M12/4/PHYSI/SP3/ENG/TZ2/XX/M

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MARKSCHEME

May 2012

PHYSICS

Standard Level

Paper 3

17 pages

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through Scoris™, by e-mail or telephone – if through Scoris™ or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through Scoris™ or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of Scoris™, please contact emarking@ibo.org.

If you have any queries on **administration** please contact:

Barry Evans
Subject Operations
IB Assessment Centre
Peterson House
Malthouse Avenue
Cardiff Gate
Cardiff CF23 8GL
GREAT BRITAIN

Tel: +(44) 29 2054 7777

Fax: +(44) 29 2054 7778

E-mail: barry.evans@ibo.org

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use Scoris™ annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

5. Personal codes/notations are unacceptable.

6. Where an answer to a question or part question is worth no marks but the candidate has attempted the part question, enter a zero in the mark panel on the right-hand side of the screen. Where an answer to a question or part question is worth no marks because the candidate has not attempted the part question, enter an "NR" in the mark panel on the right-hand side of the screen.

7. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. Scoris™ will only award the highest mark or marks in line with the rubric.

8. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp "seen" on any page, in the Options attempted by the candidate, that contains no other annotation.

9. 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 got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the "CON" stamp.

Subject Details: Physics SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the Options **[2 % 20 marks]**.
Maximum total = **[40 marks]**

1. A markscheme often has more marking points than the total allows. This is intentional.

2. Each marking point has a separate line and the end is shown by means of a semicolon (;).

3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.

4. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

5. Words that are underlined are essential for the mark.

6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect).

8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded when marking. Indicate this by adding **ECF** (error carried forward) on the script.

10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

Option A — Sight and wave phenomena

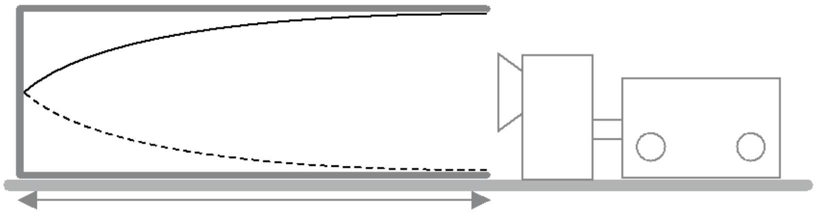
A1. (a) (i) the range of distances from the observer / distance between near and far point; within which objects can be clearly seen / clear images formed by the eye; ***[2]***

(ii) (change) the pupil diameter / (change) the brightness of light / use of (corrective) lens; ***[1]***

(b) yellow is the addition of red and green;
the filter subtracts blue from white light; ***[2]***

A2. (a) standing waves do not transfer energy;
standing waves do not have a constant amplitude;
points on a standing wave between consecutive nodes have a constant phase;
standing waves have permanent nodes/antinodes; ***[1 max]***

(b) (i) correct diagram as shown; *(dotted line not essential for the mark)* ***[1]***



(ii) wavelength of sound is $(4\times 0.910)=3.64\,\text{m}$;
speed of sound $3.64\times 92=335\,\text{m}\,\text{s}^{-1}$; ***[2]***

(c) the next harmonic has wavelength $\frac{4\times 0.910}{3}=\frac{3.64}{3}\,\text{m}$;
and so frequency $3\times 92=276\,\text{Hz}$; ***[2]***

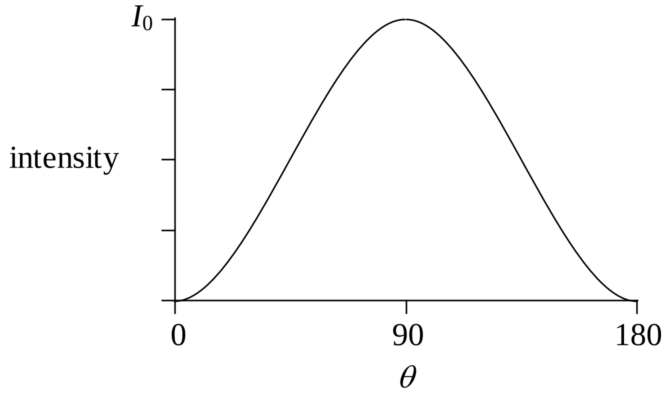
A3. (a) the two sources are seen as two distinct sources / two distinct images are formed / the central maximum of one source coincides with the first minimum of the other; ***[1]***

(b) (i) realization that the diffraction angle of the one source diffraction pattern is at 0.008 radians;
and so separation $(=1.60\times 0.008=1.28)\approx 0.013\,\text{m}$; ***[2]***

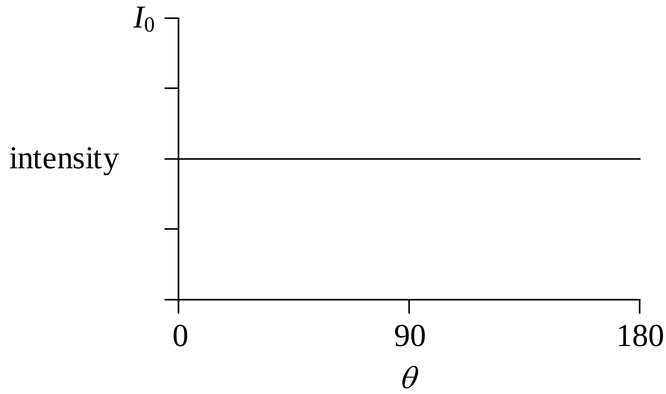
(ii) $\left(1.22\frac{528\times 10^{-9}}{b}=0.008\Rightarrow\right)b=0.081\,\text{mm}$; ***[1]***

A4. (a) light in which the <u>electric field</u> oscillates in the same plane; ***[1]***

(b) (i) zero at 0 and 180 degrees;
peak at 90 degrees; ***[2]***



(ii) horizontal straight-line;
through half the incident intensity; ***[2]***



Option B — Quantum physics and nuclear physics

B1. (a) light consists of discrete packets/quanta/bundles of energy/particle;
each photon has an energy of hf (where h is the Planck constant and f is the frequency of light); ***[2]***

(b) (i) the energy of a (em) wave depends on amplitude (not frequency);
so increasing the intensity should have resulted in electrons being emitted (at any frequency) / *OWTTE*; ***[2]***

(ii) the work function is the minimum energy required to eject an electron from a metal surface;
if the photon energy (hf) is less than the work function then no emission will take place; ***[2]***

(c) (i) recognizes that work function $= h \times$ threshold frequency;
$f_0 = \left(\frac{2.0 \times 1.6 \times 10^{-19}}{6.6 \times 10^{-34}} =\right) 4.8 \times 10^{14}\ \text{Hz}$; ***[2]***

(ii) recognize that maximum $\text{KE} = hf - hf_0$ ***or*** $hf - \phi$;
$f = \left(\frac{c}{\lambda} = \frac{3.0 \times 10^{8}}{4.2 \times 10^{-7}} =\right) 7.14 \times 10^{14}\ \text{Hz}$;
$hf\,(\text{eV}) = \left(\frac{6.6 \times 10^{-34} \times 7.14 \times 10^{14}}{1.6 \times 10^{-19}} =\right) 2.96\ \text{eV}$;
max $\text{KE} = (2.96 - 2.0 =)\ 0.96\ \text{eV}$; ***[4]***

B2. (a) (i) the α particles produced have discrete energies;
the gamma rays produced have discrete energies;
since the energies of the α particles and of the photons are determined by the difference in nuclear energy levels this implies that nuclear energy levels are also discrete; ***[3]***

(ii) the β^+ spectrum is continuous;
the neutrino was postulated to account for those β^+ with less energy than the maximum; ***[2]***

(b) recognize that $\frac{N}{N_0} = 0.23$;
$0.23 = e^{-5.3 \times 10^{-10} t}$;
$t = 2.8 \times 10^{9}\ \text{yr}$; ***[3]***

Option C — Digital technology

C1. (a) information stored digitally on the CD and in analogue form on the LP;

CD: the sound is first encoded/converted to a series of binary numbers;
the binary numbers are then converted to a series of pits and lands on the surface of the CD;

LP: the shape of the groove corresponds to the musical sound; ***[3 max]***
To award ***[3]*** *candidates must obtain the first marking point plus two others.*

(b) for destructive interference the path difference between light reflected from a pit and a land is $\frac{\lambda}{2}$ ***or*** 360 nm;
the path difference is $2d$;
therefore $2d = 360\,\text{nm}$ such that $d = 180\,\text{nm}$; ***[3]***
Award ***[2 max]*** *for a clearly labelled diagram and* ***[1 max]*** *for calculation.*

(c) (i) the ratio of charge stored to potential difference / use of the formula with symbols explained; ***[1]***

(ii) charge liberated $\left(CV = 20\times10^{-12}\times1.8\times10^{-4}\right) = 3.6\times10^{-15}\,\text{C}$;

number of photoelectrons $= \left(\frac{3.6\times10^{-15}}{1.6\times10^{-19}} =\right) 2.25\times10^{4}$;

number of photons $= \left(\frac{2.25\times10^{4}}{0.8} =\right) 2.8\times10^{4}$; ***[3]***

C2. (a) $1+\frac{800}{100}$;
9; ***[2]***

(b) (i) op-amp has a (very) large gain;
since output is finite;
the pd between X and Y has to be very small, essentially zero; ***[3 max]***

(ii) op-amp has a very high input resistance so no charge/current flows into inverting input/the two resistances are (essentially) in series; ***[1]***

C3. (a) communicates with base stations;
monitors signal strength from base stations;
selects base station with strongest signal;
allocates frequencies to cells;
connects to Internet/PSTN; ***[3 max]***

(b) any sensible environmental issue related to cellular exchange itself *e.g.* antenna attached to exchange gives visual pollution/electromagnetic pollution to people living near cellular exchanges; ***[1]***

Option D — Relativity and particle physics

D1. (a) the speed of light in a vacuum is the same for all inertial observers/observers in uniform motion; ***[1]***

(b) (i) ground observer measures a zero proper time interval for the two arrivals;
all other observers measure a time interval of $\gamma \times 0 = 0$;
hence the arrivals are simultaneous for all observers, including rocket ***[2]***
*Award **[1]** for statement that "events that are simultaneous for one observer and occur at the same place are simultaneous for all observers".*

(ii) according to the rocket observer, the ground observer moves towards the signal from tree L and away from the signal from tree R;
since the signals move at the same speed and they arrive at the same time according to the rocket observer;
signal from tree R must have been emitted first ***[2]***

D2. (a) (i) $9.1 \times 10^{-7}\,\text{s}$; ***[1]***

(ii) the gamma factor is $\gamma = \left(\dfrac{1}{\sqrt{1-0.920^2}} =\right) 2.55$;
and so $t' = \left(\dfrac{9.1 \times 10^{-7}}{2.55} =\right) 3.5 \times 10^{-7}\,\text{s}$; ***[2]***
*Award **[2]** for bald correct answer.*

(b) $98\,\text{m}$; ***[1]***

(c) equal; ***[1]***

D3. (a) the spin number of a boson is an integer value;
the spin of the kaon can be $\frac{1}{2}+\frac{1}{2}=1$ ***or*** $\frac{1}{2}-\frac{1}{2}=0$; ***[2]***

(b) (i) *X*: anti-strange quark / $\bar{s}$;
Y: antimuon / μ^{+}; ***[2]***

(ii) the process violates strangeness number conservation;
only the weak interaction allows this violation; ***[2]***

or

the decay of the kaon involves a neutrino;
any decay involving the neutrino must take place by the weak interaction;

(iii) *name*: W (boson);
sign: positive; ***[2]***

(iv) $R=\frac{h}{4\pi mc}=\frac{6.63\times10^{-34}}{4\pi(1.4\times10^{-25})\times3\times10^{8}}$;
$R=1.3\times10^{-18}$ m; ***[2]***

Option E — Astrophysics

E1. (a) (i) a constellation is a collection of stars that form a (recognizable) pattern (as viewed from Earth);
the distances between the stars may be very large;
a stellar cluster is a group of stars held together by (mutual) gravitational attraction/gravity/are physically relatively close;
there can be many thousands of stars in the cluster;
all stars in the cluster were created about the same time; ***[3 max]***

(ii) the (total) power radiated/emitted/produced (by the star); ***[1]***

(iii) luminosity of Aldebaran $= 370 \times 3.9 \times 10^{26} = 1.44 \times 10^{29}$ W;

$= \sqrt{\dfrac{1.44 \times 10^{29}}{4\pi \times 3.3 \times 10^{-8}}} = 5.9 \times 10^{17}$;

$= \dfrac{5.9 \times 10^{17}}{3.1 \times 10^{16}} = 19$ pc; ***[3]***

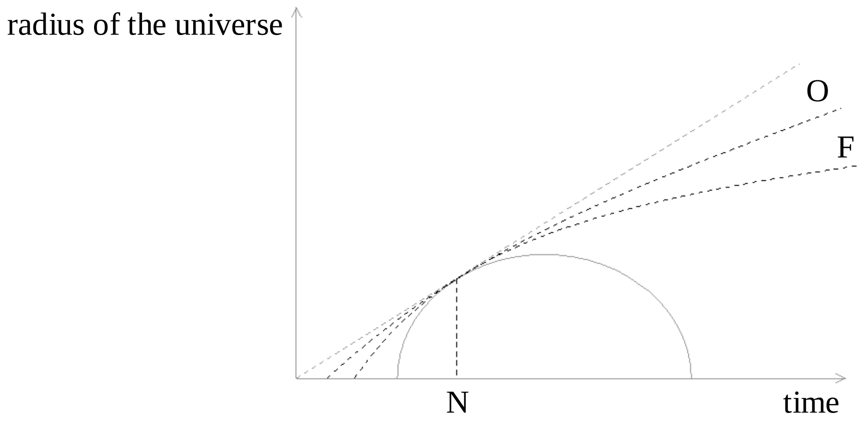
(b) (i) a measure of how bright a star appears / a (logarithmic) measure of apparent brightness; ***[1]***

(ii) expressing d in pc;
$M = -0.64$; ***[2]***

(c) the (outer layers of the star) undergo a (periodic) expansion and contraction;
which produces a (periodic) variation in its luminosity/apparent brightness;
the (average) luminosity depends on the period of variation;
by measuring the period, the luminosity can be found;
by then measuring its apparent brightness, its distance from Earth can be found; ***[5]***

E2. (a) critical density is the density for which the universe stops expanding;
after an infinite amount of time; ***[2]***

(b)



(i) the time corresponding to where the two lines touch; *(labelled N on the time axis or the graph)* ***[1]***

(ii) a slightly curved line between the dotted line and the closed universe line; ***[1]***
(labelled F)

(iii) a slightly curved line between the dotted line and the flat universe line; ***[1]***
(labelled O)

Allow an accelerating universe graph labelled either For O.

Option F — Communications

F1. (a) change of carrier frequency depends on amplitude of signal;
the (carrier) frequency increases as the signal displacement/amplitude increases / *vice versa*; ***[2]***

(b) (i) 185 and 195 kHz;
190 kHz; ***[2]***

(ii) difference on frequencies 135 kHz;
division by bandwidth to get 13/14; ***[2]***

(c) *block B*: tuning circuit;
explanation: wide range of em radiation arrives at aerial;
tuning circuit selects frequency of station required;

block C: demodulator;
explanation: separates carrier from signal wave / strips negative-going signal away / rectifies signal; ***[5]***

F2. (a) signals (A to C) are sampled sequentially;
Sample time much less than time inbetween samples;
each sample transmitted (in series) along fibre in gaps between other samples;
re-combined in correct order at end of fibre; ***[3 max]***

(b) $\frac{I}{I_0} = 10\,\text{lg}\left[\frac{25\times10^{-3}}{4\times10^{-19}}\right](=168)$;

$\frac{168}{1.8}$;

93 km; ***[3]***

(c) time between samples $= \frac{1}{32000}\left(= 3.125\times10^{-5}\text{ s}\right)$;

so as each sample takes 5×10^{-8} s there will be space for $\left(\frac{3.125\times10^{-5} - 50\times10^{-9}}{5\times10^{-8}}\right) = \frac{3.12\times10^{-5}}{5\times10^{-8}}$;

624 channels $\approx$ 620 channels; ***[3]***

allow

$\frac{3.125\times10^{-5}}{5\times10^{-8}}$ ***or*** $\frac{3.13\times10^{-5}}{5\times10^{-8}}$

$= 625 \approx 620$ channels ***or*** $= 626 \approx 630$ channels;

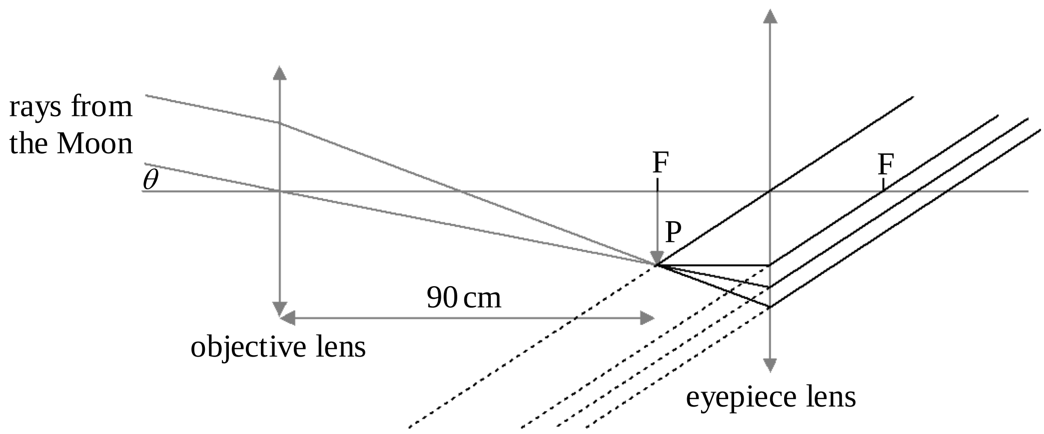
Option G — Electromagnetic waves

G1. (a) oscillating/vibrating electric and magnetic fields;
at right angles to each other;
at right angles to the direction of propagation/energy transfer of the wave/ velocity/transverse;
can travel through vacuum; ***[2 max]***
*Award **[2]** for a clearly drawn, correctly labelled diagram i.e. E and B fields at right angles to each other and at right angles to the direction of propagation.*

(b) electrons that oscillate/accelerate/move on curved paths;
electrons making transitions between energy levels; ***[2]***
Accept two specific instances of electrons being accelerated/decelerated e.g. electrons hitting metal target or electrons moving in magnetic fields.

G2. (a) (i) F at P and second F at the same distance to the right of the eyepiece; *(judge by eye)* ***[1]***

(ii)



first construction line or ray; *(judge by eye)*
second construction line or ray;
extension of these to the left as parallel lines; ***[3]***

(b) (i) $d = f_0 \tan\theta \approx f_0\theta$;
$d = 90 \times \tan(8.7\times10^{-3}) = 0.78\,\text{cm}$; ***[2]***

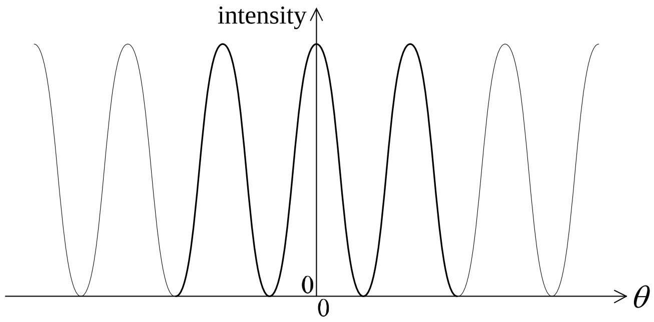
(ii) angular magnification is $M = \left(-\dfrac{f_0}{f_e} = \right)(-)3$;
hence $\theta' = -3\theta = (-)0.026\,\text{rad}$; ***[2]***

or

$\theta' = \dfrac{0.78}{30}$;
$\theta' = (-)0.026\,\text{rad}$;

G3. (a) (i) diffraction; ***[1]***

(ii) correct general shape $\left(\cos^2\theta\right)$ touching the horizontal axis;
constant amplitude;
equally spaced maxima; ***[3]***
Diagram must have at least three fringes.
*Award **[0]** for single slit diffraction pattern.*



*Award **[3]** for correct graph that shows modulation by single slit diffraction.*

(iii) $\mathrm{MQ} = \frac{1}{2}\frac{\lambda D}{d}$;

$\mathrm{MQ} = \left(\frac{650\times10^{-9}\times1.80}{2\times0.12\times10^{-3}} = \right)4.9\,\mathrm{mm}$; ***[2]***

(b) the energy gets redistributed/the total energy in the pattern is the same as the total emitted energy;
the energy that would have appeared at minima now appears at the maxima; ***[2]***