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|  | |  |  | | --- | --- | | **Physics A**  **Electromagnetism practise questions** |  | | Please note that you may see slight differences between this paper and the original.  Candidates answer on the Question paper.  **OCR supplied materials:** Additional resources may be supplied with this paper.  **Other materials required:** •   Pencil •   Ruler (cm/mm) | **Duration:** 120 mins | |  | | |  |

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## INSTRUCTIONS TO CANDIDATES

•   Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.  
•   Use black ink. HB pencil may be used for graphs and diagrams only.  
•   Answer **all** the questions, unless your teacher tells you otherwise.  
•   Read each question carefully. Make sure you know what you have to do before starting your answer.  
•   Where space is provided below the question, please write your answer there.  
•   You may use additional paper, or a specific Answer sheet if one is provided, but you must clearly show your candidate number, centre number  
    and question number(s).

## INFORMATION FOR CANDIDATES

•   The quality of written communication is assessed in questions marked with either a pencil or an asterisk. In History and Geography   
    a *Quality of extended response* question is marked with an asterisk, while a pencil is used for questions in which *Spelling, punctuation and  
    grammar and the use of specialist terminology* is assessed.  
•   The number of marks is given in brackets **[ ]** at the end of each question or part question.  
•   The total number of marks for this paper is **100**.  
•   The total number of marks may take into account some 'either/or' question choices.

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|  | |  |  | | --- | --- | |  |  | | **1.** | The diagram shows four magnetic compasses placed at the same distance from point **X**.     |  | | --- | |  |   Which of the following is most likely to be at point **X**?     |  |  | | --- | --- | | **A** | permanent magnet | | **B** | current-carrying solenoid | | **C** | current-carrying flat coil | | **D** | straight current-carrying wire |      |  |  |  | | --- | --- | --- | | Your answer |  | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **2(a).** | A magnet rotates inside a shaped soft iron core. A coil is wrapped around the iron core as shown in Fig. 5.1. The coil is connected to an oscilloscope.     |  | | --- | |  | | **Fig. 5.1** | **Fig. 5.2** |   The spinning magnet induces an e.m.f. in the coil. A graph of the e.m.f. displayed on the oscilloscope screen is shown in Fig. 5.2.   1. Explain the shape of the graph in terms of the magnetic flux linking the coil.         **[2]**     1. On Fig. 5.3 sketch a graph of the magnetic flux linkage of the coil against time. The variation of the induced e.m.f. across the coil is shown as a dotted line.      |  |  | | --- | --- | |  | **[1]** |      |  | | --- | |  | | **Fig. 5.3** |  1. The coil shown in Fig. 5.1 has 150 turns. The maximum induced e.m.f. V0 across the coil is 1.2 V when the magnet is rotating at 24 revolutions per second.  Calculate the maximum **magnetic flux** through the coil using the equation   V0 = 2π × (frequency) × (maximum magnetic flux linkage)  Give a unit with your answer.     |  |  |  |  |  | | --- | --- | --- | --- | --- | | maximum flux = |  | unit |  | **[2]** | | |
|  | |  |  | | --- | --- | |  |  | | **(b).** | A student is given a transformer with coils **X** and **Y**, as shown in Fig. 5.4.  **Fig. 5.4**  The student is intending to investigate how the maximum induced e.m.f. V0 in coil **Y** depends on the frequency f of the alternating current in coil **X**.  The changing magnetic flux density in coil **X** induces an e.m.f. in coil **Y**. Faraday’s law indicates that the maximum induced e.m.f. V0 should be directly proportional to f.  Describe how you would investigate the suggested relationship between V0 and f in the laboratory using these coils. In your description include all of the equipment used and how you would analyse the data collected.  Use the space below to draw a suitable diagram.                                **[6]** | |

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|  | |  |  | | --- | --- | |  |  | | **3.** | A current-carrying solenoid has *N* turns and radius *r*. The magnetic flux density within the core of the solenoid is *B*.  What is the magnetic flux linkage for this solenoid?     |  |  | | --- | --- | | **A** | *NB* | | **B** | π*r*2*B* | | **C** | 2π*rBN* | | **D** | π*r*2*BN* |   Your answer    **[1]** | |

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|  | |  |  | | --- | --- | |  |  | | **4.** | This question is about electric fields.  Fig. 2.1 shows the electric field pattern drawn by a student for two oppositely charged plates.    State **two** errors made by the student in this drawing of the field pattern.      **[2]** | |

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|  | |  |  | | --- | --- | |  |  | | **5.** | Fig. 6.2 shows a soft iron ring of variable circular cross-section. It has four coils containing 2, 3, 4 and 5 turns wound around it. The cross-sectional area of the ring is different for each coil.  A cell is connected across the coil with three turns.     1. Draw on Fig. 6.2 the complete paths of **two** lines of magnetic flux produced by the three-turn coil when there is a current in it.   **[1]**   1. State which **one** of the following three quantities,      |  |  |  | | --- | --- | --- | | magnetic flux | magnetic flux density | magnetic flux linkage |   is most nearly the same for all four coils in Fig. 6.2. Give a reason for your answer.    **[1]**   1. Write down **one** of the **other** two quantities in **(ii)** above. State in which coil this quantity has the largest value. Give a reason for your answer.     **[2]** | |

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|  | |  |  | | --- | --- | |  |  | | **6.** | \* **Fig. 5.1** shows a simple a.c. generator being tested by electrical engineers.    It consists of a magnet, on the shaft of a **variable speed** motor, being rotated inside a cavity in a soft iron core. The output from the coil, wound on the iron core, is connected to an oscilloscope. The grid of **Fig. 5.2** shows a typical output voltage which would be displayed on the oscilloscope screen.    According to Faraday’s law the e.m.f. induced is directly proportional to the rate of change of flux linkage. In the context of this experiment, the maximum e.m.f. induced is directly proportional to the frequency of rotation of the magnet.  Use the apparatus above to plan an experiment to validate Faraday’s law of electromagnetic induction. In your description include how the data is collected and analysed.                                          **[6]** | |

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|  | |  |  | | --- | --- | |  |  | | **7.** | **Fig. 24** shows two horizontal metal plates in a vacuum.     |  | | --- | | **Fig. 24** |   Beta-minus particles (electrons) emitted from a radioactive source have a range of speeds.  Describe and explain how a uniform magnetic field can be applied in the space between the charged plates to select beta-minus particles with a specific speed. No calculations are required.                        **[3]** | |

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|  | |  |  | | --- | --- | |  |  | | **8.** | State Faraday’s law of electromagnetic induction.    **[1]** | |

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|  | |  |  | | --- | --- | |  |  | | **9.** | A particle is moving at right angles to a uniform magnetic field of flux density *B*. The particle has mass *m*, charge *q* and moves in a circular arc of radius *r* in the region of the magnetic field.  What quantities are required to determine the momentum of this particle?     |  |  | | --- | --- | | **A** | *B*, *q* and *r* | | **B** | *B*, *q* and *m* | | **C** | *B*, *q*, *r* and *m* | | **D** | *q*, *r* and *m* |      |  |  |  | | --- | --- | --- | | Your answer |  | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **10.** | Fig. 2.1 shows a horizontal current-carrying wire placed in a uniform magnetic field.    The magnetic field of flux density 0.070 T is at right angles to the wire and into the plane of the paper. The weight of a 1.0 cm length of the wire is 6.8 × 10−5 N. The current I in the wire is such that the vertical upward force on the wire due to the magnetic field is equal to the weight of the wire.   1. Calculate the current I in the wire.      |  | | --- | | I = ........................................................... A **[2]** |  1. Suggest why it would be impossible for overhead cables carrying an alternating current to float in the Earth's magnetic field.     **[1]** | |

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|  | |  |  | | --- | --- | |  |  | | **11(a).** | A student is carrying out an experiment using a search coil.    A long solenoid is connected to an alternating current supply.  The search coil is placed at one end of the solenoid. The plane of the search coil is tilted such that it makes an angle θ with the central axis of the solenoid. The maximum alternating induced electromotive force (e.m.f.) across the ends of the search coil is E 0.   1. Name an instrument that can be used to determine E 0   **[1]**   1. The equation for E 0 is:  E 0 = KI 0 ANf sin θ  where I 0 = maximum current in the solenoid, A = cross-sectional area of the search coil, N = number of turns of the search coil, f = frequency of the alternating current in the solenoid and K = 4.0 × 10−3 VA−1 m−2 s.  The magnitude of the induced e.m.f. in the search coil can be determined using Faraday’s law of electromagnetic induction:  e.m.f. = rate of change of magnetic flux linkage  In the experiment, angle θ is changed and E 0 measured.  Suggest the quantity, or quantities, in the equation E 0 = KI 0 ANf sin θ linked to      |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  | |  |  | | --- | --- | | **1** | the ‘rate’ part of the law | |  | **[1]** |      |  |  | | --- | --- | | **2** | the ‘change of magnetic flux linkage’ part of the law. | |  | **[1]** | | | |

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|  | |  |  | | --- | --- | |  |  | | **(b).** | The diagram below shows two insulated-copper coils **A** and **B** connected in circuits.    Both coils are individually wrapped around the same iron rod. Coil **A** is connected to a cell and a switch. Coil **B** is connected to a filament lamp. The switch is initially closed and the lamp is off. The switch is then opened. The lamp flashes on for a brief time, and then remains off. Explain these observations in terms of magnetic flux.          **[3]** | |

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|  | |  |  | | --- | --- | |  |  | | **12.** | The diagram below shows two long current-carrying conductors **X** and **Y**.     The conductors are parallel to each other. **Y** experiences a force because it is in the magnetic field of **X**.  Which row gives the correct direction of the magnetic field at **Y** due to **X**, and the direction of the force experienced by **Y** due to this field?     |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  |  | | --- | --- | --- | |  | **Direction of magnetic field** | **Direction of force** | | **A** | Down into the plane of paper | To the right | | **B** | Up from the plane of paper | To the right | | **C** | Down into the plane of paper | To the left | | **D** | Up from the plane of paper | To the left | |  |      |  |  |  | | --- | --- | --- | | Your answer |  | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **13(a).** | The arrangement shown in the diagram below is used to determine the magnetic flux density between the poles of a permanent magnet     |  | | --- | |  |   The magnet is placed on the digital balance. The current-carrying wire is horizontal and at right angles to the magnetic field between the poles of the magnet. The wire is fixed.  The following results are collected.     |  |  | | --- | --- | | • | length of the wire in the uniform field of the magnet = 6.0 ± 0.2 cm | | • | balance reading with no current in wire = 80.0 g | | • | balance reading with current in wire = 82.2 g | | • | current in wire = 5.0 ± 0.1 A |   Calculate the magnetic flux density B, including the absolute uncertainty. Ignore the absolute uncertainty in the balance readings. Write your value for B to **2** significant figures and the absolute uncertainty to **1** significant figure.  B = ................................... ± ............... T **[4]** | |

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|  | |  |  | | --- | --- | |  |  | | **(b).** | The diagram below shows the top-view of a long current-carrying wire.     |  | | --- | |  |   The direction of the current in the wire is into the plane of the paper.  Draw at least **three** field lines to indicate the magnetic field pattern around this wire.  **[2]** | |

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|  | |  |  | | --- | --- | |  |  | | **14.** | Faraday’s law of electromagnetic induction is written below with two terms missing.  The ...................................... induced in a circuit is directly proportional to the rate of change of  magnetic flux ...................................... .  What are the **two** missing terms?     |  |  | | --- | --- | | **A** | current, density | | **B** | current, linkage | | **C** | electromotive force, density | | **D** | electromotive force, linkage |      |  |  |  | | --- | --- | --- | | Your answer |  | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **15.** | This question is about an electric cooker, which consists of an oven and an electromagnetic induction hob.  The electromagnetic induction hob is shown in **Fig. 4.1.**     |  | | --- | | **Fig. 4.1** |   Each cooking area has a coil below the glass-ceramic cover. When switched on, the coils carry a high-frequency **alternating** current.  A metal saucepan is placed above one of the coils. A large alternating current is induced in the saucepan base, and this causes the saucepan to heat up.   1. **Fig. 4.2**shows one of the coils at a time when the current is in the direction indicated by the arrows.      |  | | --- | | **Fig. 4.2** |   On **Fig. 4.2**, sketch the magnetic field pattern for the current-carrying coil.     |  | | --- | | **[2]** |  1. Fig. 4.3 shows the path of the large alternating current induced in the metal base of the saucepan      |  | | --- | | **Fig. 4.3** |   Explain the origin of this large current.            **[2]**   1. Explain why it would be safe for a person to place a hand on the cooking area before the saucepan is put onto it.         **[2]** | |

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|  | |  |  | | --- | --- | |  |  | | **16.** | 1. State **Faraday’s law of electromagnetic induction**.     **[1]**   1. The diagram below shows a simple transformer constructed by a student.      |  | | --- | |  |   Describe how the student can do an experiment in the laboratory to show that the maximum electromotive force (e.m.f.) *E* induced in the secondary coil is directly proportional to the number of turns *N* on the secondary coil.              **[3]** | |

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|  | |  |  | | --- | --- | |  |  | | **17.** | A student is doing an experiment on the magnetic force experienced by a current-carrying wire in a uniform magnetic field. The magnetic flux density *B* can be varied.  For a particular flux density, the current in the wire is 2.0A. The length of the wire in the field is 0.12 m. The angle between the current and the magnetic field is 30°. The force experienced by the wire is 7.7 × 10−2 N.  The student calculates *B* and records the results in a table.  Which row shows the correct table heading for *B* and the correct value for *B*?     |  |  |  |  | | --- | --- | --- | --- | |  | **Table heading for *B*** | **Value for *B*** |  | | **A** | *B* / T | 0.37 |  | | **B** | *B* / T | 0.64 |  | | **C** | *B* / Wb | 0.37 |  | | **D** | *B* / Wb | 0.64 |  |      |  |  |  | | --- | --- | --- | | Your answer |  | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **18.** | A coil with 500 turns is placed in a uniform magnetic field. The average cross-sectional area of the coil is 3.0 × 10–4 m2. The magnetic flux through the plane of the coil is reduced from 1.8 × 10–4 Wb to zero in a time t. The average electromotive force (e.m.f.) induced across the ends of the coil is 0.75 V.  What is the value of t ?     |  |  | | --- | --- | | **A** | 3.6 × 10–5 s | | **B** | 2.4 × 10–4 s | | **C** | 0.12 s | | **D** | 8.3 s |      |  |  |  | | --- | --- | --- | | Your answer |  | **[1]** | | |

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|  | |  |  | | --- | --- | |  |  | | **19.** | Fig. 3.1 shows the design of a ‘mechanical’ torch.     |  | | --- | | **Fig. 3.1** |   There is no battery in the torch. Instead, when the torch is inverted, the magnet falls a short vertical distance h through the coil of wire, as shown in Fig. 3.2. This induces an electromotive force (e.m.f.) across the ends of the coil. The e.m.f. is used to store charge in a capacitor, which lights a light-emitting diode (LED) when it discharges.     |  | | --- | | **Fig. 3.2** |   Fig. 3.3 shows the variation with time of the e.m.f. generated as the magnet falls the distance h.     |  | | --- | | **Fig. 3.3** |   Explain the shape of the curve in Fig. 3.3.                **[3]** | |

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|  | |  |  | | --- | --- | |  |  | | **20(a).** | Fig. 21.1 shows a coil of a simple generator rotating in a uniform magnetic field.  **Fig. 21.1**  The coil has 85 turns of insulated wire. The cross-sectional area of the coil is 14 cm2. Fig. 21.2 shows the variation of magnetic flux density B through the plane of the coil with time t as it rotates.  **Fig. 21.2**   1. Explain why the electromotive force (e.m.f.) induced across the ends of the coil is a **maximum** at the times when B = 0.       **[1]**     1. Draw a tangent to the curve in Fig. 21.2 when B = 0, and hence determine the **maximum** e.m.f. induced across the ends of the coil.      |  |  |  | | --- | --- | --- | | maximum e.m.f. = |  | V **[3]** | | |

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|  | |  |  | | --- | --- | |  |  | | **(b).** | Fig. 21.3 shows the variation of the e.m.f. induced across the ends of the coil with time t.  **Fig. 21.3**  The magnitude of the magnetic flux density of the uniform field is now halved and the coil is rotated at twice its previous frequency.     |  |  | | --- | --- | | On Fig. 21.3 sketch the new variation of the e.m.f. induced with time t. | **[2]** | | |

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|  | |  |  | | --- | --- | |  |  | | **21(a).** | A small thin rectangular slice of semiconducting material has width a and thickness b and carries a current I.  The current is due to the movement of electrons. Each electron has charge –e and mean drift velocity v. A uniform magnetic field of flux density B is perpendicular to the direction of the current and the top face of the slice as shown in Fig. 2.1.    **Fig. 2.1**  Here are some data for the slice in a particular experiment. number of conducting electrons per cubic metre, n = 1.2 × 1023m−3 a = 5.0 mm b = 0.20 mm I = 60 mA B = 0.080 T  Use this data to calculate   1. the mean drift velocity v of electrons within the semiconductor   v = ......................................... m s−1 **[3]**     1. the potential difference V between the shaded faces of the slice.   V = ......................................... V **[1]** | |

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|  | |  |  | | --- | --- | |  |  | | **(b).** | The slice is mounted and used as a measuring instrument called a Hall probe. A cell is connected to provide the current in the slice. The potential difference across the slice is measured by  a separate voltmeter.  A student wants to measure the magnetic flux density between the poles of two magnets mounted on a steel yoke as shown in Fig. 2.2. The magnitude of the flux density is between 0.02 T and 0.04 T.    **Fig. 2.2**   1. Suggest **one** reason why this Hall probe is **not** a suitable instrument to measure the magnetic flux density for the arrangement shown in Fig. 2.2.       **[1]**   1. Another method of measuring the magnetic flux density for the arrangement shown in Fig. 2.2 is to insert a current-carrying wire between the poles of the magnet. Explain how the magnetic flux density can be determined using this method and discuss which measurement in the experiment leads to the greatest uncertainty in the value for the magnetic flux density.               **[4]** | |

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|  | |  |  | | --- | --- | |  |  | | **22(a).** | A student conducts an experiment to confirm that the uniform magnetic flux density B between the poles of a magnet is 30 mT.  A current-carrying wire of length 5.0 cm is placed perpendicular to the magnetic field.  The current I in the wire is changed and the force F experienced by the wire is measured. Fig. 22.1 shows the graph plotted by the student.  **Fig. 22.1**  The student’s analysis is shown on the graph of Fig. 22.1 and in the space below.  Evaluate the information from Fig. 22.1 and the analysis of the data from the experiment. No further calculations are necessary.                                                **[6]** | |

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|  | |  |  | | --- | --- | |  |  | | **(b).** | Fig. 22.2 shows a transformer circuit.  **Fig. 22.2**  The primary coil is connected to an alternating voltage supply. A filament lamp is connected to the output of the secondary coil.   1. Use Faraday’s law of electromagnetic induction to explain why the filament lamp is lit.                   **[3]**   1. The primary coil has 400 turns and the secondary coil has 20 turns. The potential difference across the lamp is 12 V and it dissipates 24 W. The transformer is 100% efficient.    1. Calculate the current in the primary coil.      |  |  | | --- | --- | |  | current = ......................................... A **[2]** |  * 1. The alternating voltage supply is replaced by a battery and an open switch in series. The switch is closed. The lamp is lit for a short period of time and then remains off. Explain this observation.         **[2]** | |

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|  | |  |  | | --- | --- | |  |  | | **23.** | Fig. 1.1 shows the circular path travelled by electrons in a region of uniform magnetic field in a vacuum.    The direction of the magnetic field is perpendicular to the plane of the paper. The electrons have a speed of 7.0 × 106 m s−1 and travel in a circular path of diameter 5.0 cm.   1. Calculate the magnetic flux density B.   B = ............................................................ T **[3]**   1. Calculate the period T of the electrons in their circular orbit.   T = ........................................................... s **[1]**   1. The speed of the electrons is doubled. The period stays the same. Explain why.         **[2]** | |

**END OF QUESTION PAPER**

# Mark scheme

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| **Question** | | | **Answer/Indicative content** | **Marks** | **Guidance** |
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|  |  |  | **Total** | **1** |  |
| 2 | a | i | the flux in the coil changes/ increases/ decreases/ varies (caused by the spinning/rotating magnet)  causing a sinusoidal/alternating e.m.f./AW | B1    B1 | **or** e.m.f. is proportional to /equals rate of change of flux linkage/linking the coil   **or qualification, e.g.** magnet vertical gives minimum flux through core or maximum rate of change of flux or vice versa with magnet horizontal  **or** maximum flux is when emf is zero **or** minimum flux is when emf is maximum **or** vice versa |
|  |  | ii |  | B1 | **allow** ± cos wave of correct period, constant amplitude at least one cycle **N.B.** quality: curve must look like a reasonable sine wave as one is present on the page to copy  **Examiner’s Comments**  In part (i) many of the candidates described the phase shift that they drew in the sketch graph of part (ii) by stating either the magnitude or the rate of change of the flux linkage when the induced e.m.f. was zero or a maximum. The majority quoted Faraday’s law either in words or as a mathematical equation. Some candidates introduced current and Lenz’s law not appreciating that an oscilloscope is effectively a voltmeter. Few described the whole picture of a steadily rotating magnetic field sweeping through a coil creating a changing flux linkage. |
|  |  | iii | φ = BA = V/2πfN = 1.2/(2 × π × 24 × 150)  φ = 5.3 × 10−5  Wb / T m2 | B1  B1 | **allow no other** unit combinations; NOT T m−2 |
|  | b |  | **Level 3 (5–6 marks)** Clear description, some measurements and full analysis  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)** Some description, some measurements and some analysis.  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)** Limited description and/or limited measurements and/or limited analysis  There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.  **0 marks** No response or no response worthy of credit. | B1 × 6 | **Indicative scientific points may include:**  **Description**     |  |  | | --- | --- | | **a.** | Signal generator/a.c. supply connected to coil X | | **b.** | Coil Y connected to voltmeter / oscilloscope (can be ondiagram) | | **c.** | Use oscilloscope to determine period / frequency or readoff signal generator | | **d.** | Adjust signal generator / use of rheostat to keep currentconstant in coil X |   **Measurements**     |  |  | | --- | --- | | **1.** | Vary f and measure V | | **2.** | Keep current in coil X constant | | **3.** | Detail on how to measure e.m.f. e.g. ‘height x y-gain’ | | **4.** | Detail on how to measure period on oscilloscopescreen using time base and hence f |   **Analysis**     |  |  | | --- | --- | | **1.** | Determine f from period measurement, f = 1/T | | **2.** | Plot a graph of V against f | | **3.** | Relationship valid if straight line through the origin |   **Examiner’s Comments**  From the proposed arrangements for the investigation, it was apparent that most of the candidates were unfamiliar with the most suitable equipment for this experiment, namely a signal generator. Many improvised by using an ac supply with a variable frequency. A minority of these believed that by increasing the voltage of their power supply it would alter the frequency. Most drew a cell or battery symbol for the ac supply. Others improvised by using the rotating magnet from part (a) but had not realised the significance of the calculation in part (a)(iii) which indicated that at 24 revolutions per second the output voltage was 1.2 V. This made the suggested method of using a stop watch to find the period of rotation impracticable. Few realised that the oscilloscope as a voltmeter could measure both the output voltage and the period of the ac. The instrument was often connected in series in the primary circuit. No one realised that the input current has to be constant to provide a constant flux. Despite all of these difficulties most candidates managed to write sensible statements worthy of credit but rarely full marks.  The author of the example shown (exemplar 9) has used the rotating magnet as the ac source and continued with the clues from part (a) to produce an L3 quality answer.  **Exemplar 9** |
|  |  |  | **Total** | **11** |  |
| 3 |  |  | **D** | 1 |  |
|  |  |  | **Total** | **1** |  |
| 4 |  |  | Any **two** from:   * Direction of the field (is incorrect) (AW) * The field lines should be curved / not straight (lines) * The field line(s) should be perpendicular at the plate(s) * The separation between the field lines cannot be the same / diagram shows a uniform field | B1×2 | **Allow** answers on Fig. 2.1  **Examiner's Comments**  Almost all candidates picked up two marks for correctly identifying two errors with the field pattern shown in Fig. 2.1. The three most popular responses were:   * *The direction of the field should be from positive to negative.* * *The field lines should be perpendicular to both plates*. * *The separation between field lines cannot be the same; it's a non-uniform field.* |
|  |  |  | **Total** | **2** |  |
| 5 |  | i | Two closed loops linking primary coil | B1 | lines not touching / crossing, both passing only through iron core |
|  |  | ii | magnetic flux φ: because the loops of magnetic field (are continuous and) all pass (through the iron core) through each coil | B1 | **allow** magnetic flux is the number of lines of the magnetic field if **(i)** is correct |
|  |  | iii | for magnetic flux density: | B1 | Note: (iii) and (iv) can be answered in either order |
|  |  | iii | 3 turn coil as A is smallest   OR  for magnetic flux linkage: 5 turn coil as largest number of turns | B1 | φ is same in each coil, B = φ/A OR φ is same in each coil, m.f.l. = φN |
|  |  |  | **Total** | **4** |  |
| 6 |  |  | \* **Level 3 (5–6 marks)** At least P1 and P2 M1, M2, M4 and M5 At least A2 and A3 At least C1 and C2  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)** At least P1 M1, M4 and M2 or M5 At least A3 At least C1  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)** At least P1 At least M1 and M4 At least A3 At least C1  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. | B1 | **plan P** 1. vary speed of rotation of magnet using motor control 2. expect to see amplitude of signal increase and period of waveform decrease 3. measure (maximum) e.m.f. V and period T for each setting from oscilloscope screen.  **measurements M** 1. maximum e.m.f. 2. measured from peak to peak distance on graticule 3. and using V/cm scale setting 4. period of rotation 5. measured along t-axis of graticule 6. and using s/cm time base setting.  **analysis A** 1. record table of V, T 2. and (calculate and record) f = 1/T 3. plot graph of V against f  **conclusions C** 1. astraight line graph 2. through origin 3. is required to validate Faraday’s law. |
|  |  |  | **Total** | **6** |  |
| 7 |  |  | Apply a magnetic field at right angles to electric field   electric force = magnetic force  No resultant vertical force, so only beta-particles with a specific speed will travel horizontally | B1  B1  B1 | **Note** this mark is for the idea that E and B are perpendicular even if direction of B is incorrect **Allow** ‘apply horizontal magnetic field’  **Allow** Eq = Bqv  **Allow** v = E/B in this arrangement  **Examiner’s Comments**  This question was quite poorly answered, with many candidates not even mentioning the magnetic field. Few appreciated that the magnetic field needs to be placed perpendicularly to the electric field, although most could state the EQ = BQv. However, in a description, there was some confusion about the ‘fields’ being equal rather than the ‘forces’. No candidate gave a suitable description for the last mark but could access it through use of v = E/B. |
|  |  |  | **Total** | **3** |  |
| 8 |  |  | The induced e.m.f. is (directly) proportional / equal to the rate of change of (magnetic) flux linkage. | B1 | **Allow** with all terms defined; E =induced e.m.f., Φ = (magnetic) flux linkage and t = time.   **Examiner's Comments**  The majority of the candidates gave perfect definitions for Faraday's law. Some made reference to ‘cutting of field line’ or ‘cutting of flux’, but such answers often lacked clarity. |
|  |  |  | **Total** | **1** |  |
| 9 |  |  | **A** | 1 | **Examiner’s Comments**  Most candidates who successfully answered this question showed working equating the magnetic force to the centripetal force to show that *mv = rBq*. Some had possibly learnt the formula *r = mv/Bq* as this was also a common starting point. |
|  |  |  | **Total** | **1** |  |
| 10 |  | i | (weight = *BIL*) |  |  |
|  |  | i | 6*.*8x105 =0*.*070x*I*x0*.*01 (Any subject) | C1 |  |
|  |  | i | *I* = 0.097 (A) | A1 | **Examiner's Comments**  Most candidates gained two marks for determining the current. Only a very small number of candidates forgot to convert the 1.0 cm length into metres. |
|  |  | ii | The force on the cables will keep changing direction | B1 | **Examiner's Comments**  This was a low-scoring question with only a small number of candidates realising that the force experienced by the current-carrying cable would be changing direction. |
|  |  |  | **Total** | **3** |  |
| 11 | a | i | Oscilloscope / CRO | B1 | **Allow** a.c. voltmeter **Ignore** datalogger / multimeter   **Examiner’s Comments**  Most candidates appreciated that a voltage was to be measured, however it was evident that only a small proportion realised that it would be alternating and so a simple “voltmeter” would not be sufficient. Candidates putting the correct response of “oscilloscope” may well be those who have carried out practical work using search coils. |
|  |  | ii | |  |  | | --- | --- | | **1** | f | | **2** | θ or sin θ | | B1 B1 | **Not** any other symbol. **Only** mark quantity letters – ignore any words, but allow frequency.  **Allow** θ or sinθ with any or all of K, I0, A, N. **Only** mark quantity letters – ignore any words.   **Examiner’s Comments**  Part 1 was answered better than part 2 in general. For part 1, the majority of candidates appreciated that the “rate” will have included the frequency although many included other irrelevant (and therefore incorrect) terms too. In part 2, the concept of what causes the magnetic flux linkage to “change” did not appear to be well understood; A and/or N were often an incorrect response, presumably as the candidate was aware that these terms are included in a calculation for flux linkage. |
|  |  | iii | f = 49.67…. (Hz)    abs uncertainty = ×49.67… / 4.28… (Hz)  f = 50 ± 4 (Hz) | C1 C1 C1 A1 | Any individual raw uncertainty Max value = 54.11 (Hz) **and** min value = 45.54 (Hz) for f **Allow** **8**.**6%** as evidence of this calculation  For min / max method: difference / 2 = 4.29 (Hz) **Allow** ecf on abs uncertainty from incorrect f  Any ecf on f must be given to 2sf and uncertainty sf consistent. **Not** the paper SF penalty   **Examiner’s Comments**  A good fraction of candidates were able to score full marks on this question. It is clear that many had been well prepared in treatment of errors, and 8.6% was seen often in the working. A common mistake among more successful responses was giving the error as 4.3, rather than 4. Less successful often simply added the raw uncertainties, giving 0.33, which was often then placed on the answer line. Some candidates missed out the factor of 10−5 in their calculation of f. Other approaches to obtain errors, such as calculating maximum and minimum values for f were seen and these can also lead to full marks. |
|  | b |  | When switch is opened, there is (rate of) change in (magnetic) flux (linkage) which induces an emf / current  as the (magnetic) flux links to **B** which causes the lamp to light  (Lamp off) at start / end there is constant flux / no change in (magnetic) flux (linkage for coil **B**) | B1 B1 B1 | Not just a statement of Faraday’s law  **Allow** flux is cut by **B**   **Examiner’s Comments**  Many candidates found difficulties in appreciating what was required. A major confusion arose from a misunderstanding of the actual process, in that it was the opening of the switch which caused the lamp to light. Many knew Faraday’s law, and were able to quote it, but not able to put it correctly into the context of this question. A common error included a misunderstanding of the role of the rod. With a large number of less successful responses stating that it conducted current to the lamp. A large number of candidates did not discuss the process in the terms of magnetic flux (as was required in the question) but talked in vague terms about “magnetism”. Despite this being a challenging question, many candidates were able to score marks, and those at the top end were able to give clear and well-structured responses. |
|  |  |  | **Total** | **10** |  |
| 12 |  |  | **C** | 1 | **Examiner’s Comments**  Most candidates appear to know that the force between the two wires would be attractive, and circled C or D as their options. A few used the diagram and the right hand rule to draw arrows to help with the direction. Both of these are good practice in this style of question. A little less than half of the candidates selected the correct response with the vast majority of incorrect responses being D. |
|  |  |  | **Total** | **1** |  |
| 13 | a |  | (force =) 2.2 × 10-3 × 9.81  2.2 × 10-3 × 9.81 = B × 5.0 × 0.060 (= 0.072 T)  (absolute uncertainty =) (×0.072 = 0.0038 T)  B = 0.072 ± 0.004 | C1  C1  C1  A1 | **Allow** calculation of percentage uncertainty = 5.3% **Allow** calculation of max B (=0.0759 T) and min B (=0.0683 T)  **Note** B must be given to 2 SF and the uncertainty given to 1 SF. **Special case:** allow follow through from incorrect B calculation.  **Examiner’s Comments**  This question is based around a common experiment used to determine the magnetic flux density of a pair of magnets and the experimental design should have been familiar to many candidates, along with the use of F = BILsinθ from the data booklet. The first mark is for identifying the magnitude of the force as being the change in the apparent weight on the balance. Several candidates simply used the reading with the wire, or did not change the mass unit to kg. However, those who managed to get the correct reading for the force generally went on to calculate the magnetic flux density correctly. The uncertainties for two readings were given, and most candidates correctly calculated a percentage uncertainty of 5.3%. The final answer required the correct number of significant figures. Some candidates either did not see this, or ignored it, leaving their final answer in different significant figures. It was noted that several candidates underlined this instruction and in general they tended to follow it. It is good practice to do this. |
|  | b |  | Direction of field shown as clockwise  Three field lines shown as concentric circles and distance between adjacent field lines increasing as distance from wire increases | B1  B1 | Expect at least one field line with an arrow  **Allow** more than three lines, but distance between adjacent field lines increasing distance from wire must increase for all  **Examiner’s Comments**  This question requires the candidates to identify the direction of the field and also to appreciate that the magnitude of the field reduces as the distance from the wire increases. Only around half were able to apply the right hand rule correctly to determine the direction, and only around 10% scored both marks. The increasing separation of the field lines with distance was poorly done for the most part. Many candidates kept the same separation, however those that may have attempted to increase this did not do with any clarity, so that parts of the circle would decrease. In general, the quality of the circles meant that it was difficult to be sure what the candidate’s intention was. Some candidates were confused by the leader line, thinking it was the wire and attempted to draw a pattern around this. The question is clear that the diagram represents a top-view. |
|  |  |  | **Total** | **6** |  |
| 14 |  |  | D | 1 | **Examiner’s Comments**  The correct response is **D**. This question was correctly answered by the majority of candidates, although almost all the incorrect responses were **C**, presumably as candidates are aware that it is the e.m.f. that is induced but less familiar with Faraday’s law in general. |
|  |  |  | **Total** | **1** |  |
| 15 |  | i |  | B1  B1 | One correct line (or dot and cross) drawn Line must go through centre of coil **Allow** an incomplete line or a complete circle round the coil **Ignore** direction of arrow  More than one line drawn All lines drawn must go through centre of coil and follow correct shape and direction of field **Ignore** spacing of lines **Ignore** any lines to the right of the coil |
|  |  | ii | (the magnetic) flux (of the coil) links the base / saucepan  (the size/direction of) the flux linkage (constantly) changes/alternates (causing an alternating induced e.m.f.)  (induced) current is large because metal/base/ saucepan has low resistance | B1 x 2 | 2 out of 3 possible marking points  **Allow** (the magnetic) field lines cut the (base of the) saucepan **Allow** the (magnetic) field constantly changes/alternates **Allow** a bald statement of Faraday’s Law |
|  |  | iii | The resistance of glass-ceramic/the (cook”s) hand is (very) large  So (induced) current (or heating effect of current) is zero/negligible | M1  A1 | **Allow** glass-ceramic/hand is an insulator/not a (good) conductor  **Do not allow** the induced e.m.f. is (very) small |
|  |  |  | **Total** | **6** |  |
| 16 |  | i | (induced) e.m.f. is (directly) proportional / equal to the rate of change of (magnetic) flux linkage | B1 | **Not** current **Allow** ‘rate of cutting’ for ‘rate of change’ |
|  |  | ii | Connect the primary (coil) to an alternating voltage / current  Oscilloscope connected across secondary coil / to measure *E*     A graph of *E* against *N* will be a straight line through the origin. | B1 B1 B1 | **Allow** AC (can be on the figure) **Not** changing / variable for alternating  **Allow** voltmeter (can be on the figure) **Allow** p.d. / voltage for e.m.f. / *E* throughout **Ignore** any component (e.g. lamp or resistor) connected across the secondary coil  **Allow** (*E* ÷ *N*) = constant |
|  |  |  | **Total** | **4** |  |
| 17 |  |  | B | 1 |  |
|  |  |  | **Total** | **1** |  |
| 18 |  |  | C | 1 |  |
|  |  |  | **Total** | **1** |  |
| 19 |  |  | * + (Induced) e.m.f. is caused by a change in (magnetic) flux (linkage) / (Induced) e.m.f. is proportional (or equal to) the rate of change of (magnetic) flux (linkage) * The peaks are inverse / e.m.f. changes from positive to negative because: the rate of change of magnetic flux linking the coil changes sign **or** the flux (linkage) increases and then decreases **or** description in terms of Lenz's law as seen by coil to conserve energy * The e.m.f.becomes zero because: the (rate of) change of magnetic flux is zero when the magnet is in the middle of the coil * The second peak has a larger negative amplitude because: the **rate** of change of flux linkage is greater (when the magnet leaves the coil compared to when it enters) * The pulses have different widths because: the second Δt is shorter (since magnet accelerates)  **or** areas under curves must be the same (because total change of flux linkage is the same on entering and leaving coil) / area under curve = VΔt = NΔφ (so bigger V leads to smaller Δt) | B1 x 3 | **Maximum 3** marks from 4 marking points.  **Not** voltage or p.d. or current for e.m.f.  **Accept** ‘cutting of field lines by coil’ for ‘change in flux’  Answers to any of the last three points must link clearly to the correct graph characteristic   **Allow** the North (or South) pole first approaches then recedes **Ignore** magnet approaches then recedes / field increases then decreases **Not** torch is inverted      **Allow** no field lines are being cut     **Allow** the magnet is accelerating / is travelling faster when it exits the coil     **Examiner’s Comments**  Candidates need to remember to look at the command word in the question. Here it was ‘explain’; not ‘describe’. The key features to be explained were:   * why is an e.m.f generated? * why does the e.m.f change sign? * why does the e.m.f fall to zero halfway through the fall? * why is the maximum negative e.m.f greater than the maximum positive e.m.f / why is the width of the second peak smaller than that of the first peak?   The strongest responses were those where candidates stated at the outset what gave rise to the e.m.f. Some candidates clearly recognised the need to state Faraday’s law, but simply quoted the formula without defining any terms and so could not receive credit. Weaker responses were characterised by describing the shape of the graph in terms of the position of the magnet - often incorrectly – rather than in terms of flux linkage. A common misconception was stating that the negative peak was caused by the magnet returning after an inversion, with the zero e.m.f. just after 0.1s being caused by the magnet being temporarily stationary. However, the question clearly states that ‘Fig.3.3 shows … the e.m.f. generated … as the magnet falls the distance h’.  Exemplar 3 below demonstrates clearly this common misconception.  **Exemplar 3** |
|  |  |  | **Total** | **3** |  |
| 20 | a | i | The gradient is maximum / maximum rate of change of B / maximum rate of change of flux (linkage) | **B1** | **Allow** slope instead of gradient  **Examiner’s Comments**  Although worth just 1 mark, this question did provide good opportunity for top-end candidates to pick up one mark. Many candidates quoted Faraday’s law of electromagnetic induction, without mentioning that the **rate** of change of flux (linkage) was **maximum** at B = 0. Low-scoring candidates wrote about the orientation of the coil relative to the magnetic field or the ‘cutting’ of field lines. None of the explanations led to any marks being credited. |
|  |  | ii | Tangent drawn to curve at B = 0  gradient = 12.5      (maximum e.m.f. = 12.5 × 14 × 10−4 × 85)    maximum e.m.f. = 1.5 (V) | **C1   C1           A1** | **Allow** 11.70 to 13.30; no need to check calculation **Allow** fraction if calculated value is within the range       **Allow** ECF from the gradient value if value is outside the range   **Alternative:**     |  |  | | --- | --- | | E = BANω | **C1** | | E = 40 × 10−3 × 14 × 10−4 × 85 × 2π × 50 | **C1** | | maximum e.m.f. = 1.5 (V) | **A1** |   **Examiner’s Comments**  Most candidates followed the question and drew decent tangents on Fig. 21.2. Most of the tangents were acceptable, but a few either crossed the curve or had very thick pencil lines. A significant number of candidates quoted the maximum e.m.f. to be equal to the magnitude of the gradient of the tangent. Top-end candidates faced no obstacles here; the gradient was multiplied by [85 × 14 × 10−4] to give an answer around 1.5 V. Once again, a good number of candidates were picking the odd mark through error carried. Converting the cross-sectional area of 14 cm2 into 14 × 10−4 m2 was a challenge for some of the candidates in the middle and lower quartiles. |
|  | b |  | Sinusoidal curve with the same peak e.m.f.    Sinusoidal curve with half period | **B1     B1** | **Note** curve must show at least half a period **Allow** ± 1 small square for e.m.f. **Ignore** phase  **Note** graph must show at least half a period  **Allow** ± 1 small square for t  **Examiner’s Comments**  Most candidates scored a mark for showing that the period of the new e.m.f. trace was halved. Only a small proportional had the peak e.m.f. unchanged; the most frequent incorrect trace showed the peak e.m.f. also being halved. The sinusoidal curves were generally well-sketched. |
|  |  |  | **Total** | **6** |  |
| 21 | a | i | I = nAev; v = 60 × 10−3/1.2 × 1023 × 1.6 × 10−19  × 5.0 × 0.2 x10−6 v = 3.1 (m s −1) | **C1 C1  A1** | **allow** any subject |
|  |  | ii | V = 80 × 10−3 × 3.1 × 5.0 × 10−3  = 1.2 × 10−3 (V) | **A1** | **ecf (b)(i); allow** 1.2 mV; 1.3 × 10−3 (V)  **Examiner’s Comments** This exercise of choosing a formula, substituting values in correct units and evaluating was done well with about three quarters of the candidates gaining full marks. |
|  | b | i | Hall probe only compares B-fields / AW **or** V will be too small / less than 1 mV so not easy to measure | **B1** | allow any sensible comment, e.g. how do you convert the measured V into a B value |
|  |  | ii | find B using F = BIl; F is measured by weighing magnets  (e.g. placed on top pan balance assuming wire is fixed); graph of F against I to find B(l) from gradient / AW;  greatest uncertainty: measurement of l in  B-field sensible reason / justification for choosing l **or** small masses | **B1 B1   B1   B1 B1** | **max** 4 of the 5 marking points **alt** measure F by adding small masses to wire to return it to zero current position  **or** use readings of F at several I to find average F**/**I**,** etc.  **or** measurement of small masses in alt. method, etc quantitative suggestion about % error i.e. l small (1 mm in 60) leading to large % uncertainty **or** difficulty in determining edge / end of B-field  **Examiner’s Comments** Most candidates did not refer back to (b)(ii), noting that the potential difference across the Hall probe would be very small making the probe an unsuitable instrument for measuring the magnetic flux density, B. However almost all were familiar with the experiment where the magnets are mounted on a top pan balance with a fixed wire carrying the current. Only a small number varied the current and plotted  a graph to obtain a more accurate value of B. Also few appreciated that the edges of the field spread out making the length of wire in the field the least reliable measurement. |
|  |  |  | **Total** | **9** |  |
| 22 | a |  | **Level 3 (5-6 marks)** Clear evaluation of Fig. 22.1 **and** clear analysis  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)** Some evaluation of Fig. 22.1 **and** some analysis  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)** Limited evaluation of Fig. 22.1 **or** limited analysis  There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.  **0 marks** No response or no response worthy of credit. | **B1×6** | Use level of response annotations in RM Assessor, e.g. L2 for 4 marks, L2ˆ for 3 marks, etc.  **Ignore** incorrect references to the terms precision and accuracy  **Indicative scientific points may include:**  **Evaluation of Fig. 22.1**   * Comment on the line * The straight line misses one error bar / anomalous point ringed or indicated * Too few data points plotted * The triangle used to calculate the gradient is (too) small * Some plots should have been repeated / checked * No error bars for current * ‘Not regular intervals’ (for current) * No origin shown (AW)   **Evaluation of analysis**   * The value of B is close to the accepted value * The difference of only 7% * No absolute or percentage uncertainty in B shown (AW) * Worst-fit line or maximum / minimum gradient line could have been used to determine the (absolute or percentage) uncertainty in B * F against I graph should be a straight line or * BL = gradient (any subject)   **Examiner’s Comment** This was the second level of response (LoR) question in the paper. It required evaluation of a graph drawn by a student and the analysis shown in the box on page 24. Most candidates realised that the graph had few data points, the triangle used for the gradient was too small and the line drawn totally missed one of the error bars. The analysis shown by the candidate did not include an absolute uncertainty in B, which made the statement written by the student lack credibility. Many candidates wrote about drawing doing a line of worst-fit and determining the percentage uncertainty. This was only possible if there were more data points and the error bars for the F values reduced by perhaps repeating the measurements. Once again, there was a good spread of marks amongst the three levels. |
|  | b | i | There is a changing / fluctuating (magnetic) field / flux (linkage)   (magnetic) field / flux (linkage) in core and secondary (coil)   Statement of Faraday’s law: e.m.f. (induced) ∝ rate of change of (magnetic) flux linkage | **M1    A1    B1** | **Note:** This changing flux can be anywhere **Allow ‘**the direction of the field oscillates’   **Allow** ‘the core helps to link the flux to the secondary coil’   **Allow** ‘equal to / =‘ **Ignore** ‘cutting of flux’ **Not** just E = (−)Δ(Nϕ)/Δt  **Examiner’s Comment** The topic electromagnetic induction always challenges candidates. Successful responses often showed correct use of technical terms such as magnetic flux or flux linkage. Most candidates scored a mark for correctly stating Faraday’s law of electromagnetic induction. Many realised that an alternating current produced an alternating magnetic flux within the iron core and this change in flux produced an e.m.f. at the secondary coil. One of the popular misconceptions was that there was an alternating current (or induced e.m.f.) within the iron-core. A small number of candidates referred to **electro**magnetic field in their descriptions rather than magnetic field. |
|  |  | ii | 1 (IS =) 24/12 or 2.0 (A)   (current in primary =) 0.10 (A)  or  (VP =) 12 × 20 or 240 (V)    (current in primary =) 0.10 (A)  2 Idea of changing / increasing (magnetic) field / flux / current (in primary) at the start  Eventually current and flux (linkage) are constant, therefore no e.m.f. | **C1    A1    C1     A1  B1   B1** | **Allow** 1 sf answer         **Allow** 1 sf answer  **Note:** Any labels used must be clearly defined   **Examiner’s Comment** This question on current in the primary coil was successfully answered by most candidates. The most favourable method was to calculate the current in the secondary and then the current in the primary coil. The turn-ratio equation and P = VI were effortlessly used to arrive at the correct answer of 0.10 A.  Full marks were rarely scored but many top-end candidates did manage to score a mark for suggesting that the lamp was lit for a short period of time at the start because ‘there was a changing magnetic flux as the current increased from zero to a steady value’. Too many answers focussed on the requirement of an alternating supply for an induced e.m.f. in the secondary coil and how a battery is not an alternating supply. |
|  |  |  | **Total** | **13** |  |
| 23 |  | i | F = /   F = 1.79 × 10−15 (N)  (F = BQv) | C1 | **Alternative**: Allow e instead of Q BQv =  or BQ =  C1 |
|  |  | i | 1.79 × 10−15 = B × 1.6 × 10−19 × 7.0 × 106 (Any subject) | C1 | B = (Any subject)  C1 |
|  |  | i | B = 1.6 × 10−3 (T) | A1 | B = 1.6 × 10−3 (T) A1  **Allow**: 2 marks for 7.97 × 10−4 (T); 5.0 cm used instead of 2.5 cm (Allow 8 × 10−4 T)   **Examiner's Comments**  The majority of the candidates did extremely well in this question. The physics was clear and the manipulation of the equations was easy to follow. The majority of the candidates scored two or more marks. Many candidates had the confidence to derive an equation for the magnetic flux density B and then substitute the values. The most frequent error was to use the diameter of 5.0 cm as the radius of the circular path of the electrons. |
|  |  | ii |  |  |  |
|  |  | ii | period = 2.2 × 10−8 (s) | B1 | **Allow**: 1 mark for 4.5 × 10−8 (s) as ECF if 5.0 cm was used in **(i)**.   **Examiner's Comments**  In order to calculate the period, candidates had to divide the circumference of the path by the speed. This was effortlessly done by most candidates. There was error carried forward rule applied for candidates who used 5.0 cm as the radius in **(i)**. |
|  |  | iii | BQ = mv/r (Allow any subject) | M1 | **Allow** other alternatives, e.g:  T = 2πm/QB       M1  m, Q and B are constants (hence T is constant)     A1 |
|  |  | iii | T = distance / speed or T = 2πr/v or T ∝ r/v (hence T is constant) | A1 | or  The distance / circumference / r doubles     M1 T = distance/speed or T = 2πr/v or T ∝ r/v (hence T is constant)      A1   **Examiner's Comments**  The answers were varied. Top-end candidates often opted for a mathematical approach. A significant number of candidates gained no marks. The most common answers from such candidates was ‘distance travelled increases, so period must be the same’. A few candidates thought that the period had something to do with the relativistic increase in the mass of the electron. |
|  |  |  | **Total** | **6** |  |