# OCR A Level Physics A (H556) Physics B (H557)
## PAG 11: More Investigations
## Practice Exam Questions and Mark Scheme

**1.** A student measures the diameter of a ball in different directions.

The student's results are:

2.43 cm   2.54 cm   2.59 cm

i. State the name of a suitable measuring instrument to measure the diameter of the ball.

**[1]**

ii. Calculate the mean diameter *d* of the ball. Include the absolute uncertainty in *d*.

*d* = .................. ± .................. cm **[2]**

iii. Show that the volume of the ball is about $8.4 \times 10^{-6}$ m$^3$.

**[1]**

iv. The mass of the ball is 23 ± 1 g.
Determine the density $\rho$ of the ball.
Give your answer to an appropriate number of significant figures.

$\rho$ = ............................................ kg m$^{-3}$ **[2]**

v. Determine the percentage uncertainty in $\rho$.

percentage uncertainty = .................................................... % **[2]**

**2.** You are provided with a small bottle of cooking oil and standard physics laboratory equipment.

With the help of a **labelled** diagram, describe an electrical experiment to determine the specific heat capacity *c* of the oil. State **two** sources of uncertainty in your measurements and discuss how these could be reduced.

*In your answer, you should use appropriate technical terms spelled correctly.*

**[6]**

3. * A student is to investigate the magnetic field inside and around a solenoid.

It is suggested that the magnetic field strength $B$ inside a long solenoid is determined by various quantities, namely $B \propto \frac{NI}{L}$ where $N$ is the number of turns, $L$ is the length of the solenoid and $I$ is the current in the wire.

Apparatus is set up for an experiment as shown in Figure 6.1.

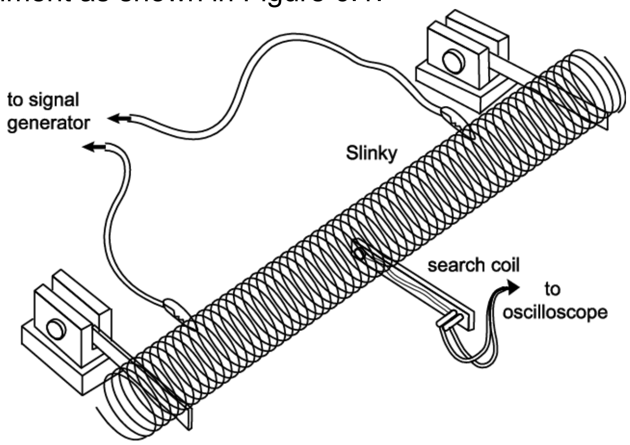


**Fig. 6.1**

A Slinky is a long spring about 70 mm in diameter which can be stretched easily and uniformly. The search coil has 5000 turns and the signal generator can produce a constant alternating current at a frequency between 0 and 1 kHz.

Plan an experiment using this equipment to investigate the validity of the relationship between $B$, at the centre of the solenoid, and **one** of the variables $N$ or $L$. Explain how you will make your measurements, how sensitive they will be and the steps that you will take to make this a valid test.

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**4.** A student is given a transformer with coils **X** and **Y**, as shown in Fig. 5.4.

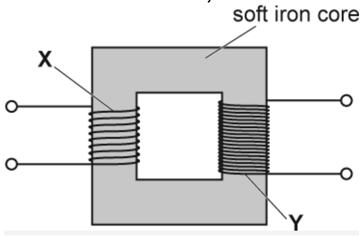


**Fig. 5.4**

The student is intending to investigate how the maximum induced e.m.f. $V_0$ 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. $V_0$ should be directly proportional to $f$.

Describe how you would investigate the suggested relationship between $V_0$ 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]**

 

**5.** A student wants to carry out an experiment to determine the input power to a small electric motor without using electrical meters. The motor is used to lift light loads. The efficiency of the motor is 15%. Describe how this student can determine the input power to the motor. Your description should include:

- the measurements taken
- the instruments used to take the measurements
- how the measurements are used to determine the input power to the motor.

*In your answer, you should use appropriate technical terms, spelled correctly*

**[4]**

**6.** Fig. 3.1 shows the design of a ‘mechanical’ torch.

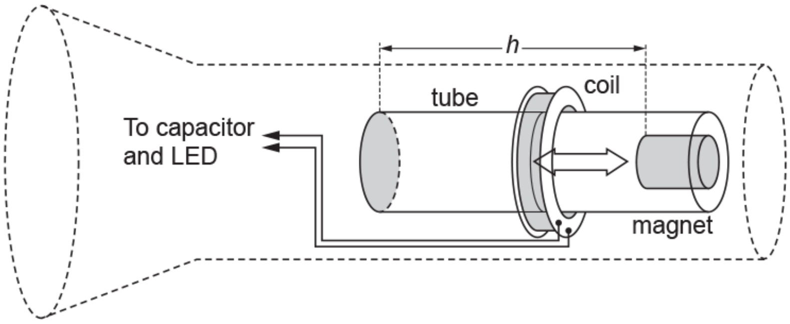


**Fig. 3.1**

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.

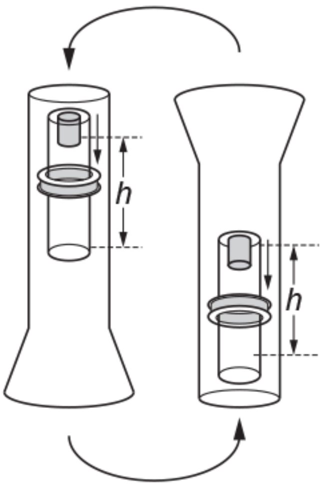


**Fig. 3.2**

Fig. 3.3 shows the variation with time of the e.m.f. generated as the magnet falls the distance *h.*

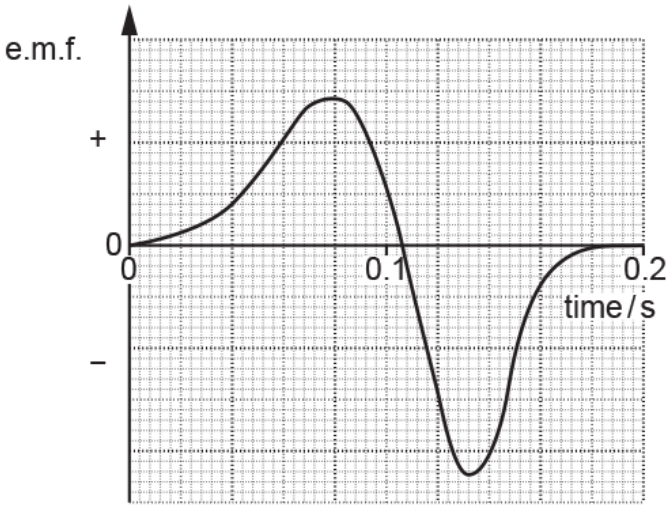


**Fig. 3.3**

 

In the torch, the gravitational potential energy of the magnet is converted into electrical energy supplied to the 50 mW LED.

You are asked to investigate whether the efficiency of this energy conversion depends on the number of inversions of the torch.

- Describe how you will make accurate measurements to collect your data. Assume that both the torch and the tube can be opened.
- Explain how you will use the data to reach a conclusion.

**[6]**

 

**7.** * A student wishes to test the equation $F = \dfrac{mv^2}{r}$ for a constant force $F$ using a whirling bung in the laboratory.

Describe with the aid of a labelled diagram how an experiment can be conducted, and how the data can be analysed to test the validity of this equation for a constant force.

**[6]**

 

**8.** 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.

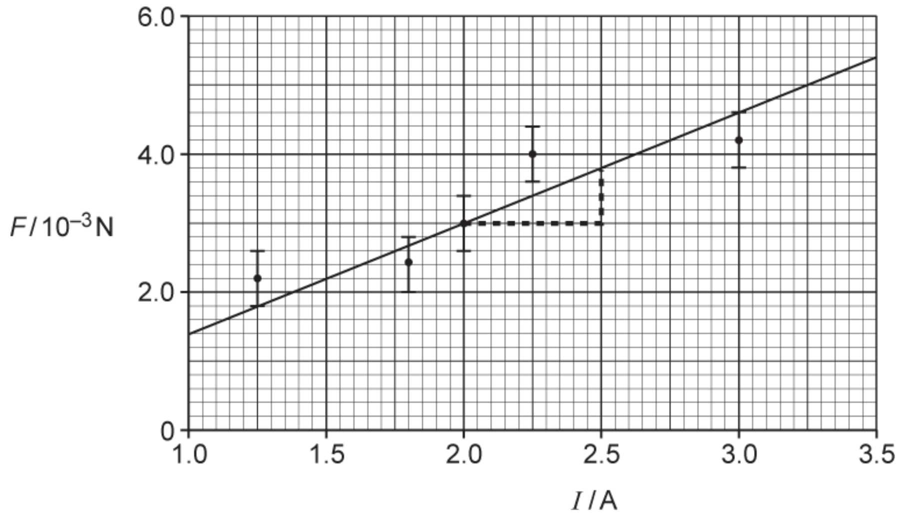


**Fig. 22.1**

The student's analysis is shown on the graph of Fig. 22.1 and in the space below.

$F = BIL$

$$\text{gradient} = BL = \frac{(3.8 - 3.0)\times 10^{-3}}{2.5 - 2.0} = 0.0016$$

$$B = \frac{0.0016}{0.05} = 0.032\,\text{T} = 32\,\text{mT}$$

This is just 2 mT out from the 30 mT value given by the manufacturer, so the experiment is very accurate.

Evaluate the information from Fig. 22.1 and the analysis of the data from the experiment. No further calculations are necessary.

 

**[6]**

**END OF QUESTION PAPER**

 

# Mark scheme

| Question | | | Answer/Indicative content | Marks | Guidance |
|---|---|---|---|---|---|
| 1 | a | i | (Vernier) Calliper or micrometer (screw gauge) | B1 | **Not** rule(r) |
| | | ii | 2.52<br><br>± 0.08 | B1<br><br>B1 | **Allow** (2.52-2.43 =) 0.09 or (2.59-2.52 =) 0.07 |
| | | iii | Volume = $\frac{4}{3} \times \pi \times (1.26 \times 10^{-2})^3$<br>$= 8.379 \times 10^{-6}$<br><br>$8.4\times10^{-6}$ m$^2$ | M1<br><br>A0 | $\frac{1}{6} \times \pi \times (2.52 \times 10^{-2})^3$ or<br>$\frac{4}{3} \times \pi \times \left(\frac{2.52\times10^{-2}}{2}\right)^3$ |
| | | iv | $\frac{0.023}{8.4\times10^{-6}}$ or 2738<br><br>2700 (kg m$^{-3}$) or 2.7 x 103 (kg m$^{-3}$) | C1<br><br>A1 | **Note** 2745 if using calculator value from **(iii)** |

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| | | | | | **Note** must be two significant figures<br>**Allow** one mark for 2.7 x 106 (kg $m^{-3}$)<br><br>A large number of candidates did not give their answer to an appropriate number of significant figures; the common answer being 2738 kg $m^{-3}$. In this case, the mass was given to two significant figures and the volume was calculated from data give to three significant figures, thus the final answer should be given to the same number of significant figures as the least significant data, i.e. to two significant figures. |
| | | v | $\frac{1}{23}$ or $\frac{0.08}{2.52}$ or $\frac{0.24}{2.52}$ or 4.3% or 3.2% or 9.5%<br><br>14% (13.8%) | C1<br><br>A1 | **Allow ECF** from **(ii)** – 3.6% or 10.7% for $\Delta d$ = 0.09<br>**Allow** maximum/minimum methods<br><br>**Note** 13% for $\Delta d$ = 0.07 or 15% for $\Delta d$ = 0.09<br>[ECF 5.5% for $\Delta d$ = 0.01] |
| | | | **Total** | **8** | |
| 2 | | | **Diagram showing**<br>• Oil in (insulated) container<br>• Electrical heater fully immersed in oil<br>• Thermometer / Temperature sensor | B1 | **Not:** oven or hotplate<br>**Allow:** 'Fully immersed' seen in the body of text<br>**Thermometer / Temperature sensor** must be spelled correctly on diagram |
| | | | **Electrical circuit** | B1 | All elements should be shown to score these diagram marks. Ignore appropriate additional items<br>Connections to heater should be clear. |

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| | | | • Ammeter in series, voltmeter in parallel with heater / joulemeter in parallel with heater<br>• Power supply /+ & - signs marked on wires | | |
| | | | **Measurements**<br>• Measure mass of oil / use known mass of oil,<br>• Measure change in temperature / initial and final temperatures<br>• Measure current, pd and (fixed) time / energy | B1 | Must have all elements.<br>**Allow:** Use of symbols<br>**Allow:** Take energy reading from joulemeter<br>**Not:** use given power rating of heater |
| | | | **Calculation**<br>Input Energy = $E = Pt = VIt$ and $c = \frac{E}{m\Delta\vartheta}$ | B1 | Input energy must be consistent with equipment used.<br>*c* must be the subject of the equation and temperature **rise** ($\Delta\theta$ or $\theta_2 - \theta_1$) must be clear.<br>**Allow**: Draw graph of temperature against time<br>$c = VI$ / [gradient × mass] |
| | | | **Uncertainties** Any **two** together with minimising action.<br>• Heat losses (make $\Delta\theta$ uncertain) – minimise by using initial $\theta$ below and final $\theta$ same amount above, room temperature<br>• Temperature varies throughout oil – minimise by stirring before taking temperature readings<br>• Some energy is required to raise temperature of the container / heater (etc) – allow by including in calculation.<br>• Temperature will continue to rise after heater is turned off - find max temperature. | 2 × B1 | These points may be scored in the description of method.<br><br>No credit for other uncertainties including heat lost to surroundings |
| | | | **Total** | **6** | |

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| 3 | | | **Level 3 (5–6 marks)**<br>A good plan with discussion of sensitivity and measurements that need taking. Detailed description of analysis needed linked to robust conclusions and consideration of a fair test.<br><br>extra points from sections may balance omissions from others<br>*The ideas are well structured providing significant clarity in the communication of the science.*<br><br>**Level 2 (3–4 marks)**<br>A good plan possibly with mention of sensitivity. Measurements that need taking should be described. Analysis linked to conclusions and possibly consideration of a fair test.<br><br>extra points from sections may balance omissions from others<br>*There is partial structuring of the ideas with communication of the science generally clear.*<br><br>**Level 1 (1–2 marks)**<br>A plan with discussion of measurements that need taking. Description of analysis needed linked to a conclusion.<br><br>*extra points from sections may balance omissions from others*<br>*The ideas are poorly structured and impede the communication of the science.*<br><br>**Level 0 (0 marks)**<br>Insufficient relevant science. | B1 | **plan P**<br><br>• investigate one variable with the other fixed<br>• oscilloscope time base can be off<br>• do rough preliminary test over range of variable to check that there is a suitable variation in oscilloscope V<br>• choose and fix f of *I* and value of other variable (M3);<br>• measure e.m.f. V for 5 or 6 settings of variable from oscilloscope screen<br><br>**sensitivity S**<br><br>• magnitude of detected signal depends on rate of change of flux linkage / Faraday's law through search coil<br>• so increases with f and B (N and A of search coil are fixed)<br>• for large B use small *L* f changing N<br>**or** large N if changing *L*<br>**measurements M**<br>• measure (maximum) e.m.f. V (using V/cm scale setting) on oscilloscope<br>• measure peak to peak distance on graticule if time base not switched off<br>• keep *L* fixed and adjust croc. clips to change N<br>**or** keep N fixed and alter *L* (use ruler)<br><br>**analysis A**<br><br>• record table of V against *N* or *L*<br>• plot graph of V against *N* or 1/ *L*<br>**conclusions C**<br>• straight line graph<br>• through origin is expected<br>• to validate given relationship<br>**fair test F**<br>• ensure that Slinky coils are uniformly spaced and not touching together anywhere<br>• croc. clips make good contact at only one point on coil |

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| | | | | | • plane of coil must be vertical **and** coaxial with Slinky |
| | | | **Total** | **6** | |
| 4 | | | **Level 3 (5–6 marks)**<br>Clear description, some measurements and full analysis<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3–4 marks)**<br>Some description, some measurements and some analysis.<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br>Limited description and/or limited measurements and/or limited analysis<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>No response or no response worthy of credit. | B1 × 6 | **Indicative scientific points may include:**<br><br>**Description**<br><br>**a.** Signal generator/a.c. supply connected to coil X<br>**b.** Coil Y connected to voltmeter / oscilloscope (can be ondiagram)<br>**c.** Use oscilloscope to determine period / frequency or readoff signal generator<br>**d.** Adjust signal generator / use of rheostat to keep currentconstant in coil X<br><br>**Measurements**<br><br>**1.** Vary *f* and measure *V*<br>**2.** Keep <u>current</u> in coil X <u>constant</u><br>**3.** Detail on how to measure e.m.f. e.g. 'height x *y*-gain'<br>**4.** Detail on how to measure period on oscilloscope screen using time base and hence *f*<br><br>**Analysis**<br><br>**1.** Determine f from period measurement, f = 1/T<br>**2.** Plot a graph of *V* against *f*<br>**3.** Relationship valid if straight line through the origin |
| | | | **Total** | **6** | |
| 5 | | | Any one from: | B1 | |

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| | | | • Mass obtained using a balance / scales<br>• Weight / load obtained using a newtonmeter / spring balance<br>• Distance / height obtained using a ruler / metre stick / measuring tape | | |
| | | | Time obtained using a clock / (stop)watch / timer or light-gate and timer or light-gate and data-logger | B1 | The term **clock** / **(stop)watch / timer /data-logger** must be spelled correctly to gain this mark |
| | | | (output power =) 'mass × *g* × distance'/time or 'weight × distance/time' or 'weight × speed' | B1 | **Allow** symbols, e.g *mgh/t*, *Wh/t* and *Wv* |
| | | | input power = output power/0.15 | B1 | |
| | | | **Total** | **4** | |
| 6 | | | **Level 3 (5 - 6 marks)**<br>Clear determination of input energy, procedure and analysis<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is clear, relevant and substantiated.*<br><br>**Level 2 (3 – 4 marks)**<br>Clear determination of input energy and procedure, but no analysis<br><br>**or** Clear analysis but limited determination of input energy and/or limited procedure<br><br>**or** Attempted determination of input energy, basic procedure, and an attempt at analysis<br><br>*There is a line of reasoning presented with some structure. The* | B1 x 6 | **Use level of response annotations in RM Assessor, e.g. L2 for 4 marks, L2^ for 3 marks, etc.**<br><br>Candidates can gain full credit for investigating the efficiency of either:<br>Method 1(M1): GPE (*nmgh*) to energy conversion in LED (*Pt*) or<br>Method 2(M2): GPE (*nmgh*) to energy stored in capacitor (½*CV*2 or ½Q2/*C*)<br><u>L1 maximum for any answers which do not use GPE as input energy</u><br><br>**Indicative scientific points may include:**<br><br>**Determination of input energy**<br><br>• record the number of inversions, *n*<br>• (use electronic / top pan balance to) measure mass of magnet *m*<br>• (use mm ruler to) measure tube length $l_t$ and magnet length $l_m$<br>• calculate $h = l_t – l_m$ |

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| | | | *information presented is in the most part relevant and supported by some evidence.*<br><br>**Level 1 (1 – 2 marks)**<br>A limited selection from the scientific points worthy of credit.<br>*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 | | • calculate (GPE =) $nmgh$<br><br>**Procedure**<br><br>• invert torch n times (with torch switched off)<br>• make sure that the magnet falls the full height h between inversions<br>• M1 switch torch on and (use stopwatch to 0.1 s to) measure time $t$ taken until LED goes out (use video with timer for greater accuracy)<br>• M1 use a darkened room or view LED through tube<br>• M2 (use voltmeter across capacitor to) measure final p.d. $V_f$<br>• M2 (with coulombmeter) measure final charge $Q_f$ stored by capacitor<br>• repeat experiment for different $n$<br><br>**Analysis of efficiency**<br><br>• M1 calculate $W = Pt$ where $P$ = 50 mW<br>• M2 calculate $W = ½CV_f^2$ or $½Q_f^2/C$<br>• calculate efficiency = $W/nmgh$<br>• compare efficiency values for different $n$<br>• plot suitable graph e.g. efficiency against $n$ / $W$ against $nmgh$<br>• plot t against $n$ (M1) / $V^2$ or $Q^2$ against $n$ (M2) with justification<br>• discuss shape / gradient of graph |
| | | | **Total** | **6** | |
| 7 | | | * **Level 3 (5–6 marks)**<br>A labelled diagram including all equipment required and a detailed description of the method leading to an appropriate analysis of data.<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* | B1 × 6 | **Equipment / labelled diagram(E)**<br><br>1. String / cord (passed through a tube) with bung at one end and load at other (accept a labelled diagram)<br>2. Stopwatch to measure time period<br>3. Suitable scale / marker to measure radius<br><br>**Method (M)** |

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| | | | **Level 2 (3–4 marks)**<br>A labelled diagram including most of the equipment required and a description of the method leading to an appropriate graph but with some misunderstanding of the relationship.<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.*<br><br>**Level 1 (1–2 marks)**<br>A diagram is included with most of the equipment required and a description of the method leading to an attempt of identifying an appropriate graph or relationship.<br><br>*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.* | | 1. Whirl bung with constant frequency and radius (in horizontal circle)<br>2. Measure time for several time periods<br>3. Measure radius either using cord markers or stopping the cord at the tube and measuring with a ruler<br>4. Vary frequency and new radius<br><br>**Analysis (A)**<br><br>1. Expect $v^2 \propto r$, or $r$ α $T^{-2}$<br>2. Plot graph; e.g $r$ against $T^{-2}$<br>3. Expect straight line through origin |
| | | | **Total** | **6** | |
| 8 | | | **Level 3 (5-6 marks)**<br>Clear evaluation of Fig. 22.1 **and** clear analysis<br><br>*There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*<br><br>**Level 2 (3-4 marks)** | **B1×6** | Use level of response annotations in RM Assessor, e.g. L2 for 4 marks, L2ˆ for 3 marks, etc.<br><br>**Ignore** incorrect references to the terms precision and accuracy<br><br>**Indicative scientific points may include:**<br><br>**Evaluation of Fig. 22.1**<br><br>• Comment on the line<br>• The straight line misses one error bar / anomalous point ringed or indicated<br>• Too few data points plotted<br>• The triangle used to calculate the gradient is (too) small<br>• Some plots should have been repeated / checked<br>• No error bars for current |

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| | | | Some evaluation of Fig. 22.1 **and** some analysis<br><br>*There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.*<br><br>**Level 1 (1-2 marks)**<br>Limited evaluation of Fig. 22.1 **or** limited analysis<br><br>*There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.*<br><br>**0 marks**<br>*No response or no response worthy of credit.* | | • 'Not regular intervals' (for current)<br>• No origin shown (AW)<br><br>**Evaluation of analysis**<br><br>• The value of $B$ is close to the accepted value<br>• The difference of only 7%<br>• No absolute or percentage uncertainty in $B$ shown (AW)<br>• Worst-fit line or maximum / minimum gradient line could have been used to determine the (absolute or percentage) uncertainty in $B$<br>• $F$ against $I$ graph should be a straight line or<br>• $BL$ = gradient (any subject) |
| | | | **Total** | **6** | |