Mark Scheme

Q1.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is A B is not correct as the peak value is 2 V C is not correct as the period is 0.22 s D is not correct as r.m.s. value of p.d. is 1.4 V		**1**

Q2.

Question number	Acceptable answers	Additional guidance	Mark
	B		**1**

Q3.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is C A is not correct as this is a unit of electric field strength B is not correct as units T m^2 could be used as a unit of flux D is not correct as Wb is a unit of flux		**1**

Q4.

Question Number	Acceptable Answer	Additional guidance	Mark
	C	increasing the speed of the magnet	**(1)**

Q5.

Question Number	Acceptable answers	Additional guidance		Mark
	B The induced emf in the coil will oppose the cell emf and cause a delay in the current to lamp Y	Lights after a delay with a final brightness the same as X		1
	A assumes the resistance of the coil is more than the resistor C ignores the magnetic effect of the coil and assumes the resistance of the coil is more than the resistor D ignores the magnetic effect of the coil			

Q6.

Question Number	Acceptable answers	Additional guidance	Mark
	The only correct answer is B A *is not correct because it is 3 divided by 2* C *is not correct because it is 3 x root 2* D *is not correct because it is* 3^2	2.1 A	1

Q7.

Question Number	Acceptable answers	Additional guidance	Mark
	C		1

Q8.

Question Number	Acceptable answers	Additional guidance	Mark
(i)	• Frequency = 50 Hz **(1)**	Example of calculation $f = \frac{1}{0.02\ \text{s}} = 50\ \text{Hz}$	1
(ii)	• Root mean square potential difference = 2.8 V **(1)**	Example of calculation $V_{\text{rms}} = \frac{4}{\sqrt{2}} = 2.83\ \text{V}$	1

Q9.

Question Number	Acceptable answers	Additional guidance	Mark
	• Alternating current/a.c. (in primary) produces changing/alternating magnetic flux/field **(1)** • The magnetic flux/field is linked to the secondary coil by the iron core **(1)** • The changing magnetic flux/field induces an emf in the secondary coil **(1)** • More turns on the secondary (will increase the rate of change of flux linkage according to Faraday's law). **(1)**	alt. to changing magnetic flux is $\Delta N\phi$ alt. quote of $V_1/V_2 = N_1/N_2$	**(4)**

Q10.

Question Number	Answer	Mark
(c)	Use of area $A = \pi r^2$ (1) Use of $\varepsilon = BA/t$ (1) Use of $I = V/R$ (1) I = 4.1 A (1) (accept 4.1 – 4.2 A depending on where rounding is done) (candidates who use a circumference instead of an area can only score MP3) Example of calculation Area of coil = $\pi \times (0.05\ \text{m})^2 = 7.9 \times 10^{-3}\ \text{m}^2$ $\varepsilon = BA/t = 0.035\ \text{T s}^{-1} \times 7.9 \times 10^{-3}\ \text{m}^2 = 2.8 \times 10^{-4}\ \text{V}$ $I = \varepsilon/R = 2.8 \times 10^{-4}\ \text{V} / 6.7 \times 10^{-5}\ \Omega$ I = 4.1 A	4

Q11.

Question Number	Acceptable answers	Additional guidance	Mark
	• The relationship between ω and turning effect is (approximately) proportional (1) • As speed increases rate of change/cut of magnetic flux increases (1) • this increases the induced current in the copper disc (1) • this will lead to an increase in force (on the copper disc as it is within a magnetic field/flux) (1)	Accept attempt to find a constant ratio and relevant conclusion Accept alternatives to flux accept ref. to emf rather than current Dependent on MP2 or 3	4

Q12.

Question Number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to the following points: • This is because there is a change of flux (linkage) as the meter is moved (1) • An emf is induced which will produce a current in the coil (as both ends of the coil are connected) (1) • Current-carrying conductor within a magnetic field experiences a force (1) • These forces oppose the coil's motion (reducing it) (1)		4

Q13.

Question number	Acceptable answers	Additional guidance	Mark
	An explanation that makes reference to the following points: • The current produces a magnetic field around the aluminium ring **(1)** • The direction of the ring field opposes the change producing it **(1)** • The fields repel, producing a force **(1)** • The electromagnetic force is equal and opposite to the weight of the ring so it remains in position shown **(1)**		4

Q14.

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>*</td><td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

Indicative content:
• (Maximum/Initial) current is equal to battery emf divided by R
Or current as switch closed
Or current as complete circuit
Or current due to battery
• Coil rotates
• (movement of) coil "cuts/changes" (magnetic) flux (linkage) / field
• Which induces an emf (according to Faraday's law)
• Opposes original emf/current according to Lenz's law
Or current reduced as effect opposes change
• The faster the coil rotates the larger this (back) emf/effect the smaller the current</td><td><table><tr><th>IC points</th><th>IC mark</th><th>Max linkage mark available</th><th>Max final mark</th></tr><tr><td>6</td><td>4</td><td>2</td><td>6</td></tr><tr><td>5</td><td>3</td><td>2</td><td>5</td></tr><tr><td>4</td><td>3</td><td>1</td><td>4</td></tr><tr><td>3</td><td>2</td><td>1</td><td>3</td></tr><tr><td>2</td><td>2</td><td>0</td><td>2</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr></table>
ic3 needs a link to coil moving
ic4 depends on ic3</td><td>6</td></tr>
</table>

Q15.

Question Number	Answer	Mark
	A	**1**

Q16.

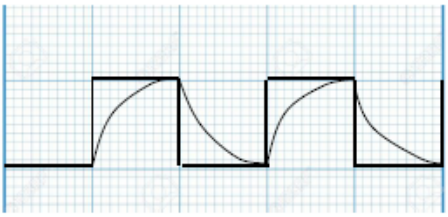
Question Number	Acceptable answers		Additional guidance	Mark
(i)	• change in magnetic flux (linkage as motor rotates) **Or** (copper disc is) cutting magnetic flux/field	(1)	Accept flux linkage for magnetic flux	2
	• therefore there is an <u>induced e.m.f.</u> (according to Faraday's law)	(1)		
(ii)	• copper disc rotates in the same direction	(1)		3
	• because it reduces the rate of magnetic flux change	(1)	Accept induced current produces magnetic fields **Or** force on current in a magnetic field for MP2 Accept alternatives to flux as in (i)	
	• so as to oppose the change that produces it	(1)		

Q17.

Question Number	Acceptable answers	Additional guidance	Mark
*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Indicative content: Generator: • coil has to be rotated • cuts magnetic flux **Or** rate of change of flux linkage • induces an emf Motor: • current provided to coil • Force on sides of coil that are perpendicular to magnetic field • rotate coil as forces provide a moment	See table below	6

IC points	IC mark	Max linkage mark available	Max final mark
6	4	2	**6**
5	3	2	**5**
4	3	1	**4**
3	2	1	**3**
2	2	0	**2**
1	1	0	**1**
0	0	0	**0**

Q18.

Question Number	Acceptable answers		Additional guidance	Mark
	• Time axis: one cycle = 50 OR two cycles =100	(1)	Example of calculation T = 1/f = 1/20 Hz = 0.050 s Two cycles = 2 × 0.050 s = 0.10 s = 100 ms Time Constant = 100 × 50 × 10^{-6} = 0.005 s In half a cycle (0.025 s) there are 0.025 s / 0.005 s = 5 Time constants	5
	• Use of time constant = *RC*	(1)		
	• Charging curve, from 25 ms to 50 ms, just about reaching 5V as shown (ecf from their T)	(1)	Ignore anything drawn in the first half cycle 	
	• One corresponding discharge curve	(1)		
	• Curve should look exponential	(1)	Time period should be marked 50 ms or equivalent	

Q19.

Question number	Acceptable answers	Additional guidance	Mark
*	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points 6 / 4 5–4 / 3 3–2 / 2 1 / 1 0 / 0	Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).	

<table>
<tr><th>Question number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>* (continued)</td><td>The following table shows how the marks should be awarded for structure and lines of reasoning.
<table>
<tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr>
<tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr>
<tr><td>Answer is partially structured with some linkages and lines of reasoning</td><td>1</td></tr>
<tr><td>Answer has no linkages between points and is unstructured</td><td>0</td></tr>
</table></td><td></td><td></td></tr>
</table>

Question number	Acceptable answers	Additional guidance	Mark
* (continued)	**Indicative content** • The supply creates a changing magnetic field in the iron core • Rate of change of flux in toothbrush coil is equal to rate of change of flux in charger coil (for an ideal transformer) • The changing flux linkage in the coil of the toothbrush induces an e.m.f. according to Faraday's law • $E = -N \, d\phi/dt$ so to step down the e.m.f. there must be fewer turns in the toothbrush coil • The e.m.f. in the toothbrush coil must be larger than the toothbrush battery • Diode is included so battery is not discharged by the alternating e.m.f.	Allow provides dc to charge battery or similar.	**6**

Q20.

Question Number	Acceptable Answer	Additional Guidance	Mark
*	This question assesses a student's ability to show a coherent and logical structured answer with linkage and fully-sustained reasoning Indicative content: IC1 As the magnet moves through the coil there is a change in magnetic flux linkage (with coil) **Or** as the magnet moves through the coil the coil cuts (lines of) magnetic flux **Or** as the magnet moves through the coil the coil cuts magnetic field lines IC2 An e.m.f. is induced across the coil IC3 This generates a current in the (capacitor) circuit IC4 The diode only allows current in one direction IC5 So capacitor is charged (repeatedly) IC6 When switch is closed capacitor discharges through the LED	Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points 6 – 4 5–4 – 3 3–2 – 2 1 – 1 0 – 0 Number of marks awarded for structure of answer and sustained line of reasoning Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout – 2 Answer is partially structured with some linkages and lines of reasoning – 1 Answer has no linkages between points and is unstructured – 0 Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning IC points / IC mark / Max linkage mark / Max final mark 6 / 4 / 2 / 6 5 / 3 / 2 / 5 4 / 3 / 1 / 4 3 / 2 / 1 / 3 2 / 2 / 0 / 2 1 / 1 / 0 / 1 0 / 0 / 0 / 0	**6**

Q21.

Question Number	Answer	Mark
(a)	The induced e.m.f. **(1)** Is equal/proportional to the rate of change of (magnetic) flux (linkage) **Or** $\varepsilon = (-)\, d(N\Phi)/\Delta t$ with symbols defined **(1)**	**2**

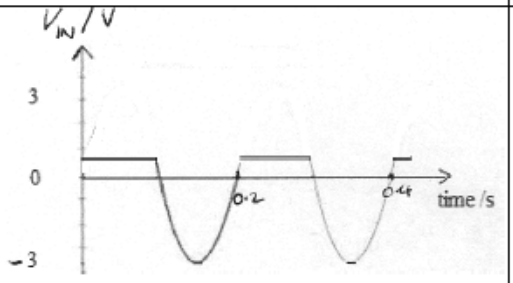
Question Number	Answer	Mark
*(b)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) the idea that due to the magnet moving there is a changing field around the ring (1) An e.m.f. induced (in a closed circuit hence a current flows) (1) Change in direction of magnet, changes the direction of e.m.f./current (1) Magnitude of e.m.f. (and current) depends on the rate of change of flux linkage **Or** magnitude of e.m.f. (and current) depends on position/ speed of magnet (1)	**4**

Q22.

Question Number	Acceptable Answer	Additional Guidance	Mark
*	This question assesses a student's ability to show a coherent and logical structured answer with linkage and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. Number of indicative points seen in answer / Number of marks awarded for indicative points 6 / 4 5-4 / 3 3-2 / 2 1 / 1 0 / 0 Indicative content: • As magnet A moves, its coil experiences a change of magnetic flux (linkage) • The change in magnetic flux linkage induces an emf in the coil • The (induced) emf causes a current in both coils • The current in the second coil causes a force to act on magnet B, driving magnet B into oscillation • Because both mass-spring systems have the same period/frequency • Resonance occurs (and magnet B oscillates with increasing amplitude)	The following table shows how the marks should be awarded for structure and lines of reasoning Answer shows a coherent and logical structure with linkage and fully sustained lines of reasoning demonstrated throughout: 2 Answer is partially structured with some linkages and lines of reasoning: 1 Answer has no linkage between points and is unstructured: 0 **Linkage Marks** IC points 1 – 4 **Three** of these points could score one linkage mark IC points 5 & 6 could score one linkage mark	**6**

Q23.

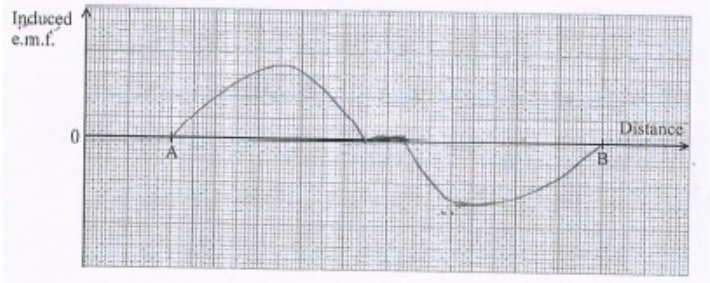
Question Number	Acceptable answers		Additional guidance	Mark
(i)	• Use of $V_{rms} = \frac{V_o}{\sqrt{2}}$ • V_{rms} = 2.4 V	(1) (1)	Example of calculation: $V_{rms} = \frac{3.4}{\sqrt{2}} = 2.4$ V	(2)

Question Number	Acceptable answers		Additional guidance	Mark
(ii)	• Energy is conserved **Or** Kirchoff's law **Or** potential difference is energy per unit charge • So the sum of p.d.s in a series circuit must equal the e.m.f. applied (MP2 is dependent on MP1)	(1) (1)	accept work done for energy accept V_{in} for emf Alternative: Current is the same in both components (1) $IV_{IN} = IV_R + IV_D$ and I cancels (1)	(2)
(iii)	• Alternate half cycles of sine curve (with peak about 3 V) • Horizontal line in 1st half cycle and negative half cycle of a sine curve in 2nd half cycle • horizontal lines/spaces at a value of potential difference of 0.6 V to 0.8 V	(1) (1) (1)		(3)

Q24.

Question Number	Acceptable Answer		Additional Guidance	Mark
(i)	• Use of y-sensitivity value • $V_0 = 4.0$ V	(1) (1)	Example of calculation: $V_0 = 2 \times 2.0\ V = 4.0$ V	2
(ii)	• Use of $I = \frac{V}{R}$ • Use of $I_{rms} = \frac{I_0}{\sqrt{2}}$ **Or** use of $V_{rms} = \frac{V_0}{\sqrt{2}}$ • $I_{rms} = 0.019$ A ECF from(i)	(1) (1) (1)	Example of calculation $I_0 = \frac{4.0\text{ V}}{150\ \Omega} = 0.0267$ A $I_{rms} = \frac{0.0267\text{ A}}{\sqrt{2}} = 0.0189$ A	3
(iii)	• Use of $R = R_1 + R_2$ • Use of $P = I^2R$ (or other valid power equation) • $P = 0.096$ W ECF from(i) and (ii)	(1) (1) (1)	Example of calculation: $R = 150\ \Omega + 120\ \Omega = 270\ \Omega$ $P = I^2R$ $= (0.019\text{ A})^2$ $\times 270\ \Omega = 0.0964$ A	3

Q25.

Question Number	Answer		Mark
*(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) **Max 6 from**		
	Reference to changing/cutting of field/flux	(1)	
	Induced e.m.f. proportional to rate of change/cutting of flux (linkage) (accept equation)	(1)	
	Initial increase in e.m.f. as the magnet gets closer to the coil	(1)	
	Identifies region of negative gradient with magnet going through the coil	(1)	
	Indication that magnet's speed increases as it falls	(1)	
	Negative (max) value › positive (max) value (this mark is dependent on awarding marking point 5)	(1)	
	Time for second pulse shorter (this mark is dependent on awarding marking point 5)	(1)	
	The areas of the two parts of the graph will be the same (since $N\varphi$ constant)	(1)	6
(b)	Two sequential pulses (if **not** two sequential pulses, scores zero)	(1)	
	Pulses same height (+/- 3 mm squares) and width (by eye)	(1)	
	Pulses in opposite directions	(1)	
	Region of zero e.m.f. in the middle	(1)	4
	<u>Example</u> (peaks could be in opposite directions)  		

Q26.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>(a)(i)</td><td>Max 2
Inconsistent number of significant figures or decimal places
Or results recorded to different precision /resolution (1)
No repeat readings (1)
More readings needed up to <u>1.5</u> cm (1)</td><td>2</td></tr>
<tr><td>(a)(ii)(1)</td><td>Attempt to use Vr= constant (1)
Correctly finds two values of Vr from values in table and makes comment
Or uses Vr value with another r or V to confirm corresponding value and makes comment (1)

<u>Example of calculation</u>

<table><tr><th>r/cm</th><th>V/V</th><th>rV/ cmV</th></tr><tr><td>1.0</td><td>0.725</td><td>0.725</td></tr><tr><td>1.5</td><td>0.483</td><td>0.725</td></tr><tr><td>2.0</td><td>0.363</td><td>0.726</td></tr><tr><td>2.5</td><td>0.29</td><td>0.725</td></tr><tr><td>3.0</td><td>0.242</td><td>0.726</td></tr><tr><td>3.5</td><td>0.21</td><td>0.735</td></tr></table></td><td>2</td></tr>
<tr><td>(a)(ii)(2)</td><td>The graph would be a straight line graph through the origin. (1)
(accept a sketch of a straight line graph going through the origin graph)</td><td>1</td></tr>
<tr><td>(b)(i)</td><td>An e.m.f. is (induced) when there is a changing (magnetic) field/flux. (1)

Because the <u>current</u> is constant there is a constant magnetic field. Or Because the <u>current</u> is constant there isn't a changing magnetic field. (1)</td><td>2</td></tr>
<tr><td>(b)(ii)</td><td>Movement of either the coil or the wire (1)
Use an alternating current/signal/supply/AC (1)
Switch the current on/off Or change current e.g. use of variable resistor (1)</td><td>3</td></tr>
<tr><td></td><td>Total for question</td><td>10</td></tr>
</table>

Q27.

Question Number	Answer		Mark
*(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) A clear statement that an alternating/changing current produces an alternating/changing magnetic field/flux	(1)	
	Reference to the iron core becomes magnetised **Or** increases magnetic field	(1)	
	the idea that the field produced in the core/wire is linked to the coil	(1)	
	(e.m.f. produced) due to EM induction **Or** reference to induced e.m.f. **Or** Faraday's law in words (do not accept induced current/voltage on its own) [be careful not to credit the random use of words/phrases like, there is flux linkage, flux cutting takes place or the field lines are cut by the coil. Also watch out for candidates who think there is a current in the coil creating the flux linkage]	(1)	**4**
(b)	(Constant current means) no change of flux (linkage) **Or** no changing (magnetic) field **Or** flux/ field is constant [do not credit 'flux won't be changing direction' or 'no flux linkage being cut' or alternating]	(1)	**1**
(c)	More than one wire in cable	(1)	
	Cable carries current in both directions **Or** Magnetic fields will cancel	(1)	**2**
(d)(i)	The larger the current the greater the (magnetic) flux/field (produced) **Or** the larger the change in current the larger the change in the (magnetic) flux/field	(1)	
	gives a greater rate of change of flux **Or** bigger change in flux in the same time **Or** a greater (induced) e.m.f./voltage/reading	(1)	**2**
(d)(ii)	the idea that frequency changes the value of (induced) e.m.f/voltage/reading **Or** the idea that the frequency changes the rate of change of (magnetic)flux	(1)	
	An understanding that there are now two factors (current and frequency) altering (induced) e.m.f/voltage/reading.	(1)	**2**
	Total for question		**11**

Q28.

Question Number	Answer		Mark
(a)	Use of $\Phi = BA$ Converts cm to m Or mT to T $\Phi = 1.1 \times 10^{-4}$ Wb Example of calculation $\Phi = 6.0 \times 10^{-2}$ m $\times$ 2.4×10^{-2} m $\times$ 74×10^{-3} T $\Phi = 1.07 \times 10^{-4}$ Wb	(1) (1) (1)	3
(b)	Use of $\mathcal{E} = \Delta\Phi/\Delta t$ Use of time = distance/speed $\mathcal{E} = 5.3$ mV (5.0 mV or 5.5 mV depending on value of Φ used, ecf value of Φ from (a)) **Or** Quotes $\mathcal{E} = Blv$ $l = 6.0 \times 10^{-2}$m used $\mathcal{E} = 5.3$ mV Example of calculation Time = 0.024 m / 1.2 m s^{-1} $t = 0.020$ s $\mathcal{E} = 1.1 \times 10^{-4}$ Wb / 0.02 s = 5.5 mV	(1) (1) (1) (1) (1) (1)	3
(c)	Use of $I = V/R$ Use of $F = BIl$ $F = 9.8 \times 10^{-5}$ N (ecf value of $\mathcal{E}$ from (b)) This force is too small to be felt. (this comment must be consistent with their value of force) Example of calculation $I = 5.5$ mV/ /0.25 $\Omega = 0.022$ A $F = 74 \times 10^{-3}$ T $\times$ 0.022 A $\times$ 0.060 m $F = 9.8 \times 10^{-5}$ N	(1) (1) (1) (1)	4
	Total for question		10

Q29.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	• use of $s = ut + \frac{1}{2}at^2$ (1) • a = 7.4 m s^{-2} (1)	Example of calculation: $s = ut + \frac{1}{2}at^2 \quad \therefore a = \frac{2 \times 0.75\text{m}}{(0.45\text{s})^2} = 7.41\text{ms}^{-2}$	(2)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>* (b)</td>
<td>
This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5 - 4</td><td>3</td></tr>
<tr><td>3 - 2</td><td>2</td></tr>
</table>
</td>
<td>Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td>
<td></td>
</tr>
</table>

1	1
0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning	
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	(1) (1) (1)
Answer is partially structured with some linkages and lines of reasoning	1	(1)
Answer has no linkages between	0	(1)

	points and is unstructured		

Indicative content:

- when the magnet falls there is a rate of change of magnetic flux linked with the tube
- the change in flux linkage for the copper tube induces an emf (Faraday's law)
- the induced emf causes a current to flow in the tube
- the induced emf (and current) are in such a direction as the oppose the change in flux linkage (Lenz's law)
- a force is exerted on the magnet opposing its motion
- plastic is not a conductor so no current is induced, shorter time to fall through the tube so teacher is correct

(6)

Question Number	Acceptable Answer		Additional Guidance	Mark
(c)	An explanation that makes reference to the following:			
	• the slit will limit the size of the induced current	(1)		
	• hence a smaller force will oppose the motion of the magnet	(1)		
	• so the time taken to fall will be less	(1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(d)	An explanation that makes reference to the following: • manual timing will be affected by reaction time (1) • the shorter the time being measured the greater the effect that reaction time will have (1)		**(2)**

Q30.

Question Number	Answer		Mark
(a)	Use of $N\Phi = NBA$ $\Phi = 1.2 \times 10^{-3}$ Wb (accept T m^2) Example of calculation $\Phi = 200 \times 3.0 \times 10^{-2}$ T$\times$ 2.0×10^{-4} m s^{-1} $\Phi = 1.2 \times 10^{-3}$ Wb	**(1)** **(1)**	**2**
(b)(i)	Time = 0.125 (s) **Or** Time = 1/8 (s) Use of $\varepsilon = (-)d(N\Phi)/dt$ $\varepsilon = (-)9.6 \times 10^{-3}$ V (ecf $N\Phi$ from (a)) Example of calculation $\varepsilon = 1.2\times 10^{-3}$ Wb /0.125 s $\varepsilon = 9.6$ mV	**(1)** **(1)** **(1)**	**3**
(b)(ii)	Maximum values when coil is horizontal **Or** maximum values when the coil is parallel to the magnetic field **Or** minimum value when coil vertical **Or** minimum value when the coil is perpendicular to the magnetic field e.m.f. determined by rate of change of flux **Or** see $\varepsilon = (-)d(N\Phi)/dt$ Greatest rate of change of flux as coil goes through horizontal **Or** greatest rate of change of flux occurs when $\theta=90°$ **Or** least rate of change of flux as it goes through vertical **Or** least rate of change of flux occurs when $\theta=0°$	**(1)** **(1)** **(1)**	**3**
(b)(iii)	Peaks would be smaller amplitude **Or** maximum e.m.f. smaller Rate of change of flux (linkage/cutting) less	**(1)** **(1)**	**2**
(c)(i)	Energy required to turn generator Transferred from kinetic energy of the car	**(1)** **(1)**	**2**
(c)(ii)	Greater rate of kinetic energy transfer/loss at high(er) speeds At slower/low speeds there is less/negligible braking effect (so car would not fully stop)	**(1)** **(1)**	**2**
	Total for question		**14**

Q31.

Question Number	Answer	Additional guidance	Mark
(a)(i)	thermionic emission		**(1)**

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(ii)	• equate $\frac{1}{2}mv^2$ and VQ (1) • $v = 2.3 \times 10^7$ m s^{-1} (1)	Example of calculation: $E = 1500\text{ V} \times 1.6 \times 10^{-19}\text{ C} = 2.4 \times 10^{-16}\text{ J}$ $v = \sqrt{\frac{2 \times 2.4 \times 10^{-16}\text{ J}}{9.11 \times 10^{-31}\text{ kg}}} = 2.3 \times 10^7\text{ m s}^{-1}$	**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(i)	• use of $F = EQ$ and $E = \frac{V}{d}$ (1) OR see $F = \frac{VQ}{d}$ • equate $F = ma$ and $F = EQ$ (1)		**(2)**

Question Number	Acceptable Answer	Additional guidance	Mark
(b)(ii)	• use of speed = distance/time (1) • $t = 8.7 \times 10^{-10}$ (s) (1) • use of a = $\frac{VQ}{dm}$ (1) • use of $s = ut + \frac{1}{2}at^2$ (1) with $u = 0$ and vertical acceleration to find s • $s = 3.3 \times 10^{-4}$ m (1)	Example of calculation: $t = \frac{0.02\text{ m}}{2.3 \times 10^7\text{ m s}^{-1}} = 8.7 \times 10^{-10}\text{ s}$ $s = \frac{1}{2} \times \left(\frac{50\text{ V} \times 1.6 \times 10^{-19}\text{ C}}{0.01\text{ m} \times 9.11 \times 10^{-31}\text{ kg}} \right) \times (8.7 \times 10^{-10}\text{ s})^2$ $s = 3.3 \times 10^{-4}\text{ m}$	**(6)**

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	• use of $V = V_0/\sqrt{2}$ (1) • vertical line (1) • positive and negative deflection shown (1) • maximum deflection 75 V (1)	Example of calculation: $V_0 = 53\text{ V} \times \sqrt{2} = 75\text{ V}$	**(4)**