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Mark Scheme (Final)

Summer 2008

GCE

GCE Physics (6733/01)

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] [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.]	✓	**1**

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 $g = 10\ \mathrm{m\ s^{-2}}$ 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:

$80 \text{ cm} \times 50 \text{ cm} \times 1.8 \text{ cm} = 7200 \text{ cm}^3$

$7200 \text{ cm}^3 \times 0.70 \text{ g cm}^{-3} = 5040 \text{ g}$

$5040 \times 10^{-3} \text{ kg} \times 9.81 \text{ N/kg}$

$= 49.4 \text{ N}$

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 (Topics)

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) $L = \sigma T^4 A = 4\pi\sigma T^4 r^2$ $L_{before} = 4\pi \times 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^4 \times (5780\ \text{K})^4 \times (6.96 \times 10^8\ \text{m})^2$ $= 3.85 \times 10^{26}$ W $L_{after} = 4\pi \times 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^4 \times (3160\ \text{K})^4 \times (1.26 \times 1011\ \text{m})^2$ $= 1.13 \times 10^{30}$ W Hence ratio = 1.13×10^{30} W ÷ 3.85×10^{26} W = 2930	**4x1**

(c) iii	**<u>H-R diagram plots</u>** 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	**<u>Sun as white dwarf</u>** 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	**<u>Future of white dwarf</u>** Cools / *T* decreases (1) Dims / fades / correct colour change [not brown dwarf] / Luminosity decreases [accept intensity here] (1)	**2x1**
(e) i	**<u>Distance to Sirius</u>** Substitution in $v \times t$ /s [ignore 8.6, accept 365 or 365¼ days] (1) 8.1×10^{16} (m) [8.13, 8.14] (1) $d = v\,t$ $= 8.6 \times 3.00 \times 10^8$ m s^{-1} x (60 x 60 x 24 x 365¼) s $= 8.1 \times 10^{16}$ m	**2x1**
(e) ii	**<u>Sirius A intensity calculation</u>** Use of $I = L / 4 \pi D^2$ (1) Correct substitution (1) 1.2×10^{-7} W m^{-2} [1.20 – 1.24] (1) $I = L / 4 \pi D^2$ $= 1.0 \times 10^{28}$ W / 4 π (8.1×10^{16} m)^2 $= 1.2 \times 10^{-7}$ 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 / $(3.00 \times 10^8 \text{ m s}^{-1})^2$ $= 1.1 \times 10^{11}$ 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**
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Topic B - Solid Materials

Question Number	Answer	Mark
2 (a)	**Metal treatment classification** Annealing: heating and slow cooling (1) Work hardening: beating only (1) Quench hardening: heating and rapid cooling (1)	**3x1**
(b) i	**Fence wire cross-section** Use of π r^2 and 10^{-3} m (1) 4.9×10^{-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	**Stress calculation** Substitution: 1500 N / 4.9 [or 5] x 10^{-6} m^2 (1) 310 MPa [accept 300, ecf] (1) $\sigma = F / A$ $= 1500$ N / 4.9×10^{-6} m^2 $= 3.1 \times 10^8$ Pa	**2x1**
(b) iii	**Extension calculation** $E = \sigma / \varepsilon$ 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) $E = F\,l / A\,\Delta l$ Δl = (1500 N x 33 m) / (210 x 10^9 Pa x 4.9 x 10^{-6} m^2) = 0.048 m = 48 mm	**4x1**
(c) i	**Young modulus experiment** (G-) clamp [vice], <u>wire</u>, pulley, mass / weight / load three correct (1) all four correct (1)	**2x1**

(c) ii	**Labelling of l** Accurate indication of l [to 1 mm] (1) Length 2 m to 6 m (1)	**2x1**
(c) iii	**Additional apparatus** Micrometer (screw gauge) / (digital) callipers (1) Ruler or similar [e.g. tape measure, metre stick] (1)	**2x1**
(c) iv	**Energy density** 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)	**Relieving stress concentrations explanation** Quality of written communication (1) Tip [end] of crack [not edge, centre; diagram ok] (1) Increases area (over which stress acts) (1) Lowers stress concentration (1)	**4x1**
(e) i	**Edge dislocation** Edge (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	**Elastomer** Hysteresis (1)	**1x1**
(f) ii	Energy gained related to area under graph (1) Difference in areas / loop area = energy gained on impact (1)	**2x1**
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Topic C - Nuclear and Particle Physics

Question Number	Answer	Mark
3 (a)	**Particle classification** Neutron: baryon and hadron (1) Neutrino: lepton (1) Muon: lepton (1)	**3x1**
(b) i	**Decay series** 8 decays (1) (238 – 206) ÷ 4 [Correct maths with 238, 206, 4] (1)	**2x1**
(b) ii	**Thorium decay series** $^{234}_{90}\text{Th} \longrightarrow\ ^{234}_{91}\text{Pa} +\ ^{0}_{-1}\beta + \bar{\nu}$ 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	**Binding energy** 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	**<u>More stable isotope</u>** 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	**<u>Deuterium</u>** Up and down <u>quarks</u> [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	**<u>Fundamental forces</u>** Quality of written communication (1) Weak force affect **all** particles / matter (1) Strong force only affect <u>quarks</u> (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	**<u>Conservation laws</u>** 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	**<u>Quark charges</u>** Use of sss = -1 to show s = -⅓ (1) Hence correct working (from baryons) to show u = ⅔ and d = -⅓ (1)	**2x1**
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Topic D - Medical Physics

Question Number	Answer	Mark
4(a)	**<u>Imaging techniques</u>** X-ray: Ionising only (1) Nuclear medicine: Ionising & injected [**ignore** soft tissue] (1) Ultrasound: transducer & soft tissue (1)	**3x1**
(b) i	**<u>X-rays for radiotherapy</u>** (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	**<u>High energy X-rays</u>** **Absorption** not dependent on proton number (1) (Have enough energy to) destroy / kill cells [not just damage](1)	**2x1**
(b) iv	**<u>Criticality of dose</u>** Too high: extra radiation could kill [harm] patient / healthy cells (1) Too low: tumour cells may not be completely destroyed (1)	**2x1**
(c) **i**	**<u>Liver ultrasound calculations</u>** 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 / 1.6×10^{-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	**<u>Frequency and Imaging depth</u>** 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)	**<u>Gamma camera diagram</u>** 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	**<u>Tellurium nuclear equations</u>** $^{131}_{52}\text{Te} \longrightarrow {}^{131}_{53}\text{I} + {}^{0}_{-1}\beta$ 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**	**<u>Half-life definition and calculation</u>** 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**
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