T11 *[101 marks]*

1. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

2. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

3. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

4. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

5a. *[2 marks]*

Markscheme

force in correct location on diagram, *ie* arrow on coil;
force direction to the right;
*Award **[1 max]** if any other forces drawn.*

Examiners report

[N/A]

5b.

[3 marks]

Markscheme

$L = (2\pi rN) = 2 \times \pi \times 1.25 \times 10^{-2} \times 150 = (11.8)\,\text{m};$

$F = (\text{BIL}) = 0.40 \times 10^{-3} \times 0.45 \times 10^{-3} \times 11.8;$

$= 2.1 \times 10^{-6}\text{N}/2.1\mu\text{N}$

Examiners report

[N/A]

5c.

[3 marks]

Markscheme

(as the coil moves the) conductor cuts the magnetic field / there is a change in flux linkage;
induces an emf across the coil / a current through the coil;
opposes the driving potential difference;
reduces the (net) current;

Examiners report

[N/A]

6a.

[3 marks]

Markscheme

speed as the whole of the coil enters the field
$= \sqrt{2 \times 9.81 \times 0.05}$ (=0.99 ms^{-1});
$\left(\varepsilon = (-)\,\frac{\Delta\varphi}{\Delta t}\right) = 0.05 \times 0.99 \times 25 \times 10^{-3};$
1.23(mV) ***or*** 1.24(mV0; *(allow use of g= 10 to give 1.25(mV))*

*Award **[3]** for a bald correct answer.*
*Use of factor 4 appears if candidate thinks all sides of coil contribute to emf **[2 max]**.*

Examiners report

[N/A]

6b.

[3 marks]

Markscheme

current (induced) in the coil;
this will act so as to oppose the movement / reference to Lenz's law;
force will be upwards/resistive/counteracts the effect of gravitational force;

Examiners report

[N/A]

7.

[1 mark]

Markscheme

B

Examiners report

This was the most difficult question in the paper for the candidates. Perhaps a simple sketch of a coil in a magnetic field would have helped them realise that there will be two occasions in the cycle when the power output is zero. Hence A and B (the most common options) must be incorrect. This is a $\sin^2$ curve and the average power will be just half the maximum.

8.

[1 mark]

Markscheme

C

Examiners report

[N/A]

9.

[1 mark]

Markscheme

B

Examiners report

[N/A]

10.

[1 mark]

Markscheme

B

Examiners report

[N/A]

11a.

[3 marks]

Markscheme

field caused by (induced) current must be downwards;
to oppose the change that produced it;
hence the current must be clockwise;

Examiners report

This was generally very well answered with candidates recognizing how Lenz's Law relates to the situation. The point that was most commonly missed was the direction of the field caused by the induced current.

11b.

[3 marks]

Markscheme

$\varepsilon = \left(\frac{\Delta\Phi}{\Delta t} =\right) \frac{2.4\times10^{-5}-1.2\times10^{-5}}{2.0\times10^{-3}}$ or 6.0×10^{-3}(v);

$I = \left(\frac{\varepsilon}{R} = \frac{6.0\times10^{-3}}{3.0\times10^{-3}} =\right) 2.0\,(\mathrm{A})$;

*Award **[2]** for a bald correct answer.*

Examiners report

As with many of the calculation questions on this paper, this was very well answered.

12.

[1 mark]

Markscheme

D

Examiners report

[N/A]

13.

[1 mark]

Markscheme

C

Examiners report

[N/A]

14.

[1 mark]

Markscheme

A

Examiners report

This is an application of Lenz‟s law that needs to be fully understood. The conventional current implies a south pole at the left end of the coil and so must oppose the motion of the magnet. The magnet must either be moving away from the coil or the coil must be moving away from the magnet.

15.

[1 mark]

Markscheme

C

Examiners report

[N/A]

16.

[1 mark]

Markscheme

B

Examiners report

[N/A]

17. *[1 mark]*

Markscheme

C

Examiners report

[N/A]

18. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

19. *[1 mark]*

Markscheme

C

Examiners report

It would seem that most candidates intuitively chose between A and B, with only those who understood Lenz's Law selecting C or B. The essence of the solution is that as the square is entering the field the flux linkage is increasing, while as it is leaving the linkage is decreasing. Hence neither A nor B can be correct. And since the direction of the current is such as to try to reduce the change in flux linkage, it should set up a magnetic field out of the page as the loop enters the field. Hence C is the correct answer.

Candidates clearly need more practice in the application of Lenz's Law in a variety of different situations.

20. *[1 mark]*

Markscheme

D

Examiners report

[N/A]

21a. *[6 marks]*

Markscheme

(i) rate of change of flux (linkage) leads to induced emf (Faraday);
direction of emf tends to oppose the change (Lenz);
thus emf in one direction as magnet enters and in the opposite direction as it leaves coil;
magnet going faster so second peak larger;
magnet going faster so width of second peak is less;

(ii) attempted use of $\varepsilon = -N\frac{\Delta\varphi}{\Delta t}$;
recognition that the maximum pd is 0.8 (V);
$\left(\frac{\Delta\varphi}{\Delta t} = -\frac{0.8}{1500} = -\right) 5.3 \times 10^{-4} \left(\mathrm{Wbs^{-1}}\right)$;

Examiners report

(i) This was generally poorly answered, with candidates often failing to refer to Faraday's and Lenz's laws or the specifics of the graph.

(ii) Many candidates used the correct value for the potential difference but were unsure of the meaning of rate of change of magnetic flux; it was commonly believed that this was simply Φ which left candidates searching for a time value.

21b. *[5 marks]*

Markscheme

(i) the value of the direct current (or voltage) that dissipates same power (in a resistor);
Do not allow
$\frac{I_0}{\sqrt{2}}$ *etc.*

(ii) I_0=396 (nA);
V_0=I_0R=0.59 (V);

(iii) damps oscillation / *OWTTE*;
dissipation of energy in coil/magnet;

Examiners report

(i) The definition of the rms current in terms of the equivalent direct current was very poorly known and many simply said that it was the peak value divided by root 2.

(ii) Few managed to do this well with the most common (incorrect) answer being 0.42V.

(iii) Although many hinted at damping, few candidates overtly mentioned it or related it to the dissipation of energy in the coil.

22. *[1 mark]*

Markscheme

A

Examiners report

The statistics of the question show confusion among the candidates who were obviously unclear about how to get the direction of the magnetic force on electrons.

23. *[1 mark]*

Markscheme

B

Examiners report

[N/A]

24. *[1 mark]*

Markscheme

B

Examiners report

Candidates should first read the question and look through the possible responses, consulting the data booklet only if necessary. Clearly if a transformer is ideal then the power output will equal the input.

25. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

26a. *[4 marks]*

Markscheme

(i) *minimum:* zero / *–BA (minus sign required)*
maximum: BA } *(both needed)*

(ii) *Look for these main points:*
(Faraday's law states that the) induced emf equals/is proportional to the rate of change of flux/flux linkage; { *(must see induced)*
speed greater so time for change shorter / flux (linkage) is unchanged;
greater rate of change (of flux *etc*) gives a greater (induced) emf;
*Award **[1 max]** if answer states flux (linkage) change is larger.*

Examiners report

[N/A]

26b. *[4 marks]*

Markscheme

(i) (equivalent) direct current;
dissipating same power in a (fixed) resistor (as the rms current);

(ii) maximum current $= \left(\sqrt{2} \times 2.3 =\right) 3.2/3.3\text{mA};$
maximum power = $(3.3^2 \times 15 =) 0.16$mW;

Examiners report

[N/A]

27. *[1 mark]*

Markscheme

B

Examiners report

Far too many candidates thought that the rms value was half of the peak value.

28.

[1 mark]

Markscheme

B

Examiners report

There were, questionably, two plausible responses to this question – A and B. Both were accepted.

As the metallic wing moves through the Earth‟s magnetic field so an emf will be induced between R and P in such a direction as to move (positive) charge from R to P. This would indicate that B was the correct response.

But as a result of P being now more positive than R, it can be argued that an electric field is established from P to R. This would result in response A.

It is impossible to tell whether the confusion was due to the slightly ambiguous nature of the question or whether candidates were unable to use the correct hand to analyse the situation. But the poor showing in Q 23 would suggest it may be the latter; in which case this is an area of the syllabus that needs more attention.

29.

[1 mark]

Markscheme

C

Examiners report

Too many candidates, here and elsewhere, are omitting to read the axes when interpreting a graph. In this case they missed the power of ten.

30.

[1 mark]

Markscheme

D

Examiners report

[N/A]

31.

[1 mark]

Markscheme

B

Examiners report

32.

[1 mark]

Markscheme

B

Examiners report

33a.

[2 marks]

Markscheme

the product of (the magnitude of) the normal component of magnetic field strength;
and area through which it passes/with which it is associated;

or

$\varphi = BA \cos \theta$;
all terms defined/shown on a diagram;

Examiners report

Definitions of magnetic flux were mixed, ranging from complete and secure statements of the appropriate equation (with clear definition of the angle between the normal to the area and the magnetic field strength) to vague attempts that mentioned flux without a consideration of the direction between area and field direction.

33b.

[3 marks]

Markscheme

(i) letter T clearly marked at 5.0ms ***or*** 15ms;

(ii) 2.0V/Wbs^{-1};
emf equals rate of change of flux; {*(clear statement or equation must be present to award this mark*)
Use of slope to obtain answer is incorrect – this yields a value of 1.8.

(iii) 4.2V;

Examiners report

(i) Many candidates wrongly identified either 0 ms, 10 ms or 20 ms as the point at which the flux linkage was a maximum.

(ii) Those that had a clear understanding of the relationship between emf and rate of change of flux moved quickly and unambiguously to the correct answer. Those who did not understand the physics evaluated the gradient at 4.0 ms and failed to gain credit.

(iii) The calculation of rms induced emf was well done by the vast majority of candidates.

34a.

[4 marks]

Markscheme

(i) electrons are moving at right angles to the magnetic field;
electrons experience a force directed along the rod / charge is separated in the rod;
the work done by this force to achieve this separation leads to an induced emf;

(ii) the product of magnitude of field strength and the rate at which the area is swept out by the rod is changing / the rate at which the rod cuts through field lines;

Examiners report

It continues to be apparent that candidates find this a difficult area of the syllabus in which a clear and unshakeable understanding of the concepts is required.

(i) A good number did not consider the forces acting on the electrons as instructed and therefore gained few, if any, marks. Of the remainder, some were able to discuss the forced motion of the electrons in the field and how this leads to the direction of the forces on the electrons along the rod. It was rare to see a consideration of the connection between the work done on the electrons and the emf itself.

(ii) Only a few candidates could adequately explain what is meant by a rate of change of flux. The “rate of change” aspect was usually missing.

34b. *[4 marks]*

Markscheme

(i) $B = \frac{\varepsilon}{vl}$;

(must see the data book equation re-arranged or correctly aligning substitution with equation)

$= \left(\frac{15\times10^{-3}}{6.2\times1.2} =\right) 2.0\text{mT}$; *(accept 2+sf)*

*To award **[2]** both steps must be seen.*

(ii) Lenz's law states that the direction of the induced emf/current is such as to oppose the change producing it;
there is a current in the rod due to the induced emf;
the force on the current/rod due to the magnetic field is in the opposite direction to the force producing the motion of the rod;

Examiners report

(i) The calculation of magnetic field strength followed directly from a substitution into a Data Booklet equation and so was often well done apart from the inevitable power of ten errors by those who forgot the "m" in "mV".

(ii) This was very poor indeed. Many could not even state Lenz"s law adequately and could get no further. It was rare to see a good link made between the law itself and the induced current in the circuit.

35a. *[1 mark]*

Markscheme

induced emf/induced current acts so as to oppose the change causing it;

Examiners report

[N/A]

35b. *[4 marks]*

Markscheme

ball Q enters/leaves magnetic field / experiences changing flux;
so an emf/current is induced;
this causes a magnetic field;
which opposes the motion of / exerts an upward force on ball Q;

or in terms of energy:
ball Q moves through a magnetic field / experiences changing flux;
so an emf/current is induced;
current causes dissipative heating due to resistance;
some kinetic energy changes to thermal energy;

Examiners report

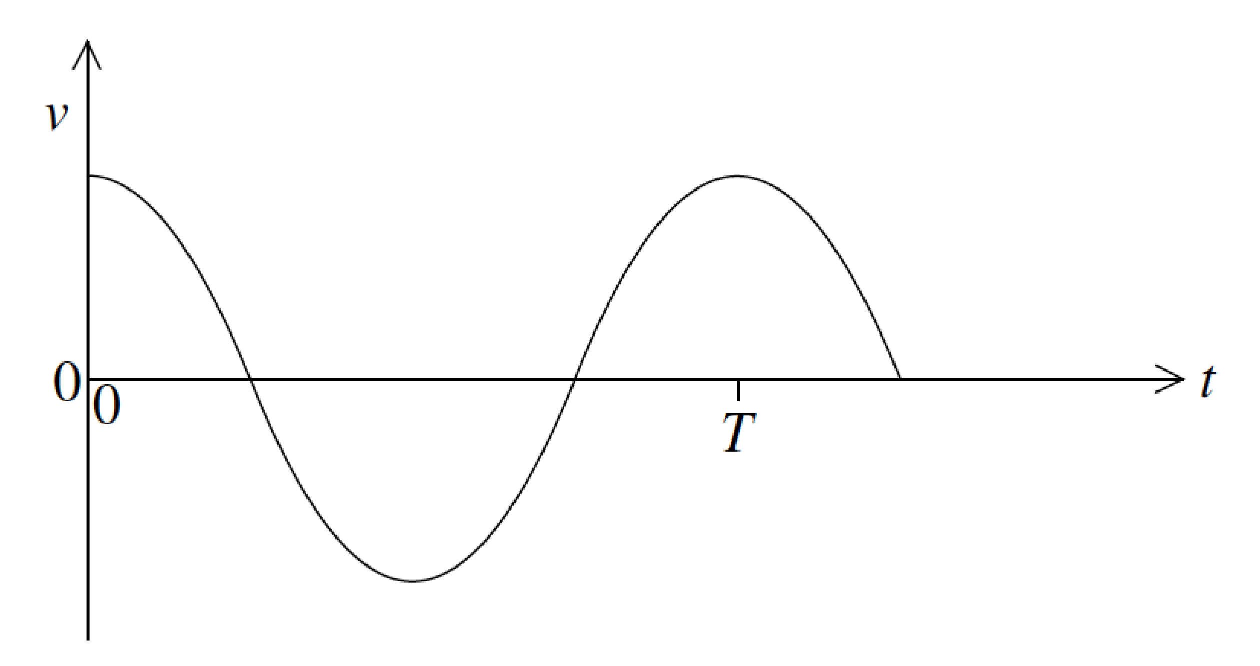
[N/A]

36a.

[3 marks]

Markscheme

(i)



cosine wave same frequency as original;
phase correct;

(ii) emf in phase or antiphase with answer to (a)(i);

Examiners report

[N/A]

36b.

[3 marks]

Markscheme

max speed $=8.2\times10^{-2}\times2\pi\times2.5(=1.29 ms^{-1})$;
$\varepsilon=58\times10^{-6}\times0.18\times1.29$;
13.5 μV;

Examiners report

[N/A]

36c.

[4 marks]

Markscheme

frequency of the emf doubles / period halves;
because same change of flux in half the time / because frequency of emf must equal frequency of oscillation;
maximum emf doubles;
maximum speed doubles / flux changes at twice rate;

Examiners report

[N/A]

37. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

38. *[1 mark]*

Markscheme

A

Examiners report

[N/A]

39a. *[1 mark]*

Markscheme

$t = \frac{1}{4}\frac{2\pi \times 4.5 \times 10^{-4}}{9.4 \times 10^{6}}$;

$= 7.5 \times 10^{-11}$ s

Examiners report

[N/A]

39b. *[4 marks]*

Markscheme

(i) the flux in the loop is changing and so (by Faraday's law) an emf will be induced in the loop;

(by Lenz's law) the induced current will be (counter-clockwise) and so there will be a magnetic force opposing the motion;

requiring work to be done on the loop;

(ii) it is dissipated as thermal energy (due to the resistance) in the loop / radiation;

Examiners report

[N/A]