edexcel
advancing learning, changing lives

Mark Scheme (Final)
January 2009

GCE

GCE Physics (6733/01)

Edexcel Limited. Registered in England and Wales No. 4496750
Registered Office: One90 High Holborn, London WC1V 7BH

A PEARSON COMPANY

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 $g = 10\ m\ s^{-2}$ 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] [Bald answer scores 0, reverse calculation 2/3]	✓	**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.

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 $\frac{1}{2} F \Delta x$ [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** $r = r_0 A^{⅓}$ [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)** $r_U / r_P = A_U^{⅓} / A_P^{⅓}$ $= 238^{⅓} / 31^{⅓}$ $= 7.6831^{⅓}$ $= 1.97$	**(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)	<u>Quark classifications</u> 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)	<u>Conservation laws</u> 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)	Reflection coefficient calculations 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 <u>ionisation</u>	**(1)**
(e) (i)	**X-ray tube** Thermionic emission / release electrons [not "accelerates electrons"] **(1)** No air molecules [accept just particles] to impede <u>electrons</u> **(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 compare 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**