Mark Scheme January 2009

GCE

GCE Physics (8540/9540)

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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) Horizontal force of hinge on table top

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 / Wes opposite direction to horizontal. May show direction by arrow. Do not acce 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. 'resonance'
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	<u>Complete the table</u> <table><tr><th>Source</th><th>Absorber</th><th>Effect on count rate</th><th>Radiations emitted</th><th></th></tr><tr><td>A</td><td></td><td></td><td>Beta</td><td>**(1)**</td></tr><tr><td>B</td><td></td><td>Eg reduced[allow 'slightly reduced', 'significantly reduced' etc] (Reduced to) background (Reduced to) background</td><td></td><td>**(1)**</td></tr><tr><td>C</td><td></td><td></td><td>Alpha, beta and gamma</td><td>**(1)**</td></tr><tr><td>D</td><td></td><td>(Reduced to) background (Reduced to) background (Reduced to) background</td><td></td><td>**(1)**</td></tr></table> [do not allow 'stopped' for 'reduced to background']	**(4)**
	Total	**4**

Question Number	Answer	Mark
2 (a)	Determine the acceleration of free fall Attempt to measure the gradient of the vertical motion graph or use of appropriate equation(s) of motion [Allow this mark even when the gradient is taken over a small range] **(1)** Answer [Allow answers in the range (9.6 – 10.0) m s^{-2}. This mark is consequent on the first mark being obtained ie no bald answer] **(1)** Eg gradient = $\frac{59\ \text{m s}^{-1}}{6\ \text{s}}$ = 9.83 m s^{-2}	**(2)**
(b)	Height above point A Attempt to measure area under vertical motion graph or use of appropriate equation of motion taking values from the graph [for equations involving 'g' they must use their value from part (i)] **(1)** Answer [Only accept 177 m for area under graph method. For use of equation methods accept values in the range (172 – 180) m and for these methods this mark is consequent on the first mark being obtained] **(1)** Eg Area under graph = $\frac{6\ \text{s} \times 59\ \text{m s}^{-1}}{2}$ = 177 m	**(2)**
(c)	Distance from A Time at which condition described occurs ie 4.9 s [do not accept 5 s for this mark] **(1)** Attempt to measure area under horizontal motion graph or use of $s = ut$ [For their time and allow 50 m s^{-1}] **(1)** Answer [240 m. Only give this mark if 48 m s^{-1} and 4.9 s have been used] **(1)** Eg Time = 4.9 s Area under graph for this time or *ut* = 48 ms^{-1} x 4.9 s = 235.2 m	**(3)**
	Total	**7**

Question Number	Answer	Mark
3 (a)(i)	The height from the ground **Either** Deducts 2.4 s from 3.8 s / 1.4s seen **(1)** Selects $s = (ut) + \frac{1}{2}at^2$ or 2 appropriate equations **(1)** Subtracts value obtained for second mark from 28 m / value for distance fallen seen [9.6(1) m, 9.8 m if 10 m s^{-2} is used] **(1)** Answer [18 m] **(1)** Eg t = 3.8 s -2.4 s = 1.4 s $s = (ut) + \frac{1}{2}at^2$ $= \frac{1}{2}$ x 9.81 m s^{-2} x $(1.4\ s)^2$ = 9.6(1) m [9.8 m if g = 10 m s^{-2} used] height = 28 m – 9.6(1) m = 18 (.39 m) [18(.2) if g = 10 m s^{-2} used] **Or** Use of equation to calculate initial velocity at point of release / 23.5 m s^{-1} seen **(1)** Selects $s = (ut) + \frac{1}{2}at^2$ or 2 appropriate equations **(1)** Uses minus *g* and correctly applies values to *v* and *u* throughout **(1)** Answer [Allow answers in the range (18 – 19) m] **(1)** Eg $V = u + at$ 0 = u – 9.81 m s^{-2} x 2.4 *s* u = 23 .5(4) m s^{-1} $s = ut + ½at^2$ = 23.54 m s^{-1} x 3.8 s - ½ 9.81 m s^{-2} x 3.8^2 s^2 = 18. 4(7) m	**(4)**
(a)(ii)	Assumption made That ball falls with constant acceleration / that ball's acceleration is 9.8(1) m s^{-2} [or 10 m s^{-2}] / that (air) resistance (force) is negligible / time at zero velocity is negligible / the ball is caught close to the Earth('s surface) [Do not accept 'force of gravity acts downwards' or 'no force'. Accept 'no friction' or 'no resistance'] **(1)**	**(1)**
(b)	Why force is reduced QWOC **(1)** **Either** (To catch ball) velocity of ball has to be reduced (to zero) or change in velocity is the same or the relative velocity between the ball and hand is reduced **(1)** (By moving his hand as described) time to do this is lengthened **or** acceleration is reduced **(1)** Therefore **force applied by the hand** or **the force applied to the ball** is reduced **(1)** By Newton's third law / an equal but opposite (reduced) force is applied by the ball or is applied to the hand **(1)** [The link to N3 must be made for this mark. An answer which only	

	states 'the force applied by the ball to the hand is reduced' simply repeats what is already stated in the question] **Or** (To catch ball) momentum of the ball has to be reduced (to zero) or impulse is the same or momentum change is the same **(1)** (By moving his hand as described) time to do this is lengthened **(1)** [For 'rate of change of momentum is reduced' give both these marks] Therefore **force applied by the hand** or **the force applied to the ball** is reduced **(1)** By Newton's third law / an equal but opposite (reduced) force is applied by the ball or is applied to the hand **(1)** [see advice above] **Or** (To catch ball) kinetic energy has to be reduced (to zero) **(1)** (By moving his hand as described) means that the work required to do this takes place over a longer distance **(1)** Therefore **force applied by the hand** or **the force applied to the ball** is reduced **(1)** By Newton's third law / an equal but opposite (reduced) force is applied by the ball or is applied to the hand **(1)** [see advice above]	**(5)**
	Total	**10**

Question Number	Answer	Mark
4(a)	Show weight is ~ 0.3 N Use of $\pi r^2 t$ to find volume or 3.5(3) (x 10^{-6} m^3) seen **(1)** [Award this mark even when the diameter value is use for the radius] Appropriate values substituted into density equation **(1)** Answer [0.31 N. No ue but must have 2 d.p. Accept values in range 0.305 N – 0.314N] **(1)** Eg volume = $\frac{\pi \text{ x } (30 \text{ x } 10^{-3} \text{ m})^2}{4}$ x 5 x 10^{-3} m = 3.53 x 10^{-6} m^3 Mass = 3.53 x 10^{-6} m^3 x 8900 kg m^{-3} = 3.14 x 10^{-2} kg Weight = 3.14 x 10^{-2} kg x 9.81 N kg^{-1} = 0.308 N	**(3)**
(b) (i)	State Newton's first law A body will remain at rest or will move with uniform speed in a straight line / uniform velocity / zero acceleration **(1)** [Do not allow 'uniform motion'] unless acted upon by a resultant / unbalanced force or if forces are balanced **(1)**	**(2)**
(ii)	Label magnitude of forces *P* = *Q* = 0.3 N / their value [must have both marked] **(1)** *X* = *Y* = 0.6 N / 2 x their value [must have both marked] **(1)**	**(2)**
(iii)	Describe Newton third law force Magnitude = 0.3 N / their value [accept 'same size as Q'] **(1)** Direction = Upwards[Allow arrow pointing upwards or states 'opposite direction to Q'. Do not allow arrow pointing sideways] **(1)** Type = Gravitational [not 'reaction force'] **(1)** Object = Earth [Do not accept ground or Earth's surface] **(1)**	**(4)**
	Total	**11**

Question Number	Answer	Mark
5(a)	<u>Principle of moments</u> For equilibrium / balance **(1)** Sum of the moments clockwise = the sum of the moments anticlockwise or sum of the moments about a point is zero **(1)** [Sum or equivalent eg total/net/resultant, **not all**, must be seen at least once]	**(2)**
(b) (i)	<u>Upward force on rod L</u> Moments equation with **correct** values **(1)** Answer [18 N] **(1)** Eg F x 120 (x 10^{-3} m) = 27 N x 80 (x 10^{-3} m) F = 18 N	**(2)**
(ii)	<u>Weight of lid</u> Use of 120 (x 10^{-3} m) in determining the moment of the lid or for correct anticlockwise moment ie 18 N[their value] x 20 (x 10^{-3} m) **(1)** Answer [3.0 N ecf their value of force from b(i)] **(1)** Eg 18 N x 20 (x 10^{-3} m) = W x 120 (x 10^{-3} m) W = 3 N	**(2)**
(iii)	<u>Resultant normal contact force</u> Size [15 N ecf their values from bi and bii] **(1)** Direction [Downwards. Or arrow pointing down, but not sideways] **(1)**	**(2)**
	Total	**8**

Question Number	Answer	Mark
6(a)	<u>Principle of conservation of energy</u> Either Energy can neither be created or destroyed **(2)** Or Energy cannot be created / destroyed / is not lost / is not gained or **total** energy is constant **(1)** (merely) transformed / changed / transferred / converted from one form to another or in a closed / isolated system **(1)** [Simple statement 'energy is conserved' gets no marks. $\Delta Q = \Delta U + \Delta W$, with terms defined acceptable for first mark]	**(2)**
(b) (i)	<u>Loss in gravitational p.e</u> Use of $\Delta gpe = mg\Delta h$ [Allow their value for height e.g. 9 m and 9 cos30 m] **(1)** Correct height value used ie 4.5 m / 9 m sin 30 seen **(1)** [Candidates may measure the height of P(and scale their measurement) rather than use 9 m sin 30 - the angle 30° is accurately drawn on the diagram] Answer [290 J] **(1)** Eg Δgpe = 6.5 kg x 9.81 m s^{-2} x 9 m sin30 = 286.9 J	**(3)**
(ii)	<u>Kinetic energy of box</u> Use of $ke = \frac{1}{2}mv^2$ **(1)** Answer [220 J] **(1)** [Eg E_K = 0.5 x 6.5 kg x 8.2 m s^{-1} x 8.2 m s^{-1} = 218.5 J	**(2)**
(iii)	<u>How principle of conservation of energy applies</u> Some of the gpe or difference in gpe lost and ke gained or calculated difference eg (290 J – 220 J =) 70 J is transferred[allow phrases such as 'lost as'] to thermal / internal energy (and sound) **(1)** [For this mark they must refer to 'gpe', or 'gravitational (potential) energy' ie not just 'some energy is transferred'. Allow also 'potential energy'.] (Doing work) overcoming the resistive / frictional forces (so total energy remains the same) [Allow simple statements such as 'due to friction' or 'caused by friction' but not 'lost to friction' for this mark] **(1)** [If candidates use the work done equation to calculate the average frictional force allow this for second mark eg 70 J = $F\Delta x$]	**(2)**
	Total	**9**

Question Number	Answer	Mark
7 (a)	Complete atomic equation $^{131}_{54}$Xe **(1)** $^{0}_{-1}$e [accept $^{0}_{-1}\beta$, $^{0}_{-1}\beta^{-}$, $^{0}_{-1}$beta. Allow numbers on right-hand side of symbol. Do not allow Β or b. Ignore additional emissions other than alpha] **(1)**	**(2)**
(b)	Meaning of decay constant Fraction of nuclei that decay every second or the probability that a nucleus will decay in one second or $\lambda = \frac{A}{N}$ provided all symbols are defined ie λ = decay constant, A = activity, N = number of undecayed nuclei or $\frac{0.693}{\lambda} = T_{1/2}$ with symbols defined **(1)**	**(1)**
(c)	Show half life is ~ 8 days Use of $\frac{0.693}{\lambda} = T_{1/2}$ **(1)** Answer [8.1 days. At least 1 d.p. required, no ue] **(1)** Eg $T_{1/2} = \frac{0.69}{9.9 \times 10^{-7}\ \mathrm{s}^{-1}}$ (= 7 x 10^5 s) = 7 x 10^5 s x $\frac{1}{3600\ \mathrm{s} \times 24\ \mathrm{h}}$ = 8.07 days	**(2)**
(d) (i)	Calculate the number of atoms Use of $A = \lambda N$ **(1)** Answer [2.2 x 10^{12} (atoms)] **(1)** Eg $N = \frac{2.2 \times 10^{6}\ \mathrm{Bq}}{9.9 \times 10^{-7}\ \mathrm{s}^{-1}}$ = 2.2(2) x 10^{12} atoms	**(2)**
(ii)	Hence calculate mass of iodine Divides number of atoms obtained for d(i) by 6 x 10^{23} and multiplies by 131 (g) or calculates atoms per gram and divides this into number of atoms obtained in d(i) **(1)** Answer [4.8 x 10^{-10} g or 4.8 x 10^{-13} kg. Ecf their value from d(i)] **(1)**	**(2)**
(e)	Why nuclear structure is unaffected Gamma radiation is (pure) energy / electromagnetic radiation / is a wave / consists of photons **(1)** (As such) it has no (charge or rest) mass or contains no particles or nucleus has dropped to lower energy state [Do not allow 'virtually no mass'. Accept 'not a particle'] **(1)**	**(2)**
	Total	**11**

Question Number	Answer	Mark
1 (a)	<u>Current decrease</u> • <u>Temperature</u> (of fuse) increase **(1)** • Resistance (of fuse) increases **(1)**	**(2)**
(b)	<u>Charge calculation</u> • Use of charge = current x time **(1)** • Attempt to find area of graph **(1)** • Charge = 45 C **(1)** [accept As for unit] [answer of 50 C i.e. 2.5 × 20, scores 1st mark only] **Example of answer** Charge = area under graph Charge = ½ (2.5 A + 2.0 A) × 20 s Charge = 45 C	**(3)**
	Total for question	**5**

Question Number	Answer	Mark
2 (a) (i)	<u>Resistance of lamp working normally</u> • Use of *V=IR* **(1)** • Resistance of lamp = 12 Ω **(1)** **Example of answer** R_{lamp} = 3.0 V ÷ 0.25 A R_{lamp} = 12 Ω	**(2)**
(ii)	<u>Resistance of *R*</u> • pd across R = 6 V **(1)** • Resistance of R = 24 Ω **(1)** **OR** • resistance calculation whole circuit = 36 Ω **(1)** • *R* = 36 – 12 = 24 Ω (ecf candidates' R_{lamp}) **(1)** **Example of answer** V_R = 9.0 V – 3.0 V = 6 V *R* = 6 V÷ 0.25 A *R* = 24 Ω	**(2)**
(b) (i)	<u>Total resistance</u> • Use of $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ with 20 Ω and their answer to (a)(i) **(1)** • Resistance of parallel combination (7.5 Ω) **(1)** • Addition of 15 Ω to a parallel combination attempt **(1)** (correct answer is 22.5 Ω)	**(3)**
(ii)	<u>Explanation</u> • Second circuit has lower total resistance **OR** first circuit has higher total resistance**(1)** • P = V^2/R and V constant for both circuits **(1)** • First circuit dissipates the lower power **(1)** (3rd mark conditional on one of the other two marks being scored) (candidates who use P = I^2 R score max 1 for the resistance statement) OR • Second circuit has larger total current **OR** first circuit has lower total current **(1)** • P = VI and V constant for both circuits **(1)** • First circuit dissipates the lower power **(1)** (3rd mark conditional on one of the other two marks being scored) OR Correct calculation of powers 2.25 W and 3.6 W scores max 1 (Candidates' answer for (b)(ii) must be consistent with the numerical calculations in earlier parts)	**(3)**
	Total for question	**10**

Question Number	Answer	Mark
3 (a)	• Component A: Any one; metallic resistor, wire, fuse wire, lamp **(1)** • Component B: thermistor, diode **(1)**	**(2)**
(b)	• Increasing temperature leads to increase in ions/atoms/particles/molecules vibrations/oscillations **(1)** • reducing drift velocity (of charge carriers) **(1)** (first two marks can be scored even if candidate thinks this only applies to component A) • (But for) component B the increase in temperature increases the number of charge carriers **(1)** • Increase in n greater than decrease in v **(1)** • Qowc **(1)**	**(5)**
	Total for question	**7**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>4(a) (i)</td><td><u>Diagram</u>
• Labelled trapped mass of gas (1)
• Volume scale OR means of varying the pressure (1)
• Pressure gauge (1)
(only mark experiment setups that would work)</td><td>(3)</td></tr>
<tr><td>(ii)</td><td><u>Constants</u>
• Mass of gas OR number of moles OR number of molecules (1)
• Trapped in container OR sealed apparatus (1)
[NOT; same amount of oil each time]

• Temperature (of gas) (1)
• Experiment done slowly/ readings taken after time to allow temperature to adjust (1)
[NOT; experiment done at room temperature]</td><td>(4)</td></tr>
<tr><td>(b)(i) and (ii)</td><td><u>graph</u>
• Plot V against 1/p OR p against 1/V (1)
• Graph should pass through the origin (1)
OR
• Plot pV against V or pV against p (1)
• Horizontal line (1)
OR
• lg p against lg V (1)
• Gradient = -1 and finite intercept (1)</td><td>(2)</td></tr>
<tr><td></td><td>Total for question</td><td>9</td></tr>
</table>

Question Number	Answer	Mark
5(a)(i)	<u>Current</u> • Current in one lamp 0.5 A **(1)** • Current in battery 2.0 A (ecf current for 1 lamp) **(1)** **Example of answer** $I = P \div V$ = 6 W ÷ 12 V = 0.5 A Current in battery = 4 × 0.5 A = 2.0 A	**(2)**
(ii)	<u>Combined resistance</u> Method 1 • Calculation of current through one lamp **(1)** • Substitution of 2× candidates current in $R = V/I$ **(1)** • Answer = 1.5 Ω **(1)** **OR** Method 2 • Total power = 96 W **(1)** • Use of $R = V^2/P$ **(1)** • Answer = 1.5 Ω **(1)** **OR** Method 3 • Use of $R = V^2/P$ to find resistance of one lamp **(1)** • Use of resistors in parallel formula (ecf their value for one lamp)**(1)** • Answer = 1.5 Ω **(1)** **Example of answer** Total power = 2 × 48 W = 96 W $R = V^2 \div P = (12\ \text{V})^2 \div 96\ \text{W}$ R = 1.5 Ω	**(3)**
(b)	<u>Small internal resistance of car</u> Large current needed (to start car) **(1)** Small internal resistance reduces the lost volts **OR** maximises terminal p.d. **OR** reference to I = E / (R +r) equation to justify max I (can be rearranged) **OR** reference to V = E – Ir to justify max V **(1)** (do not credit reference to I = V/R)	**(2)**
	Total for question	**7**

Question Number	Answer	Mark
6(a)	Specific latent heat • Energy/unit mass required **(1)** • to change a solid to a liquid **(1)** • At constant temperature **(1)** (equation with symbols defined scores 1st mark)	**(3)**
(b)(i)	Labelled diagram • Heater connected to power supply and switch **(1)** • Ammeter in series and voltmeter in parallel OR use of joulemeter **(1)**	**(2)**
(ii)	Apparatus • Balance or measuring cylinder **(1)** • Stopwatch/ timer/clock **(1)** (if more than two items listed mark the first two)	**(2)**
(iii)	Heater not turned on • To allow heater to reach temperature of the ice **(1)** Or • until ice has reached its melting point Or • until state of equilibrium is reached	**(1)**
(iv)	Calculation • (Turn on heater and) record current, potential difference and time**(1)** • Find the masses of water collected from both funnels **(1)** • Subtract mass collected from funnel without a heater from the one with a heater **(1)** • Use $\Delta m\ L = V\ I\ t$ **(1)** **(2nd and 3rd marks:** candidates who ignore 2nd beaker and find mass of ice before and after heating can score 1 mark)	**(4)**
	Total for question	**12**

Question Number	Answer	Mark
7(a)(i)	Symbols • ΔU increase/gain in internal energy (of system) **(1)** • ΔQ thermal energy given to (system) or energy gained by heating **(1)** • ΔW work done on the system **(1)** (ΔU is change in internal energy, ΔQ is energy due to heating and ΔW is energy due to work i.e. **all three correct** but underlined words missing can score max 1)	**(3)**
(ii)	Effect on ΔQ and ΔW • ΔQ and ΔW are equal and opposite **(1)** ($\Delta Q = - \Delta W$)	**(1)**
(b)(i)	Temperature calculation • Record a pair of values from the graph and convert kPa to Pa **(1)** • Use of $pV = nRT$ **(1)** • Temperature = 297 K (accept 290 K to 300 K) **(1)** (use of 50 kPa and 0.025 m^3, i.e. finding ΔP and ΔV, gives 206K; scores 1/3) **Example of answer** $T = (pV) \div (nR)$ $T = (90 \times 10^3 \text{ Pa} \times 0.020 \text{ m}^3) \div (0.73 \text{ mol} \times 8.31 \text{ J K}^{-1} \text{ mol}^{-1})$ $T = 296.7$ K	**(3)**
(b)(ii)	Temperature at Z • Record two values of volume from horizontal part of graph **(1)** • Use $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ **(1)** • Temperature = 644 K to 667 K **(1)** OR • Takes P and V values at Z (40 kPa, 0.1 m^3) **(1)** • Use of $pV = nRT$ **(1)** • Temperature = 659K **(1)** OR • use $\frac{P_1V_1}{T_2} = \frac{P_2V_2}{T_2}$ **(1)** • for any point on graph + Z **(1)** • Temperature = 644 K to 667 K **(1)** Temperature = 644K to 667K **Example of answer** $T_2 = (V_2 T_1) \div V_1$ $T_2 = (0.100 \text{ m}^3 \times 297 \text{ K}) \div 0.045 \text{ m}^3$ $T_2 = 660$ K	**(3)**
	Total for question	**10**

6733 Unit Test PHY3 (Topics)

Topic A - Astrophysics

Question Number	Answer	Mark
1 (a)	**Wien's Law graph** λ_{max} AND m **(1)** T AND K **(1)** Inverse proportion shown **(1)** [accept λ_{max}^{-1} against T and straight line through origin or vice versa, allow both labels ✓ both units ✓]	**(3)**
(b)(i)	**Suhail temperature and radius calculations** Use of $L = \sigma T^4 A$ **(1)** Correct substitution [including 5.67×10^{-8}] **(1)** 4020 (K) [accept '4000K (2sf)'] **(1)** $T = \sqrt[4]{(L / (\sigma A))}$ $= \sqrt[4]{(9900 \times 3.9 \times 10^{26}\ W / (5.67 \times 10^{-8}\ W\ m^2\ K^{-4} \times 2.6 \times 10^{23}\ m^2))}$ $= 4023$ K	**(3)**
(ii)	Use of $4 \pi r^2$ **(1)** 1.44×10^{11} (m) **(1)** Correct ratio to answer [accept 200 to 210]**(1)** $r_{Suhail} = \sqrt{A / 4\pi}$ $= \sqrt{2.6 \times 10^{23}\ m^2 / 4\pi}$ $= 1.44 \times 10^{11}$ m $= (1.44 \times 10^{11}\ m / 6.96 \times 10^{8}\ m)\ r_{\odot}$ $= 207\ r_{\odot}$	**(3)**
(iii)	**Suhail star type** Red giant (star) [accept red supergiant] **(1)** $r_s >> r_{\odot}$ with numerical value [e.g. $r_s = 207\ r_{\odot}$]**(1)** $L_s >> L_{\odot}$ with numerical value **(1)** T of 4000 K (is typical of red giants) / gives $\lambda_{max} = 725$ nm, hence reddish **(1)**	**(4)**
(c)(i)	**Pulsar** Neutron star **(1)**	**(1)**
(ii)	$1.4\ m_{\odot}$ **(1)**	**(1)**

(iii)	Axis of rotation shown on each side of pulsar and labelled **(1)** Magnetic field loops clearly shown, at angle to axis, labelled **(1)** Two radio wave emissions clearly shown **(1)**	**(3)**
(iv)	Lighthouse idea: (continuous) waves "sweeping" out from pulsar **(1)** Lighthouse idea: waves detected when they pass across Earth **(1)**	**(2)**
(d) (i)	**Cepheid variable explanation** Quality of written communication **(1)** Period and luminosity linked **(1)** Measure / observe intensity (from Earth) **(1)** Use $I = L / 4 \pi D^2$ (to find distance) **(1)**	**(4)**
(ii)	**Cepheid period measurement** Multiple and/or repeat readings made **(1)** 5.4 days [accept 5.3 – 5.5 days] **(1)**	**(2)**
(e) (i)	**Hertzsprung-Russell diagram** Decreasing temperature scale with at least three values**(1)** Logarithmic nature [e.g. 40000, 10000, 2500; in range 50000 K – 2000 K for extremes of scale] **(1)**	**(2)**
(ii)	**Sirius A and Sirius B** A on main sequence and at $T = 10^4$ K**(1)** B at 25000 K [ecf] and below 10^{-2} $L_{\odot}$**(1)**	**(2)**
(iii)	White dwarf **(1)**	**(1)**
(iv)	$L_B << L_A$ or $I_B << I_A$ [B is much *dimmer* than A] **(1)**	**(1)**
	Total	**32**

Topic B – Solid Materials

Question Number	Answer	Mark
2 (a)	**Hooke's Law** Force / *F* AND Newtons / N **(1)** Extension / Δx / Δl AND metres / m **(1)** [or both labels ✓, both units ✓] Straight line through origin [only] **(1)**	**(3)**
(b) (i)	**Definitions** Can be drawn / pulled / made (easily) into wire **(1)** Yield (stress / point / strength) **(1)** Quench Hardening **(1)** Returns to original length (after being stressed) / reversible deformation **(1)** Creep **(1)** Fatigue **(1)**	**(6)**
(ii)	**Brittle and Tough** Brittle: Elastic / not plastic behaviour (until fracture) **(1)** Tough: Absorbs energy plastically **(1)**	**(2)**
(c)(i)	**Drill area 'show that'** Attempted use of $\sigma = F / A$ (any *A*, any 10^n) **(1)** Use of πr^2 [accept *d* instead of *r*] **(1)** 1.42×10^6 and 6.35×10^{-2} implied **(1)** $1.1(2) \times 10^8$ (Pa) [accept 1.08] **(1)** $\sigma = F / A$ $= 1.42 \times 10^6$ N/ $\pi (6.35 \times 10^{-2})^2$ $= 1.12 \times 10^8$ Pa	**(4)**
(ii)	**Stress calculation** Use of $E = \sigma / \varepsilon$ [1.12×10^8 Pa / 1.65×10^{11} Pa**] (1)** 6.79×10^{-4} [accept 6×10^{-4} or 6.7×10^{-4}] **(1)**	**(2)**

(iii)	**Length calculation** Use of $\varepsilon = \Delta l / l$ [i.e. $l = 1.33 / 6.79 \times 10^{-4}$] **(1)** 1960 m [ecf] **(1)**	**(2)**
(iv)	**Energy stored calculation** Substitution in ½ $F\ \Delta x$ [½ x 1.42 MN x 1.33 m] **(1)** 9.44×10^5 J **(1)**	**(2)**
(d) **(i)** **(ii)**	**Edge dislocation explanation** Diagram showing planes / rows AND labelled atoms / molecules / ions **(1)** Half-row of atoms / molecules **(1)** Slip plane correctly shown [horizontal line just below gap] **(1)**	**(2)** **(1)**
(iii)	**Dislocations description** Quality of written communication **(1)** Context: when metal is stressed **(1)** Dislocations move [or description of this] **(1)** Reducing stress concentrations / absorbs energy plastically / allows plastic deformation **(1)**	**(4)**
(e)	**Stress-strain graph** Shape [steep rise, then almost level] **(1)** Straight line to 3.9 GPa at strain 0.03, with working shown **(1)** Area = energy density [may be implied]**(1)** Breaks between 4 and 5 GPa with strain in range 0.16 to 0.20, with working shown **(1)**	**(4)**
	Total	**32**

Topic C – Nuclear and Particle Physics

Question Number	Answer	Mark
3 (a) (i)	**Beta-minus spectrum** Correct shape [bump and drop to x-axis] **(1)** Number of beta / particles **(1)** Kinetic energy (MeV) **(1)**	**(3)**
(ii)	**Neutron decay** ${}^{1}_{0}$n to ${}^{1}_{1}$p **(1)** Correct equation with ${}^{0}_{-1}\beta^{(-)}$ and $\bar{\nu}$ **(1)**	**(2)**
(b)	**Nuclear forces** EM: Repulsive AND SN: Attractive [accept EM attractive AND repulsive] **(1)** EM: protons [accept charged particles] AND nucleons / n and p [accept quarks] **(1)** EM: infinite / beyond nucleus AND SN: within nucleus / 10^{-14} m - 10^{-18} m **(1)**	**(3)**
(c)(i)	**Binding energy per nucleon calculation** Attempt at Δm with 8p and 8n **(1)** 0.137 (u) **(1)** Multiply u by 930 MeV **(1)** 7.96 (MeV) [accept 8.0] **(1)** Δm = (8 x 1.007 276 u) + (8 x 1.008 665 u) – 15.990 527 u = 0.137 u ΔE = 0.137 u x 930 MeV / u = 127 MeV ΔE / A = 127 MeV / 16 = 7.96 MeV	**(4)**
(ii)	**Binding energy per nucleon graph** O near A = 16, on line and at 8 MeV **(1)**	**(1)**
(iii)	Correct shape [start near origin, steep rise, shallow fall to > 6 MeV] **(1)**	**(1)**

(iv)	Peak = 9 MeV [accept answer between 8.5 MeV and 10 MeV inclusive] **(1)**	**(1)**
(d)	**Nuclear radii ratio** $r = r_0 A^{1/3}$ [may be implied] **(1)** 6.20 r_0 OR 3.14 r_0 OR 7.4 x 10^{-15} m OR 3.8 10^{-15} m [may be implied] **(1)** Ratio 1.97 **(1)** $r_U / r_P = A_U^{1/3} / A_P^{1/3}$ $= 238^{1/3} / 31^{1/3}$ $= 7.6831^{1/3}$ $= 1.97$	**(3)**
(e) (i)	**Quark structure deduction** u u d **(1)** proton **(1)** Correct cancelling in decay 3, with s to d shown **(1)**	**(3)**
(ii)	Quark classifications Baryon: Ω^-, Ξ^0, Λ^0, p / X [ecf, accept three baryons with both mesons] **(1)** Meson: π^-, π^0 or both **(1)** No leptons, five [or six] particles are hadrons **(1)**	**(3)**
(iii)	**Strange quark charge** [From Ω^-] Q(sss) = -1, hence -⅓ **(1)**	**(1)**
(iv)	**Exchange forces discussion** Quality of written communication **(1)** Electromagnetic only acts on charged particles **(1)** Decay two particle(s) neutral **(1)** Change in quark flavour **hence** weak **(1)**	**(4)**
(v)	Conservation laws Baryon number in A: $+1 \neq 0 + 0$ **(1)** Charge number in C: $-1 \neq 0 + 0$ **(1)** Hence A and C not possible / only B possible **(1)**	**(3)**
	Total	**32**

Topic D – Medical Physics

Question Number	Answer	Mark
4(a)	**Inverse square law graph** Intensity / I AND W m^{-2} **(1)** Distance / d / r AND m [or r^2 and m^2] **(1)** Inverse (square) shape [not touching either axis] **(1)** [accept I against d^{-2} and straight line through origin, allow both labels ✓ both units ✓]	**(3)**
(b) (i)	<u>Reflection coefficient calculations</u> Use of α equation **(1)** Correct substitution **(1)** 2.4×10^{-4} / 0.024% **(1)** $\alpha = (Z_2 - Z_1)^2 / (Z_2 + Z_1)^2$ $= ((1.63 - 1.58) \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1})^2 / ((1.63 + 1.58) \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1})^2$ $= 2.43 \times 10^{-4} = 0.0243\%$	**(3)**
(ii)	**Transmission percentage** 1 - α / 100 - α% **(1)** 99.98% [ecf] **(1)**	**(2)**
(iii)	**Coupling medium explanation** At skin / boundary: almost 100% reflection with no gel [none with gel] **(1)** Hence ultrasound enters body (for imaging when gel used) **(1)**	**(2)**
(iv)	**A-scan description** Quality of written communication **(1)** Pulse, in, out **(1)** Measure time delay (of reflected pulse) **(1)** Use $d = v\,t$ **(1)** Depth = ½d [or use ½t] **(1)**	**(5)**

(d) (i)	**X-ray summary table** kV AND MV [if value given: accept 30 - 100 kV, 1 – 25 MV] **(1)** Strongly / Z^3 AND not strongly [accept 'yes, no' or similar] **(1)**	**(2)**
(ii)	X-ray damage due to ionisation	**(1)**
(e) (i)	**X-ray tube** Thermionic emission / release electrons [not "accelerates electrons"] **(1)** No air molecules [accept just particles] to impede electrons **(1)** Accelerate electrons [accept 'speed up'] **(1)**	**(3)**
(ii)	**Anode features** • Release X-rays + when hit by electrons • Rotates + reduce temperature rise / increase area hit • Made of Tungsten + good property, e.g. high melting point • Copper heat sink + to dissipate heat • Oil coolant + to dissipate heat • Bevelled shape + to direct X-ray (to patient) • High voltage + to accelerate electrons First feature stated **(1)** First explanation **(1)** Second feature **(1)** Second explanation **(1)**	**(4)**
(f)(i)	**Dilution study** To give a similar activity to sample from patient / not accurate to comp samples with greatly different activity with same detector **(1)**	**(1)**
(ii)	Time to allowing mixing / dilution with (patient's) blood **(1)**	**(1)**
(iii)	125 000 (Bq) used [i.e. conversion of kBq] **(1)** Dilution factor 5 ÷ 6010 or 5 ÷ 6000 **(1)** 104 (Bq) **(1)**	**(3)**
(iv)	Multiply by ratio 104 ÷ 120 [or 100 ÷ 120] **(1)** 5 litres / 5000 cm^3 / 5.2 litres / 5200 cm^3 **(1)** [accept activity ratio compared to volume ratio calculations]	**(2)**
	Total	**32**

6733 Unit Test PHY3 - Practical Test

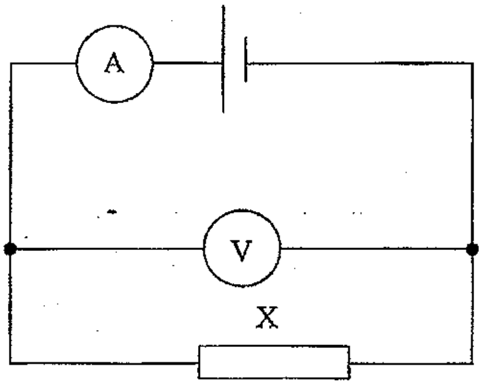
6733/2A

Leave blank

Question A

(a) (i) Set up the circuit as shown in the diagram below with the resistor labelled X in the circuit.

Before you connect 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.



Circuit set up correctly without help. (Ignore polarity errors) **(2)** 2

(ii) Connect the power supply. Measure the current I_X in the resistor X and the potential difference V_X across X.

I_X = 6.8 mA | 6.0 to 8.0 mA to 0.1 mA or better + unit (1)

V_X = 1.52 V | 1.35 to 1.65 V to 0.01 V or better + unit (1)

(2) 2

(iii) Replace resistor X by resistor Y. Measure the current I_Y in the resistor Y and the potential difference V_Y across Y.

I_Y = 14.3 mA | I_Y 13.0 to 18.0 mA to 0.1 mA or better + unit (1)

V_Y = 1.51 V | $V_Y \leq V_X$ to 0.01 V or better + unit (1) and $\geq$ 1.0 V

(2) 2

In (ii), (iii) and (iv) penalise systematic error in I −1 once only.
Systematic error in V, −1 once only.
I and V reversed, −2.
Series connection $I_C \approx 5.0$ mA, then do not award marks in part (iv)

(iv) Connect resistor X so that it is in parallel with resistor Y. Measure the current I_C in the combination of resistors and the potential difference V_C across the combination.

I_C = 20.8 mA

V_C = 1.50 V

$I_C \leq (I_X + I_Y)$ to 0.1 mA or better + unit (1) and sensible
$V_C \leq V_Y$ to 0.01 V or better + unit (1)

(2) 2

In (ii), (iii) and (iv) penalise incorrect unit for I once only
incorrect unit for V once only.
incorrect precision for I once only
incorrect precision for V once only.

Disconnect the power supply.

(v) Using your results from parts (ii), (iii) and (iv), calculate the resistance R_X of X, the resistance R_Y of Y and the resistance R_C of the parallel combination.

$R_X = \frac{1.52}{6.8 \times 10^{-3}} = 224\,\Omega$

$R_Y = \frac{1.51}{14.3 \times 10^{-3}} = 106\,\Omega$

$R_C = \frac{1.50}{20.8 \times 10^{-3}} = 72\,\Omega$.

$R = \frac{\text{Candidate's } V}{\text{Candidate's } I}$ used consistently (1)
Correct calculation for at least 2 values (1)
2/3 s.f. + unit for all 3 values (1)

(3) 3

(vi) Use your experimental values of R_X and R_Y to calculate the expected resistance R_T, of the parallel combination.

$\frac{1}{R_T} = \frac{1}{224} + \frac{1}{106}$

$= 0.0139\,\Omega^{-1}$

$\therefore R_T = 72\,\Omega$.

Correct substitution (1)
Correct calculation ≥ 2 s.f. + unit (1) ecf unit.
Award 2 marks if correct answer.

Determine the percentage difference between R_C and R_T.

No percentage difference to 2 significant figures.

Correct calculation of % difference or no % difference to a given number of s.f. (1)
(Allow, R_C, R_T or average as denominator)

Suggest possible reasons for any difference between R_C and R_T.

Voltmeter may take some current / Voltmeter may have infinite resistance (1)
Ammeter measures current through voltmeter (1)

Small uncertainties in reading meters (1)
Additional resistance of connecting wires (1)
Higher temperature so resistance values increased (1) Maximum (1) mark

(4) 4

Leave blank

(b) (i) Record the mass M of the block of wood and the small hook. This value is written on the block's top surface.

M = 95.4 g.

Place the 100 g mass on the block of wood. Record the total mass M_T of the block and the 100 g mass.

M_T = 195.4 g.

Position the block on the bench so that the mass hanger is just below the pulley. Add 10 g slotted masses to the 10 g mass hanger until it is clear that the block accelerates across the bench when given a gentle tap in the direction of travel.

Record the total mass m of the hanger and the slotted masses needed to cause this acceleration.

m = 80 g.

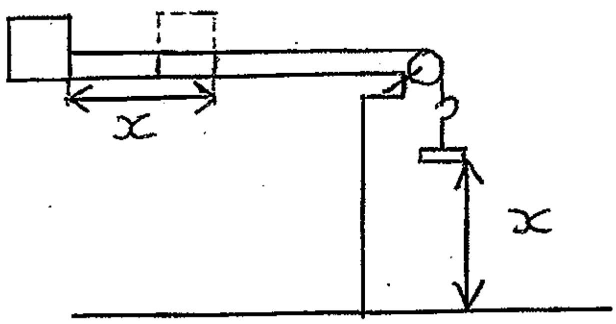
m 60 to 100 g + unit (seen anywhere) and M_T correct (1)

(Allow measurement of M_T on, for example, top pan balance)

(1) 1

(ii) Determine the maximum distance x over which the block is accelerated.

Explain, with the aid of a diagram, how you did this.



x = 62.0 cm.

Two positions of the block or mass shown or implied with the distance moved clear and correct (1)

[This can be shown horizontally or vertically]

Mass reaching floor shown / implied / stated (1)

x recorded to the nearest mm or better with unit and $\geq$ 60.0 cm but less than the height of the bench (1)

(3) 3

Leave blank

(iii) With the aid of the two small pieces of masking tape, mark the distance x on the bench. Determine the time t taken for the block of wood to travel this distance from rest. [Allow a wide range of values for t]

t = 1.28, 1.32, 1.35, 1.28, 1.37 s | t from ≥ 3 readings (2) with unit seen somewhere.

$\bar{t}$ = 1.32 s | [t from 2 readings (1)]

All values to nearest second – no mark.
Systematic error e.g. 0.01325 – no mark.

(2) 2

(iv) Calculate the acceleration a of the block given that $a = \frac{2x}{t^2}$.

$a = \frac{2 \times 0.620}{1.32^2} = 0.712 \text{ m s}^{-2}$ | Correct calc ≥ 2 s.f. + unit (1)

The frictional force F opposing the motion of the block is given by

$$F = mg - (M_T + m)a$$

Calculate F.

$F = 0.080 \times 9.81 - (0.1954 + 0.080)0.712$
$= 0.59$ N.

Correct substitution (1)
[Accept g = 9.8 or 10 m s^{-2}]
Value 0.2 N to 1.0 N 2/3 s.f. + unit from correct calculations of a and F (1)

(3) 3

Q1A 24

(Total 24 marks)

Question B

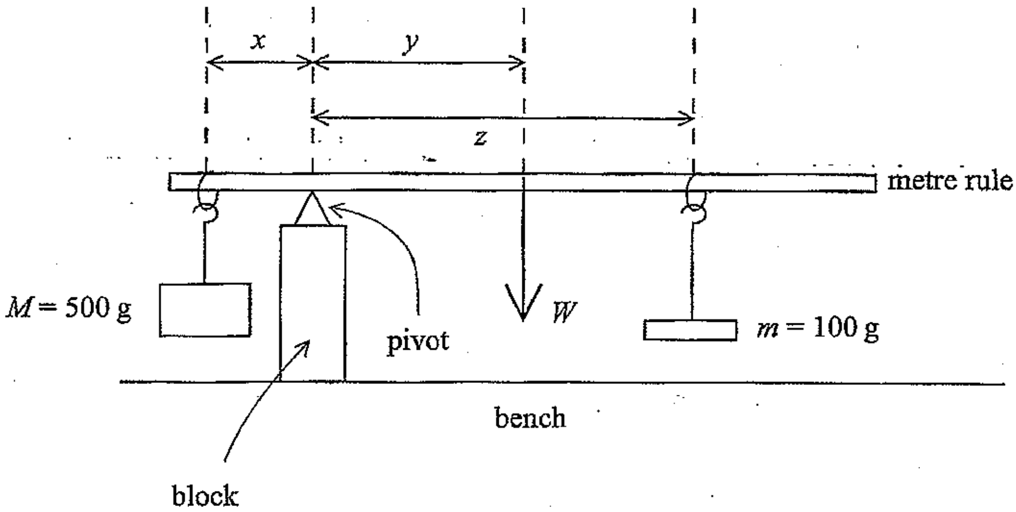
(a) Determine the position of the centre of mass of the metre rule.

Position of centre of mass = 506 mm

Recorded to the nearest mm or better and in range 480 mm to 520 mm with unit (1).

(1) 1

(b) You are to investigate a model of a crane in which the weight of a mass that is being lifted on one side of a pivot is counterbalanced by a large weight placed on the opposite side of the pivot.



Place the pivot on the block of wood. Place the rule on the pivot at the 20.0 cm mark on the rule. Place one of the loops of thread at the 5.0 cm mark on the rule and suspend a mass $M = 500$ g from this point. Using the other loop of thread suspend a mass $m = 100$ g on the opposite side of the pivot. Move the position of the 100 g mass until the system is in equilibrium with the rule approximately horizontal. Determine the distances x, y and z shown on the diagram.

x = 20.0 − 5.0 = 15.0 cm

y = 50.6 − 20.0 = 30.6 cm

z = 71.4 − 20.0 = 51.4 cm

x = 15.0 cm and y correct (Position of Centre of mass − 20.0) (1)

z recorded to the nearest mm or better with unit seen somewhere (1)

Scale readings shown for z on diagram or here. (1)

3

If no value recorded in (a), accept 28.0 cm ≤ y ≤ 32.0 cm.

Leave blank

(c) By considering the uncertainty in the measurements taken on the metre rule determine the percentage uncertainty in your measurement of x. Which of the quantities x, y or z is likely to have the lowest percentage uncertainty? Explain your answer.

$\Delta x = 2$ mm.

% uncertainty $= \frac{2}{150} \times 100 = 1.3\%$.

z is the longest length and so will have the smallest percentage uncertainty

$\Delta x = 1$ mm or 2 mm (1)
Correct calculation of percentage (1) ecf wrong Δx
Longest length chosen (1)

(3) 3

(d) Applying the principle of moments to this situation, the following equation is obtained.

$$Mgx = Wy + mgz \quad \text{[Equation 1]}$$

where W = the weight of the metre rule.

Using your results from part (b), determine W.

$0.500 \times 9.81 \times 0.150 = W \times 0.306 + 0.100 \times 9.81 \times 0.514$

$0.736 = W \times 0.306 + 0.504$

$\therefore 0.306W = 0.232$

$\therefore W = 0.757$ N.

Correct substitution for weight with consistent distance units (1)
Correct calculation for weight with unit and ≥ 2 s.f. (1)
Value ± 10% of Supervisor's value (2)

(4) 4

[Value ± 20% of Supervisor's value (1)].

[When judging accuracy (last 2 marks) allow mass or weight and ignore units.
When comparing masses allow Supervisor to use $g = 9.81$ ms^{-2} or $g = 10$ ms^{-2}]

Leave blank

(e) Without altering the position of the 100 g mass hanger, add a further 100 g to the hanger to give a new value of m of 200 g. Keeping the 200 g mass and the 500 g mass in the same positions, move the position of the rule on the pivot until the system is again in equilibrium with the metre rule approximately horizontal.

Record the new position of the pivot.

New position of pivot = 26.7 cm

Determine new values for x, y and z. Hence determine a second value for W.

$x = 26.7 - 5.0 = 21.7$ cm

$y = 50.6 - 26.7 = 23.9$ cm

$z = 71.4 - 26.7 = 44.7$ cm

Sensible values of x, y and z from new pivot position with unit seen somewhere (1)

[x increased by distance pivot moves, y and z decreased by distance pivot moves]

$0.500 \times 9.81 \times 0.217 = W \times 0.239 + 0.200 \times 9.81 \times 0.447$

$1.064 = 0.239W + 0.877$

$0.239W = 0.187$

$\therefore W = 0.784$ N.

W values within 10% of each other (2)

[W values within 20% of each other (1)]

(3) 3

(f) Calculate the percentage difference between the two values of W. Using your result from part (c), comment on the extent to which this percentage difference may be due to experimental uncertainty.

% difference

$= \frac{0.784 - 0.757}{\frac{1}{2}(0.784 + 0.757)} \times 100\%$

$= 3.5\%$

Taking into account all measurements for both sets of results, difference can be explained by experimental error.

i.e. $2(1.3 + \%\text{unc in } y + \%\text{unc in } z)$

Correct calc of % difference with average as denominator (1)

Comment related to size of experimental uncertainty in part (c) (1)

Conclusion (1)

(3) 3

Leave blank

(g) Equation 1 in part (d) may be re-written in the form:

$$\frac{y}{x} = -\frac{g}{W}\frac{mz}{x} + \frac{Mg}{W} \qquad \text{[Equation 2]}$$

In this equation x, y, z and m are all variables. M, g and W are constants. Equation 2 may be compared to that of a straight line. You are to plan an experiment to investigate this model, where **only** the movement of the pivot is used to restore balance when the value of m is changed. Your plan should include:

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

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

(iii) an indication of the expected results.

Vary the mass suspended (1)

m and M are in fixed positions (1)

or rule

Move pivot/hand until rule balanced / in equilibrium (1)

Record (m) x, y and z (1)

At least 5 different sets of readings (1)

[May be stated / shown in table / shown on graph]

Max (4)

Plot $\frac{y}{x}$ against $\frac{mz}{x}$ (1)

Straight line with -VE slope (1)

Intercept = $\frac{Mg}{W}$, Slope = $-\frac{g}{W}$ (1)

(7)

7

Q1B

24

(Total 24 marks)

TOTAL FOR PAPER: 48 MARKS

END

Question Number	Answer	Mark
1 (a) **(i)** **(ii)** **(iii)**	<u>What happens to the property</u> Increases **(1)** Decreases **(1)** Decreases **(1)**	**(3)**
(b)	<u>Property which increases at larger wavelengths</u> Diffraction / Fringe width/spacing (in 2-slit interference) / Period / Wavelength shift in Doppler effect **(1)**	**(1)**
(c)	<u>Effect of wavelength on particle behaviour</u> Short(er) wavelengths are (more) particle-like **(1)** [Or converse statement about larg(er) wavelengths] [Ignore references to energy momentum, photoelectric emission unless linked particle-like behaviour]	**(1)**
	Total	**5**

Question Number	Answer	Mark
2 (a)	<u>Calculation of wavelength</u> Use of $\lambda = vT$ or $f = 1/T$ and $v = f\lambda$ **(1)** Correct answer [1.81, 3 sig fig minimum, no u.e.] **(1)** [Allow 1.82] Example calculation: $\lambda = vT = 1.51 \text{ m s}^{-1} \times 1.20 \text{ s} = 1.812 \text{ (m)}$	**(2)**
(b)	<u>Graph for leaf X</u> 2 cycles of a sinusoidal wave of period 1.2 s **(1)** [Zero crossings to be consistent to nearest half square] Cosine graph, with scale on displacement axis and amplitude 0.08 m **(1)**	**(2)**
(c)	<u>Graph for leaf Y</u> Sinusoidal graph lagging 0.3 s behind the graph drawn for X [check peaks only] **(2)** [Allow **1** mark if Y graph leads X graph by 0.3 s] [Ignore zero crossings and displacement scale; accept zero displacement up to t = 0.3 s]	**(2)**
	Total	**6**

Question Number	Answer	Mark
3 (a)	<u>Calculation of power output</u> Use of $P = IA$ [Can omit efficiency here] **(1)** Correct answer [7.2×10^3 , 2 sig fig minimum, no u.e.] **(1)** Example calculation: $P_{elec} = 0.19 \times 1400 \text{ W m}^{-2} \times 27 \text{ m}^2 = 7182$ (W)	**(2)**
(b) (i)	<u>Power output in Mars orbit</u> Use of $P_{Mars}/P_{Earth} = (r_{Earth}/r_{Mars})^2$ or equivalent formula for I **(2)** OR Use of P (or I) = k/r^2 for Earth, to give k **(1)** Use formula again, knowing k, for Mars **(1)** OR Use of $P = 4\pi r^2 I$ to give P_{Sun} [3.96×10^{26} W] **(1)** Use formula again, knowing P, for Mars **(1)** Correct answer [3.1 kW, or 3.0 kW if 7 kW used] **(1)** Example calculation: $P_{elec} = 7182 \text{ W} \times (1.5 \times 10^{11} \text{ m} / 2.3 \times 10^{11} \text{ m})^2 = 3055$ W	**(3)**
(ii)	<u>Assumption</u> EITHER Intensity obeys inverse square law OR (space is a vacuum) / contains very few atoms **(1)** No radiation (OR light OR energy) absorbed **(1)** OR Sun-to-satellite distance = Sun-to-planet distance **(1)** Satellite orbit radius << Sun-to-planet distance **(1)** [Ignore reference to light from other stars and blocking of light by other bodies and changes in efficiency or anything already referred to in question e.g. arrays perpendicular to rays, Sun radiates uniformly in all directions]	**(2)**
	Total	**7**

Question Number	Answer	Mark
4(a)	Description of force R Normal reaction / normal contact **(1)** Car/wheels/tyres Ground/road/Earth/earth **(1)** [Both answers needed for mark]	**(2)**
(b)(i)	Acceleration and proof of formula v^2/r OR $\omega^2 r$ OR resultant force/m OR $(R\text{-}mg)/m$ **(1)** Upwards / towards O / towards the centre / centripetal **(1)**	
(ii)	Resultant (OR unbalanced OR net OR accelerating) force = $R - mg$ OR = mv^2/r **(1)** Hence $R - mg = mv^2/r$ **(1)**	**(4)**
(c) (i)	Gradient Use of gradient = $\Delta R/\Delta v^2$ **(1)** Correct answer [in the range 12.7 to 14.8 (N s^2 m^{-2})] **(1)** [Accept 0.0127 to 0.0148 (kN s^2 m^{-2}) i.e. mark numerical value only and ignore units] [Note that ΔR = 18 – 12 (scales misread) leading to a gradient of 15 will score first mark only as value is outside range] Example calculation: gradient = $(16.5 - 11.0) \times 10^3$ N/(400 m^2 s^{-2}) = 13.75 (N s^2 m^{-2} or kg m^{-1})	**(2)**
(ii)	Calculation of r Use of gradient = m/r **(1)** (OR Use of $R = mv^2/r + mg$ with coordinates from graph) Correct answer [74 to 88 m] **(1)** [Allow ecf from incorrect gradient, BUT if they didn't convert kN to N in gradient calculation they must do so here to earn both marks] Example calculation: r = gradient/m = (1120 kg)/(13.75 kg m^{-1}) = 81.45 m	**(2)**
	Total	**(10)**

Question Number	Answer	Mark
5(a)(i)	Acceleration-time graph Inverted version of displacement graph **(1)**	**(1)**
(ii)	Formula $(2\pi f)^2 x_0 m$ OR $4\pi^2 f^2 x_0 m$ **(1)** [Ignore leading negative but must be x_0 and not just x]	**(1)**
(b)(i)	Where soil is most likely to break free Q/at ends with a valid reason **(1)** Possible reasons: Acceleration is greater (Resultant) force (needed) is greater Soil keeps moving whilst root (or plant) turns round	**(1)**
(ii)	More effective strategy Double f because acceleration (or force) is increased more/greater **(1)** Quantitative statement **(1)** Possible statements: Force (or acceleration) is proportional to x_0 but to f squared Doubling x_0 doubles force (or acceleration) but doubling f quadruples it States equation and points out that f is squared	**(2)**
	Total	**5**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>6(a)</td><td>
<u>Explanation of observations</u>

QOWC (1)

Slits act as coherent sources (1)

<table>
<tr><td>At maximum
Or At O / P</td><td>waves in phase</td><td>constructive interference
Or reinforcement</td><td>(1)</td></tr>
<tr><td>At minimum</td><td>waves in antiphase Or exactly out of phase</td><td>destructive interference
Or cancellation</td><td>(1)</td></tr>
<tr><td>Or</td><td>(1)</td><td>(1)</td><td></td></tr>
</table>
[Can score marks either horizontally or vertically but not both]

At maximum, path difference = $n\lambda$ (1)
(Or At O, path difference = 0 Or At 1st maximum/P, path difference = λ)

At minimum, path difference = $(n + ½)\lambda$ (1)
(Or At 1st minimum, path difference = ½ λ)
</td><td>(Max 5)</td></tr>
<tr><td>(b) (i)</td><td>
<u>Wavelength calculation from formula</u>

Correct answer [3.4 cm] (1)

Example calculation:
$\lambda = xs/D$ = (4.1 cm)(8.2 cm)/(10.0 cm) = 3.36 cm
</td><td>(1)</td></tr>
<tr><td>(ii)</td><td>
<u>Correct wavelength calculation</u>

Use of Pythagoras for S_2P (1)

Use of $\lambda = S_2P - S_1P$ (1)

Correct answer [2.9 cm] (1)
[Bald answer of 3 cm scores 0/3 while bald answer of 2.9 cm scores 3/3]

Example calculation:
$S_2P = \sqrt{(10.0\text{ cm})^2 + (8.2\text{ cm})^2}$
= 12.93 cm
λ = 12.9 cm - 10.0 cm
= 2.9 cm
</td><td>(3)</td></tr>
<tr><td>(iii)</td><td>
<u>Condition for formula to be valid</u>

$s \ll D$ OR $s \gg \lambda$ (1)
[if in words then need idea of ‘much less than’ or ‘much greater than’]
[Ignore any stated values]
</td><td>(1)</td></tr>
<tr><td></td><td>Total</td><td>10</td></tr>
</table>

Question Number	Answer	Mark
7 (a)	Why the equation is true *hf* is the energy of a photon **(1)** φ is the minimum energy to remove the electron / the energy to remove a surface electron **(1)** Difference is E_{max} by conservation of energy **(1)**	**(3)**
(b)	Measuring E_{max} Circuit to apply a reverse p.d. (anode negative) **(1)** P.d variable from zero **(1)** [Accept potential divider or d.c. supply with arrow through it or labelled variable d.c. supply, but not series rheostat] Ammeter and voltmeter suitably positioned **(1)** [Allow A, mA, μA, nA, pA but not I or M] [Don't worry if ammeter is placed so its reading includes voltmeter current] Increase *V* until *I* falls to zero / vary *V* until *I* just falls to zero **(1)** Record voltmeter reading **(1)** Multiply stopping potential (Or V_S) by *e* **(1)** (Or Stopping potential (Or V_S) gives E_{max} in eV) [if stating qV_S then must equate *q* to *e*]	**(Max 5)**
(c)	Calculation of *f* Use of $E_{max} = hf - \varphi$ **(1)** Correct answer [8.4×10^{14} Hz or s^{-1}] **(1)** Example calculation: $f = (E_{max} + \varphi)/h = (2.0 \times 10^{-19} + 3.6 \times 10^{-19})$ J/(6.63×10^{-34} J s) $= 8.45 \times 10^{14}$ Hz	**(2)**
	Total	**10**

Question Number	Answer	Mark
8 (a)	How wavelength depends on galaxy distance (Observed) wavelength increases as distance increases **(1)** Wavelength change (OR redshift) is proportional to distance (to galaxy) **(1)** [Allow $\Delta\lambda \propto d$ without symbols defined]	**(2)**
(b) (i)	Why expansion rate is expected to decrease with time Gravitational attraction slows down the galaxies / **(1)** KE converted to GPE so galaxies slow down [Accept force or pull of gravity, but not just "gravity"]	**(1)**
(ii)	Open and closed universes Open: graph A, keeps on expanding **(1)** Closed: graph B, eventually (stops expanding and) contracts **(1)** [Ignore references to Big Crunch] [Maximum of 1 if graphs A and B not referred to]	**(2)**
(iii)	Condition to be satisfied (Average mass-energy) density is below critical/threshold value **(1)** [Or converse statement if it is clear that candidate is stating condition for graph B to be followed]	**(1)**
(c)	Sketch graph Single line rising from origin, whose gradient initially decreases (but not to zero), then starts to increase **(1)**	**(1)**
	Total	**7**
	Total for paper	**60**

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