IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

MARKSCHEME

May 2007

PHYSICS

Standard Level

Paper 3

11 pages

General Marking Instructions

Subject Details: Physics SL 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	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

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

Option A — Mechanics Extension

A1. (a) (i) horizontal: $24\,\text{m s}^{-1}$; ***[1]***

(ii) vertical: $14\,\text{m s}^{-1}$; ***[1]***

(b) appropriate use of kinematic equation;
correct substitution;
$h = 7.1\,\text{m}$; ***[3]***

A2. (a) *translational*: sum of external forces $= 0$;
rotational: sum of moments $= 0$; ***[2]***

(b) clockwise moment $= (5.0 \times 7.0) + (12 \times d)$;
anticlockwise moment $= (22 \times 9.0)$;
equate and solve to yield $d = 14\,\text{m}$; ***[3]***

A3. (a) change in potential energy per unit mass / work done per unit mass;
in moving small / point mass from infinity to the point; ***[2]***
Do not allow "from a long distance away".

(b) (i) asymptotic at large *r* <u>and</u> in negative gravitational potential region;
line stops at surface line; ***[2]***
Do not allow asymptotic to y-axis.

(ii) loss of gravitational potential $= 6.67 \times 10^{-11} \times \frac{m_{\text{Moon}}}{r_{\text{Moon}}}$;
equates loss of gravitational potential to $\frac{1}{2}v^2$;
$v = 2.4\,\text{km s}^{-1}$; ***[3]***

(iii) meteorite may have initial speed/velocity <u>towards</u> Moon / contribution of Earth's gravity; ***[1]***

(c) (i) constant; ***[1]***

(ii) decreasing; ***[1]***

Option B — Quantum Physics and Nuclear Physics

B1. (a) $eV = \frac{hc}{\lambda}$;

$\lambda = \frac{6.6\times10^{-34}\times3\times10^{8}}{(1.6\times10^{-19}\times25000)}$; *(condone power of ten error in this mark)*

$= 4.95\times10^{-11}\,\text{m}$; ***[3]***

(b) shows twice $25\,\text{kV}$ maximum frequency by eye;
characteristic spectrum position unchanged; ***[2]***

B2. (a) electron occupies one of a finite number of levels;
photon <u>emitted</u> when electron <u>drops to lower</u> level / photon <u>absorbed</u> when electron <u>rises to higher</u> level;
spectral line corresponds to energy difference / reference to $\frac{hc}{\lambda}$; ***[3]***

(b) (i) $\frac{1.88\times6.56}{4.86}(=2.54\,\text{eV})$ ***or*** explicit working from $E = hf$; ***[1]***

(ii) arrow connects $n=3$ and $n=2$ <u>and</u> arrow connects $n=4$ and $n=2$;
both arrows from higher to lower level <u>and</u> lines correctly identified by wavelength; ***[2]***

B3. (a) (i) (electron) anti-neutrino; ***[1]***

(ii) lepton; ***[1]***

(b) (i) $\lambda = \frac{\ln 2}{5700}$; ***[1]***

(ii) $0.075 = 0.24\times e^{-1.21\times10^{-4}\times t}$;

$t = \frac{\ln\left(\frac{240}{75}\right)}{1.21\times10^{-4}}$;

$t = 9.7\times10^{3}$ year; ***[3]***

(c) measure activity of source;
determine number of molecules chemically;
activity $= \lambda\times N$, hence half-life; ***[3]***
*Award **[1 max]** for method that measures activity and then waits before re-measuring.*

Option C — Energy Extension

C1. (a) process in which no energy enters or leaves system; ***[1]***

(b) (i) arrows all consistently anticlockwise; ***[1]***

(ii) top or bottom line parallel to *V* axis marked A; ***[1]***

(iii) left-hand curve marked B; ***[1]***
Allow right-hand curve if arrows consistently clockwise in (b)(i).

(c) $1 \text{ square} = 10^5 \times 10^{-4} = (10\,\text{J})$;
area inside curve calculated;
answer in range $450 - 550\,\text{J}$; ***[3]***

(d) (i) second law states total entropy of universe increases/remains same for any change; ***[1]***

(ii) cold chamber entropy decreases;
more thermal energy rejected to surroundings than removed from cold chamber;
entropy increase to surroundings greater than entropy loss to cold chamber; ***[3]***

C2. (a) non-renewable as cannot be re-generated; ***[1]***
Do not award mark for just stating "non-renewable".

(b) no global warming effect / no CO_2 emission;
fossil fuels can be used as source of chemicals;
waste quantity is small compared with fossil;
waste can be controlled; ***[2 max]***

(c) fission of nucleus gives energy and further neutrons;
these neutrons produce further fission; ***[2]***

(d) 180 MeV converted to $180 \times 10^6 \times 1.6 \times 10^{-19}\,\text{J}\,(2.9 \times 10^{-11}\,\text{J})$;
$450\,\text{MW} \times \frac{100}{23}$;
$\frac{\text{required energy}}{\text{energy per fission}}$; *(allow ECF)*
$6.7 \times 10^{19}\,(\text{s}^{-1})$; ***[4]***

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 – 20 000 Hz; ***[1]***

(b) transforms sound pressure variations in air into <u>larger</u> 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;
<u>to build up</u> a 3D image; ***[3 max]***

(ii) X-ray gives (2D) shadow image of patient;
CT gives 3D image of section; ***[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]***

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. $1.6\times10^{21}\sqrt{\left(\frac{10\times1.2\times10^{-14}}{5.3\times10^{-16}}\right)}$

2.4×10^{22} m; ***[4]***

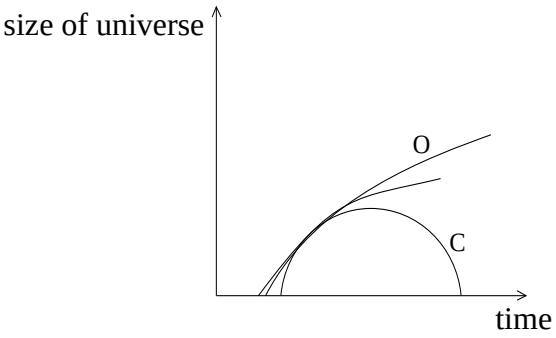
F2. (a) (i) peak higher;
peak to left; ***[2]***

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 3K / 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]***

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) $\gamma = \dfrac{1}{\sqrt{\left(1 - \left(\dfrac{v^2}{c^2}\right)\right)}} = 7.1$;
time $(= 3.1 \times 10^{-6} \times 7.1) = 2.2 \times 10^{-5}\,\text{s}$;
$\text{distance} = 6.5\,\text{km}$; ***[3]***

(c) muon at rest in its reference frame measures the <u>proper time</u> 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 $\dfrac{v}{c} = 0$ <u>non-zero</u>;
mass rises to become asymptotic at $\dfrac{v}{c} \to 1$;
line horizontal for $\dfrac{v}{c} < 0.5$; ***[3]***

(b) (i) $2.5\,(\text{MeV c}^{-2})$; ***[1]***

(ii) $\gamma = \left(\dfrac{m}{m_0}\right) = 5$;
$5 = \dfrac{1}{\left(\sqrt{1 - \left(\dfrac{v^2}{c^2}\right)}\right)}$;
$= 0.98c$; ***[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.*

Option H — Optics

H1. (a) (i) ray drawn to surface with correct refraction;
second ray with correct refraction and image location; ***[2]***

(ii) $n = \frac{\text{real depth}}{\text{apparent depth}}$;
$6.5\,\text{m}$; ***[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 <u>and</u> image drawn in, labelled I; ***[3]***

(b) (i) <u>point</u> closer than which eye cannot focus; ***[1]***

(ii) image formed 21cm from lens $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$; $\begin{cases} (\textit{real is} + \textit{ve, allow new} \\ \quad \textit{Cartesian solution}) \end{cases}$
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]***