

The mark can be gained from seeing f or ω or T given explicitly or from a substitution in the peak emf equation in the second mark.

✓$_2$ A correct answer gains both marks.

2

(d)



Either solid or dashed line gains mark ✓

The mark is dependent on the exact crossing of the time axis which has a tolerance of ± 1 small square.

The vertical axis figures is not expected.

Also ignore errors in height and the exact positions of the peaks.

Only a rough sinusoidal shape is expected. A triangular shape with very slightly rounded edges would be acceptable.

1

[6]

4. (a) Vertically up (third row of table) ✓

1

(b) (Using Flemings LHR) the configuration of the letters is S N ✓

Answer must be near / on the dashed lines.

1

(c) The tesla is the (strength) of the magnetic field / flux density that produces a force of 1 newton in a wire of length 1m with 1 ampere (flowing perpendicular to the field). ✓
(owtte but must contain 1N, 1A and 1m)

For mark a reference to 1N, 1A and 1m must be seen. However the word 'unit' is equivalent to '1'.

E.g. unit force = 1N.

Do not allow definitions based on F = Bqv.

1

(d) Use of ($B = F / I\ l$) $= m\ g / I\ l$ ✓ (mark may come from substitution as in next line)

Treat power of 10 error as an AE so lose one mark only.

$B = 0.620 \times 10^{-3} \times 9.81 / (3.43 \times 0.0500) = 0.035$ or 0.036 (T) ✓

Lack of use of 'g' is a PE and scores zero.

2

[5]

5. (a) period determined from at least 4 cycles, in range 3.8(0) to 5.0(0) × 10^{-4} s ✓

$\text{frequency} = \dfrac{1}{\text{period}}$ in range 2300 ± 300 Hz ✓

accept 2 sf period, 2.3×10^3 Hz

2

(b) peak to peak voltage = 6.8 divisions seen ✓

rms voltage = 24 mV ✓

accept 24.0 or 24.1 mV

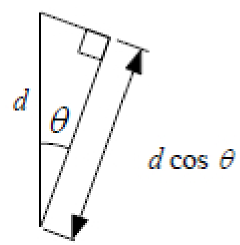
2

(c) flux linked with the search coil depends on the <u>area</u> of coil presented $_1$✓
area is proportional to $d \cos\theta$ $_2$✓

[flux linked with the search coil depends on component of B perpendicular to the plane of the coil$_1$ ✓
component is prop $B \cos\theta$, or suitable sketch]$_2$ ✓

for $_1$✓ accept $N\varphi = BA$

for $_2$✓ accept evidence in sketch, e.g.



2

(d) six correctly calculated values of $\cos\theta$; accept all to 3 sf or all to 4 sf $_1$✓

axes labelled, correct separator and unit with l, suitable scales $_2$✓

plots correct to half a square (check at least one) $_3$✓

ruled straight line extrapolated to meet either or both axes $_4$✓

[for false plot allow $_2$✓ and $_4$✓ = 2 MAX]

$\theta l°$	l/cm	$\cos\theta$
10	6.7	0.985
34	5.6	0.829
50	4.4	0.643
60	3.4	0.500
72	2.1	0.309
81	1.1	0.156

4

(e) direct proportionality is confirmed since graph is a straight line with zero [negligible] intercept✓

[allow ecf for false plot]

must refer to intercept

1

(f) idea of repositioning trace $_1$✓

(to reposition the trace) so that an end of the line is aligned with [close to] a (horizontal) graduation $_2$✓

(to reposition the trace) so that the line is aligned with the <u>central</u> (vertical) graduation on the screen $_3$✓

associates *y*-shift and *x*-shift correctly with trace change $_4$✓

accept clear marks on Fig 7 for all except 4th point

allow alignment with graduation (can be major or minor) of either end of the line for$_2$✓

4

(g) adjust *y*-voltage gain to a less sensitive [precise] setting [20 mV cm^{-1}] ✓

since *l* is increased beyond the range of the screen [vertical length of trace is too great] ✓

because induced emf is proportional to rate of change of flux linkage [or quotes Faraday's Law] ✓

and rate of change of flux linkage is doubled [same flux change in half the time] ✓

accept 'reduce Y gain' but reject 'use lower Y gain setting'
no credit for suggestions that time-base setting should be changed
answer without quantitative detail 2 MAX

3 MAX

(h) evidence of suitable test employed to test whether curve shows exponential decrease, e.g. valid measurement of half life over more than one region $_1$✓

states that trend is not exponential $_2$✓

cannot earn $_2$✓ without valid $_1$✓

2

[20]