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Mark Scheme Summer 2008

GCE

GCE Physics (8540/9540)

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Contents

Mark scheme notes

Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

(iii) <u>Horizontal force of hinge on table top</u>

66.3 (N) or 66 (N) **and** correct indication of direction [no ue] ✓ **1**
[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

1. Mark scheme format

1.1 You will not see 'wtte' (words to that effect). Alternative correct wording should be credited in every answer unless the ms has specified specific words that must be present. Such words will be indicated by underlining e.g. '<u>resonance</u>'
1.2 Bold lower case will be used for emphasis.
1.3 Round brackets ( ) indicate words that are not essential e.g. "(hence) distance is increased".
1.4 Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

2. Unit error penalties

2.1 A separate mark is not usually given for a unit but a missing or incorrect unit will normally cause the final calculation mark to be lost.
2.2 Incorrect use of case e.g. 'Watt' or 'w' will **not** be penalised.
2.3 There will be no unit penalty applied in 'show that' questions or in any other question where the units to be used have been given.
2.4 The same missing or incorrect unit will not be penalised more than once within one question but may be penalised again in another question.
2.5 Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
2.6 The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

3. Significant figures

3.1 Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in 'show that' questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
3.2 Use of an inappropriate number of significant figures will normally be penalised in the practical examinations or coursework.
3.3 Using $g = 10\ m\ s^{-2}$ will **not** be penalised.

4. Calculations

4.1 Bald (i.e. no working shown) correct answers score full marks unless in a 'show that' question.

4.2 If a 'show that' question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.

4.3 **use** of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.

4.4 **recall** of the correct formula will be awarded when the formula is seen or implied by substitution.

4.5 The mark scheme will show a correctly worked answer for illustration only.

4.6 Example of mark scheme for a calculation:

<u>'Show that' calculation of weight</u>

Use of L × W × H ✓

Substitution into density equation with a volume and density ✓

Correct answer [49.4 (N)] to at least 3 sig fig. [No ue] ✓
[Allow 50.4(N) for answer if 10 N/kg used for g.]
[If 5040 g rounded to 5000 g or 5 kg, do not give 3rd mark; if conversion to kg is omitted and then answer fudged, do not give 3rd mark] **3**
[Bald answer scores 0, reverse calculation 2/3]

Example of answer:

80 cm × 50 cm × 1.8 cm = 7200 cm^3

7200 cm^3 × 0.70 g cm^{-3} = 5040 g

5040 × 10^{-3} kg × 9.81 N/kg

= 49.4 N

5. Quality of Written Communication

5.1 Indicated by QoWC in mark scheme, placed as first mark.

5.2 Usually it is part of a max mark.

5.3 In SHAP marks for this are allocated in coursework only but this does not negate the need for candidates to express themselves clearly, using appropriate physics terms. Likewise in the Edexcel A papers.

6. Graphs

6.1 A mark given for axes requires both axes to be labelled with quantities and units, and drawn the correct way round.

6.2 Sometimes a separate mark will be given for units or for each axis if the units are complex. This will be indicated on the mark scheme.

6.3 A mark given for choosing a scale requires that the chosen scale allows all points to be plotted, spreads plotted points over more than half of each axis and is not an awkward scale e.g. multiples of 3, 7 etc.

6.4 Points should be plotted to within 1 mm.

- Check the two points furthest from the best line. If both OK award mark.
- If either is 2 mm out do not award mark.
- If both are 1 mm out do not award mark.
- If either is 1 mm out then check another two and award mark if both of these OK, otherwise no mark.

6.5 For a line mark there must be a thin continuous line which is the best-fit line for the candidate's results.

Question Number	Answer	Mark
1 (a)	<u>Add missing information</u> For four correct responses in the 'vector or scalar' column (1) For the 'base unit' column :- 4 correct responses (3) 3 correct responses (2) 2 correct responses (1)	**(4)**
	Total for question	**(4)**

Quantity	Base unit	Vector or scalar
	m	vector
	kg m^2 s^{-2}	scalar
	kg m^2 s^{-3}	scalar
	kg m s^{-1}	vector

Question Number	Answer	Mark
2(a)(i)	Describe motion Constant / uniform acceleration or (acceleration of) 15 m s^{-2} (1) (Followed by) constant / uniform speed / velocity (of 90 m s^{-1}) (1)	**(2)**
(a)(ii)	Show that distance is approximately 800 m Any attempt to measure area under graph or select appropriate equations of motion required to determine **total** distance (1) Correct **expression** or **value** for the area under the graph between either 0 – 4 s [240 m] or 4-10 s [540 m] (1) Answer : 780 (m) (1) Eg distance = 60 m s^{-1} x 4 s + 90 m s^{-1} x 6 s = 240 m + 540 m = 780 (m) Eg distance in first 4 s s = $\frac{v+u}{2}$ t = $\frac{90\,\mathrm{m\,s^{-1}} + 30\,\mathrm{m\,s^{-1}}}{2}$ 4 s = 240 m Distance in final 6 s s = ut = 90 m s^{-1} x 6 s = 540 m Total distance = 240 m + 540 m = 780 (m)	**(3)**
(b)	Sketch graph Graph starts at 760 m - 800 m/their value and initially shows distance from finishing line decreasing with time (1) **The next two marks are consequent on this first mark being awarded** **Curve with increasing negative gradient** followed by straight line (1) Graph shows a straight line **beginning** at coordinate (4 s, 540 m) **and** finishes at coordinate (10 s, 0 m) (1)	**(3)**
	Total for question	**(8)**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>3(a)</td><td><u>Principle of conservation of linear momentum</u>
Provided no external [other/resultant/outside] force acts (1)

The total momentum (of a system) does not change[is constant] / total momentum before (collision) = total momentum after (collision) [‘Total’ or ‘sum’ should be seen at least once, do not accept ‘all’] (1)</td><td>(2)</td></tr>
<tr><td>(b)(i)</td><td><u>Measuring velocity</u>

<table><tr><td>Tickertape</td><td>Light gate(s)/sensor</td><td>Motion sensor</td><td>Video</td><td>(1)</td></tr><tr><td>Tickertimer</td><td>Datalogger/PC/timer</td><td>Datalogger/PC</td><td>Metre rule / markings on the track</td><td>(1)</td></tr></table>[The points above maybe labelled on the diagram]

Description of distance measured and corresponding time or
$v = \frac{d}{t}$ or any mention of a distance against time graph[mention of gradient not required for this mark] (1)</td><td>(3)</td></tr>
<tr><td>(b)(ii)</td><td><u>Further measurements</u>
The mass(es) of both A and B / the trolley<u>s</u> (1)</td><td>(1)</td></tr>
<tr><td>(b)(iii)</td><td><u>Explain constant velocity requirement</u>
Either
(For the law to be demonstrated) there must be no <u>external</u> [accept ‘outside’] force /<u>resultant</u> force / friction acting (1) [do not accept closed system]

(If the trolley(s) are moving with constant velocity) the <u>external</u>[accept ‘outside’] force / <u>resultant</u> force / (effect of)friction (acting on the system)is zero. (1)

Or
There must be no <u>external</u> [accept ‘outside’] force / <u>resultant</u> force / friction acting [do not accept closed system] (1)

if <u>acceleration</u> is zero (1)

Or
The velocity / speed measurements required are the velocities / speeds (at the instant) when the trolleys collide (1)

Measurement of these velocities is impossible / difficult (1)</td><td>(2)</td></tr>
<tr><td></td><td>Total for question</td><td>(8)</td></tr>
</table>

Question Number	Answer	Mark
4(a)(i)	<u>Give expression</u> *W* = *R* + *F* (1)	**(1)**
(a)(ii)	<u>Complete statements</u> ……. surface / ground (1) ……. Earth ('s mass) [Only accept this answer] (1) ……. gardener('s hands) / hand(s) (1)	**(3)**
(b)(i)	<u>Add to diagram</u> Line inclined to the vertical pointing to the left and upwards (1)	**(1)**
(b)(ii)	<u>Explain change in direction and magnitude</u> The force (at X) will have a magnitude greater than F or the force (at X) must increase. (1) This is because the wheelbarrow / it has to be lifted / tilted/ supported/ held up (by the vertical component) (1) And also because the wheelbarrow / it has to be moved (forward by the horizontal component) (1)	**(3)**
	Total for question	**(8)**

Question Number	Answer	Mark
5(a)(i)	Magnitude of normal contact force 11 N	**(1)**
(a)(ii)	Show that this is consistent with the principle of moments Use of the principle of moments (because shelf is balanced) (1) Calculation showing moments equal (1) eg 22 N x 35 (x 10^{-2}) m = 11 N x 70 (x 10^{-2}) m 7.7 (N m) = 7.7 (N m) [accept 770 (N cm) = 770 (N cm)]	**(2)**
(b)(i)	Normal contact force at B Use of the principle of moments (1) [Ecf their moment expression for the shelf from aii] Answer [48.5 N - 49.0 N] (1) eg 22 N x 35 (x 10^{-2}) m + 44 N x 60 (x10^{-2}) m = F x 70 (x 10^{-2}) m F = 48.71 N	**(2)**
(b)(ii)	Why a limit to the distance from B QOWC (1) **States** point about which moments are to be considered eg about B (1) Equates the moments for the limiting position for the point considered eg for the point B the (clockwise) moment of the ornament = the (anticlockwise) moment (of the weight) of the shelf (1) States that for any further increase in distance (eg from B) of the ornament the moments will no longer be equal or the shelf will be unbalanced (1) [accept descriptions that mean or describe unbalanced eg the shelf will tip] Calculation or description to explain why the limiting position is less than 20 cm from B or 17.5 cm seen (1) **QOWC + Max 3** Eg 22 N x 35 cm = 44 N x d *d* = 17.5 cm	**(4)**
(b)(iii)	Normal contact force at A for limiting position Zero / 0 / 0 N / 0 n / Zero N / Zero n / Zero newtons / 0 newtons	**(1)**
	Total for question	**(10)**

Question Number	Answer	Mark
6(a)	<u>Show speed is about 2 m s^{-1}</u> **Either** Substitution into force x distance (1) Equates work done and kinetic energy (1) **Or** Substitution into equation for force (1) Correct use of $v^2 = u^2 + 2as$ or two appropriate equations (1) Answer [(1.94 – 1.97) (m s^{-1})] (1) Eg Work done = 2.75 N x 1.25 m $\frac{1}{2}$ 1.80kg x v^2 = 2.75 N x 1.25 m v = 1.95 (m s^{-1}) **Or** $a = \frac{F}{m} = \frac{-2.75\,N}{1.80\,kg}$ = - 1.53 m s^{-2} $v^2 = u^2 + 2as$ $0 = u^2 + 2 \times - 1.53$ m s^{-2} x 1.25 m u = 1.95 (m s^{-1})	**(3)**
(b)	<u>Momentum</u> Momentum equation [In symbols or numbers] (1) Answer [(3.5 - 3.6) kg m s^{-1} or N s. Ecf candidates value for speed] (1) Eg 1.8 kg x 1.95 m s^{-1} = 3.51 kg m s^{-1}	**(2)**
(c)	<u>Momentary force</u> Selects $F = \frac{\Delta p}{t}$ or v = u + at and F = ma (1) Average value of unbalanced force (1) Average value of momentary force (1) Eg $F = \frac{\Delta p}{t}$ **Or** v = u + at ; 2 ms^{-1} = (0 +) a x 0.7 s $= \frac{3.51\,kg\,m\,s^{-1}}{0.7\,s}$ F = ma; $F = 1.8\,kg \times \frac{2\,m\,s^{-1}}{0.7\,s}$ = 5.0 (N) = 5.0 (N) Average value of force applied = 5.0 N + 2.75 N = 7.75 N	**(3)**
	Total for question	**(8)**

Question Number	Answer	Mark
7(a)	<u>Show that rate of decay of radium is about 7 x 10^{13}Bq</u> Power divided by alpha particle energy (1) Answer [(7.1 – 7.2) x 10^{13} (Bq)] (1) [Give 2 marks for reverse argument ie 7 x 10^{13} Bq x 7.65 x 10^{13} J (1) (53.5 – 53.6) (W) (1)] Eg Rate of decay = $\frac{55\ \text{W}}{7.65 \times 10^{-13}\ \text{J}}$ = 7.19 x 10^{13} (Bq)	**(2)**
(b)	<u>Show that decay constant is about 1.4 x 10^{-11} s^{-1}</u> Use of λ = $\frac{0.69}{T_{1/2}}$ (1) Answer [(1.35 – 1.36) x 10^{-11} (s^{-1})] (1) Eg λ = $\frac{0.69}{1620\ \text{years} \times 3.15 \times 10^{7}\ s}$ = 1.35 x 10^{-11} (s^{-1})	**(2)**
(c)	<u>The number of radium 226 nuclei</u> Use of A = λN (1) Answer [(5.0 -5.4) x 10^{24}] (1) Eg 7.19 x 10^{13} Bq = 1.35 x 10^{-11} s^{-1} x N N = 5.33 x 10^{24}	**(2)**
(d)	<u>The mass of radium</u> Divides number of radium 226 nuclei by 6.02 x 10^{23} and multiplies by 226 (1) Answer [1870 – 2040 g] Eg Mass of radium = 226 g x $\frac{5.33 \times 10^{24}}{6 \times 10^{23}}$ = 2008 g	**(2)**
(e)	<u>Why mass would produce more than 50 W</u> The (daughter) nuclei (radon) formed as a result of the decay of radium are themselves a source of (alpha) radiation / energy (1) Also accept (having emitted alpha) the nucleus[allow sample/radium/atom] (maybe left excited and therefore also) emits gamma Also accept (daughter) nucle(us)(i) recoil releasing (thermal) energy Do not accept Nucleus may emit more than one alpha particle Nucleus may also emit beta particle	**(1)**
	Total for question	**(9)**

Question Number	Answer	Mark
8(a)	<u>Paths of alpha particles</u> Path A drawn less deflected than B (1) Path A drawn as a straight line (1)	**(2)**
(b)(i)	<u>Why alpha source inside container</u> Alpha would be absorbed by [accept would not get through] container (material) (1)	**(1)**
(b)(ii)	<u>Why the same kinetic energy?</u> **Either** To restrict observation to two variables / closeness of approach and deflection **or** so that speed / velocity / (kinetic) energy does not have an effect (on the observation / deflection /results / contact time)	**(1)**
(b)(iii)	<u>Why an evacuated container?</u> **Either** so that alphas do not get absorbed by / collide with / get deflected by / stopped by / scattered by / get in the way of / ionise / lose energy to <u>atoms</u> / <u>molecules</u> (of air) [Do not accept 'particles' of the air] **or** so that all alphas reach the foil with the <u>same (kinetic) energy</u>	**(1)**
	Total for question	**(5)**
	Total marks for paper	**(60)**

Question Number	Answer	Mark
1 (a)	Diode or LED (1)	**1**
(b) (i)	Use of R = V / I current between 75 and 90 ignoring powers of 10 (1) answer 6.7 – 8.0 Ω (1) Example of answer R = 0.60 V ÷ (85 × 10^{-3}) A R = 7.06 Ω	**2**
(b) (ii)	Infinite OR <u>very</u> high OR ∞	**1**
(c)	**ANY ONE** Rectification / AC to DC / DC supply [not DC appliances] Preventing earth leakage Stabilising power output To protect components A named use of LED if linked to LED as component in (a) (eg calculator display / torch) A voltage controlled switch (Allow current in only one direction)	**1**
	Total for question	**5**

Question Number	Answer	Mark
2 (a)	Resistivity definition Resistivity = resistance × (1) × cross sectional area / length (1) $\rho = RA/l$ with symbols defined scores 2/2 equation as above without symbols defined scores 1/2 equation given as $R = \rho l/A$ with symbols defined scores 1/2 (1st mark is for linking resistivity to resistance with some other terms)	**2**
(b) (i)	Resistance calculation Converts kW to W (1) Use of $P = V^2/R$ OR $P = VI$ and $V = IR$ (1) Resistance = 53 Ω (1) **Example of answer** $R = (230\ V)^2 \div 1000\ W$ $R = 53\ \Omega$	**3**
(b) (ii)	Length calculation Recall $R = \rho l/A$ (1) Correct substitution of values (1) Length = 6.3 m (accept 6.2 m) (1) ecf value of R **Example of answer** $l = (52.9\ \Omega \times 1.3 \times 10^{-7}\ m^2) \div (1.1 \times 10^{-6}\ \Omega\ m)$ $l = 6.3\ m$	**3**
(b) (iii)	**Proportion method** Identifies a smaller diameter is needed (1) Diameter = 0.29 mm (1) **OR** **Calculation method** Use of formula with l = half their value in (b)(ii) (1) Diameter = 0.29 mm (1) (Ecf a wrong formula from part ii for full credit) **Example of answer** $d_{new} = 0.41\ mm \div \sqrt{2}$ $d_{new} = 0.29\ mm$	**2**
	Total for question	**10**

Question Number	Answer	Mark
3 (a)	**Definition of E.M.F.** Energy (conversion) or work done (1) Per unit charge (1) [work done/coulomb 1/2, energy given to a charge 1/2, energy given to a charge of a coulomb 2/2] **OR** $E = W/Q$ (1) Symbols defined (1) (E = 1 J/C scores 1) **OR** $E = P/I$ Symbols defined (E = 1 W/A scores 1) ((Terminal) potential difference when no current is drawn 1/2)	**2**
(b) (i)	Internal resistance calculation Attempt to find current (1) Pd across r = 0.2 V (1) r = 0.36 (Ω) (1) [You must follow through the working, I have seen incorrect methods getting 0.36 Ω] Example of answer I = 2.8 V ÷ 5.0 Ω r = (3.0 − 2.8) V ÷ 0.56 A = 0.36 Ω	**3**
(b) (ii)	Combined resistance Use of parallel resistor formula (1) Resistance = 3.3 Ω [accept 3 1/3 but not 10/3] (1)	**2**
(b) (iii)	Voltmeter reading (ecf bii) Current calculation using 3 V with either 3.3 Ω or 3.7 Ω (1) Total resistance = 3.7 Ω [accept 3.66 to 3.73 Ω] OR use of $V = E - Ir$ (1) Voltmeter reading = 2.7 V (1) **OR** Potential divider method, ratio of resistors with 3.7 Ω on bottom (1) Multiplied by 3.0 V (1) 2.7 V (1) Example of answer R_{total} = 3.7 Ω I = 3 V ÷ 3.7 Ω = 0.81 A $V_{voltmeter}$ = 3.3 Ω × 0.81 A = 2.7 V	**3**
(c)	Ideal voltmeter Ideal voltmeter has infinite resistance OR extremely high resistance OR highest possible R OR much larger resistance than that of component it is connected across OR quotes value > 1 M Ω (1) Current through voltmeter is zero (negligible) OR doesn't reduce the resistance of the circuit OR doesn't reduce the p.d. it is meant to be measuring. (1)	**2**
	Total for question	**12**

Question Number	Answer	Mark
4 (a)	<u>Circuit diagram</u> Potentiometer correctly connected i.e potential divider circuit (1) Ammeter in series and voltmeter in parallel with bulb (1) (light bulb in series with resistance can score second mark only)	**2**
(b) (i)	<u>Graph</u> +I,+V quadrant; curve through origin with decreasing gradient (1) [do not give this mark if curve becomes flat and then starts going down i.e. it has a hook] -I,-V quadrant reasonably accurate rotation of +I,+V quadrant (1)	**2**
(b) (ii)	<u>Shape of graph</u> As current/voltage increases, temperature of the lamp increases / lamp heats up (1) Leading to increase in resistance of lamp (1) Rate of increase in current decreases OR equal increases in V lead to smaller increases in I (1) Qowc (1) Ecf if a straight line graph is drawn max 3 R constant (1) V α I (1) Qowc (1)	**4**
	Total for question	**8**

Question Number	Answer	Mark
5(a)	Thermal contact Allows energy to flow from one body/object to another (1)	**1**
(b)	Thermometer Difficulty (1) } x 2 Explanation (1) } (Difficulty and explanation might occur in one section or wrong way round) **Examples of answers that score 1 or 2 marks.** Size of the sample (1) poor thermal contact OR not all of the thermometer in contact with sample (1) Glass/gas is poor conductor (1) slow to respond to temperature changes (1) Slow to respond (1) apparatus is large/bulky or has a large mass (1) Can't measure temperature of a solid (1) poor thermal contact (1) Limited range of temperatures (1) can explode if it gets too hot, or pressures too high. Might make reference to gas liquifying or glass melting (1) Not everything is at the same temperature (1)length of tubing or size of apparatus or size of sample (1) Glass bulb might expand on heating (1) so volume might not be constant (1) Thermometer takes heat from sample (1) so result not accurate (1) Coarse scale on pressure gauge (1) inaccurate results (1) **Examples of answers that score 1 mark maximum** Not very portable (1) Calculations have to be done (1) Takes a long time to set up (1) Fragility of glass (1)	**4**
	Total for question	**5**

Question Number	Answer	Mark
6(a)	<u>Absolute zero of temperature</u> (Temperature at which) pressure / volume (of a gas) is zero. (1) OR (Temperature at which) the <u>kinetic energy</u> of the molecules is zero)	**1**
(b) (i)	<u>Number of moles show that calculation</u> Recall $pV = nRT$ (1) Addition of air pressure (1) Conversion to kelvin (1) Number of moles = 0.52 (mol) (1) Reverse calculations using n = 0.5 to arrive at one of the other values can score maximum 3 **Example of answer** $n = \frac{((1.0+1.1)\times10^5\,\text{Pa}\times5.8\times10^{-3}\,\text{m}^3)}{8.31\,\text{JK}^{-1}\text{mol}^{-1}\times(273+10)\text{K}}$ n = 0.52 mol	**4**
(b) (ii)	<u>Mass of air</u> Mass = 1.5 x 10 $^{-2}$ kg (1) **Example of answer** mass = 0.52 mol × 0.029 kg mol^{-1} = 0.015 kg	**1**
(b) (iii)	<u>Temperature calculation</u> Use of $P_1/T_1 = P_2 / T_2$ (1) Correct P_2 1.6 × 10^5 Pa (1) Lowest temperature = 216 K (-57 ^{0}C) (1) **OR** Use of $pV = nRT$ (must see correct value of R) (1) Correct P_2 1.6 × 10^5 Pa (1) Lowest temp 215K - 223K (-58 to -50 ^{0}C) (1) **Example of answer** $T_2 = \frac{((1.0+0.6)\times10^5\,\text{Pa}\times283\ \text{K})}{2.1\times10^5\,\text{Pa}}$ T_2 = 216 K	**3**
	Total for question	**9**

Question Number	Answer	Mark
7(a)	Smoke particle motion (Smoke particles) move due to collisions with air molecules (1) Resultant force is produced by the collision imbalance/multiple collisions OR Idea of varying or different resultant force OR change of momentum (1)	**2**
(b)	Air molecules motion Motion of (air molecules) is random OR collisions are random (1) EITHER: They are moving fast/faster than smoke particles OR The smoke particles are hit by different numbers of (air molecules) OR Large number of (air molecules) (1)	**2**
(c)	Motion of one particle A single path that has Different length straight sections (arrows not necessary) (min 5) (1) In different directions(1)	**2**
	Total for question	**6**

Question Number	Answer	Mark
8(a)	Mean square speed Attempt to find either squares or a mean of all 5 values (1) $<c^2> = 3.1 \times 10^5$ (311640) as answer (1) $m^2 s^{-2}$ (1) (The unit mark is independent)	**3**
(b)	Real gas molecules No forces (negligible force) act or no bonds (1) Between molecules / particles / atoms (1) (consequent mark) (No external force is acceptable for the first mark) (Ignore reference to gravity / gravitational forces) (collisions are elastic so there is no PE scores zero)	**2**
	Total for question	**5**
	Total for paper	**60**

Topic A - Astrophysics

Question Number	Answer	Mark
1 (a)	**<u>Core remnant stars</u>** All core remnants ticked AND no main sequence (1) < 1.4 $M_{\odot}$ column: White dwarf only (1) > 2.5 $M_{\odot}$ column: Black hole only (1)	**3x1**
(b)	**<u>CCD advantages</u>** · Higher (quantum) efficiency / more sensitive / detect fainter or more distant stars · More linear **response** [or equivalent] · Digital / link to computer / remote imaging · No processing time / use repeatedly · Quicker image collection [i.e. quicker & reason] · Wider range of frequency / wavelength / e.m. radiation (1) + (1) **<u>CCD disadvantage</u>** Resolution / pixel size larger / pixilates if magnified (1)	**3x1**
(c) i	**<u>Hydrogen burning</u>** Quality of written communication (1) <u>Nuclear</u> <u>fusion</u> reaction [accept nuclei, nucleus, fusing] (1) Hydrogen / deuterium /protons turn into He [penalise contradictions, e.g. molecules atoms; accept symbols] (1) Release of energy (1)	**4x1**
(c) ii	**<u>Sun as red giant calculation</u>** Attempted use of $L = \sigma T^4 A$ (accept r substituted as A) (1) $A = 4 \pi r^2$ [or $A \propto r^2$ if ratios calculated directly] (1) 3.85×10^{26} (W) or 1.13×10^{30} (W) [or substitution as ratio] (1) 2930 [accept 2900 - 2940] (1) $L = \sigma T^4 A = 4 \pi \sigma T^4 r^2$ $L_{before} = 4 \pi \times 5.67 \times 10^{-8}$ W m^{-2} K$^4 \times (5780$ K$)^4 \times (6.96 \times 10^8$ m$)^2$ $= 3.85 \times 10^{26}$ W $L_{after} = 4 \pi \times 5.67 \times 10^{-8}$ W m^{-2} K$^4 \times (3160$ K$)^4 \times (1.26 \times 1011$ m$)^2$ $= 1.13 \times 10^{30}$ W Hence ratio = 1.13×10^{30} W ÷ 3.85×10^{26} W = 2930	**4x1**

(c) iii	**H-R diagram plots** X at 10^0 on main sequence [± 1 mm by eye] AND between 5000 K and centre of 5000 – 10 000 K box (1) Y above and to right of actual $X_\odot$ (1) Attempt to plot Y at 3160 K [between 5000 K and 2500 K] (1) Attempt to plot Y between $10^3\ L_\odot$ and $10^4\ L_\odot$ [ecf] (1)	**4x1**
(d) i	**Sun as white dwarf** Any 2 [comparative statements] of Higher temperature / hotter Lower luminosity [accept Power, not E or I] No fusion in core [or equivalent; not just "not on main sequence] More dense (1) + (1)	**2x1**
(d) ii	**Future of white dwarf** Cools / *T* decreases (1) Dims / fades / correct colour change [not brown dwarf] / Luminosity decreases [accept intensity here] (1)	**2x1**
(e) i	**Distance to Sirius** Substitution in *v* x *t* /s [ignore 8.6, accept 365 or 365¼ days] (1) 8.1×10^{16} (m) [8.13, 8.14] (1) $d = v\,t$ $= 8.6 \times 3.00 \times 10^8 \text{ m s}^{-1} \times (60 \times 60 \times 24 \times 365¼) \text{ s}$ $= 8.1 \times 10^{16} \text{ m}$	**2x1**
(e) ii	**Sirius A intensity calculation** Use of $I = L / 4 \pi D^2$ (1) Correct substitution (1) 1.2×10^{-7} W m^{-2} [1.20 – 1.24] (1) $I = L / 4 \pi D^2$ $= 1.0 \times 10^{28} \text{ W} / 4 \pi (8.1 \times 10^{16} \text{ m})^2$ $= 1.2 \times 10^{-7} \text{ W m}^{-2}$	**3x1**

(e) iii	**<u>Mass rate conversion</u>** $E = m c^2$ seen [or implied] (1) Correct substitution (1) 1.1×10^{11} kg (s^{-1}) (1) 1.0×10^{28} W = 1.0×10^{28} J s^{-1} $\Delta m = \Delta E / c^2$ $= 1.0 \times 10^{28}$ J / (3.00×10^8 m $s^{-1})^2$ $= 1.1 \times 10^{11}$ kg	**3x1**
(e) iv	**<u>Peak wavelength calculation</u>** Use of Wien's law (1) 2.93×10^{-7} m (1) $\lambda_{max} = 2.90 \times 10^{-3}$ m K / 9900 K $= 2.93 \times 10^{-7}$ m	**2x1**
		32

Topic B - Solid Materials

Question Number	Answer	Mark
2 (a)	**<u>Metal treatment classification</u>** Annealing: heating and slow cooling (1) Work hardening: beating only (1) Quench hardening: heating and rapid cooling (1)	**3x1**
(b) i	**<u>Fence wire cross-section</u>** Use of π r^2 and 10^{-3} m (1) 4.9 x 10^{-6} (m^2) [do not accept m] (1) $A = \pi r^2$ $= \pi \times (0.5 \times 2.50 \times 10^{-3})^2$	**2x1**
(b) ii	**<u>Stress calculation</u>** Substitution: 1500 N / 4.9 [or 5] x 10^{-6} m^2 (1) 310 MPa [accept 300, ecf] (1) $\sigma = F / A$ $= 1500 \text{ N} / 4.9 \times 10^{-6} \text{ m}^2$ $= 3.1 \times 10^8$ Pa	**2x1**
(b) iii	**<u>Extension calculation</u>** $E = \sigma / \varepsilon$ and $\varepsilon = \Delta l / l$ (or $E = F l / A \Delta l$) (1) Substitution in $E = \sigma / \varepsilon$ and $\varepsilon = \Delta l / l$ [or in $E = F l / A \Delta l$, ecf, ignore 10^n] (1) 0.048 (m) [ecf] (1) 48 mm [accept 47 – 49 mm, bald answer scores 4/4] (1) $E = F l / A \Delta l$ $\Delta l = (1500 \text{ N} \times 33 \text{ m}) / (210 \times 10^9 \text{ Pa} \times 4.9 \times 10^{-6} \text{ m}^2)$ $= 0.048$ m = 48 mm	**4x1**
(c) i	**<u>Young modulus experiment</u>** (G-) clamp [vice], <u>wire</u>, pulley, mass / weight / load three correct (1) all four correct (1)	**2x1**

(c) ii	**<u>Labelling of *l*</u>** Accurate indication of *l* [to 1 mm] (1) Length 2 m to 6 m (1)	**2x1**
(c) iii	**<u>Additional apparatus</u>** Micrometer (screw gauge) / (digital) callipers (1) Ruler or similar [e.g. tape measure, metre stick] (1)	**2x1**
(c) iv	**<u>Energy density</u>** Energy density = area [may be implied by use] (1) 4.5 – 5.5 x 10^n (1) 5 x 10^7 J m^{-3} / 50 MJ m^{-3} [when rounded to 1 s.f.] (1)	**3x1**
(d)	**<u>Relieving stress concentrations explanation</u>** Quality of written communication (1) Tip [end] of crack [not edge, centre; diagram ok] (1) Increases <u>area</u> (over which stress acts) (1) Lowers <u>stress concentration</u> (1)	**4x1**
(e) i	**<u>Edge dislocation</u>** <u>Edge</u> (dislocation) (1)	**1x1**
(e) ii	Horizontal line [on or] between third and fourth rows (1)	**1x1**
(e) iii	Bonds beak and reform / rows slide past each other (1) Bonds break one at a time (1) Less force required (compared to breaking plane of bonds) (1)	**3x1**
(f) i	**<u>Elastomer</u>** Hysteresis (1)	**1x1**
(f) ii	Energy gained related to area under graph (1) Difference in areas / loop area = energy gained on impact (1)	**2x1**
		32

Topic C - Nuclear and Particle Physics

Question Number	Answer	Mark
3 (a)	**<u>Particle classification</u>** Neutron: baryon and hadron (1) Neutrino: lepton (1) Muon: lepton (1)	**3x1**
(b) i	**<u>Decay series</u>** 8 decays (1) (238 – 206) ÷ 4 [Correct maths with 238, 206, 4] (1)	**2x1**
(b) ii	**<u>Thorium decay series</u>** $^{234}_{90}\text{Th} \longrightarrow {}^{234}_{91}\text{Pa} + {}^{0}_{-1}\beta + \bar{\nu}$ Th $\longrightarrow$ Pa + β (1) 234, 90, 234, 91, 0, -1 (1) antineutrino [accept symbol; ignore gamma / energy; do not accept any contradiction] (1)	**3x1**
(b) iii	Neutron turns into a proton [accept down quark turns into up quark; words required; ignore beta] (1)	**1x1**
(b) iv	234 AND 92 / U / uranium (1) Uranium-234 / $^{234}_{(92)}\text{U}$ (1)	**2x1**
(c) i	**<u>Binding energy</u>** Energy required to separate a nucleus into nucleons (1)	**1x1**
(c) ii	8n + 6p (1) Substitution / *m* = 0.1098 u (1) Multiply by 930 [only, or $E = m c^2$ route] (1) 102 MeV [or 103 MeV] (1) Δm = (6 x 1.007 28 u) + (8 x 1.008 67 u) - 14.003 24 u = 0.1098 u ΔE = 0.1098 u x 930 MeV/u = 102 MeV	**4x1**

(c) iii	**More stable isotope** Binding energy per nucleon attempted (1) 7.4 (MeV) and 7.3 (MeV) [accept 7.1, ecf] (1) Hence carbon-12 [based on two values, ecf] (1) BE / *A* (^{14}C) = 102 MeV / 14 = 7.3 MeV BE / *A* (^{12}C) = 89 MeV / 12 = 7.4 MeV	**3x1**
(d) i	**Deuterium** Up and down quarks [accept u and d quarks] (1) One proton = uud AND one neutron = udd (1) [contradiction, e.g. electron: max 1/2 if otherwise all correct]	**2x1**
(d) ii	**Fundamental forces** Quality of written communication (1) Weak force affect **all** particles / matter (1) Strong force only affect quarks (1) Electromagnetic force affects charged particles / charges (1) Weak only [supported by reference to neutrino] (1)	**5x1**
(d) iii	Z^0 [accept just Z, e.c.f. for strong: gluon or em:photon] (1)	**1x1**
(e) i	**Conservation laws** First reaction, Q: 0 + 0 ≠ 1 + 1 (1) Second reaction B: 1 = 1 + 0 AND Q: -1 = -1 + 0 (1) Hence only Ω^- decay possible [based on B and Q conservation for this decay, accept simple ticks and crosses] (1)	**3x1**
(e) ii	**Quark charges** Use of sss = -1 to show s = -⅓ (1) Hence correct working (from baryons) to show u = ⅔ and d = -⅓ (1)	**2x1**
		32

Topic D - Medical Physics

Question Number	Answer	Mark
4(a)	**Imaging techniques** X-ray: Ionising only (1) Nuclear medicine: Ionising & injected [**ignore** soft tissue] (1) Ultrasound: transducer & soft tissue (1)	**3x1**
(b) i	**X-rays for radiotherapy** (1 – 25) MeV (1)	**1x1**
(b) ii	Labelled [x3] diagram showing patient, tumour and at least three beam positions [or equivalent labels] (1) Tumour always targeted [accept as label in diagram] (1) Healthy cells receive lower dose (1)	**3x1**
(b) iii	**High energy X-rays** **Absorption** not dependent on proton number (1) (Have enough energy to) destroy / kill cells [not just damage](1)	**2x1**
(b) iv	**Criticality of dose** Too high: extra radiation could kill [harm] patient / healthy cells (1) Too low: tumour cells may not be completely destroyed (1)	**2x1**
(c) **i**	**Liver ultrasound calculations** Use of $x = v\,t$ with metres [0.12 or 0.24] (1) 1.6×10^{-4} s / 0.16 (ms) (1) $t = x / v$ $= 2 \times 0.12$ m / 1500 m s^{-1} $= 0.16$ ms	**2x1**
ii	Use of $f = 1 \div T$ [$= 1 / 1.6 \times 10^{-4}$ s] (1) 6250 Hz [accept 5000 Hz] (1)	**2x1**
iii	$1500 \div 3 \times 10^{6}$ seen (1) $\lambda = v / f$ $= 1500 \div 3 \times 10^{6}$ $= 5 \times 10^{-4}$ m	**1x1**

(c) iv	**Frequency and Imaging depth** Quality of written communication (1) Higher frequency implies lower wavelength (1) (Smaller wavelength) gives better resolution / detail (1) More attenuation / less penetration with higher frequency (1)	**4x1**
(d)	**Gamma camera diagram** 1 = (Lead) collimator (1) only transmits γ-rays at right angles to patient (1) 2 = Scintillation (crystal) / NaI scintillator [may be in function box] (1) Gives off light / photons / scintillates (when struck by γ-rays) (1) 3 = photomultiplier (tubes) (1) to amplify number of / multiply electrons / current (1)	**6x1**
(e) i	**Tellurium nuclear equations** $^{131}_{52}\text{Te} \longrightarrow {}^{131}_{53}\text{I} + {}^{0}_{-1}\beta$ Te → I + β [accept e, ignore (anti)neutrino, gamma, Q] (1) 131, 52, 131, 53, 0, -1 AND numbers balance (1)	**2x1**
(e) ii	$^{130}_{52}\text{Te} + {}^{1}_{0}\text{n} \longrightarrow {}^{131}_{52}\text{Te}$ (1)	**1x1**
(e) **iii** **iv**	**Half-life definition and calculation** Time taken for activity (or amount of nuclide) to half due to excretion / biological processes (1) Correct substitution (1) 8.0 days [accept 8 or 8.013] (1) $1/t_r = 1/t_e - 1/t_b$ $= (1 / 5.8 \text{ days}) - (1 / 21 \text{ days})$ $t_r = 8.0$ days	 **1x1** **2x1**
		32

6733/02 Practical Test PHY3

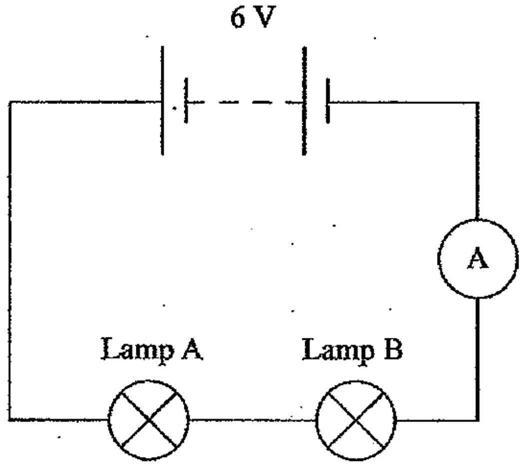
Group 1

Leave blank

Question 1A

(a) (i) Set up the circuit as shown in the diagram below. Note at this stage the voltmeter with which you have been provided is not used.

Before you connect your circuit to the power supply, have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit, the Supervisor will set it up for you. You will only lose two marks for this.



Ignore lamps reversed, but answers must be consistent throughout

Circuit set up correctly without help. **(2)** 2.

(ii) Connect the power supply and measure the current I in the circuit.

I = 0.055 A. | I to 1mA or better between 50mA and 65mA with unit **(1)** 1

(Allow centre value if low voltage supply)

(iii) Observe lamps A and B. State and explain your observations.

Lamp B is brighter than lamp A | (1) Must be comparison. Not allow lamp A not working.

Temperature of lamp B must be greater than temperature of lamp A. | (1)

Or Power / Voltage / Resistance greater for B. **(2)** 2.

(iv) Use the voltmeter to measure the potential difference V_A across lamp A and then the potential difference V_B across lamp B. If you do not know how to connect the voltmeter into the circuit, ask the Supervisor for assistance. You will only lose one mark for this.

V_A = 0.22 V | Both measured to 0.01V or better with unit (1)

V_B = 5.66 V. | $V_B >> V_A$ with

$5.0V \leq V_A + V_B \leq 6.5V$ (1)

Disconnect the power supply.

No indication that Supervisor gave help (1) 3

N 3 1 2 0 2 A 0 2 1 2

Leave blank

The normal operating voltage of both lamps is 6 V. Explain the relevance of your values of V_A and V_B to your observations in (iii).

Comment on V_B related to the brightness of B (1)

Comment on V_A related to the brightness of A (1)

$V_B \gg V_A$ or $R_B \gg R_A$ stated after calculation or $P_B \gg P_A$ stated after calc. or V_B at operating voltage, V_A not. (1)

Current is the same in both lamps seen here or in (a)(iii) or in calculations (1)

Max (3)

(6) 3

(b) (i) You have been provided with an inclined runway. Determine the time t taken for the sphere to travel a distance x of 0.800 m down the runway.

t = 1.41, 1.41, 1.41, 1.38, 1.43 s

$\bar{t}$ = 1.41 s

Sensible t from ≥ 3 results + unit (2) [0.5 s to 2.5 s]

[2 results (1)]

All readings to nearest second or systematic error e.g. 0.0141 s or 1 reading 0 marks.

More than ½ readings to 0.1 s or better else −1

(2) 2

(ii) The final speed v of the sphere at the end of the distance x is given by $v = \frac{2x}{t}$. Calculate v.

$v = \frac{2 \times 0.8}{1.41}$

$= 1.13$ m/s

Correct calc. ≥ 2 s.f. + unit (1)

(1) 1

(iii) Use the top pan balance to measure the mass m of the sphere. Hence find the linear kinetic energy of the sphere after travelling 0.800 m down the runway.

Mass = 4.78 g

K.E. = $\frac{1}{2} \times 4.78 \times 10^{-3} \times 1.13^2$

$= 3.05 \times 10^{-3}$ J

Use of $\frac{1}{2}mv^2$ (1)

Correct calc ≥ 2 s.f. + unit (1)

J or $kg \cdot m^2 s^{-2}$

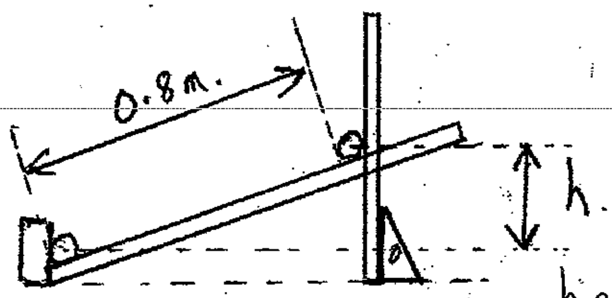
(2) 2

N31202A0312

Turn over

Leave blank

(iv) In the space below draw a diagram of the inclined runway. Show carefully on your diagram the vertical height h through which the sphere moved when it travelled a distance of 0.800 m down the runway.



Correct diagram with runway of finite thickness (1) and 0.8m or 2 sphere positions hence h shown correctly (1)

Determine the height h. State any techniques you used to obtain an accurate value for h.

h = 10.2cm

h recorded to nearest mm or better with unit (1) in range 5.0cm to 15.0cm.

Vertical rule checked with set square / Eye level with reading (1)

Can be scored from diagram but allow statement.

Hence find the gravitational potential energy lost by the sphere as it moved down the runway.

$mgh = 4.78 \times 10^{-3} \times 9.81 \times 0.102$
$= 4.78 \times 10^{-3}$ J.

Correct calc $\geq$ 2s.f. + unit (1)

5

e.c.f. mass conversion and unit error. Allow $g = 10$ N.kg^{-1}

N31202A0412

Leave blank

(v) Calculate the value of $\frac{\text{Kinetic energy gained by the sphere}}{\text{Gravitational potential energy lost}}$.

$3.05 \times 10^{-3} / 4.78 \times 10^{-3}$

$= 0.64$

Value with no unit. 0.60 → 0.80 (2)

[0.50 → 0.90 (1)]

Value must be obtained from correct calculations

Calculate the percentage difference between your value of this ratio and the theoretical value which is 0.71.

$\% \text{ diff} = \frac{0.64 - 0.71}{0.71} \times 100\%$

$= 9.9\%$

Correct calc with 0.71 as denominator (1)

3

(3)

Q1A 24

(Total 24 marks)

N 3 1 2 0 2 A 0 5 1 2

Leave blank

Question 1B

(a) Many modern road bridges have a single pillar from which the bridge is suspended. You are to investigate a model of this arrangement using the extension of a spring to measure the force.

An identical spring to the one used in the experimental arrangement must first be calibrated. Measure the unstretched length l of the coiled part of the vertically suspended spring.

l = 47.3 − 45.0 = 2.3 cm

l recorded to nearest mm or better and in range 1.6 cm to 2.6 cm with unit. (1)

Add the 100 g mass hanger to the spring and determine the extension x of the spring. Add further 100 g masses and determine the corresponding extensions.

The force F extending the spring is given by:

$$F = mg$$

where m = total mass suspended from the spring and g = gravitational field strength.

Use the table below for your results. The force F has been calculated for you. You may use the additional column to assist in the recording of your results.

m/kg	F/N	Position of lowest point /cm	x/mm
0.00	0.00	45.0	0
0.10	0.98	42.4	26
0.20	1.96	38.7	63
0.30	2.94	35.1	99
0.40	3.92	31.6	134
0.50	4.91	28.0	170

(4) 4

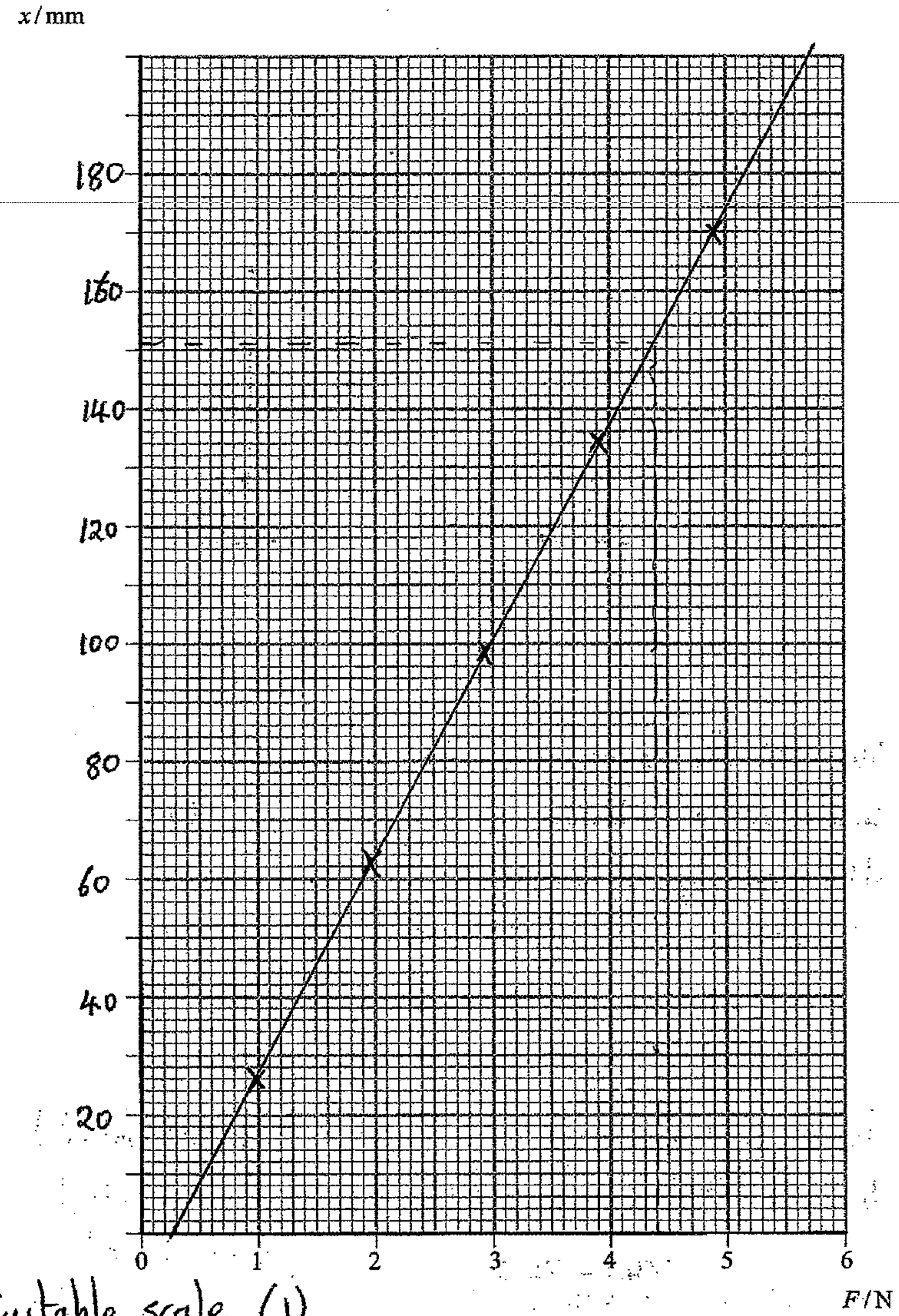
(b) Using the grid on page 7 plot a graph of x against F.

(2) 2

Scale readings shown (1) or length.
5 correct points ± 4mm from examiners best-fit straight line (2) [Ignore 0, 0]
[4 points .... (1)]

M 3 1 2 0 2 A 0 6 1 2

Leave blank



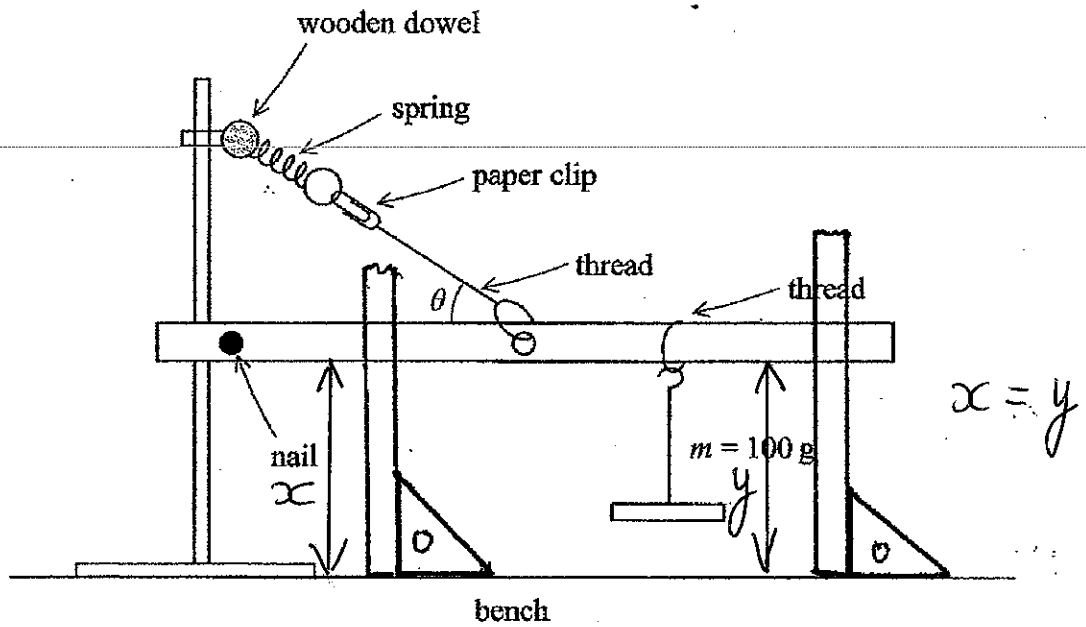
Suitable scale (1)
Plots and line (1)

N 3 1 2 0 2 A 0 7 1 2

Turn over

Leave blank

(c) The apparatus shown in the diagram below has already been set up for you. Move the mass $M = 100$ g so that it is suspended from the 90.0 cm mark on the rule.



Adjust the height of the boss holding the wooden dowel until the metre rule is horizontal. Explain how you ensured that the metre rule was horizontal. You may add to the above diagram if you wish.

Measured the height above the bench at 2 places. (1)

Used set square as shown to check metre rule vertical (1)

[If not shown on diagram, very clear description of use of set square must be given] **(2)**

2

(d) Measure the height h_1 of the centre of the nail above the bench and the height h_2 of the centre of the dowel above the bench. Hence calculate the angle θ between the metre rule and the thread.

$h_1 = 345$ mm

$h_2 = \frac{1}{2}(747+735) = 741$ mm.

$\tan\theta = \frac{741-345}{400}$

$= 0.99$

$\theta = 44.6°$

400 ← 390mm to 410mm.

heights recorded to the nearest mm with units seen once (1)

Correct calc of θ ≥ 2 s.f. + unit (1) with base length in range 390mm to 410mm.

2

Note candidates may $\sin\theta$ by measuring hypotenuse.

N 3 1 2 0 2 A 0 8 1 2

Leave blank

(e) Measure the stretched length s of the coiled part of the spring. Using your value of l from part (a) determine the extension e of the spring.

$s =$ 174 mm.

$e =$ 174 − 23 = 151 mm.

S recorded to the nearest mm or better in the range 140 mm to 240 mm (1)

e calculated correctly with unit seen somewhere. (1)

Using the calibration graph from part (b) determine the tension T in the spring.

$T =$ 4.4 N.

Force read off graph correctly with unit within ½ square of candidates line. (1)

(3) 3

(f) When the rule is horizontal and in equilibrium, the following equation applies:

$$T \sin \theta = g \left(\frac{q}{p}\right) M + W \quad \text{where}$$

p = distance from the centre of the nail to the centre of mass of the rule, which may be assumed to be at the 50.0 cm mark,

q = distance from the centre of the nail to the position on the rule from which mass M is suspended,

W = weight of the metre rule.

Determine p and q and use the information from parts (d) and (e) to calculate W.

$p = 40.0$ cm.

$q = 80.0$ cm.

$W = T\sin\theta - Mg\left(\frac{q}{p}\right)$

$= 4.4 \sin(44.6) - 0.1 \times 9.81 \times \left(\frac{0.8}{0.4}\right)$

$= 3.09 - 1.96$

$= 1.13$ N.

p and q correct with q 0.790 m to 0.810 m and p 0.390 m to 0.410 m (1)

substitution (1) Allow e.c.f. p, q, T and θ.

Correct calc of W to 2/3 s.f. + unit (1)

(3) 3

N 3 1 2 0 2 A 0 9 1 2

Turn over

Leave blank

(g) A student wishes to investigate how $T\sin\theta$ depends on the mass suspended from the rule at the 90.0 cm mark. You are to plan this investigation. Your plan should include:

(i) an indication of the values in the equation which are constant,

(ii) a description of how the experiment would be performed,

(iii) a sketch of the graph to be plotted,

(iv) an indication of the expected results.

i) (p) q, (W and g) are constant (1)
[Not T or θ]

ii) Vary M. (1)

Move dowel or nail (1)

Measure/Determine θ (1)

Measure / Determine extension (1) } Max (3)

Force determined (1)
[Use newton meter]

Allow e.c.f. wrong experiment

iii) Plot $T\sin\theta$ against M. (1) Plot $T\sin\theta$ against q.
[or Plot M against $T\sin\theta$ (1)]

iv) Straight line +VE intercept (1)

Slope = $g(q/p)$, Intercept = W. (1) Slope = $\frac{Mg}{p}$ Intercept = W

→ straight line −VE intercept (1)

(8)

Q1B 24

(Total 24 marks)

slope = $\frac{p}{qg}$, Intercept = $-\frac{Wp}{qg}$

TOTAL FOR PAPER: 48 MARKS

END

N 3 1 2 0 2 A 0 1 0 1 2

6733/02 Practical Test PHY3

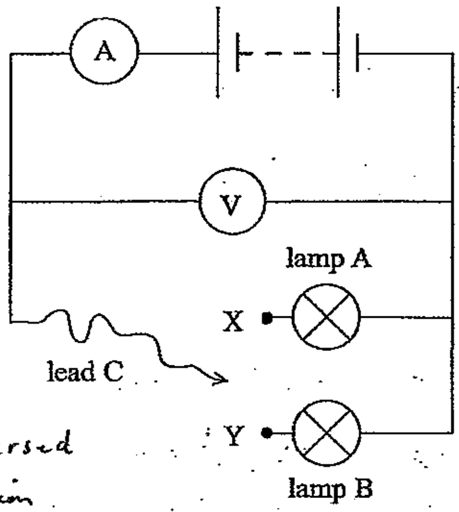
Group 2

Leave blank

Question 2A

(a) (i) Set up the circuit as shown in the diagram below. Note that the lead C is to be connected to the lamps A and B in turn.

Before you connect the battery to the circuit have your circuit checked by the Supervisor. You will be allowed a short time to correct any faults. If you are unable to set up the circuit, the Supervisor will set it up for you. You will only lose two marks for this.



• Ignore lamps reversed
• Systematic/Conversion errors (−1) once, then ecf.

Circuit set up correctly without help.

(2) 2

(ii) Connect the battery. Then connect lead C to lamp A. Measure the current I_A in the circuit and the potential difference V_A across the lamp.

I_A = 0.265 A

V_A = 5.43 V

I_A 0.25 → 0.30 A (when rounded) measured to 1 mA or better + unit (1)
V_A 5.0 → 6.5 V measured to 0.01 V or better + unit (1)

(Penalise unit, then precision, then range)

(2) 2

(iii) Connect lead C to lamp B. Measure the current I_B in the circuit and the potential difference V_B across the lamp.

I_B = 0.056 A

V_B = 5.76 V

I_B 50 → 68 mA measured to 1 mA or better + unit (1)
Sensible $V_B > V_A$ and measured to 0.01 V or better + unit (1)

[Apply unit of I penalty, once only. Apply unit of V penalty once only]

(2) 2

(iv) Leaving lead C connected to lamp B, connect the spare lead between points X and Y so that the lamps are in parallel. Measure the current I_T in the circuit and the potential difference V_T across the lamps.

I_T = 0.317 A

V_T = 5.40 V

$I_T < (I_A + I_B)$ measured to 1 mA or better + unit. (1)
Sensible $V_T < V_A$ measured to 0.01 V or better + unit (1)

(2) 2

[Watch out for centres with meters on 10 A range giving currents to 0.01 A only]

Disconnect the battery.

N 3 1 2 0 3 A 0 3 1 2

Turn over

Leave blank

(v) Comment on the relationship between

1. I_A, I_B and I_T

(Expect) $I_T = I_A + I_B$ (1)

$I_A + I_B = 0.265 + 0.056 = 0.321$ A

$I_T = 0.317$ A $< (I_A + I_B)$ (1) Sensible comparison.

2. V_A, V_B and V_T.

(Expect) $V_A = V_B = V_T$ (1)

But $V_B > V_A > V_T$ (1) Sensible comparison.

Discuss, from the evidence of your results, whether the battery has a significant internal resistance.

The greater the current drawn from the cell the smaller the p.d. between the terminals (1)

Hence cell has significant internal resistance. (1)

(6) 6

(b) (i) You have been provided with an inclined runway. Determine the time t taken for the sphere to travel a distance x of 0.800 m down the runway.

$t = 1.41, 1.41, 1.41, 1.38, 1.43$ s

$\bar{t} = 1.41$ s

Sensible t from ≥ 3 results (0.5 to 2.5 s) + unit (2)

[2 results -- (1)]

[If all readings to whole seconds — NO MARKS. ≥ half the readings to 0.01 s or better, else (−1)]

(2) 2

(ii) The linear acceleration a of the sphere down the runway is given by $a = \frac{2x}{t^2}$.

Calculate a.

$a = \frac{2 \times 0.8}{1.41^2}$

$= 0.805$ m s^{-2}

Correct calc ≥ 2 s.f. + unit (1)

(1) 1

[If t given as 0.0141 s — systematic error −2]

N 3 1 2 0 3 A 0 4 1 2

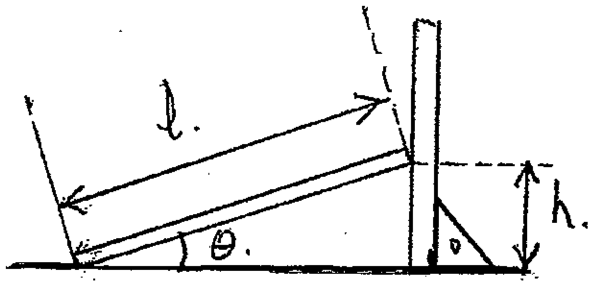
Leave blank

(iii) The theoretical acceleration of an object that is sliding down a runway is given by $g\sin\theta$, where

g = acceleration of freefall and

θ = the angle between the runway and the bench.

In the space below draw a diagram of the inclined runway. Show θ carefully on your diagram.



Hence correct θ shown } with

Correct diagram with runway of finite thickness on a bench (1)

correct corresponding l and h. (1)

Take such measurements as are necessary to determine $\sin\theta$. Show these measurements on your diagram. State any techniques you used to obtain an accurate value for $\sin\theta$.

l = 1.20 m.

h = 15.3 cm

Vertical rule checked with set square

Eye level with reading / Measurements at end of runway

CAN BE SHOWN ON DIAGRAM

h recorded to the nearest mm or better with unit, h ≥ 5 cm (1)

(1)

Hence calculate $g\sin\theta$.

$9.81 \times \frac{0.153}{1.2}$

= 1.25 m s^{-2}

ACCEPT g = 9.8 or 10.

Correct calc ≥ 2s.f. + unit (1)

(ecf from (ii) on unit) (5)

5

(iv) Calculate the value of $\frac{a}{g\sin\theta}$.

$\frac{0.805}{1.25}$

= 0.644

Value 0.60 → 0.80 (2)

[0.50 → 0.90 (1)]

If unit given (-1)

No ecf on value

(2)

2

Q2A

24

(Total 24 marks)

N 3 1 2 0 3 A 0 5 1 2

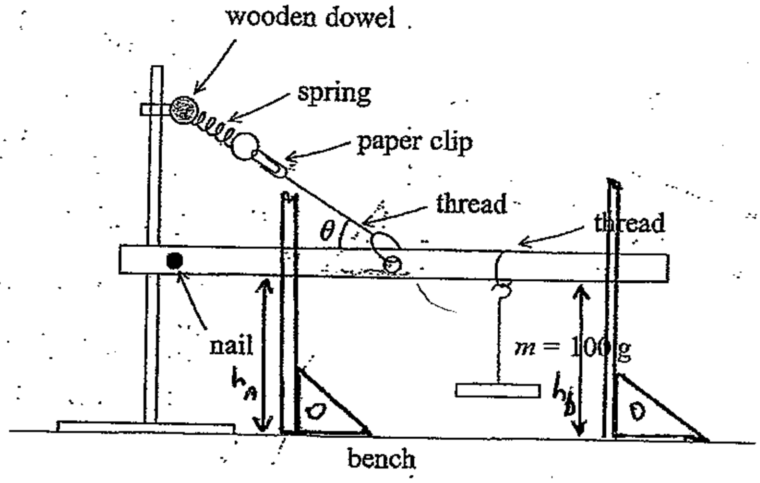
Turn over

Leave blank

Question 2B

(a) Many modern road bridges have a single pillar from which the bridge is suspended. You are to investigate a model of this arrangement using the extension of a spring to measure the force.

The apparatus shown in the diagram below has already been set up for you.



Move the mass m = 100 g so that it is suspended from the 90.0 cm mark on the rule.

Adjust the height of the boss holding the wooden dowel until the metre rule is horizontal. Explain how you ensured that the metre rule was horizontal. You may add to the above diagram if you wish.

Measure the height above the bench at two places, $h_A = h_B$ (1)

Used set square as shown to check that the metre rule is vertical (1)

(2) 2

(b) Measure the height h_1 of the centre of the nail above the bench and the height h_2 of the centre of the dowel above the bench. Hence calculate the angle θ between the horizontal metre rule and the thread.

h_1 = 345 mm.

$h_2 = \frac{1}{2}(747 + 735) = 741$ mm.

$\tan\theta = \frac{741 - 345}{400} = 0.99$

$\theta = 44.6°$

Allow use of $\sin\theta$.

heights recorded to nearest mm with units seen once (1)

Correct calc. of θ, ≥ 2s.f. + unit (1)

(Accept 390 to 410 mm NOT 500 mm)

(2) 2.

N 3 1 2 0 3 A 0 6 1 2

Leave blank

(c) You have been provided with a spring which is identical to the one in the experimental arrangement. Measure the unstretched length l of the coiled part of this spring.

$l =$ 23 mm.

l recorded to the nearest mm or better and in the range 1.6cm to 2.4cm (1)

Measure the stretched length s of the coiled part of the spring that is supporting the metre rule. Hence determine the extension e of the spring.

$s =$ 174 mm

$e =$ 174 − 23 = 151 mm.

s recorded to the nearest mm or better and in the region of 20 cm (1)

e calculated correctly with unit seen somewhere (1)

Calculate the tension T in the spring given that $T = ke$, where k = the spring constant $= 25\ \text{N m}^{-1}$ for this spring.

T = 25 × 0.151

= 3.78 N.

Correct calc of T to 2/3 s.f. + unit (1)

(4) 4

(d) When the rule is horizontal and in equilibrium, the following equation applies:

$$T\sin\theta = \frac{mgq}{p} + W \quad \text{where}$$

p = distance from the centre of the nail to the centre of mass of the rule, which may be assumed to be at the 50.0 cm mark,

q = distance from the centre of the nail to the position on the rule from which the mass m is suspended,

W = the weight of the metre rule.

Determine p and q and use the information from parts (b) and (c) to calculate W.

p = 40.0 cm (Accept 39.0 – 41.0)

q = 80.0 cm. (Accept 79.0 – 81.0) p and q correct (1)

W = T sin θ − Mgq/p

= 3.78 sin (44.6) − (0.1 × 9.81 × 0.8)/0.4

Correct substitution (1)

= 2.65 − 1.96

= 0.69 N.

Correct calc of W to 2/3 s.f. + unit (1)

(3) 3

N 3 1 2 0 3 A 0 7 1 2

Turn over

Leave blank

(e) Suspend the mass $m = 100$ g from the 70.0 cm mark on the rule and adjust the height of the boss holding the wooden dowel until the rule is horizontal. Repeat parts (b), (c) and (d) to obtain a second value of W.

$h_2 = \frac{1}{2}(720 + 707) = 714$ mm.

$h_1 = 345$ mm

$\tan\theta = \frac{714 - 345}{400} = 0.923.$

$\theta = 42.7°$

$s = 153$ mm.

$e = 153 - 23 = 130$ mm.

$T = 3.25$ N.

$p = 400$ mm, $q = 600$ mm.

$W = 3.25 \sin(42.7) - \frac{0.1 \times 9.81 \times 0.6}{0.4}$

$= 2.20 - 1.47$

$= 0.73$ N.

h_2 to nearest mm and < value in (b) (1)
(ecf on precision)

s to nearest mm and less than value in (c) (1)
(ecf on precision)

q 60.0 ± 1.0 cm (1)

W values same within ± 0.2 N (2)
[± 0.4 N (1)]

(5)

5

(f) Explain which of your values of W you consider to be the more accurate.

First value because all the measurements made are greater

(1)

(1)

1

N 3 1 2 0 3 A 0 8 1 2

Leave blank

(g) Using the equation $T\sin\theta = \frac{mgq}{p} + W$ a student wishes to investigate how $T\sin\theta$ depends on the distance of the 100 g mass from the nail. You are to plan this investigation. Your plan should include:

(i) an indication of the values in the equation which are constant,

(ii) a description of how the experiment would be performed,

(iii) a sketch of the graph to be plotted,

(iv) an indication of the expected results.

i) m, (g, p and W) are constant (1)

ii) Vary q. (or move mass along rule) (1)

Adjust the position of the nail, boss or dowel to make the rule horizontal. (1)

(Measure h_2 and h_1 to) determine θ (1)

(Measure the length of the stretched spring to) find the extension (1)

Calculate the tension (in the spring) (1)

} Max (2)

iii) Plot $T\sin\theta$ against q. (1)

iv) Straight line +VE intercept (1)

Slope = $\frac{mg}{p}$, Intercept = W. (1)

7

If wrong expt, (fix q vary M), they lose first two marks, can get marks in (ii) and allow ecf for graph in (iii) and (iv)

(7)

Q2B 24

(Total 24 marks)

TOTAL FOR PAPER: 48 MARKS

END

N 3 1 2 0 3 A 0 9 1 2

Question Number	Answer		Mark
1(a)(i)	Why speed is unchanged Force/Weight [not acceleration] is perpendicular to velocity/motion/direction of travel/instantaneous displacement [not speed] OR no component of force/weight in direction of velocity etc No work is done OR No acceleration in the **direction of motion**	✓ ✓	**2**
(a)(ii)	Why it accelerates Direction (of motion) is changing Acceleration linked to a change in velocity	✓ ✓	**2**
(b)	Speed of satellite Use of $a = v^2/r$ Correct answer [3.8 to 4.0 x 10^3 m s^{-1}] Example calculation: $v = \sqrt{}(2.7 \times 10^7 \text{ m} \times 0.56 \text{ m s}^{-2})$ [Allow 1 mark for $\omega = 1.4 \times 10^{-4}$ rad s^{-1}]	✓ ✓	**2**
			6

Question Number	Answer		Mark
2 (a)(i)	Demonstrating the stationary wave Move microphone between speaker and wall OR perpendicular to wall OR left to right OR towards the wall [could be shown by labelled arrow added to diagram] **Oscilloscope**/**trace** shows sequence of maxima and minima	✓ ✓	**2**
(a)(ii)	How nodes and antinodes are produced Superposition/combination/interference/overlapping/crossing of emitted/incident/initial and reflected waves Antinodes: waves (always) in phase OR reference to coincidence of two compressions/rarefactions/peaks/troughs /maxima/minima, hence constructive interference/reinforcement Nodes: waves (always) in antiphase/**exactly** out of phase OR compressions coincide with rarefactions etc, hence destructive interference / cancellation	✓ ✓ ✓	**3**
(a)(iii)	Measuring the speed of sound <u>Measure</u> separation between (adjacent) **nodes** / **antinodes** and double to get λ/this is ½λ [not between peaks and troughs] Frequency known from/produced by signal generator OR measured on CRO / by digital frequency meter Detail on measurement of wavelength OR frequency e.g. measure several [if a number is specified then ≥3] node spacings and divide by the number [not one several times] OR measure several (≥3) periods on CRO and divide by the number OR adjust cro so only one full wave on screen Use v (allow c) = $f\lambda$	✓ ✓ ✓ ✓	**4**
(b)(i)	Application to concert hall Little or no sound /amplitude OR you may be sat at a node	✓	
(b)(ii)	Sensible reason Examples: Reflected wave not as strong as incident wave OR walls are covered to reduce reflections OR waves arrive from elsewhere [reflections/different speakers] OR such positions depend on wavelength / frequency	✓	**2**
			11

Question Number	Answer		Mark
3 (a)(i)	Amplitude and frequency 0.17 m 0.8(3) Hz or s^{-1}	 ✓ ✓	 **2**
(a)(ii)	Maximum velocity Use of $v_{max} = 2\pi f x_0$ Correct answer Example calculation: v_{max} = 2π x 0.83 Hz x 0.17 m OR Use of maximum gradient of *h* versus *t* graph Answer to 2 sig fig minimum	 ✓ ✓ ✓ ✓	 **2**
(a)(iii)	Velocity-time graph Wave from origin, period 1.2 s Inverted sine wave with scale on velocity axis &initial peak value 0.9 m s^{-1}	 ✓ ✓	 **2**

(b)(i)	Definition of SHM Acceleration / resultant force proportional to displacement OR Acceleration / resultant force proportional to distance from a fixed point [not just distance from equilibrium but 'distance from equilibrium position' is acceptable] OR *a* = (-) constant x *x* [with *a* and *x* defined] OR *F* = (-) constant x *x* [with *F* and *x* defined] Acceleration /resultant force directed towards the fixed point / in opposite direction (to displacement) OR negative sign in equation explained [e.g *a* and *x* in opposite directions]	✓ ✓	**2**
(b)(ii)	Verifying SHM Read off *h* value and use it to get displacement [only penalise the first mark if *h* used for displacement throughout] Plot acceleration-displacement graph OR calculate ratios eg *a*÷*x* Straight line through the origin OR check ratios to see if constant Negative gradient / observe acceleration and displacement have opposite signs OR constant is negative OR Use $x = x_o\cos(2\pi ft)$ for a range of *t* OR Read off *h* and get *x* Use values of x_o and *f* from part (a) OR Use $a=-(2\pi f)^2x$ for range of *x* Add equilibrium value to *x* to get *h* OR Use value of *f* from part (a) If results agree with values of *h* (or *a*) from graph it is SHM	✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓	**4**
			12

Question Number	Answer		Mark
4	Identification of graphs C B E D	✓ ✓ ✓ ✓	**4**
			4

Question Number	Answer		Mark
5(a)(i)	Line B Knot T at 2.4 m [±½ small square, no label needed]	 ✓	
(a)(ii)	Knots Q, R, S at 0.6, 1.2, 1.8 m [±½ small square, no labels needed] [ecf from wrong position of knot T i.e. Q at ¼T, R at ½T & R at ¾T]	✓	**2**
(b)	How model represents the Universe and its behaviour Knots/letters/points represent <u>galaxies</u> Reference to expansion of Universe / galaxies moving apart [NOT galaxies move away and stay same distance apart]	 ✓ ✓	 **2**
(c)	How model illustrates Hubble's law Stating or showing velocities are different for 2 of the knots [Shown by either calculating speeds or comparing distances moved between diagrams A and B] Calculation of velocity for at least 2 of the knots [other than T] Use of their data to show speed (of knot) $\propto$ distance (from P) Examples: determine values of $v \div d$ [allow $v \div \Delta d$] sketch graph of v against d [allow v against Δd]	 ✓ ✓ ✓	 **3**
(d)	Defects of the model Any 2 sensible points Examples: Galaxies are not evenly spaced Initial spacing of knots is not zero No force pulling galaxies/Universe apart Rate of expansion of Universe OR speed of galaxies increasing/ not constant [not speed decreasing] Relative sizes of knot and spacing are unrealistic Universe is 3 dimensional/galaxies are not in a straight line	 ✓✓	 **2**
			9

Question Number	Answer		Mark
6(a)	Meaning of statement (5.89×10^{-19} J / work function) is the energy needed to remove an electron [allow electrons] from the (magnesium) surface/plate **Consequent mark** **Minimum** energy stated or indicated in some way [e.g. at least /or more]	✓ ✓	**2**
(b)(i)	Calculation of time Use of $P = IA$ Use of $E = Pt$ [use of $E = IAt$ scores both marks] Correct answer [210 (s), 2 sig fig minimum, no u.e.] [Reverse argument for calculation leading to either intensity, energy or area gets maximum 2 marks] Example calculation: $t = (5.89 \times 10^{-19}\ \text{J})/(0.035\ \text{W m}^{-2} \times 8 \times 10^{-20}\ \text{m}^2)$	✓ ✓ ✓	**3**
(b)(ii)	How wave-particle duality explains immediate photoemission QOWC Photon energy is *hf* / depends on frequency / depends on wavelength **One/Each** photon ejects **one/an** electron The (photo)electron is ejected **at once/immediately** [not just 'photoemission is immediate']	✓ ✓ ✓ ✓	**4**
			9

Question Number	Answer		Mark
7(a)(i)	Length of pendulum Substitution of T and g into a correct form of $T = 2\pi\sqrt{(l/g)}$ Correct answer [1 m (0.99 m to 1.01 m depending on value g used)] [note: need to check method as an incorrect rearrangement can also lead to a value of 1.01] Example calculation: $l = 9.81 \text{ m s}^{-2} \times (2.00 \text{ s}/2\pi)^2$	✓ ✓	2
(a)(ii)	Reason for variation in period ***l* varies** with temperature OR ***g* varies** from place to place/with altitude [ignore references to angle of swing as 'small amplitude' in stem]	✓	1
(a)(iii)	Mass-spring system Appropriate conclusion linked with relevant statement about what affects/doesn't affect either m or k Examples: No, mass/m doesn't change Yes, mass changes plus a valid reason No, spring constant/stiffness/k doesn't change Yes, spring constant/stiffness/k changes e.g. with temperature/age No, independent of g	✓	1
(b)(i)	Calculation of wavelength Correct answer [32.6 (mm), 3 sig fig minimum, no u.e.] Example calculation: $\lambda = (3.00 \times 10^8 \text{ m s-1})/(9.19 \times 10^9 \text{ Hz})$	✓	1
(b)(ii)	Part of spectrum Microwaves	✓	1
(b)(iii)	Energy level spacing Use of $\Delta E = hf$ or hc/λ [**If unexpected λ send response to review**] Dividing their ΔE by 1.6×10^{-19} Correct answer [3.8×10^{-5} (eV), no u.e.] Example calculation: $\Delta E = (6.63 \times 10^{-34} \text{ J s}) \times (9.19 \times 10^9 \text{ Hz})/(1.60 \times 10^{-19} \text{ J eV}^{-1})$	✓ ✓ ✓	3
			9
	Total for paper		**60**

Question Number	Answer	Mark
1 (a) (i) **(ii)**	GM_S/R^2 GM_E/r^2 } *(symbols **must** be as given in the Q, though allow lower case m)* (1)	**1**
(b) (i)	Evidence of equating of GM_S/R^2 and GM_E/r^2 (ecf from part a) (1) Correct answer 570 - 580 (1) Example of answer: $\frac{GM_S}{R^2} = \frac{GM_E}{r^2} \quad \rightarrow \quad \frac{M_S}{R^2} = \frac{M_E}{r^2} \quad \rightarrow \quad \frac{R^2}{r^2} = \frac{M_S}{M_E}$ $\therefore \frac{R}{r} = \sqrt{\frac{M_S}{M_E}} = \sqrt{\frac{2.0\times10^{30}\ \text{kg}}{6.0\times10^{24}\ \text{kg}}} = \sqrt{3.33\times10^5} = 577$	**2**
(ii)	1.5 x 10^8 km x 1/601 [ignore powers of 10 in distance value] (1) **Correct** answer 2.5 - 2.6 x 10^5 km (or 2.5 - 2.6 x 10^8 m) (1)	**2**
(c)	Letter L on or against line to left of point P (coming within one Earth radius of dotted line) (1) <u>Reason*</u>: [*Consequent marks; allow **only** if L position correct or not shown] Reference to centripetal force/centripetal acceleration/ (net) force towards Sun (1) Force due to Sun must be > force due to Earth (1)	**3**
		8

Question Number	Answer	Mark
2 (a) (i)	$W = QV$ (1) Correct answer 3.2 nJ [3.2 x 10^{-9}J, etc.] (1) Example of answer: $W = QV = 0.8 \times 10^{-9}\ \text{C} \times 4.0\ \text{V} = 3.2 \times 10^{-9}\ \text{J}$	**2**
(ii)	+0.8 (nC) on top plate **and** -0.8 (nC) on bottom plate (1) (**both** needed)	**1**
(b)	Statement (E =) 'Area' **or** (E =) ½ Q*V* (1) See calculation ½ x 4.0 x 0.8 **or** ½ x base x height (1) **OR** C found from graph (1) Use of W = ½ CV^2 (1) Example of answer: $C = \frac{Q}{V} = \frac{0.8 \times 10^{-9}\ \text{C}}{4.0\ \text{V}} = 2.0 \times 10^{-10}\ \text{F}$ $\therefore W = ½CV^2 = \frac{2.0 \times 10^{-10}\ \text{F} \times (4.0\ \text{V})2}{2} = 1.6 \times 10^{-9}\ \text{J}$	**2**
(c) (i)	Correct answer 0.2 nC (1)	**1**
(ii)	Graph is straight and through origin (1) ends at 3.0V and their Q (1)	**2**
(iii)	Attempt to **use** *C* = *Q*/*V* or *C* = Δ*Q*/Δ*V* (1) Correct answer 0.067 nF / 67 pF (1) Example of answer: $C = \frac{Q}{V} = \frac{0.2 \times 10^{-9}\ \text{C}}{3.0\ \text{V}} = 6.7x10^{-11}\ \text{F}$	**2**
		10

Question Number	Answer	Mark
3 (a)	**<u>Either</u>:** (manipulating units of both sides) **Any** valid unit given for *B* (1) Valid unit given for *n* (1) Demonstration of equivalence of LHS and RHS (1) **<u>Or</u>:** (taking units of RHS and showing equivalence to units of B) Valid unit given for *n* (1) Unit of RHS simplified to N A^{-1} m^{-1} or base unit equivalent (1) Justification that N A^{-1} m^{-1} is unit of B, via e.g. B = F/Il or some other valid relationship (1) Example of answer: $[B] = [F/Il]$ = N A^{-1} m^{-1} $[\mu_o nI]$ = (N A^{-2}) (m^{-1}) A = N A^{-1} m^{-1} = $[B]$ [Brackets not required. Allow e.g. 'F = N', 'n = m^{-1}', 'I = A', etc.]	3
(b)	$n = 1/50$ (x 10^{-6}) **or** $n = 2$ (x 10^4) (1) [NB If B = $\mu_o I/2\pi r$ used, score 0/2] Correct answer 0.010 T (1) Example of answer: $B = \mu_o nI = 4\pi \times 10^{-7}\ \mathrm{N\,A^{-2}} \times \left(\frac{1}{50 \times 10^{-6}\ \mathrm{m}}\right) \times 0.40\ \mathrm{A} = 0.010\ \mathrm{T}$	2
(c) (i)	Currents have same direction for A and B, but opposite directions for C and D. (1)	1
(ii)	Graph curve for CD: Is mirror image of original in time axis (1) Uses only negative force values with amplitude 1.0 unit. (1)	2
		8

Question Number	Answer	Mark
4 (a) (i)	1.2 keV = $1.2 \times 10^3 \times 1.6 \times 10^{-19}$ J **OR** Use of $e\Delta V$ with e as 1.6×10^{-19} C and V as 1200 V (1) Use of $\Delta(\frac{1}{2}m_e v^2)$ with m_e as $9.1(1) \times 10^{-31}$ kg. (1) Correct answer 2.0 - 2.1 $\times 10^7$ ms^{-1} (1)	**3**
(ii)	1200 x 8/100 = 96 (eV delivered per electron) (1) 96/2.4 = 40 (1) **Or** 2.4 x 100/8 = 30 (incident eV needed per photon) (1) 1200/30 = 40 (1) **Or** 1200 / 2.4 = 500 (photons per electron, ideally) (1) 500 x (8/100) = 40 (1)	**2**
(b)	Electrons on screen repel electrons in beam / force opposes electron motion/decelerating force (1) Electrons (in beam) decelerated /slowed / velocity reduced/ work done by electrons (against force) (1) Electron (kinetic) energy reduced (not 'shared') (1) Fewer photons (per electron, stated or implied) (1) Trace less bright (1) QoWC (1) **Max 4**	**4**
		9

Question Number	Answer	Mark
5(a)	Scale interval is 0.1 (V) (1)	**1**
(b) (i)	**Use** of $\mathcal{E}$ = (-)$N\Delta\varphi/\Delta t$ (1) Correct answer 9.6 x 10^{-7} (Wb) / 0.96 (μWb) [ignore +/-] (1) Example of answer: $\Delta\phi = \varepsilon \times \frac{\Delta t}{N} = 0.12\text{ V} \times \frac{40\times10^{-3}\text{ s}}{5000} = 9.6\times10^{-7}\text{ Wb}$	**2**
(ii)	**Use** of 'φ' or '$\Delta\varphi$' or 'flux' = BA, or B = $\mathcal{E}$ Δt/NA (1) Correct answer 0.012 T / 0.013 T (1) Example of answer: $\varphi = BA$ $\therefore B = \frac{\varphi}{A} = \frac{9.6\times10^{-7}\text{ Wb}}{\pi\times\left(\frac{1.0\times10^{-2}\text{ m}}{2}\right)^2} = 0.012\text{ T}$ [N.B. φ = 0.96μWb → 0.012T, φ = 1μWb → 0.013T]	**2**
		5
	Total for paper	**40**

6735/02 Practical Test PHY5

Group 1

Leave blank

Question 1A

(a) (i) Suspend a total mass of 400 g from one of the springs. Give the mass a small vertical displacement and determine the period T_1 of the subsequent oscillations.

$20T_1$/s : 16.77, 16.73

T_1 = 0.838 s Whole secs or Not T (−2)

$\Sigma nT \geq 30$ for both T_1 & T_2 (2)

Seconds in all answers or (−1)

Put the mass of 400 g on the other spring and determine the period T_2 of vertical oscillations for this spring.

$20T_2$/s : 16.81, 16.76

T_2 = 0.839 s

[≥ 20 gets (1)]

Repeats for all T shown (1)

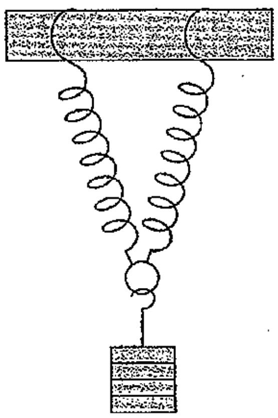
Calculate the average value T of the periods T_1 and T_2.

$T = \frac{0.838 + 0.839}{2}$ = 0.838 s

(3)

3

(ii) Hook the 400 g mass onto the loops of **both** springs as shown in the diagram below.



Correct calc^n. of T_p/T to 3 s.f. & no unit

allow 1:1.414 (1)

Determine the period T_p of vertical oscillations for this arrangement of springs.

$20T_p$/s : 12.05, 12.04

T_p = 0.602 s

In range 0.69 → 0.72

1.44 ← 1.39 (2)

Calculate the ratio T_p/T.

$\frac{T_p}{T} = \frac{0.602}{0.838}$ = 0.718

[0.67 → 0.74

1.48 ← 1.34 gets (1)]

(3)

3

N 3 1 1 9 6 A 0 2 1 6

Leave blank

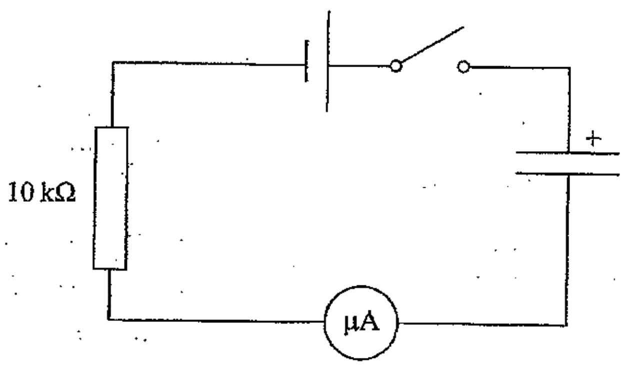
(iii) Theory predicts that for a parallel arrangement of identical springs $T_p/T = 1/\sqrt{2}$. Discuss the extent to which your results support this prediction.

$1/\sqrt{2} = 0.707$	$1/\sqrt{2}$ found $\geq$ 2SF (1)
% Difference = $\frac{0.718 - 0.707}{0.707} \times 100\%$ = 1.6%	% difference calculated with 0.707 as the denominator (1)
This is acceptable experimental error and so the results support the suggestion, particularly as the springs are not exactly parallel	Sensible comment based on % difference related to possible experimental error (1)

(3)

3

(b) (i) The circuit shown in the diagram below has been set up ready for you to use.



QUESTION 1A CONTINUES ON THE NEXT PAGE

Leave blank

Discharge the capacitor by connecting one of the spare leads across it. Now remove the lead.

Close the switch and determine the time t that it takes for the current in the circuit to fall from 100.0 μA to 36.8 μA. Open the switch when you have done this.

t/s : 11.22, 11.23 | t in range 8 → 15 s with unit (1) Better than whole sec

$\bar{t}$ = 11.2 s

Describe the procedure you adopted to make this timing as accurate as possible.

Discharged capacitor before each reading. | Repeat shown with for both mean (1) | Discharge C each time (1)

(3) 3

(ii) Connect the second capacitor **in parallel** with the capacitor in the circuit, making sure that its polarity is correct. When you have done this, you **must** ask the Supervisor to check your circuit before proceeding. If your circuit is not correct, the Supervisor will correct it for you. You will only lose 1 mark for this.

Follow the same procedure as before to determine the time t_p for the current to drop from 100.0 μA to 36.8 μA for the parallel arrangement of capacitors. Open the switch when you have done this.

No help with circuit anywhere (1)

t_p/s : 21.73, 21.62

$\bar{t}_p$ = 21.7 s

t_p/t correctly calculated and no (1) (≥ 2 sf) unit - ecf a)(ii)

Calculate the ratio t_p/t.

t_p/t = 21.7/11.2

= 1.94

In range 1.60 → 2.40 (2) [1.20 → 2.80 gets (1)]

(4) 4

(Total 16 marks) Q1A 16

N 3 1 1 9 6 A 0 4 1 6

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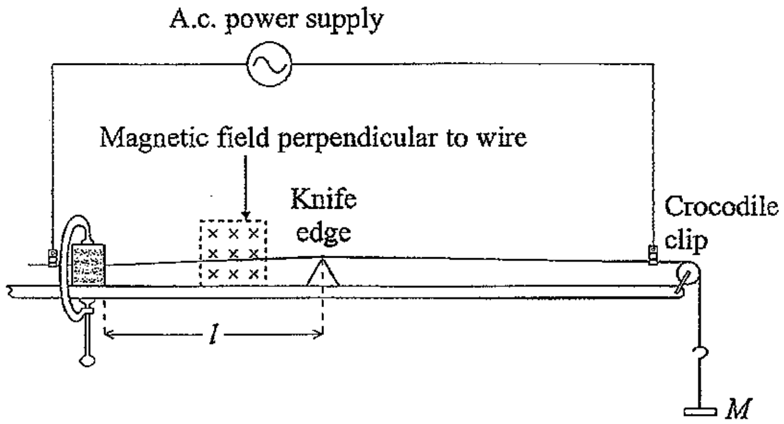
Question 1B

(a) (i) The apparatus has been set up for you as shown in the diagram with $M = 100$ g. For clarity the magnets have not been drawn.



When there is an alternating current in the wire the current passes through the magnetic field. This causes the section of the wire between the wooden blocks and the knife edge to oscillate up and down. Explain why this oscillation occurs.

• By Fleming's LHR, wire experiences a force perpendicular to the field.
• As the current is alternating, the force alternates, causing the wire to oscillate

Force perpendicular to field or vertical (1)
alternating current hence alternating force/field (1)

(2) 2

(ii) Switch on the power supply. Increase the length l until you can see that the amplitude of the vibration is at a maximum.

Determine, as accurately as possible, the length l_1 at which this resonance occurs.

l_1/cm : 44.3, 43.9, 44.0. $\bar{l}$ = 44.1 cm

± 2 cm of Supervisor (2)
[± 3 cm gets (1)]

Explain carefully how you ensured that your value for l_1 was as accurate as possible.

[(-1) if no unit seen]

• Approached resonance from both directions. (1)

• (1)

• viewing technique

Leave blank

Estimate the percentage uncertainty in your value for l_1.

$\Delta l = \pm 2$ mm (half spread)

% uncertainty = $\frac{2}{441} \times 100$ = 0.5 %

Range, ½ range provided > 1 mm (allow ≥ 2 mm from single reading.) and correct % calc^n. (1)

Use your value of l_1 to calculate the wavelength λ of the stationary (standing) wave.

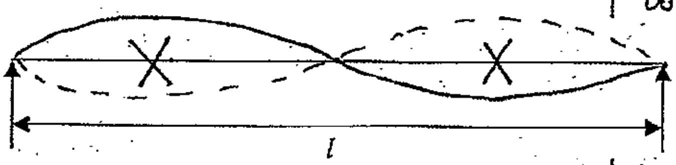
$\lambda = 2l_1$ = 2 × 44.1 cm

= 88.2 cm

$\lambda = 2l_1$ + unit (1)

(6) 6

(b) (i) If l is increased without changing the mass M a stationary wave with two antinodes can be formed. Draw below the shape of this oscillation.



Correct shape, with 2 antinodes and

X close to one of the antinodes (1)

On your sketch mark with an **X** where the magnet may be placed to produce the greatest effect.

both l_1 + l_2 repeated (1)

(ii) Increase l and adjust the position of the magnet until you can see that the amplitude of this mode of vibration is at a maximum. Determine an accurate value of this length, l_2.

l_2/cm : 90.3, 86.7, 88.4. $\bar{l}_2$ = 88.5 cm

$l_2 = 2l_1$ ± 20 mm (1)

Hence determine a second value for λ.

$\lambda = l_2$ = 88.5 cm.

$\lambda = l_2$ and unit for l_2 & λ seen once each.

(4) 4

Both given to mm precision (1)

Switch off the power supply.

QUESTION 1B CONTINUES ON THE NEXT PAGE

Leave blank

(c) Take measurements to determine the diameter d of the wire.

d/mm : 0.267, 0.266, 0.263 | 0.25 mm < d < 0.29 mm with unit (1)

$\bar{d}$ = 0.265 mm | Repeat (1)

The density ρ of the material of the wire is given by:

$$\rho = \frac{4Mg}{\pi d^2 f^2 \lambda^2}$$

where f is the frequency of the a.c. supply that is written on the card.

Calculate a value for ρ.

Average λ = 88.4 cm = 0.884 m

$$\rho = \frac{4 \times 0.100 \times 9.81}{\pi \times (0.265 \times 10^{-3})^2 \times 50^2 \times 0.884^2}$$

$= 9.1 \times 10^3$ kg m^{-3}

Correct S.I. units shown in calculation and answer given to 2/3 sf + unit (1)

Value (8.9 – 10.9 × 10³ kg m⁻³) (N.O. e.c.f.) (1)

4

(4)

Q1B 16

(Total 16 marks)

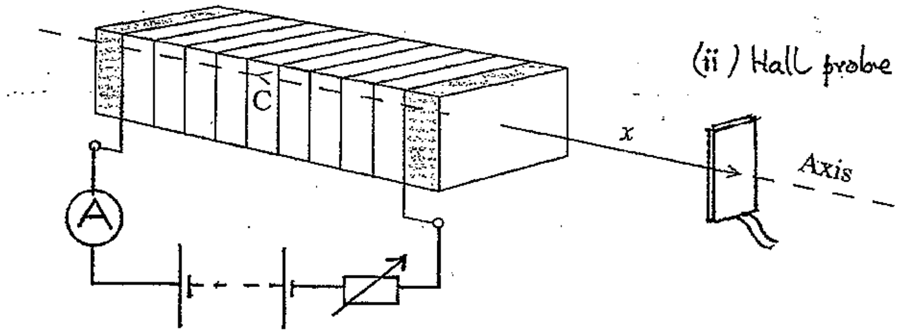
N 3 1 1 9 6 A 0 8 1 6

Leave blank

Question 1C

You are to plan an investigation of how the magnetic field strength varies along the axis of a solenoid. You are then to analyse a set of data from such an experiment.

(a) (i) A solenoid is set up as shown in the diagram below. Add to the diagram the circuit you would connect to the solenoid to set and maintain a known value of current in the solenoid.



(i) Circuit **(3)**

If not connected to solenoid No gap (-2)

Gap for solenoid no penalty

power supply (1)
some means of varying supply, or labelled 'variable' (1)
ammeter connected correctly in series (1)

3

(ii) Draw how you would place a Hall probe to measure the magnetic field strength at a point along the axis a distance x from the centre C of the solenoid. You should draw the Hall probe outside the solenoid and should take care to show the orientation of the chip (sensor) correctly.

Clearly shown/perpendicular crossing and to axis. or stated (1) **(1)**

1

(iii) Describe how you would determine the distance x. You may add to the diagram if you wish.

- Measure length of solenoid.
- Put rule inside solenoid so that its zero end is at mid point of solenoid.
- Read x directly from rule

Determine centre of solenoid (1)

Suitable technique for x inside and outside solenoid (1)

(2)

2

QUESTION 1C CONTINUES ON THE NEXT PAGE

N 3 1 1 9 6 A 0 9 1 6

Turn over

Leave blank

(b) The solenoid has a length of 276 mm and has 337 turns. When the current in the solenoid was adjusted to 500 mA, the calibrated Hall probe indicated that the magnetic field strength at the centre of the solenoid was 0.761 mT.

The magnetic field strength B at the centre of a solenoid having n turns per metre is given by:

$$B = \mu_0 n I$$

when the current in the solenoid is I.

Discuss the extent to which you think that the Hall probe is correctly calibrated.

$B = 4\pi \times 10^{-7} \times \frac{337}{0.276} \times 0.500$

$= 7.67 \times 10^{-4}$ T $=$ 0.767 mT

The Hall probe reads 0.761 mT, which is less than 1% different. This is an acceptable difference.

Correct substitution of data (1)

0.767 mT (value, 3 s.f. and unit) (1)

Sensible comment (accept 'very small' difference) (1)

(3)

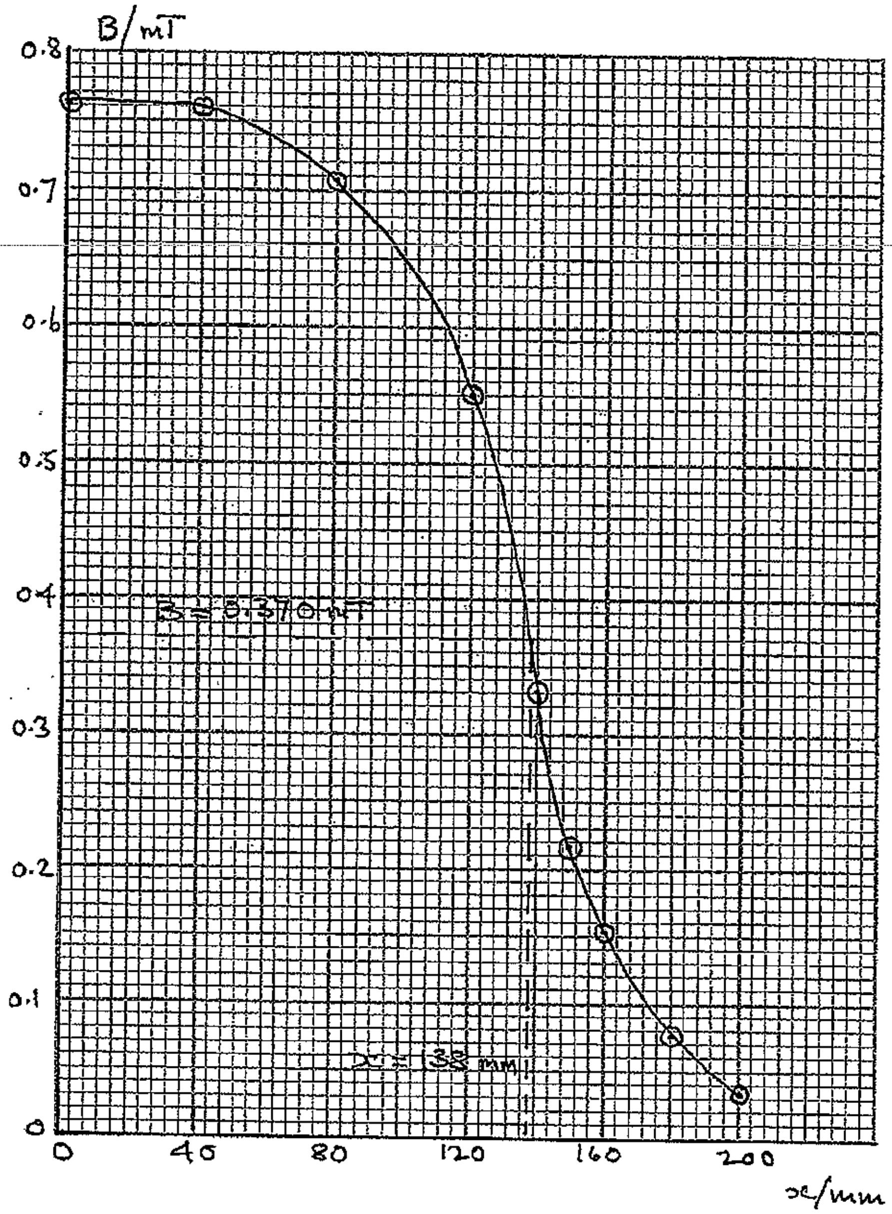
3

(c) The following data were obtained when the magnetic field strength B was measured along the axis at different distances x from the centre of the solenoid, keeping the current constant at 500 mA.

x / mm	B / mT
0	0.761
40	0.760
80	0.706
120	0.549
140	0.330
150	0.217
160	0.151
180	0.077
200	0.032

Plot a graph of B against x on the grid opposite.

Leave blank



(4)

GRAPH — Scale : At least ½ graph paper in both x & y, avoiding 3's etc. (1)
Axes : labelled with quantity and units (1)
Plots : Accurate to ½ square (1)
Line : Smooth, thin curve of best fit (1)

4

QUESTION 1C CONTINUES ON THE NEXT PAGE

(d) Theory suggests that the magnetic field strength at the end of a long solenoid is exactly half that at its centre. Discuss the extent to which this experiment supports this suggestion.

End of solenoid is $\frac{276}{2}$ = 138 mm	x = 138 mm at end
From the graph, when x = 138 mm,	Bend read off correctly at x=138 mm with unit (1)
field strength is 0.370 mT	
$\frac{B_{end}}{B_{centre}} = \frac{0.370\text{ mT}}{0.761\text{ mT}} = 0.49$	% difference calculated
This differs by only 2% from "exactly half" (0.50), which is acceptable experimental error.	(need not show actual calculation) (1) and hence sensible comment (1)
The experiment therefore supports the suggestion.	

3

(3)

Leave blank

Q1C

16

(Total 16 marks)

TOTAL FOR PAPER: 48 MARKS

END

6735/02 Practical Test PHY5

Group 2

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Question 2A

(a) (i) Suspend a total mass of 300 g from one of the springs. Give the mass a small vertical displacement and determine the period T_1 of the subsequent oscillations.

$20T_1$/s : 14.63, 14.63

T_1 = 0.732 s

Put the mass of 300 g on the other spring and determine the period T_2 of vertical oscillations for this spring.

$20T_2$/s : 14.70, 14.74

T_2 = 0.736 s

Calculate the average value T of the periods T_1 and T_2.

$T = \frac{0.732 + 0.736}{2} = 0.734$ s

ΣnT ≥ 30 (2) for both (≥ 20 (1)) T_1 & T_2 + unit

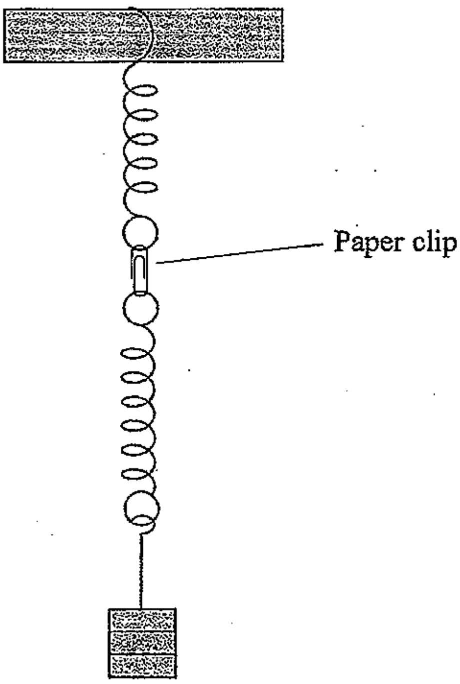
Repeats for all shown (1)

SE − 2 whole seconds left as nT or f

(3)

3

(ii) Remove one of the springs from the rod. Connect it to the other spring using the paper clip to give a series arrangement of springs as shown in the diagram below.



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Determine the period T_s of vertical oscillations for this series arrangement of springs.

$20T_s$ / s = 20.82, 20.82 | Correct calc^n. of T_s/T to 3sf & no unit (1)

T_s = 1.04 s | In range 1.39–1.44 (2)

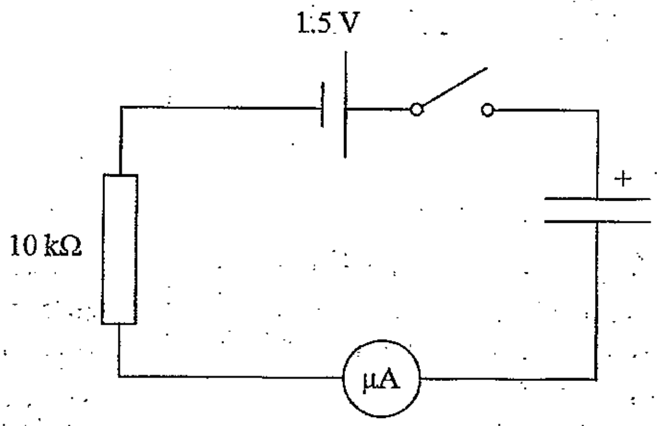
Calculate the ratio T_s / T.

T_s/T = 1.04/0.734 = 1.42 | [1.34–1.48 gets (1)]

Inverted :– 0.707 (1) 0.69–0.72 (2) 0.67–0.74 (1) **(3)**

3

(b) (i) The circuit shown in the diagram below has been set up ready for you to use.



Discharge the capacitor by connecting one of the spare leads across it. Now remove the lead.

Close the switch and determine the time t that it takes for the current in the circuit to fall from 100.0 μA to 36.8 μA. Open the switch when you have done this.

t/s : 25.24, 25.21 | t in range

$\bar{t}$ = 25.2 s | 15–30 s + unit (1)

(Not whole seconds)

Describe the procedure you adopted to make this timing as accurate as possible.

Discharged capacitor before each reading (1) Repeat shown (1)

(1)

(3)

3

Leave blank

(ii) Connect the second capacitor **in series** with the capacitor in the circuit, making sure that its polarity is correct. When you have done this, you **must** ask the Supervisor to check your circuit before proceeding. If your circuit is not correct, the Supervisor will correct it for you. You will only lose 1 mark for this.

Follow the same procedure as before to determine the time t_s for the current to drop from 100.0 μA to 36.8 μA for the series arrangement of capacitors. Open the switch when you have done this.

t_s/s : 12.66, 12.70

$\bar{t}_s$ = 12.7 s

Calculate the ratio t_s/t.

$t_s/t = \frac{12.7}{25.2} = 0.504$

anywhere
No help with circuit (1)
t_s/t correctly calculated to ≥2sf (1)
In range 0.40 → 0.60 (2)
[0.30 → 0.70 gets (1)]
no unit
(allow ecf from a(ii)) **(4)**

4

(iii) For this circuit, the time *t* is proportional to the capacitance *C* of the circuit. Discuss whether your results suggest that the two capacitors have the same capacitance when taking into account a manufacturing tolerance of 20%.

If $t \propto C$, then the capacitance of the two capacitors in series is 0.504 of the capacitance of the first capacitor.

If the capacitors were of the same value this would be exactley half, ie. 0.500.

The difference is less than 1% ~~and well within the 20%~~ tolerance of the capacitors, suggesting that the two capacitors were of the same nominal capacitance.

Should be 0.500 if equal (1)
% difference calculated using 0.504 as denominator (1)
Related to 20% (or 40%) (1)

(3)

3

(Total 16 marks)

Q2A

16

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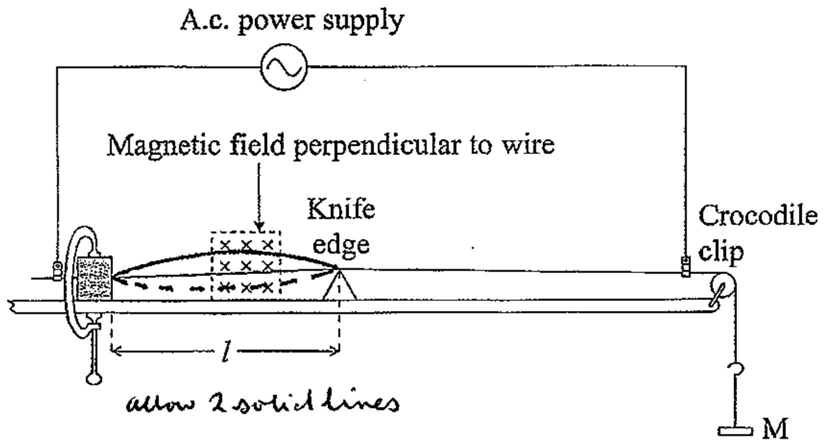
Question 2B

(a) The apparatus has been set up for you as shown in the diagram with $M = 100$ g. For clarity the magnet has not been drawn.



The fundamental mode of a stationary (standing) wave can be formed on a length l of the wire. Draw on the diagram the shape you would see. State the relationship between the wavelength λ of the wave and the length l.

(see diagram)

$\lambda = 2l$

Correct shape, with one antinode (1)

$\lambda = 2l$ (1)

(2) 2

(b) (i) Switch on the power supply. Increase l until you can see that the amplitude of vibration of the wire is at a maximum.

Determine, as accurately as possible, the length l_1 at which this resonance occurs.

l_1/cm: 44.0, 43.4, 43.6. $\bar{l}_1 = 43.7$ cm

±2 cm of Supervisor (2)
[±3 cm gets (1)]
allow cm.
−1 no unit

Explain carefully how you ensured that your value for l_1 was as accurate as possible.

• Approached resonance from both directions. (1)

Viewing technique (1)

The frequency f of the supply is as stated on the card. Use this value and your value for l_1 to determine a value for the speed c of the wave along the wire.

$c = f\lambda = 50 \times 2 \times 0.437$ | $c = f\lambda$ used to give correct speed, with unit (no ecf from $\lambda = l$) (1)

$= 43.7 \text{ ms}^{-1}$

(5) 5

(ii) Add 300 g to the mass hanger to make $M = 400$ g. For standing waves on a wire the tension T in the wire and the resonant length l are related by the equation:

$$T = k\,l^2$$

You are to determine the new resonant length, l_2.

Explain whether you would expect the new length to be longer or shorter than l_1.

EGs

Larger, because increasing mass increases T and $l \propto \sqrt{T}$ | $l \propto \sqrt{T}$, or words to this effect (1)

Increase T increases l

(Mentions stretching − 1)

Suggest where the magnet should be placed to obtain the largest possible vibration.

In the centre of the new length (1)

Adjust the position of the knife edge and magnet until you can see that the amplitude of vibration of the wire is at its maximum value for the fundamental mode. Determine an accurate value of this length, l_2.

l_2/cm : 89.4, 89.7, 88.9 : $\bar{l}_2 = 89.3$ cm | l_1 & l_2 repeated (1) | $l_2 = 2l_1 \pm 20$ mm (1) | [... mm gets (1)]

Estimate the percentage uncertainty in your value for l_2.

$\Delta l = \pm 4$ mm (half spread) | Range or ½ range provided ≥ 1 mm (allow ≥ 1 mm if from single reading) and correct % calcn. (1)

% uncertainty $= \frac{4}{893} \times 100 = 0.4\%$

(5) 5

QUESTION 2B CONTINUES ON THE NEXT PAGE

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(c) Take measurements to determine the diameter d of the wire.

d/mm : 0.267, 0.266, 0.263 | 0.25 mm < d < 0.29 mm with unit (1)

$\bar{d}$ = 0.265 mm | Repeat (1)

The density ρ of the material of the wire is given by:

$$\rho = \frac{4Mg}{\pi d^2 c^2}$$

Use $M = 0.100$ kg and your value for the speed c from (b)(i) to calculate a value for ρ.

$\rho = \frac{4 \times 0.100 \times 9.81}{\pi \times (0.265 \times 10^{-3})^2 \times 43.7^2}$ | Correct S.I. units shown in calculation and answer given to 2/3 sf + unit (1)

$= 9.3 \times 10^3$ kg m^{-3} | Value (8.0 – 10.0) × 10^3 kg m^{-3} (1)

[Allow e.c.f. for value of c ONLY]

(4)

4

Q2B

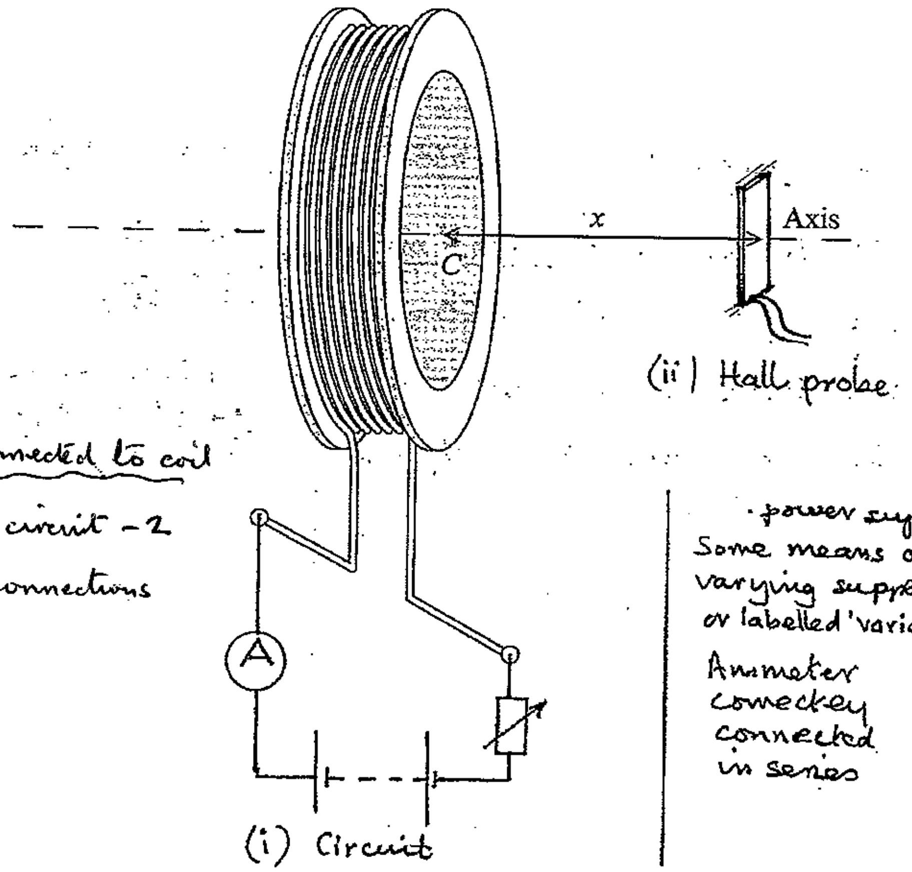
(Total 16 marks)

Leave blank

Question 2C

You are to plan an investigation of how the magnetic field strength varies along the axis of a coil. You are then to analyse a set of data from such an experiment.

(a) (i) A flat circular coil is set up as shown in the diagram below. Add to the diagram the circuit you would connect to the coil to set and maintain a known value of current in the coil.



If not connected to coil

No gap in circuit – 2

Allow no connections

· power supply (1)
Some means of varying supply, or labelled 'variable' (1)
Ammeter connected in series (3) (1)

3

(ii) Draw how you would place a Hall probe to measure the magnetic field strength at a point along the axis a distance x from the centre C of the coil. You should be careful to show the orientation of the Hall chip (sensor) correctly.

must cross axis . Clearly shown ⊥r to axis (1) **(1)** 1

(iii) Describe how you would determine the average diameter of the coil. You may add to the diagram if you wish.

- Used rule & two set squares
- Repeated in ⊥r direction
- Made allowance for thickness of coil.

Any (2) sensible points of technique

2

(2)

Turn over

Leave blank

(b) The coil has a diameter of 124 mm and has 70 turns. When the current in the coil was adjusted to 500 mA, the calibrated Hall probe indicated that the magnetic field strength at the centre of the coil was 0.350 mT.

The magnetic field strength B at the centre of a coil having a radius r and N turns is given by

$$B = \frac{\mu_0 N I}{2r}$$

when the current in the coil is I.

Discuss the extent to which you think that the Hall probe is correctly calibrated.

$B = \frac{4\pi \times 10^{-7} \times 70 \times 0.500}{0.124}$	Correct substitution of data (1)
$= 3.55 \times 10^{-4}$ T = 0.355 mT	0.355 mT (value, 3sf and unit) (1)
The Hall probe reads 0.350 mT, which differs by only just over 1%	Sensible comment (accept 'very small' difference) (1)
This is an acceptable difference	

(3)

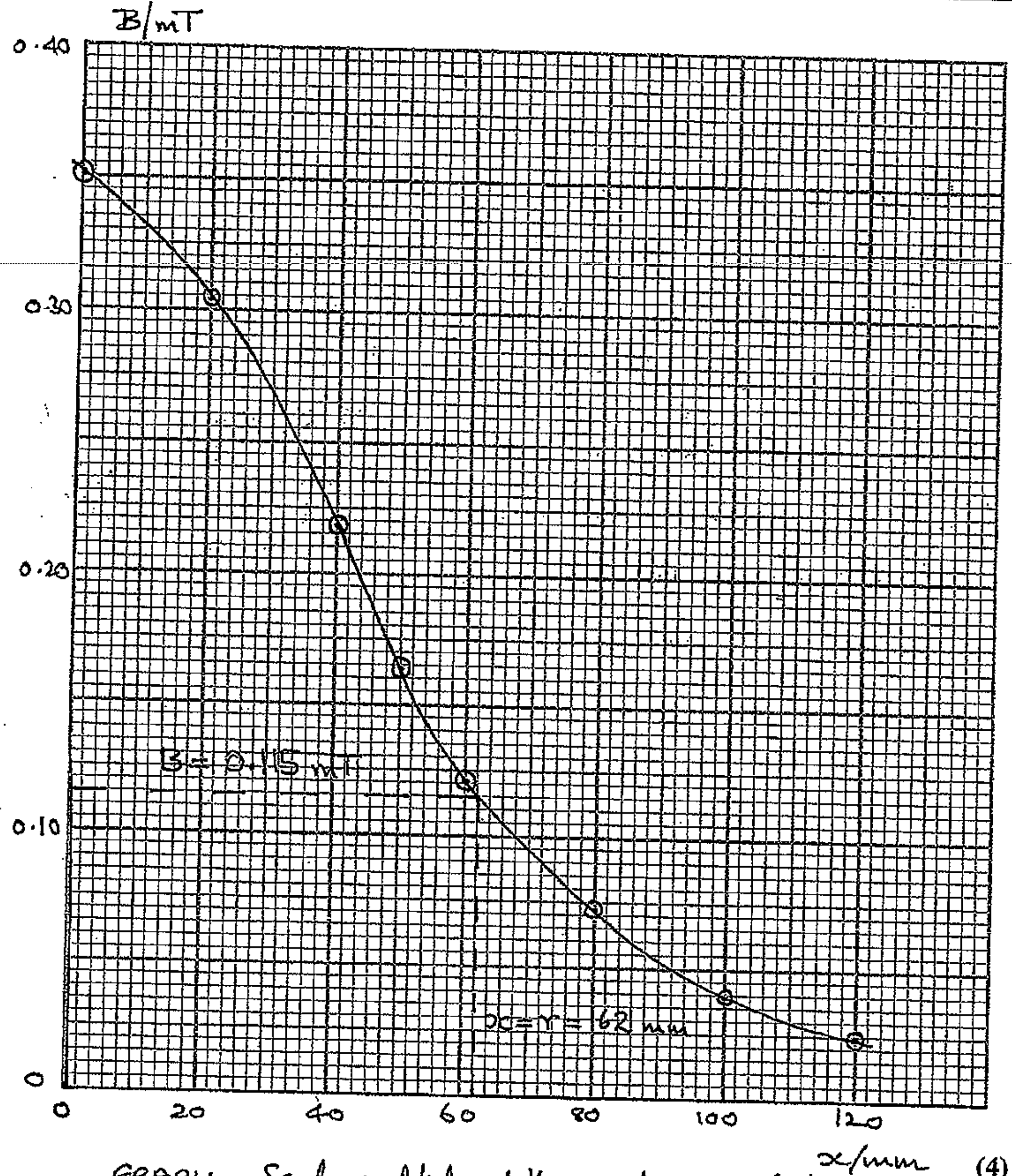
3

(c) The following data were obtained when the magnetic field strength B was measured along the axis at different distances x from the centre of the coil, keeping the current constant at 500 mA.

x / mm	B / mT
0	0.350
20	0.304
40	0.219
50	0.163
60	0.120
80	0.071
100	0.039
120	0.024

Plot a graph of B against x on the grid opposite.

Leave blank



(4)

GRAPH
Scale : At least ½ graph paper in both x & y direction, avoiding 3's, etc. (1)
(transposed −1) ← Axes : Labelled with quantity & units (1)
Plots : Accurate to ½ square (1)
Line : Thin, smooth curve of best fit (1)

4

QUESTION 2C CONTINUES ON THE NEXT PAGE

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(d) Theory suggests that when $x = r$, the radius of the coil, the magnetic field strength is $1/\sqrt{8}$ of the field strength at the centre of the coil. Discuss the extent to which this experiment supports this suggestion.

When $x = r = 62$ mm

$B = 0.115$ mT

$1/\sqrt{8}$ of field at centre

$= \frac{0.350 \text{ mT}}{\sqrt{8}}$

$= 0.124$ mT

The experimental value is about 7% different, which is acceptable experimental error.

B read off at 62mm correctly with unit (1)

% difference calculated either value or av value as denominator, and hence sensible comment. (1) (1)

{ need not show calculation

3

(3)

Q2C

(Total 16 marks) 16

TOTAL FOR PAPER: 48 MARKS

END

Question Number	Answer	Mark
1 (a)	use of $c = 3 \times 10^8$ m s^{-1} ✓ times a number between 0.002 and 0.006 ✓ ⇨ $\upsilon = 6 \times 10^5$ m s^{-1} to 18×10^5 m s^{-1} use of $s = \upsilon t$ ✓ with t = 2 or 3 times 24 × 3600 s ✓ ⇨ s between 1.04 × 10 m and 4.67×10^{11} m expressed as 10^{11} (i.e. order of magnitude) e.c.f. ✓	**5**
(b)	rectangle labelled N and S plus some field lines with correct arrows ✓ ≥ 4 symmetric field lines (<u>not</u> joining) ✓	**2**
(c) (i) (ii)	out of paper / eastwards ✓ Fleming / LHR ✓ any spiral path ✓ looping round PQ ✓	**4**
(d) (i) (ii)	3 days as 3 × 24 × 3600 s ÷ 1.2 s ✓ ⇨ 216000 transits ÷ 100 ✓ making N = 2160 / 2200 ionising collisions N × 14 eV ✓ ⇨ initial energy = 30 240 / 30 800 / 28 000 eV times 1.6×10^{-19} J eV^{-1} e.c.f. ✓ ⇨ 4.5 - 4.9×10^{-15} J ✓	**5**

(e)	(i)	mv^2/r (i.e. mass × acceleration)	✓	
		Bev (magnetic force)	✓	
		⇨ $r = mv/Be$		
	(ii)	use of m = 1.66 / 1.67 / 1.7 × 10^{-27} kg <u>and</u> e = 1.6 × 10^{-19} C	✓	
		so radius r between 519 m and 531 m	✓	**4**
(f)	(i)	**either** concave falling curve with marked axes ρ & h	✓	
		starting on / cutting ρ axis <u>and</u> not touching h axis	✓	
		or axes $\ln\rho$ and h straight line with negative slope	✓	
		starting on y axis / 1:17150	✓	
	(ii)	$\rho/\rho_0 = e^{-kh}$ [no mark]		
		⇨ $kh = (6.5 \times 10^{-5}\ m^{-1})(150 \times 10^3\ m)$	✓	
		$\rho/\rho_0 = 5.8 \times 10^{-5}$	✓	
		i.e. atmosphere very, very thin		**4**
(g)	(i)	charged particles / protons and electrons	✓	
		knock / remove <u>electrons</u> from / off atoms / molecules [*not* collide with atoms or molecules]	✓	
	(ii)	mention energy levels	✓	
		unique to element / N and O are different	✓	
		<u>photon</u> emitted (by transitions between levels)	✓	**5**
(h)	(i)	g / 9.8 m s^{-2} / gravitational field assumed constant	✓	
		m / 400 kg / (total) mass of rocket assumed constant	✓	
	(ii)	Earth's (gravitational) field is radial / obeys inverse square law	✓	
		fuel is used up (as rocket ascends)	✓	**4**
				33

Question Number	Answer		Mark
2 (a)	high frequency / ≥ 50 kHz / radio frequency	✓	
	a.c. p.d. / voltage / supply or ~	✓	
	(correctly) connected to every other	✓	
	≥ 4 tubes	✓	
	of increasing length	✓	
	vacuum	✓	**max 5**
(b)	pair of values of k.e. and υ^2 read from graph / gradient	✓	
	$\upsilon^2 > 5 \times 10^{16}$ m s^{-2}	✓	
	⇨ $m_p = 1.62 - 1.69 \times 10^{-27}$ (kg) <u>to 3 s.f.</u>	✓	**3**
(c) (i)	(values 1.3 – 1.7, 3.1 – 3.5, 6.0 – 6.5) any **two** correct	✓✓	
(ii)	$\Delta E = c^2\Delta m$ / $E = mc^2$	✓	
	⇨ one value for Δm ($\times 10^{-28}$ kg)	✓	
	use of m_p from (i) [no mark]		
	⇨ one value of $\Delta m/m_p$: about 10%, 20%, 40%	✓	**5**
(iii)	curve approaches / is asymptotical to horizontal / becomes horizontal / flattens out / levels off / gradient decreases	✓	
	at 9×10^{16} / $(3 \times 10^8)^2$ / c^2 / 9	✓	
	(so) tubes then have a constant length / become constant in length / do not increase in length	✓	**3**
			16

Question Number	Answer		Mark
3 (a) (i)	$N + Y = W$	✓	
(ii)	W / 55 N × a distance = Y × a distance	✓	
	distances must be 5 – 7 mm: 42 – 45 mm / 9 – 10 mm $\cos\theta$: 70 – 72 mm $\cos\theta$	✓	
	⇨ Y = 6.8 N – 7.9 N	✓	**4**
(iii)	1. reload the contents (of the case) / repack the case	✓	
	to reduce the moment (of W) / to move G towards the bottom of the case **or** toward C / the wheel	✓	
	2. increase the angle between the handle and the ground	✓	
	to get G above C / to reduce horizontal distance from C to line of action of W by a greater factor than that from C to line of action of Y	✓	**4**
(b) (i)	appreciation that area of (first) rectangle / at gives speed v	✓	
	Δv_{accel} = (3 m s^{-2})(8 s) / 30 small squares each worth 0.8 m s^{-1}	✓	
	⇨ 24 m s^{-1}	✓	
(ii)	appreciation that area of second is of same area as first / Δv_{decel} = (4 m s^{-2})(6 s) [negative idea *not* needed]	✓	**4**
(iii)	use of $P = IV$ / $E = IVt$	✓	
	use of $P = Fv$ / $E = Fvt$	✓	
	(3000 N)v = (96 A)(750 V) / equating the Ps or Es	✓	
	⇨ v = 24 m s^{-1}		**3**
			15

Question Number	Answer		Answer
4 (a)	$\rho = m/V$	✓	
	correct substitutions	✓	
	use of $\Delta H = mc\Delta T$ with $c = 610$ J kg^{-1} K^{-1}	✓	
	⇨ ΔH = 6300 (J) / 6340 (J) / 6.3 (kJ)	✓	**4**
(b) (i)	the purpose / principle is to transfer energy / heat from inside the freezer / cold to the kitchen / hot	✓	
	T_c temperature inside / of freezer and T_h temperature of room / kitchen	✓	
	W is electrical work / energy **or** W powers the pump / freezer / motor	✓	
	Q_h and Q_c heat / energy transferred to hot and from cold (respectively)	✓	**4**
(ii)	use of kelvin temperatures	✓	
	⇨ η_p = 255 K ÷ 40 K = 6.4	✓	
(iii)	$W = Q_c/\eta_p$ = 6300 J ÷ 6.4 e.c.f.	✓	
	⇨ 990 J		**3**
(c) (i)	$mu' = mu - E/c$ **or** $m\Delta u = E/c$	✓	
	$(u - u')/\Delta u = E/mc$ **or** hf/mc	✓	
(ii)	use of Doppler formula $\Delta f/f = u/c$	✓	
	state $E = hf$	✓	
	$E' - E = \Delta E$ / $f' - f = \Delta f$	✓	
	⇨ $E' = E(1 + u/c)$ / $hf(1 + u/c)$		**5**
			16

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