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Mark Scheme (Results)
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GCE

GCE Physics (6733/01)

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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 / 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:

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

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

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

$= 49.4 \text{ N}$

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
Topic A - Astrophysics

(a) Revision notes errors

Red giant → cepheid (variable) ✓✓

White dwarf → red (super)giant / supernova / core remnant > 2.5 $M_\odot$ ✓✓

Red giant → main sequence (star) ✓✓ **6**

(b) Wien's law

(i) • Wavelength of peak [or maximum] intensity [allow brightness, but not power / energy / L] ✓
• Absolute or Kelvin (surface) temperature (of star) ✓ **2**

Spectrum

(ii) Microwave / infra-red [accept i.r.] ✓ **1**

(iii) $\lambda_{max} = 1.05$ (mm) ✓

Substitution in $T = 2.90 \times 10^{-3}$ m K ÷ their λ_{max} with $\times 10^{-3}$ ✓
[2.90×10^{-3} m K ÷ 1.05×10^{-3} m, with mm → m conversion required]

$T = 2.76$ [accept range 2.6 – 2.9] K ✓ **3**

(c) Supernova minimum mass

(i) $8\ M_\odot$ [accept 1.6×10^{31} kg] ✓ **1**

Energy from Sun

(ii) $1 \times 10^{10} \times 365(¼) \times 24 \times 60 \times 60 / 3(.15) \times 10^{17}$ ✓

Use of $E = P \times t$ ✓

$1(.2) \times 10^{44}$ J [Beware $E = \frac{P}{t} \Rightarrow 1.24 \times 10^{9}$ J] ✓ **3**

$E = P \times t$
$= 3.9 \times 10^{26}$ W $\times 1 \times 10^{10} \times 365(¼) \times 24 \times 60 \times 60$ s
$= 1.2 \times 10^{44}$ J

(iii) $10^{46} \div (1.2\ x)\ 10^{44}$ [ecf for any E] ✓

80 – 100 [ecf] [accept 83:1 or 1:0.012] ✓
[inverted answer scores zero, unless values identified for 1/2] **2**

Supernova future

(iv) neutron star / pulsar ✓

black hole ✓

n.s. if > 1.4 $M_\odot$ OR b.h. if > 2.5 $M_\odot$ ✓ **3**

(d) Neutron star density

(i) $\rho = m \div V$ and $4/3\ \pi r^3$ ✓

4.2 [or 4.3] × 10^{17} (kg m^{-3}) ✓ **2**

$\rho = m \div V$
$= 3m \div 4\ \pi r^3$
$= 3 \times 6.0 \times 10^{24}$ kg $\div (4\ \pi (150\ \text{m})^3)$
$= 4.2 \times 10^{17}$ kg m^{-3}

Neutron formation

(ii) Quality of written communication ✓

Main sequence: fusion (reaction) / (ms) p → n / beta plus decay ✓

[post ms] $p + e^- \rightarrow n$ ✓

[post ms] due to gravitational collapse / implosion ✓ **4**

(e) Intensity of Sun

(i) Use of $I = L \div (4\pi D^2)$ ✓

597 OR 1380 (ignore 10^n) ✓

597 W m^{-2} AND 1380 W m^{-2} [accept W km^{-2} with appropriate values] ✓ **3**

$I = L \div (4\pi D^2)$
$I_M = 3.90 \times 10^{28}$ W $\div (4\pi (2.28 \times 10^{11}\ \text{m})^2)$
$= 597$ W m^{-2}
$I_E = 3.90 \times 10^{28}$ W $\div (4\pi (1.50 \times 10^{11}\ \text{m})^2)$
$= 1380$ W m^{-2}

597 ÷ 1380 [ecf, accept $(2.28 \div 1.50)^2$] ✓

43% ✓ **2**

Total **32**

Topic B - Solid Materials

(a) Revision notes errors

Plastically → elastically	✓✓	
Rigid thermosets → thermoplastics	✓✓	
Fibre → particle	✓✓	**6**

(b) Energy density units

(i) J m^{-3} [or energy equation reduced to correct base units]	✓	
N m^{-2} [or stress shown to reduce to kg m^{-1} s^{-2}]	✓	
$\Delta l \div l$ / no units for strain AND J = N m / correct mathematical reduction	✓	**3**

Energy density calculation

(ii) Use of strain = $\Delta l \div l$	✓	
Substitution in $\frac{1}{2} \sigma \varepsilon$	✓	
1.0×10^6 (J m^{-3})	✓	**3**

E.D. = $\frac{1}{2} \sigma \varepsilon = \frac{1}{2} \sigma \Delta l \div l$
$= \frac{1}{2} \times 5.2 \times 10^8$ Pa $\times 8.0 \times 10^{-3}$ m $\div$ 2.0 m
$= 1.04 \times 10^6$ J m^{-3}

Energy density of mild steel

(iii) Any attempt at area under graph	✓	
300×10^6 Pa $\times$ 0.15	✓	
4.5×10^7 (J m^{-3}) [accept range 4 – 5 with $\times 10^7$]	✓	**3**

(c) Property definitions

(i) Tough: absorbs energy (before breaking)	✓	
by plastic deformation	✓	
Strong: high(er) UTS / high(er) stress (before breaking)	✓	**3**

Force calculation

(ii) Attempted use of $\sigma = F / A$ [accept use of r instead of A for 1/3] ✓

Use of $A = \pi r^2$ (ignore 10^n) ✓

3.8 (or 4) $\times 10^{-3}$ N ✓ **3**

$\sigma = F / A = F / \pi r^2$
$F = \sigma \pi r^2$
$= 3 \times 10^8$ Pa $\times \pi (2.0 \times 10^{-6}$ m$)^2$
$= 3.8 \times 10^{-3}$ N

Stiffest part of curve

(iii) Initial slope indicated ✓ **1**

Young modulus calculation

(iv) Any attempt at gradient / stress ÷ strain ✓

Correct pair of values for linear region above stress 0.25 / Extended gradient at start of curve ✓

5.5 GPa [5.2 – 5.6 with GPa or GNm^{-2}] ✓ **3**

(d) Hardening techniques

(i) Quality of written communication ✓

WH: repeated ✓

beating / hammering / bending [not working] ✓

QH: heat, then cool rapidly ✓ **4**

Effect of work hardening

(ii) Any two from:

More brittle, harder, stiffer [or less flexible] ✓✓ **2**

(iii) Dislocations entangle [or description of this] ✓ **1**

Total **32**

Topic C - Nuclear and Particle Physics

(a) Revision notes errors

Muon → meson [accept pion or kaon] ✓✓

Strange → top [all three "keywords" may be changed] ✓✓

Neutrons → protons ✓✓ **6**

(b) Neutron star density

(i) $\rho = m \div V$ and $4/3\ \pi\ r^3$ ✓

4.2×10^{17} (kg m^{-3}) ✓ **2**

$\rho = m \div V$
$= 3m \div 4\ \pi\ r^3$
$= 3 \times 6.0 \times 10^{24}$ kg $\div$ $(4\ \pi\ (150\ m)^3)$
$= 4.2 \times 10^{17}$ kg m^{-3}

Neutron number

(ii) $6.0 \times 10^{24} \div 1.66 \times 10^{-27}$ ✓

3.6×10^{51} ✓ **2**

Neutron radius

(iii) Attempted use of $r = r_0 A^{1/3}$ [or from first principles, ecf] ✓

9.8×10^{-16} m / 1.0×10^{-15} m ✓ **2**

$r_0 = r / A^{1/3}$
$= 150 / (3.6 \times 10^{51})^{1/3}$
$= 9.8 \times 10^{-16}$ m

Neutron formation

(iv) ${}^{1}_{1}p + {}^{0}_{-1}e \rightarrow {}^{1}_{0}n + \nu$

Correct symbols ✓

Correct values [ignore neutrino numbers] ✓ **2**

Fundamental interaction explanation

(v) Quality of written communication ✓

• weak ✓

• change of quark flavour / u → d / uud → udd ✓

• involves neutrino ✓ **4**

(c)	Exchange particle		
(i)	gluon	✓	**1**
	Delta particle charge		
(ii)	(+)2	✓	
	Conservation of charge and p = +1 / [or (+2) = (+1) + (+1)]	✓	**2**
	Quark compositions		
(iii)	p = uud	✓	**1**
(iv)	B: +1 = +1 + 0 hence baryon	✓	
	Cancelling of $d\bar{d}$ shown or explained	✓	
	uuu	✓	**3**
(d)	Energy spectrum graph		
(i)	Correct shape: starts on y-axis [allow origin], peaks and asymmetric	✓	
	Reaches x-axis	✓	**2**
	Additional particle explanation		
(ii)	Spread of β^- energies observed	✓	
	Conservation of energy expected	✓	
	Missing energy carried away by other particle	✓	**3**
	Lepton name		
(iii)	(anti) neutrino	✓	
	electron antineutrino [accept anti electron neutrino]	✓	**2**
	[$\bar{\nu}_e$ only scores 1/2]		
		Total	**32**

Topic D - Medical Physics

(a) Revision notes errors

Amplitude → brightness / intensity of pixel	✓✓	
Diagnosis → therapy / destruction of tissue	✓✓	
Large → short /small	✓✓	**6**

(b) Technetium use

(i) Metastable	✓	**1**
(ii) Any two of • 6 hour half-life – not too short for study nor to too long for added dose • gamma (only) emitter – minimises dose to patient / cell damage • gamma emitter – can be detected out of body / by gamma camera • very long half-life daughter – negligible harm to patient	✓✓	**2**

Different half-lives

(iii) Quality of written communication	✓	
t_b = time for activity to half due to biological processes / excretion	✓	
t_e due to combined effects of t_r and t_b / time to half activity within body	✓	
Reference to $1/t_e = 1/t_r + 1/t_b$	✓	**4**

(c) Gamma camera

1. Collimator	✓	
Absorbs photons / gammas not at 90^0 to the camera	✓	
2. Photomultiplier tube	✓	
Amplifies (number of) electrons	✓	
3. (NaI) Scintillator (crystal)	✓	
produce light (flashes) / photons	✓	**6**

[ecf on all names if in incorrect box]

(d) Transmitted percentage

(i) 70% ✓ **1**

Specific acoustic impedance calculation

(ii) Correct substitution: 1.63×10^6 kg m^{-2} s^{-1} × (1 + √0.30) ÷ (1 - √0.30) ✓

✓

5.58 / 5.6 [accept 4.76]

✓ **3**

($5.6 \times$) 10^6 kg m^{-2} s^{-1} [conditional mark, with ecf on use of 0.30 of 4.76]

(iii) Speed of sound calculation

Substitution in $c = Z \div \rho$ [$c = 1.63 \times 10^6$ kg m^{-2} $s^{-1} \div 1060$ kg m^{-3}] ✓

1540 m s^{-1} ✓ **2**

(e) MeV X-ray energies for therapy

(i) Absorption not dependent on proton number / independent of medium ✓

✓ **2**

(Sufficient energy to) destroy / kill cells

Multiple beam explanation

(ii) Clear diagram with at least two beam paths, focused on labelled target ✓

✓

Tumour / target cells always hit OR greater dose where beams cross

✓ **3**

Lower dose to healthy / surrounding tissue

X-ray intensity

(iii) Use of $I = P \div 4\pi r^2$ or $I\,d^2 = k$ ✓
[8.0×10^5 W $m^{-2} \div 4\pi$ (0.5 m)^2 / P = 2.5 x 10^6 W / $k = 2.0 \times 10^5$ W]

2.0 kW m^{-2} ✓ **2**

Total **32**