



MARKSCHEME

May 2007

PHYSICS

Higher Level

Paper 3

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General Marking Instructions

Subject Details: **Physics HL Paper 3 Markscheme**

General

A markscheme often has more specific points worthy of a mark than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.

When deciding upon alternative answers by candidates to those given in the markscheme, consider the following points:

- ◆ Each marking point has a separate line and the end is signified by means of a semicolon (;).
- ◆ An alternative answer or wording is indicated in the markscheme by a “/”; either wording can be accepted.
- ◆ Words in (...) in the markscheme are not necessary to gain the mark.
- ◆ Words that are underlined are essential for the mark.
- ◆ The order of points does not have to be as written (unless stated otherwise).
- ◆ If the candidate’s answer has the same “meaning” or can be clearly interpreted as being the same as that in the markscheme then award the mark.
- ◆ Mark positively. Give candidates credit for what they have achieved, and for what they have got correct, rather than penalizing them for what they have not achieved or what they have got wrong.
- ◆ Effective communication is more important than grammatical accuracy.
- ◆ Occasionally, a part of a question may require a calculation whose answer is required for subsequent parts. If an error is made in the first part then it should be penalized. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded.
- ◆ Units should always be given where appropriate. Omission of units should only be penalized once. Ignore this, if marks for units are already specified in the markscheme.
- ◆ Deduct **1 mark in the paper** for gross sig dig error *i.e.* for an **error of 2 or more digits**.

e.g. if the answer is 1.63:

2	<i>reject</i>
1.6	<i>accept</i>
1.63	<i>accept</i>
1.631	<i>accept</i>
1.6314	<i>reject</i>

However, if a question specifically deals with uncertainties and significant digits, and marks for sig dig are already specified in the markscheme, then do **not** deduct again.

Option D — Biomedical Physics

- D1.** mass $\propto L^3$;
 energy loss $\propto L^2$;
 rate of heat loss/unit mass $\propto L^{-1}$ *or* $L \propto m^{\frac{1}{3}}$;
 $\left(\frac{35}{20}\right)^{\frac{1}{3}} = 1.2$; [4]
- D2.** (a) 20–20000 Hz; [1]
- (b) transforms sound pressure variations in air into larger pressure changes (in the cochlea); [1]
- (c) different cilia / hairs respond to different frequencies;
 amplitude depends on degree of stimulus / *OWTTE*; [2]
- (d) cochlea loses ability to respond to (some) frequencies;
 frequency loss is selective;
 speech contains range of frequencies and so it appears distorted; [3]
- (e) 10 log 6000;
 38 dB; [2]
- D3.** (a) scattering;
 photoelectric; [2]
- (b) (i) X-ray image taken of target from many directions;
 computer produces detailed image of slice;
 repeated for many slices;
to build up a 3D image; [3 max]
- (ii) X-ray gives (2D) shadow image of patient;
 CT gives 3D image of section; [2]
- D4.** refers to basal metabolic rate (b.m.r.);
 explains that b.m.r. is metabolic rest state of body;
 muscles not 100% efficient;
 additional energy losses can be to environment;
 additional energy losses can be due to respiration; [4 max]

- D5.** (a) states that effective half-life is less than physical half-life / states 8 d shorter than 75 d;
iodine excreted exponentially;
excretion adds to decay rate; [3]
- (b) (i) 7.2 d; [1]
- (ii) iodine collects at sites;
stays in body; [2]

Option E — The History and Development of Physics

- E1.** (a) (i) planet apparently reverses direction / over course of several nights / relative to stars / *OWTTE*; [1]
- (ii) Mars appears to move relative to (background) stars;
 lines drawn from each Earth position to correct Mars position; [2]
Both marks can be awarded for a diagram.
- (b) (i) Moon orbits Earth;
 Moon rotates on axis;
 same time period for both; [3]
- (ii) observer’s position unchanged after 24 hours have elapsed;
 Moon has moved in orbit; [2]
- E2.** (a) thought to apply throughout the universe; [1]
- (b) Newton law of gravitation is between force and mass of any two bodies;
 Kepler law can be derived from Newton (and is thus confirmed) / shows derivation correctly; [2]
- E3.** magnetic field used;
 magnetic field at 90° to electric;
 field strengths adjusted so that net force on electron zero / electron un-deflected;

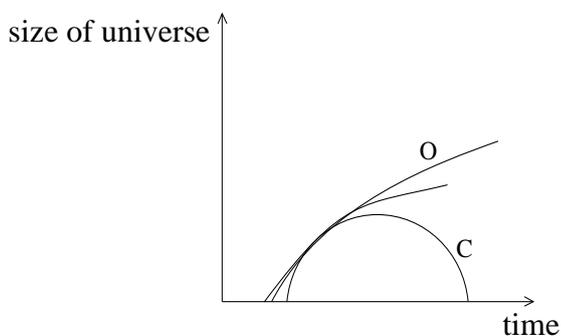
$$\text{speed} = \frac{\text{electric field strength}}{\text{magnetic field strength}};$$
 [4]
- { *Award these three marking points
 if presented in a clearly drawn
 and well - labelled diagram.*
- E4.** (a) *Thomson:*
 atom large amorphous positive charge with embedded point electrons;
Do not award marks for “plum pudding model” without description.
- Rutherford:*
 small, dense, positive nucleus;
 electrons outside nucleus fill atomic space; [3]
Award the above marking points if presented in a clearly drawn and well-labelled diagram.
- (b) neutron has no charge / neutral;
 early detection methods relied on charge / ionization; [2]

- E5.** (a) theoretical verification of Rydberg / explanation of spectral lines / prediction of spectral lines;
 fine or hyperfine structure unexplained / cannot be extended to heavier atoms; [2]
Award any other valid point.
- (b) recognises that $n = 1$ and $n = \infty$ for ionization;
Can infer from $\left(\frac{1}{1^2}\right)$.
 $\frac{1}{\lambda} = R_H$;
 so $E = hcR_H$;
Can receive marks from use of both $E = hf$ and $c = f\lambda$.
 $= (6.63 \times 10^{-34} \times 3.0 \times 10^8 \times 1.1 \times 10^7) = 2.2 \times 10^{-18} \text{ J}$; [4]
 $\left\{ \begin{array}{l} \text{Do not allow ECF if} \\ \text{incorrect value of } n \text{ used.} \end{array} \right.$
- (c) de Broglie postulated that particles have an associated wavelength / idea of standing wave;
 Schrödinger described/associated electrons using / with a wave function;
Award any two of the following.
 because the electron is confined to the atom it can only have certain allowed wave functions;
 these define the allowed stable orbits;
 the wave function measures the probability of locating the electron within its allowed orbit / *OWTTE*; [4]

Option F — Astrophysics

- F1.** (a) (i) (total) power emitted; [1]
- (ii) mass / temperature / surface area / radius / type of star / composition; [1]
- (b) (i) outer surface expands and contracts;
changing (surface) temperature / changing any other relevant property of surface; [2]
- (ii) L_A and L_B read-offs; (allow 900-1100 and 9000-11000)
- use of $\frac{L_A}{L_B} = \frac{b_A \times d_A^2}{b_B \times d_B^2}$ **or** clear correct ratio;
- correct substitution into correct equation;
- e.g. $1.6 \times 10^{21} \sqrt{\left(\frac{10 \times 1.2 \times 10^{-14}}{5.3 \times 10^{-16}}\right)}$
- 2.4×10^{22} m; [4]

- F2.** (a) (i) peak higher;
peak to left; [2]
- In parts (ii) and (iii) allow credit for appearance of marking points in either part (ii) or (iii), but only credit each point once overall.*
- (ii) radiation (approximately) same from all directions;
radiation has characteristics of black body radiation; [2]
- (iii) radiation characteristic of 3 K / low temperature;
describes “big bang” as hypothesis that universe is expanding;
expansion is the result of an energy release at beginning of universe; [3]
- (b) (i) non-coincident starts (not at beginning);
correct shapes and correctly labelled;
coincident at appropriate place; [3]



- (ii) density > critical density;
critical density is density of “flat” universe / gravity acts to contract universe / *OWTTE*; [2]

- F3.** (a) *galaxy*: collection of gravitationally bound stars;
galactic supercluster: cluster is a group of galaxies;
 super cluster is a collection of clusters; [3]
- (b) age of universe = $\frac{1}{H_0}$;
 $\frac{1}{H_0} = \left(\frac{d}{v} \right) = \frac{190 \times 10^6 \times 3.1 \times 10^{16}}{1.3 \times 10^7}$;
 = 14×10^9 year **or** 4.2×10^{17} s ; [3]
- F4.** (a) mass limit of star above which it cannot become a white dwarf; [1]
- (b) Chandrasekhar limit is exceeded;
 to yield supernova;
 resulting in neutron star/black hole; [3]

Option G — Relativity

- G1.** (a) (i) length measured by observer at rest with respect to object; [1]
- (ii) time interval between two events measured in a reference frame where the events occur at the same place; [1]
- (b) (i) $0.99 \times c \times 3.1 \times 10^{-6}$;
 $= 0.92 \text{ km}$; [2]
- (ii) $\gamma = \frac{1}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}} = 7.1$;
 time $(= 3.1 \times 10^{-6} \times 7.1) = 2.2 \times 10^{-5} \text{ s}$;
 distance $= 6.5 \text{ km}$; [3]
- (c) muon at rest in its reference frame measures the proper time for decay; to observers, because muons are in frame moving with respect to them muons take longer, this is time dilation; [2]
Allow [2 max] if answer is correctly stated in terms of length.

- G2.** (a) initial mass at $\frac{v}{c} = 0$ non-zero;
 mass rises to become asymptotic at $\frac{v}{c} \rightarrow 1$;
 line horizontal for $\frac{v}{c} < 0.5$; [3]
- (b) (i) $2.5 (\text{MeV } c^{-2})$; [1]
- (ii) $\gamma = \left(\frac{m}{m_0}\right) = 5$;
 $5 = \frac{1}{\sqrt{1 - \left(\frac{v^2}{c^2}\right)}}$;
 $= 0.98c$; [3]

- G3.** speed of light independent of observer;
as light is reaching B carriage moves forward;
so B sees light from the left (person X) first;
not simultaneous; **[4]**
Award [0] if invalid or incorrect statements are given.

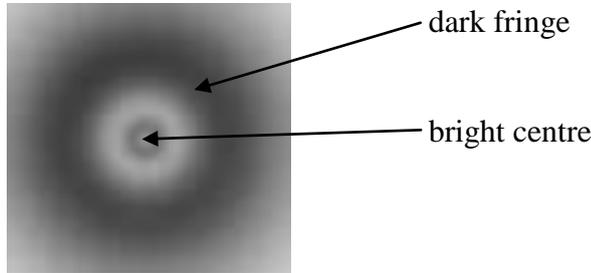
- G4.** (a) (i) region of extreme curvature in space-time;
such that escape speed is c (or greater) / light cannot escape; **[2]**
- (ii) radius of boundary inside which mass must fit for black hole to be possible; **[1]**
- (iii) 5.9×10^4 m ;
no mass lost; **[2]**
- (b) (i) deflect the path of spacecraft / send into orbit round black hole / “attracted” by
black hole; **[1]**
- (ii) matter distorts space; (*do not allow “warps”*)
particles in space-time follow shortest path;
path curved as mass approaches black hole/matter;
this is interpreted as a force / *OWTTE*; **[4]**

Option H — Optics

- H1.** (a) (i) ray drawn to surface with correct refraction;
second ray with correct refraction and image location; [2]
- (ii) $n = \frac{\text{real depth}}{\text{apparent depth}}$;
6.5 m; [2]
- (b) (i) ray drawn to surface with correct reflection by eye;
second ray with correct reflection by eye;
construction lines to show image formed above water; [3]
- (ii) disturbed surface leads to many reflections in different directions / diffuse reflection; [1]
- H2.** (a) one correct ray;
second correct ray;
image construction lines clear and image drawn in, labelled I; [3]
- (b) (i) point closer than which eye cannot focus; [1]
- (ii) image formed 21 cm from lens $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$; $\left\{ \begin{array}{l} \textit{real is + ve, allow new} \\ \textit{Cartesian solution} \end{array} \right.$
so $\frac{1}{u} = \frac{1}{8} + \frac{1}{21}$;
 $u = 5.8 \text{ cm}$; [3]
Award [2 max] if 25 cm used for v.
- (c) (i) *chromatic*:
different amounts of refraction for different colours/wavelengths;
colour fringing of image;
spherical:
rays parallel to principal axis at edge of lens brought to different focus from those near centre of lens / *OWTTE*;
image blurred / *OWTTE*; [4]
- (ii) restrict aperture; [1]

- H3. (a) (i) circular pattern light and dark markings clearly labelled; $\left. \begin{array}{l} \textit{Minimum is centre} \\ \textit{with 2 fringes outside it.} \end{array} \right\}$

bright centre to pattern clearly labelled;



[2]

Award [1 max] for an intensity-position graph if it has a central maximum and is clearly a diffraction pattern (must see central maximum, first minimum, first maximum at least) and award [2 max] if there is a mention of circular symmetry.

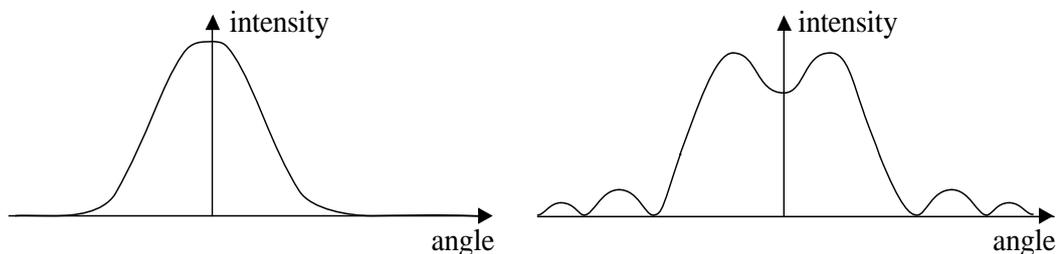
(ii) $\sin \theta = \frac{1.22\lambda}{d} = \frac{1.22 \times 450 \times 10^{-9}}{0.25} = 2.2 \times 10^{-6}$; $\left\{ \begin{array}{l} \textit{Do not award if} \\ \textit{1.22 factor missing} \end{array} \right.$
 diameter = $2 \times 0.75 \times \sin(\textit{or tan})\theta = 3.3 \times 10^{-6}$ m;

[2]

(b) (i) resolution of telescope = $\left(\frac{1.22 \times 4.5 \times 10^{-7}}{0.25} \right) = 2.2 \times 10^{-6}$; $\left\{ \begin{array}{l} \textit{Allow ECF if 1.22} \\ \textit{is missing in (a)(ii).} \end{array} \right.$
 $d = 2.2 \times 10^{-6} \times 1.5 \times 10^{17}$;
 $= 3.3 \times 10^{11}$ m;

[3]

- (ii) separation $2d$ shows definite dip between maxima; $\left\{ \begin{array}{l} \textit{Award these two marking points} \\ \textit{for words or diagram.} \end{array} \right.$
 separation $\frac{d}{2}$ shows small or no dip;
 general shapes of curves good showing 2+ minima, asymmetric higher-order maxima, reducing heights of maxima; $\left\{ \begin{array}{l} \textit{Award this marking point} \\ \textit{on the basis of a diagram.} \end{array} \right.$



[3]