A Level Physics B (Advancing Physics)
H557/03 Practical skills in physics
Sample Question Paper

Date – Morning/Afternoon
Time allowed: 1 hour 30 minutes

You must have:
• the Data, Formulae and Relationships Booklet

You may use:
• a scientific calculator

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided.
- Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION
- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended responses will be assessed in questions marked with an asterisk (*).
- This document consists of **16** pages.

SECTION A

Answer **all** the questions.

1 A teacher uses strobe photography to demonstrate the motion of a tennis ball thrown under gravity. She opens the camera shutter in a darkened room and throws the tennis ball in front of the lens as the strobe flashes at 20 ± 2 Hz. **Fig. 1** shows the result, superimposed on a metric grid.

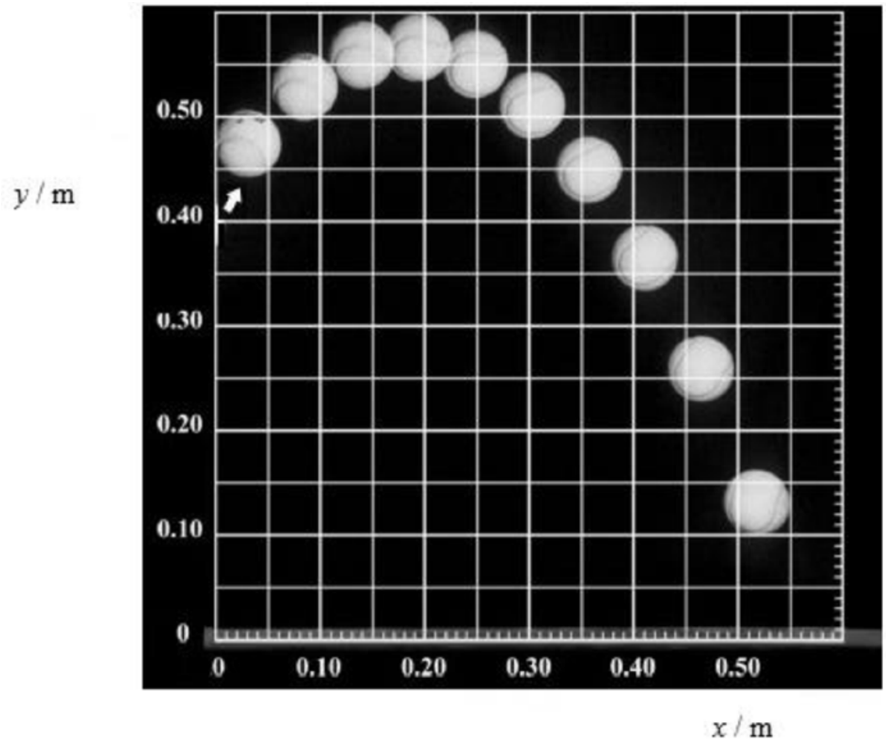

Fig. 1

A student takes measurements of the *y* position from **Fig. 1**, starting from the image centred on $x = 0.20$ m. He measures the *y* positions from the bottom of the ball and performs calculations; some are recorded in the table below. He concludes that *g*, the acceleration of gravity, is 9.2 ± 0.4 m s^{-2}.

t / s ± 10%	y / m ± 0.005 m	Δy / m	$\Delta y/\Delta t$ / m s^{-1}	Δv / m s^{-1}	$\Delta v/\Delta t$ / m s^{-2}
0	0.54				
0.05	0.52	0.02	0.40		
0.10	0.48	0.04	0.80	0.40	
0.15	0.42	0.06	1.20	0.40	
0.20	0.33	0.09	1.80		
0.25	0.22	0.11	2.20		
0.30	0.10	0.12	2.40		

(a) **(i)** Record further values in the spaces provided to complete the data in the table.

[2]

(ii) Complete your own analysis of the data by calculating the mean value for g with an estimate of its uncertainty.

g = …………….. ± ……………. m s^{-2} **[2]**

(iii) You are planning to improve the accuracy of this experiment to estimate g. Suggest and explain which of the measured quantities is most worth improving to achieve this.

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(b) **(i)*** It is suggested that the horizontal velocity component of the motion is constant at 1.0 m s^{-1}.
Test this hypothesis, making your method clear. Explain your judgement and conclusion.

You may wish to use the table provided to record values taken from **Fig. 1**.

[6]

(ii) The teacher states that the vertical and horizontal components of the motion shown illustrate Newton's first two laws of motion.

Explain how the two components of the motion could illustrate these laws of motion.

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2 The experiment illustrated in **Fig. 2.1** is to be used to investigate aspects of the electric field between parallel plates. The charged ball bounces continuously between the plates.

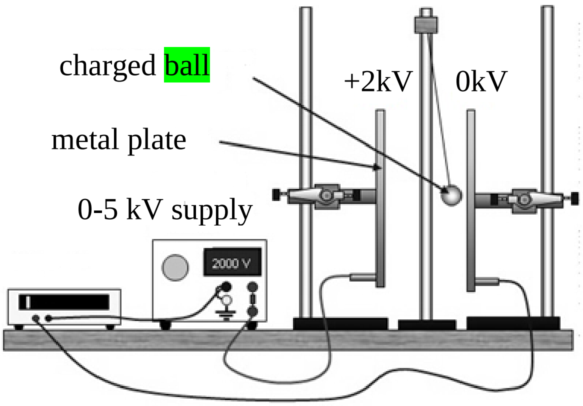

Fig. 2.1

Fig. 2.2

(a) **(i)** **Fig. 2.2** shows a close up of the parallel plates.

Draw five lines on **Fig. 2.2** to represent the uniform electric field between the plates.
Add a labelled line to represent the + 500 V equipotential.

[3]

(ii) State the effect on the electric field strength between the plates of:

1 halving the separation of the plates

....

....

2 halving the p.d. from the supply.

....

.... **[2]**

(b) **(i)** Calculate the force on the ball when charged to +2.0 kV and placed between the plates with a p.d. of 2.0 kV.

radius of ball = 2.0×10^{-2} m
plate separation = 8.0×10^{-2} m

force = ………………… N **[3]**

(ii) Calculate or state the work done by the electric field per coulomb on the ball as the ball moves across half the separation of the plates.

work done per unit charge = …………………. J C^{-1} **[1]**

(c) The ball bounces between the plates at a constant rate.

Explain why the ball bounces at a constant rate although it gains energy from the electric field each time it moves between the plates.

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3 **Fig. 3.1** shows a short bar magnet being dropped vertically through a small horizontal coil.

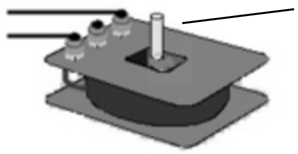

Fig. 3.1

Fig. 3.2 shows the graph of how the e.m.f. induced in the coil varies with time, as the magnet passes through the coil.

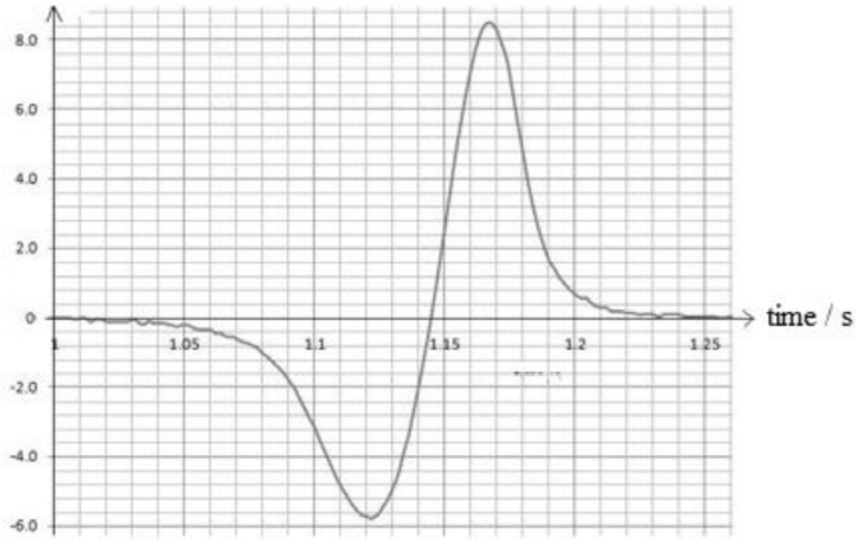

Fig. 3.2

(a)* Identify and explain the main features of the peaks of induced emf shown on **Fig. 3.2**, in terms of Faraday's law of electromagnetic induction.

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…………………………………………………………………………………………………… **[6]**

(b) An experiment is being planned for dropping a much longer bar magnet through the small coil of **Fig. 3.1** and measuring the induced emf.

Sketch and label an apparatus diagram.

State **one** aspect that would need to be controlled in order to obtain accurate data and explain how you would achieve this.

[3]

3 **(c)** Explain how the graph in **Fig. 3.2** would change if:

1 a much longer bar magnet replaced the short bar magnet.

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2 a much larger diameter coil replaced the small coil.

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………………………………………………………………………………………………………. **[4]**

(d) The data in **Fig. 3.2** were obtained using an 1100 turn coil.

Calculate the total flux linking the coil from when the magnet **enters** the coil to the point at which the magnet is central within the coil.

flux linked = ……………………….….Wb **[2]**

SECTION B

Answer **all** the questions.

4 A student wanted to use a capacitor and a resistor in an electronic timer.
She used the circuit shown in **Fig. 4.1** to test a capacitor **C** and variable resistor $\mathbf{R_2}$.

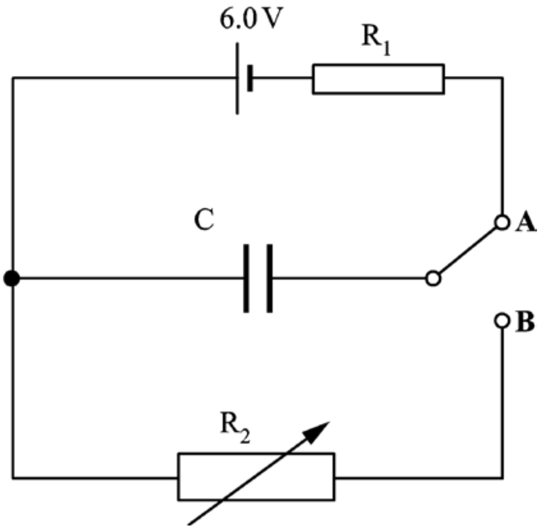

Fig. 4.1

In one test the capacitor was first charged through the fixed resistor $\mathbf{R_1}$ by connecting the switch to **A**. It was then discharged through the variable resistor $\mathbf{R_2}$ by connecting the switch to **B**. The student used a data-logger to measure how the voltage across capacitor **C** varied as it charged and then discharged through the two different resistors. A data table of her results is shown in **Fig.4.2**.

charging through R_1		**discharging through R_2**	
***t* / ms**	**p.d.$_1$ / V**	***t* / s**	**p.d.$_2$ / V**
0	0.00	0	6.00
2	0.46	2	5.54
4	0.89	4	5.11
6	1.28	6	4.72
8	1.65	8	4.35
10	1.98	10	4.02
12	2.29	12	3.71
14	2.58	14	3.42
16	2.84	16	3.16
18	3.09	18	2.91
20	3.31	20	2.69
22	3.52	22	2.48
24	3.71	24	2.29
26	3.89	26	2.11
28	4.05	28	1.95
30	4.20	30	1.80

Fig.4.2

(a) **Figs. 4.3a** and **4.3b** show the charge and discharge curves for the data in the table in **Fig. 4.2**.

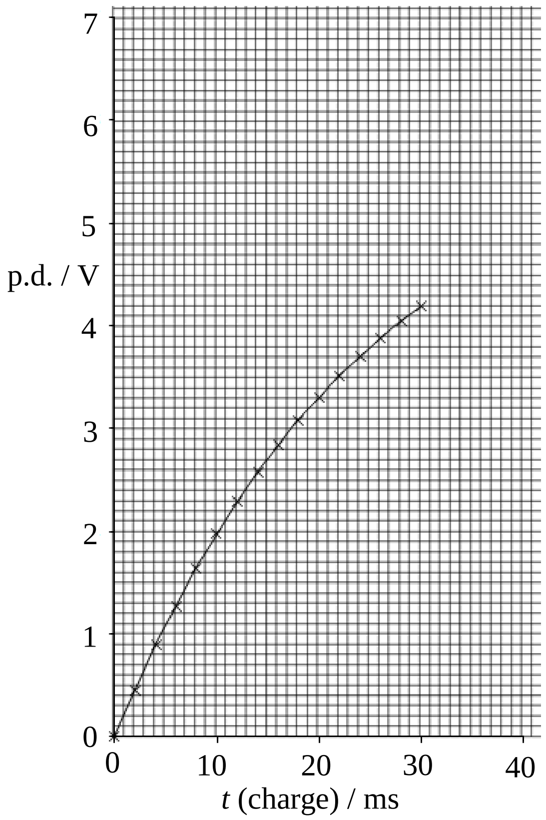

Fig. 4.3a

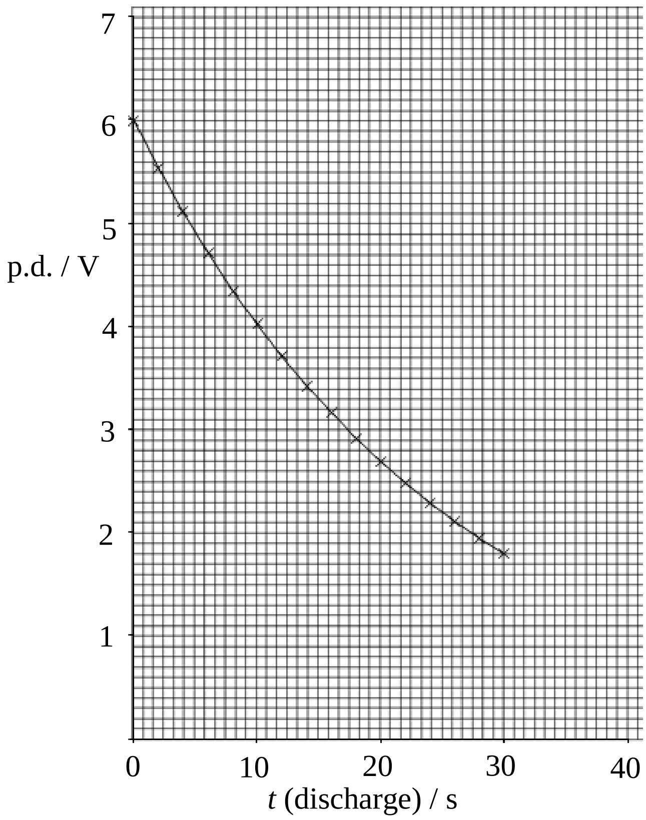

Fig. 4.3b

(i) Using the graph of **Fig. 4.3b**, show that the time constant for the discharge is less than 30 seconds.

[3]

(ii) The capacitor has a value of 4700 μF. Show that the initial discharge current would be about 1 mA.

[4]

(iii)* The student calculated the total amount of charge to flow from the capacitor in the first 30 seconds. She used two methods:

Method 1 – using the relationship $\Delta Q = C\,\Delta V$

Method 2 – using $I = \frac{V}{R}$ *and* the area under the I (t) graph where R is 5.0 kΩ

Show how the total charge flow may be calculated in both cases and comment on how the two methods compare.

[6]

(b) In the student's proposed timer, the p.d. across $\mathbf{R}_2$ must fall to 1.0 V in less than 50 seconds.

Use suitable calculations to demonstrate whether the circuit meets this requirement.

[4]

(c) Calculate the value of the charging resistor $\mathbf{R}_1$.

resistance = **………………………** Ω **[3]**

END OF QUESTION PAPER

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…day June 20XX – Morning/Afternoon

A Level Physics B (Advancing Physics)

H557/03 Practical skills in physics

SAMPLE MARK SCHEME

Duration: 1 hour 30 minutes

MAXIMUM MARK 60

This document consists of 16 pages

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

SCORIS

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *scoris assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to scoris and mark the **required number** of practice responses ("scripts") and the **required number** of standardisation responses.

   YOU MUST MARK 10 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the scoris 50% and 100% (traditional 50% Batch 1 and 100% Batch 2) deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, email or via the scoris messaging system.

5. Work crossed out:

   a. where a candidate crosses out an answer and provides an alternative response, the crossed out response is not marked and gains no marks

   b. if a candidate crosses out an answer to a whole question and makes no second attempt, and if the inclusion of the answer does not cause a rubric infringement, the assessor should attempt to mark the crossed out answer and award marks appropriately.

6. Always check the pages (and additional objects if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add a tick to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)

   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in any way relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question.

   Note: Award 0 marks – for an attempt that earns no credit (including copying out the question).

8. The scoris **comments box** is used by your Team Leader to explain the marking of the practice responses. Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**

   If you have any questions or comments for your Team Leader, use the phone, the scoris messaging system, or e-mail.

9. Assistant Examiners will send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:

- Read through the whole answer from start to finish.

- Decide the level that **best fits** the answer – match the quality of the answer to the closest level descriptor.

- To select a mark within the level, consider the following:

  Higher mark: A good match to main point, including communication statement (in italics), award the higher mark in the level
  Lower mark: Some aspects of level matches but key omissions in main point or communication statement (in italics), award lower mark in the level.

Level of response questions on this paper are **1(b)(i), 3(a), and 4(a)(iii)**.

11. **Annotations**

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
___	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

12. **Subject-specific Marking Instructions**

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet **Instructions for Examiners**. If you are examining for the first time, please read carefully **Appendix 5 Introduction to Script Marking: Notes for New Examiners**.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>1</td><td>(a)</td><td>(i)</td><td><table><tr><td>0.40</td><td>8.0</td></tr><tr><td>0.40</td><td>8.0</td></tr><tr><td>0.60</td><td>12.0</td></tr><tr><td>0.40</td><td>8.0</td></tr><tr><td>0.20</td><td>4.0</td></tr><tr><td>✓
3 Δv values correct</td><td>✓
5 $\Delta v/\Delta t$ values correct</td></tr></table></td><td>2</td><td>Correct values entered into table</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>$g = (\Delta v/\Delta t)_{\text{average}}$ (± ½ range)

= 8.0 ✓

± 4 (m s^{-2}) ✓</td><td>2</td><td>accept ± 2 / 3 / 4 (m s^{-2}) on uncertainty estimate</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>Δt from strobe is ± 10% (and is used twice to find $\Delta v/\Delta t$)✓

may contribute up to about ± 20% and is largest % uncertainty ✓</td><td>2</td><td>accept improve y measurement because ± % on Δy varies between ± 5% when y smallest to ± 1% when y largest, (but lower y values could be ignored)
both required</td></tr>
</table>

Question			Answer	Marks	Guidance
1	(b)	(i)*	**Level 3 (5–6 marks)** Test carried out with at least 3 evaluations to check constancy. Complete answer with conclusion yes $v_{horizontal}$ sensibly constant (within limits of position measuring precision from image ,about ± 0.5 cm uncertainty/ 50cm max displacement at best) *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** proposed test: Δx check constant **or** $x \propto t$ **or** x / t = constant (if measuring from left edge of ball). Test carried out with at least 2 evaluations to check constancy *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** $v_{horizontal}$ in range 1.1 ± 0.1 m s^{-1} scores 2 transfers data from graph to table scores 1 *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.	6	

Question			Answer	Marks	Guidance
		(ii)	Laws: identifies 1st law with constant $v_{horizontal}$ **and** links constant $v_{horizontal}$ to lack of $F_{horizontal}$ ✓ identifies 2nd law with constant $a_{vertical}$ **and** links $a_{vertical}$ to constant $F_{vertical}$ **or** constant weight ✓	**2**	
			Total	**14**	

Question			Answer	Marks	Guidance
2	(a)	(i)	5 lines parallel, symmetric and evenly spaced ✓ field direction - ← + ✓ straight equipotential ¼ across from earthed plate and perpendicular to *E* field ✓	3	
		(ii)	1 (*E* = *V*/*d* x ½ for *d*) doubles *E* ✓ 2 (*E* = *V*/*d* x ½ for *V*) halves *E* ✓	2	
	(b)	(i)	$F = EQ = VQ/d$ ✓ $= V^2 r / kd$ ✓ $= 2000^2 \times 0.02 / (9.0 \times 10^9 \times 0.08) = 1.1 \times 10^{-4}$ (N) ✓	3	apply uniform field equation combine with $V = kQ/r$ algebraic manipulation / numerical evaluation
		(ii)	1000 (J C^{-1}) ✓	1	accept half the p.d. across the plates **or** complete calculation of Fd/Q = 1000 (J C^{-1})
	(c)		The ball can lose k.e. at each bounce to sound **or** heat and to the air by air resistive drag forces ✓ so ball accelerates until energy gained per passage = energy lost per passage (between the plates) ✓	2	alternative Allow credit for same charge transferred each time Thus experiences the same accelerating force
			Total	**11**	

Question			Answer	Marks	Guidance
3	(a)*		**Level 3 (5–6 marks)** All 3 features fully explained: sense and amplitude explained in terms of changes of <u>flux linking</u> coil. Explanations involve reference to Faraday's Law or $\varepsilon = (-) N \Delta\Phi / \Delta t$. **Sense:** increase in $N \Delta\Phi$ is + ve and decrease – ve. **Amplitude:** peak occurs when rate of change of flux linkage is greatest, may be mathematically expressed. **Area:** equated to total change of flux linkage with coil $= \Sigma \varepsilon \Delta t = (-) N \Delta\Phi$ **or** sum of strips and same flux links coil on way in as unlinks from coil on way out. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** 2 or 3 features quite well explained: sense and amplitude explained in terms of changes of flux through coil. Explanation may involve reference to Faraday's Law or $\varepsilon = (-) N \Delta\Phi / \Delta t$. Area simply equated to change of flux and idea that increase = decrease in flux **or** both end points have zero flux through coil. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)**	6	**Indicative scientific points may include:** **Features of induced peaks to be explained** • Sense of each peak opposite • Amplitude of 2nd peak larger because greater speed or greater $(-)N \Delta\Phi / \Delta t$ • area under peaks is equal because $\Sigma \varepsilon \Delta t = (-) N \Delta\Phi$ **Vocabulary guidelines** • Level 3 in terms of changing <u>flux linkage</u> $N \Phi$ with coil • Level 2 in terms of changes of <u>flux</u> Φ through coil • Level 1 in terms of <u>field lines</u> B being cut by coil **Marking guidelines** • **accept** arguments using mathematical symbolism

Question			Answer	Marks	Guidance
			1 or 2 features explained at a low level in terms of cutting lines of magnetic field e.g. cut in opposite direction, cut at a different rate, total field cut on way in equals field cut on way out. Some attempt at $\Delta B / \Delta t$. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.		
	(b)		<u>Labelled sketch:</u> horizontal coil connected to data-logger **or** oscilloscope and vertical magnet ✓ OR plastic guide tube to keep long magnet vertical .... etc. <u>identify</u> uncertainty in timing as control variable ✓ <u>method:</u> increase sampling rate to reduce uncertainty in time **or** increase sensitivity in scale for p.d. **or** use automatic trigger on d-logger **or** identify using longer bar magnet increases transit time and thus reduces percentage uncertainty ✓	3	ignore clamps stands / unlabelled parts max 1 marks for diagram credit up to 2 sensible points - max 2 marks for method

Question			Answer	Marks	Guidance
	(c)		1 Peaks separate in time **or** a period of no emf between ✓ because only change in flux linking coil when magnetic poles enter or leave coil ✓ OR Second peak much greater amplitude and shorter duration ✓ due to higher velocity (under acceleration of gravity) as pole leaves coil and flux linkage changes at much greater rate ✓ 2 Very small **or** zero induced emf ✓ because flux of magnet loops close to magnet and does not reach to link with the much larger diameter coil ✓	4	
	(d)		Total flux linking coil = area under graph $N\Phi = \Sigma \varepsilon \Delta t$ **or** counting squares **or** area Δ ✓ ($\Phi = A / N = ½ \times 0.08 \times 5.8 \times 10^{-3} / 1100$) $= 0.21 \times 10^{-6}$ (Wb)✓	2	
			Total	**15**	

Question			Answer	Marks	Guidance
4	(a)	(i)	Time constant is the time taken for the voltage to fall to 1/e of original value **or** 0.37 x 6 ✓ = 2.2 V ✓ Shown on graph to be about 25 seconds ✓	3	ORA accept answers using initial tangent at t = 0 accept answers in range 24.5 to 25.5 s
		(ii)	$R = \tau / C$ ✓ $R = 25 / 4700 \times 10^{-6} = 53(2)0\ \Omega$ ✓ Then I = V/R = 6 / 5320 ✓ = 1.1×10^{-3} A ✓	4	Credit correct answers based on own value of time constant from part **(a)** OR $I = \Delta Q / \Delta t = C\Delta V / \Delta t$ with ΔV = 0.50 V gives 1.2 mA for full marks
		(iii)*	**Level 3 (5–6 marks)** Performs both calculations correctly and appreciates the strengths and limitations of both. Principally: for Method 1 relies on $Q \alpha V$ which is valid; for Method 2 the y-axis needs to be re-interpreted and the area being measured (integration by counting squares) gives an approximate estimated answer. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Performs both calculations successfully but method may not be completely clear **or** does not compare them sufficiently well. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*	6	**expected comparison of two methods** • method 1 does not depend on the time variation of $V(t)$, only on the accuracy of start and end p.d.s. and the R and C values. It is a calculation based on theory. • method 2 depends on counting squares and fractions of squares under the exponential decay curve which is an approximation to the area under the graph leading to an estimate of the charge flow. **points worthy of credit :** • method 1 calculation: $\Delta Q = C\Delta V$ with ΔV = (6 – 1.8) V • gives 19.7 mC • method 2 estimation: re-scaling of y-axis to represent current • area under $I(t)$ represents $\Delta Q = I \Delta t$ = • $V\Delta t/R$ •

Question			Answer	Marks	Guidance
			Level 1 (1–2 marks) Attempts one or both calculations but does not successfully compare the two methods. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** No response or no response worthy of credit.		• each 1 cm square 1 x 10/5000 = 2 mC • between 0 and 30 s there are about 10 squares • so total charge flow = 10 x 2.0 x 10^{-3} = 20 mC accept answers in range 18 to 22 mC
	(b)		$V_t = V_0 \exp(-t/\tau)$ ✓ in which V_0 = 6 V, V_t = 1 V ✓ so t = 25 x ln 6 = 45 s ✓ (ecf on RC value) 45 < 50 so YES it does meet requirement ✓	4	accept alternative method: after another τ p.d. will drop to 2.2/e = 0.81 V so YES
	(c)		charge & discharge graphs match time constant except for factor 1000 on time scale OR charge $V = 6(1–e^{-t/R_1C})$ t in s & discharge $V = 6\,e^{-t/R_2C}$ t in ms ✓ so R_2C = 1000 R_1C ✓ R_1 = 5320 / 1000 = 5.3 (Ω) ✓	3	**accept** other correct methods e.g. both graphs take same time value to reach ½ V max except for time scale in s and ms OR full calculation of time constant during charging Accept 5000/1000 = 5.0 (Ω)
			Total	**20**	

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