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Mark Scheme Final Version
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GCE

GCE Physics (6733/01)

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General Marking Guidance

These instructions should be the first page of all mark schemes

- 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.

6733 Unit Test PHY3
Topic A - Astrophysics

Question Number	Answer	Mark
1(a) (i)	**Sun now & as red giant** Similarity: (nuclear) fusion / burning (in core) OR mass (1) Difference: H vs. He fusion / r.g. lower (surface) *T* / r.g. higher core *T* / r.g. lower (mean) density [assume r.g. referred to if not specified] (1) **White Dwarf star terms** Hot, low, (surface) area, off (the main sequence) Any three correct (1) All four correct (1)	4
(b) (i)	**Fusion energy release** $E = m c^2$ attempted (1) $^{-29}$ (kg) [may be implied] (1) $E = 3.8(3) \times 10^{-12}$ J [accept 3.82] (1)	3
(ii)	**Brown dwarf wavelength** $_{(max)} T = 2.90 \times 10^{-3}$ m K used (1) Correct substitution (1) $_{(max)} = 2.90 \times 10^{-6}$ m / 2900 (nm) [penalise unit contradiction] (1)	3
(iii)	**Planck distribution curve** Correct asymmetric shape: steeply up and shallower, concave fall (1) Peak at 3000 nm (1) -red / spectrum is outside visible region (1) Intensity (in visible region) too low / zero (to detect) [accept not visible] (1)	4
(iv)	**Jupiter mass ratio** 0.08 x 2.0 x 1030 (W) [1.6×10^{29} seen] (1) 1.2 % / 1.6×10^{27} compared to 1.6×10^{29} (1) [accept reverse working to 0.095 $M_{\odot}$, 0.085% score 1/2]	2

(c) (i)	**Large mass star fusion rate** Quality of written communication (1) (30 $M_\odot$ star) fuses at a greater rate AND spends less time on m.s. (1) [accept power, luminosity] (30 $M_\odot$ star) has greater temperature / (gravitational) forces / pressure (1) leaves main sequence after <u>hydrogen</u> (and/or He) burning ceases / <u>H</u> fuel depleted (in core) [accept H "used up"] (1)	4
(ii)	**2.2 $M_\odot$ core remnant** Neutron star (1)	1
(iii)	**Sun evolutionary phases** Red giant (1) White dwarf (1) Black dwarf (1) [-1 mark per error only if more than three phases circled]	3
(d) (i)	**Hertzsprung-Russell diagram** *L* and *T* (1) $L_\odot$ (1) K [not ^{0}K] (1)	3
(ii)	Diagonal line **through** [must be touching] X (1) Correct [steeping] curvature at both ends (1)	2
(iii)	**Use of H-R diagram** Read L **from diagram** (1) **Measure** Intensity (on Earth) (1) Use $I = L \quad D^2$ (to find *D*) (1)	3
	Total	**32**

Topic B - Solid Materials

Question Number	Answer	Mark
2(a) (i)	**Quench hardening and annealing** Similarity: heating (and cooling) (1) QH: cool rapidly / cool in water or oil (1) A: allow to cool (slowly / in air) (1) [1/2 if QH & A unspecified or interchanged]	3
(ii)	**Work hardening** Quality of written communication (1) Repeatedly beaten (1) Dislocations mentioned (1) Dislocations entangle / increase in number (1)	4
(b)	**Energy density base units** LHS = $\underline{J\ m^{-3}}$ (1) RHS = N m^{-2} AND m / m [or "no unit" stated] (1) J = N m [or algebra for LHS: kg m^{-1} s^{-2}] (1)	3
(c) (i)	**Polymer classifications** Perspex = amorphous thermoplastic (1) Nylon = semi-crystalline thermoplastic (1) Melamine = rigid thermoset (1) Polythene = semi-crystalline thermoplastic (1)	4
(ii)	**Polymer products** Melamine (1)	1
(iii)	Polythene (1)	1

(iv)	**Guitar string calculation** Stress = force ÷ area attempted / 5 x 10^7 (N m^{-2}) (1) Correct substitution in $E = \frac{F/A}{\Delta l/l}$ [0.02 required] (1) l = 0.80 m (1)	3
(d) (i)	**Stress-strain graph regions** Necking = C or D (1) Elastic deformation = A or B (1) Plastic flow = E [ignore extra C or D] (1)	3
(ii)	**Young modulus calculation** Attempt at gradient / stress ÷ strain (1) Sensible pair of values [from linear region, ignore x10^n] (1) 1.35 [allow 1.30 - 1.40] (1) x 10^{11} Pa [or N m^{-2}] (1)	4
(iii)	**Second material** **Straight** line [allow slight curvature at end] (1) Less steep than original line (1) Stops at = 2.6 x 10^{-3} (1)	3
(e) (i)	**Composite material** Made from two (or more) materials to use the <u>properties</u> of both (1) [accept "qualities" but not strengths, advantages, mixture or alloy]	1
(ii)	**Composites classification** Laminate (1) Fibre (composite) (1)	2
	Total	32

Topic C - Nuclear and Particle Physics

Question Number	Answer	Mark
3(a)	**Radiation comparisons** Both: charged / from **nucleus** / increase stability of **nucleus** / ionising / particles (1) Any two from • ionisation: alpha > beta • range: alpha < beta / penetration: alpha < beta / absorption differences $^{++}$ - [not *just* / lepton / electron or positron [not *just* electron] (1) + (1)	**3**
(b) (i)	**Nuclear equation completion** $^{4}_{2}$ $^{9}_{4}$Be $\rightarrow$ $^{12}_{6}$C + $^{1}_{0}$X Nucleon numbers: 4, 9, 12 and 1 (1) Proton numbers: 2, 4, 6 and 0 [*A* & *Z* swapped can score 1/2] (1) X = neutron [no ecf] (1)	**3**
(ii)	**Carbon-12 nucleus radius** $r = r_0 12^{⅓}$ (1) 2.7×10^{-15} (m) [accept 2.8] (1)	**2**
(iii)	**Density calculation** use of = $m \div V$ (1) m = $12 \times 1.66 \times 10^{-27}$ (kg) / 1.99×10^{-26} (kg) (1) $^{-15}$ m)^3 / 8.7×10^{-44} m^3 [ecf their *r* if 3×10^{-15} m to 1sf] (1) 2.3×10^{17} kg m^{-3} [accept 1.8×10^{17} kg m^{-3}] (1)	**4**
(iv)	**Carbon-12 atom constituents** L = 6 (1) B = 12 (1) Hadrons = 12 (ecf: same as number of baryons) (1) Quarks = 36 (ecf: 3 x Hadrons) (1)	**4**

(c) (i)	***N* - *Z* plot** *N* = **number** of neutrons AND *Z* = **number** of protons (1)	 1
(ii)	***N* - *Z* plot explanation** Quality of written communication (1) Nuclides move to stable region (by decaying) (1) Description of diagonal move f / N-1 AND Z+1 (1) [accept arrow in diagram]	 3
(d) (i)	**Quark flavours** Up / u AND down / d (1) Anti-up / $\bar{u}$ AND anti-down / $\bar{d}$ (1) [mark horizontally for 1/2, -1 per extra particle beyond four]	 2
(ii)	**Feynman diagram labelling** u u d / $\bar{u}$ $\bar{d}$ $\bar{d}$ (1) t AND $\bar{t}$ (1)	 2
(iii)	**Fundamental interaction** Strong (1)	 1
(iv)	**Top quark decay** Weak interaction (1) Change of (quark) flavour (1)	 2
(v)	**Exchange particle charge** t: (+)⅔ AND b: -⅓ (1) Hence Q = +1 (1) Y = W^+ (1)	 3
(vi)	**Anti-top quark decay** Creation of matter and antimatter (from energy) (1) [accept counting of quarks and antiquarks] Conservation of (mass/)energy (1)	 2
	Total	**32**

Topic D - Medical Physics

Question Number	Answer	Mark
4(a)	**Radiation comparisons** Both charged / from nucleus / ionising / particles / mutation and/or destruction of cells [or DNA] (1) Any two from • Mass: alpha > beta • ionisation: alpha > beta • penetration: alpha < beta OR absorption differences / range: alpha < beta ++ - [not *just*	3
(b) (i)	**Effective half-life calculation** $1/t_e = 1/8 + 1/21$ (1) 5.8 days [not 5.9 - rounding error, decimal required] (1)	2
(ii)	**Percentage remaining after one month** 30/6 / 5 half-lives (1) 5 halvings shown / $(½)^5$ / 1/32 / 0.03 [may be implied, ecf to their n] (1) 3% [nearest whole is asked for] (1)	3
(c) (i) (ii)	**X-rays tube** Filament emits electrons / thermionic emission (not accelerates) (1) Vacuum allows <u>electrons</u> to pass / no air to absorb <u>electrons</u> (1)	1 1
(iii)	Tungsten (1) **Most** (99%) of electron energy becomes heat / internal energy (1) Rotating stops anode melting / allows a larger target area to be used (1) [accept "avoid heat concentration in one area", not "to cool anode"]	3
(iv)	**X-ray tube power calculation** Attempt to use $I = P$ r^2 (1) 4.2×10^7 W [accept 43 MW] (1)	2

(d)	**Anti-scatter grid** Lead (1) Any ray passing between grid, to film (1) *Any* ray being scattered within patient AND then **absorbed** by grid (1) At least two rays [these must be straight lines from source], scattering within body and then being absorbed by grid (1)	4
(e) (i) (ii)	**Ultrasound A-scans and B-scans** B-scan (1) Any three from [may be from different rows, do not accept repetition of picture] (3)	4
(f) (i)	**Specific acoustic impedance of air** Z = 1.3 kg m^{-3} x 330 m s^{-1} (1) 429 / 430 [no u.e.] (1)	2
(ii)	**Reflection coefficient calculation** Use of $(Z_1 - Z_2)^2 / (Z_1 + Z_2)^2$ (1) $(1.63 \times 10^6 - 430)^2 \div (1.63 \times 10^6 + 430)^2$ [must be shown, Z may be swapped] (1) 0.999 / 99.9% [apply u.e. if wrong unit given] (1)	3
(iii)	**Use of coupling medium** Quality of written communication (1) To avoid reflection (without gel) at skin [or soft tissue / boundary] (1) Ensure transmission (with gel) into patient / through skin (1) Gel similar Z to skin / soft tissue [more than "impedance matching"] (1)	4
	Total	**32**
	Total for paper	**96**

A scan	B-scan
Single pulse	Multiple pulses / array
Single angle for scan	Many / varying angles / axes
Reflection controls **amplitude**	Reflection controls **brightness**
Image is pulses	Image is picture
Used for depth measurements	Used to produce picture / lateral measurements