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Mark Scheme Final Version
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GCE

GCE Physics (6731/01)

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These instructions should be the first page of all mark schemes

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

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 / 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. '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:

'Show that' calculation of weight

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)	<table><tr><th>Quantity *Y*</th><th>Quantity *X*</th><th>Graph</th></tr><tr><td></td><td></td><td>B</td></tr><tr><td></td><td></td><td>B</td></tr><tr><td></td><td></td><td>C</td></tr><tr><td></td><td></td><td>A</td></tr></table>	✓ ✓ ✓ ✓ **(4)**
	Total for question	**(4)**

Question Number	Answer	Mark
2 (a)	Principle of moments For equilibrium / balance (1) [Accept 'stable' for equilibrium] Sum of moments clockwise = sum of the moments anticlockwise or sum of moments (about a point) is zero. (1) [Sum or equivalent eg total / net / resultant, not all, must be seen at least once. Accept ∑ for sum.]	**(2)**
(b) i	Weight of ruler Any correct moment [calculation or value] (1) Use of the principle of moments (1) [For this mark the moment of the ruler must be added to the moment of the 0.5 N – allow one wrong distance] Answer [1.2 N] (1) Eg 1.1 N x 20 (10^{-2}) m = W x 10 (x 10^{-2}) m + 0.5 N x 20 (x 10^{-2} m) W = 1.2 N	**(3)**
(b) ii	Additional weight Use of the principle of moments (1) [Allow one wrong distance for this mark. Allow this mark for subtracting moments ie 0.33 (N m) – 0.05 (N m) even if the candidate then states the difference as the answer for the total weight or weight added. If a value for the moment of the weight of the ruler is included give 0/3] Total weight at 60 cm [3.3 (N)] (1) Weight added [(3.3 – 0.5) 2.8 N] (1) Eg 1.1 N x 30 (x 10^{-2}) m = F x 10 (x 10^{-2}) m F = 3.3 N Weight added = 3.3 N – 0.5 N = 2.8 N	**(3)**
	Total for question	**(8)**

Question Number	Answer	Mark
3 (a)	Show that the speed is approximately 30 m s^{-1} Sets $E_K = mg\Delta h$ (1) Substitution into formulae of 9.8(1) m s^{-2} or 10 m s^{-2} and 50 m. (1) [Also allow substitution of 60 m for this mark] Answer [31 m s^{-1}. 2 sig fig required. No ue.] (1) Eg $\frac{1}{2} mv^2 = mg\Delta h$ $v^2 = 2gh = 2 \times 9.81 \text{ m s}^{-2} \times 50 \text{ m}$ $v = 31.3 \text{ (m s}^{-1}\text{)}$ Answer is 31.6 m s^{-1} if 10 m s^{-2} is used Also allow the following solution although this is not uniformly accelerated motion. $v^2 = u^2 + 2as$ $v^2 = 0 + 2 \times 9.81 \text{ m s}^{-2} \times 50 \text{ m}$ $v = v = 31.3 \text{ (m s}^{-1}\text{)}$	**(3)**
(b) i	Average braking force [ecf value of v] For the equation $\frac{1}{2} mv^2$ (1) [give this mark if this is shown in symbols, words or values] Attempts to obtain the difference between two energy values that relate to with and without the braking system or for setting an energy value equal to Force x 80 m (1) Answer [800 N if 30 m s^{-1} used; If 31.3 m s^{-1} or 31.6 m s^{-1} are used accept answers in the range 1100 N - 1300 N; If 34 m s^{-1} is used answer is 2000 N] (1) Eg $(367875 \text{ J})_{\text{ke after free fall}} - (273375 \text{ J})_{\text{ke at 27m/s}} = 94500 \text{ J}$ $F \times 80 \text{ m} = 94500 \text{ J}$ $F = 1180 \text{ N}$ Also allow the following solution. Selects $v^2 = u^2 + 2as$ and $F = ma$ (1) Attempts to obtain the difference between two forces / accelerations that relate to with and without the braking system. (1) Answer [800 N if 30 m s^{-1} used; If 31.3 m s^{-1} or 31.6 m s^{-1} are used accept answers in the range 1100 N - 1300 N; If 34 m s^{-1} is used answer is 2000 N] (1) Eg Braking force = (-) 750 ($\frac{(31.3 \text{ m s}^{-1})^2 - (0)^2}{2 \times 80 \text{ m}}$ - $\frac{(27 \text{ m s}^{-1})^2 - (0)^2}{2 \times 80 \text{ m}}$) = (-) 1175 N	**(3)**

(b) ii	Why braking force of this magnitude not required Air resistance (would also act to reduce speed) (1) Or Number and/or mass of passengers will vary Or Friction [ignore references to where forces act for this mark. A bald answer ie 'friction' is acceptable] Or Accept some (kinetic) energy is transferred [not 'lost'] to thermal energy [accept heat] (and sound) Or Work is done against friction	**(1)**
(b) iii	Explain whether braking force would change QWOC: (1) Either The kinetic energy will be greater (because the mass of the passengers has increased) (1) (hence) more work would have to be done(by the braking system) (1) (The distance travelled, P to Q, is the same therefore) greater (braking) force is required (1) Or Momentum (of the truck) will be greater (because the mass of the passengers has increased) (1) Rate of change of momentum will be greater or [allow] the time taken to travel (80 m) will be the same [if the candidate writes 'constant' allow this if you feel they mean 'same'] (1) (Therefore) greater (braking) force is required (1) Or (Allow) Change in velocity and the time taken (for the truck to travel 80 m) will be the same or (Average) deceleration / acceleration will be the same [accept 'constant' if they mean 'same'. Also accept any fixed value for acceleration eg 9.8 m s^{-2}] (for greater mass of passengers) (1) (since) F = ma and mass has increased (1) A greater (braking) force is required (1)	**(4)**
	Total for question	**(11)**

Question Number	Answer	Mark
4 (a) i	Additional height Answer [5 (m)] (1) Eg distance = area of small triangle = 0.5 x 1 s x 10 m s^{-1} = 5 m	**(1)**
(a) ii	Total distance travelled [Allow ecf of their value] Distance travelled between 1 s and 4s [45 m] (1) Answer [50 m] (1) Eg distance fallen = area of large triangle = 0.5 x 3 s x 30 m s^{-1} = 45 m total distance = 45 m + 5 m = 50 m	**(2)**
b	Objects displacement 40 m (1) Below (point of release) or minus sign (1) [Ecf candidates answers for additional height and distance ie use their distance – 2 x their additional height]	**(2)**
c	Acceleration time graph Line drawn parallel to time axis extending from t = 0 (1) [Above or below the time axis] The line drawn parallel to the time axis extends from 0 s to 4 s (1) [If line continues beyond or stops short of 4 s do not give this mark] Acceleration shown as minus 10 m s^{-2} (1) [This mark is consequent on the second mark being obtained]	**(3)**
	Total for question	**(8)**

Question Number	Answer	Mark
5 (a)	Account for the force When the flea pushes (down) on the surface the surface [accept ground, not earth] pushes back / upwards (1) with an equal (magnitude of) force (1) [A statement of Newton's 3rd law gets no marks – it must be applied]	**(2)**
(b) i	Show acceleration is about 1000 m s^{-2} Either Selects $v^2 = u^2 + 2as$ Or two appropriate equations of motion (1) Correct substitution into the equation (1) [Do not penalise power of ten error. Allow 0.4 mm and 0.9 m s^{-1} substitutions for this mark.] Answer [in range (1025 – 1060) m s^{-2}, must be given to at least 3 sig fig. No ue] (1) Eg (0.95 m s^{-1})^2 = 2 x a x 0.44 (x 10^{-3}) m a = 1026 (m s^{-2}) Or Sets changing Ke = work done (as legs expand) (1) Correct substitution into the equation (1) Answer [1030 m s^{-2}, must be given to at least 3 sig fig. No ue] (1) Eg Δ Ke = average F x height ½ m (0.95 m s^{-1})^2 = m x a x 0.44 x (10^{-3}) m a = 1026 (m s^{-2})	**(3)**
(b) ii	Resultant force (Allow ecf) Answer [4.1 x 10^{-4} N. 4(.0) x 10^{-4} N if 1000 m s^{-2} used. Ue.] (1) Eg Force = 4 x 10^{-7} kg x 1030 m s^{-2} = 4.12 x 10^{-4} N	**(1)**
(c) i	What constant force opposes upward motion The weight of / gravitational attraction / gravitational force / gravitational pull / force of gravity / accept pull of earth (on flea) (1) [Not just 'gravity'. Accept bald answers ie 'weight']	**(1)**

(c) ii	Change in height Selects $s = (\frac{v+u}{2})\,t$ or uses $v = u + at$ (to find a) then either $v^2 = u^2 + 2as$ or $s = ut + \frac{1}{2}at^2$ (1) Correct substitution (1) [If two equations are used 'a' is negative] Answer [4.4(2) cm. Do not accept 4.5 cm] (1) [Nb the correct answer can be obtained from omitting ut and using +a – this would get 1/3] [Use of $s = ut + \frac{1}{2}at^2$ or $v^2 = u^2 + 2as$ with IaI = g and u = 0.95 m s^{-1} will get 1/ 3 if no attempt is made to find 'a'. For candidates who use a = 1000 m s^{-2} from bi give no marks] Eg $s = (\frac{0 + 0.95\ \text{m s}^{-1}}{2})\ 9.3 \times 10^{-2}$ s = 0.0442 m Or $a = -\frac{0.95\ \text{m s}^{-1}}{9.3 \times 10^{-2}\ \text{s}} = -10.2\ \text{m s}^{-2}$ $s = 0.95\ \text{m s}^{-1} \times 9.3 \times 10^{-2}\ \text{s} + \frac{1}{2} \times -10.2\ \text{m s}^{-2} (9.3 \times 10^{-2}\ \text{s})^2 = 0.0442\ \text{m}$ or $0 = (0.95\ \text{m s}^{-1})^2 + 2 \times -10.2\ \text{m s}^{-2} \times s$ hence s = 0.0442m	**(3)**
	Total for question	**(10)**

Question Number	Answer	Mark
6 (a)	Identify particle Alpha (particle) / Helium nucleus / $^4_2$He / He $^4_2$ / $^4_2\alpha$ / α^4_2 / $^4_2$alpha / alpha $^4_2$ /α	**(1)**
b	Momentum of particle Momentum equation [In symbols or with numbers] (1) Either Correct substitution into $\frac{1}{2}mv^2$ = energy (1) Use the relationship to determine the mass [6.6 x 10^{-27} kg] (1) Answer [9.3 x 10^{-20} (kg m s^{-1}) Must be given to 2 sig fig. No unit error] (1) Or Rearrangement of $E_K = \frac{1}{2}mv^2$ to give momentum ie $\frac{2E_K}{v}$ (1) Correct substitution (1) Answer [9.3 x 10^{-20} kg m s^{-1}. Must be given to 2 sig fig. No unit error] (1) Eg $\frac{1}{2}$m(1.41 x 10^7 m s^{-1})^2 = 6.58 x 10^{-13} J $m = \frac{2\ x\ 6.58\ x\ 10^{-13}\ J}{(1.41\ x\ 10^7\ m\ s^{-1})^2}$ = 6.6 x 10^{-27} kg momentum = 6.6 x 10^{-27} kg x 1.41 x 10^7 m s^{-1} = 9.3 x 10^{-20} (kg m s^{-1}) Or Momentum = $\frac{2 \times 6.58 \times 10^{-13}\ J}{1.41 \times 10^7\ m\ s^{-1}}$ = 9.3 x 10^{-20} (kg m s^{-1})	**(4)**
c	Consistent with the principle of conservation of momentum (Since total) momentum before and after (decay) = 0 (1) State or show momentum / velocity are in opposite directions (1) [Values of momentum or velocity shown with opposite signs would get this mark] Calculation ie 3.89 x 10^{-25} kg x 2.4 x 10^5 m s^{-1} = 9(.3) x 10^{-20} (kg m s^{-1}) (1) Eg 3.89 x 10^{-25} kg x 2.4 x 10^5 m s^{-1} = 9(.3) x 10^{-20} kg m s^{-1}	**(3)**
	Total for question	**(8)**

Question Number	Answer	Mark
7 (a)	<u>Calculate the ratio the densities of the atom and the nucleus</u> Density equation [In symbols or numbers] (1) Show the relationship between density and radius. (1) [Candidates who start by stating that density is inversely proportional to the radius cubed would get both these marks. Candidates who show an expression where the mass is divided by $\frac{4}{3}\pi r^3$ would get both these marks. Candidates who write Ratio = $(1/10^5)^3$ would get both of these marks.] Factor 10^{-15} established. [Some working must be shown for this mark] (1) Eg $(\text{Density})_{\text{atom}} = \frac{m}{\frac{4}{3}\pi r_{\text{atom}}^{\ 3}}$ or Density $\alpha \frac{1}{r^3}$ $(\text{Density})_{\text{nucleus}} = \frac{m}{\frac{4}{3}\pi r_{\text{nucleus}}^{\ 3}}$ $\frac{(\text{Density})_{\text{atom}}}{(\text{Density})_{\text{nucleus}}} = \left(\frac{r_{\text{nucleus}}}{r_{\text{atom}}}\right)^3$ $= (10^{-5})^3$ Assumption – (entire) mass of the atom is concentrated in the nucleus[there must be a reference to the nucleus] (1) [eg mass of the atom =/approx = mass of the nucleus; most / majority of the atom's mass is in the nucleus. The following would not be awarded marks; The atom is mostly empty space; mass of the electrons is negligible; the nucleus is a very dense.]	**(4)**
(b)	<u>Observation</u> A very small percentage of particles [accept 'very few' not just 'a few'. Do not accept 'some'] are deflected through angles greater than 90^o / are back-scattered / deflected back. (1) [Allow; nearly all / most (alpha) particles pass through (the atom) without being deflected (showing the atom is virtually empty space).] [Accept 'nearly all', not 'many' for the word 'most'.]	**(1)**
	Total for question	**(5)**

Question Number	Answer	Mark
8 (a)	How a beta-minus particle ionises When a beta particle removes [accept repel] an electron from an atom / molecule (1)	**(1)**
(b)	How ionisation determines range State that each ionisation requires energy (1) The energy (to ionise) is obtained from the (transfer of) (kinetic) energy of the beta particle (which is therefore reduced) (1) Along its path it produces many ionisations until all its (kinetic) energy is used up (1) The more ionising a particle the shorter its range or the less ionising the greater the range (1) [Candidates may give the wrong reason for ionisation or even compare alpha and beta but still award this mark.] Max 3 marks from 4 [Note that the word 'kinetic' is not essential for marks 2 and 3]	**(3)**
(c)	Why more ionisation is produced towards the end of its range (Towards the end of its range) the beta particle is travelling slower or has less kinetic energy (than at the beginning of its range) (1) (as a result it takes longer travelling a given length) and therefore has more (close) encounters with atoms / molecules or more opportunities to ionise (atoms / molecules) or will remain in contact (with atoms / molecules) longer or will collide with more (atoms / molecules per unit length) or ionisation (of atoms/molecules) is more frequent (towards end of range) (1)	**(2)**
	Total for question	**(6)**
	Total for paper	**60**