N12/4/PHYSI/SP3/ENG/TZ0/XX/M

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MARKSCHEME

November 2012

PHYSICS

Standard Level

Paper 3

19 pages

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.

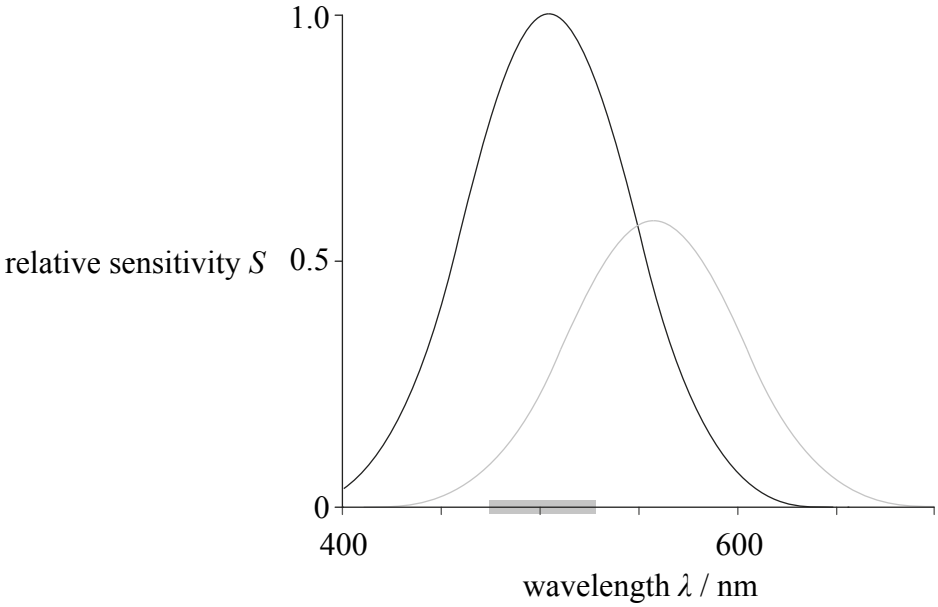
10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

Option A — Sight and wave phenomena

A1. (a) *Look for differences below within the two sections provided on the question paper. Care is needed to award **[1]** only for each difference.*

rods: scotopic vision/dim light and cones: photopic vision/bright light;
rods: cannot distinguish colour and cones: can distinguish colour / *OWTTE*;
rods: better peripheral vision and cones: detailed central vision;
*Award **[2 max]** for ECF if rods and cones consistently confused.* ***[3]***

(b)



show curve centered as shown at the correct wavelength (range permitted shown in grey);
of increased height; ***[2]***

(c) *red light*:
red / brighter / no change;

blue light:
black / darker / no colour; ***[2]***

A2. (a)

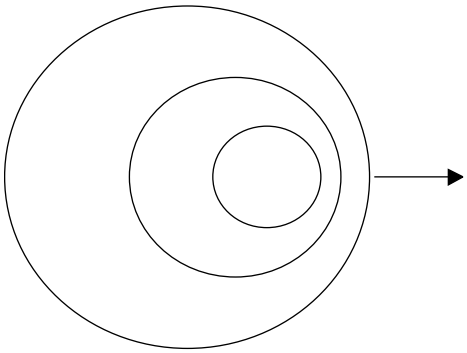


diagram showing (non concentric) wavefronts closer together in front/further apart behind source;
frequency is higher as source approaches (because more wavefronts are received per unit of time);
frequency is lower as source recedes (because fewer waverfronts are received per unit of time); ***[3]***

(b) $360 = 400\left(\frac{340}{340 + u_s}\right)$;

$u_s = 38\,\text{m s}^{-1}$; ***[2]***

*Award **[2]** for a bald correct answer.*

A3. (a) the electric field vector oscillates in one plane/direction only; ***[1]***

(b) (i) $n = \tan\phi$ *(no marks for this alone)*
n is refractive index of reflecting material and ϕ is the angle of incidence/ reflection (in air) for a completely plane polarized reflected ray; ***[1]***

or

maximum polarization occurs when the refracted ray is at 90 degrees to the reflected ray;

(ii) $n = \tan\phi = \tan 56$;
$n = 1.48$; ***[2]***
*Award **[2]** for a bald correct answer.*

A4. *graph*: ***[2 max]***
correct single slit diffraction pattern with appropriate labelling (*eg* angle/θ) of horizontal axis;
identical diffraction pattern with peak separated by less than half the width of central maximum;

explanation: ***[2 max]***
light from each lamp produces a diffraction pattern on retina of eye;
some statement/Rayleigh criterion quoted to the effect that because the minimum of one falls too close to the maximum of the other they cannot be resolved, so diffraction pattern looks the same as that from a single lamp/source; ***[4]***

Option B — Quantum physics and nuclear physics

B1. (a) shine white light through;
a tube of the gas;
then observe with spectroscope/grating/prism; ***[3]***

(b) (i) continuous spectrum crossed by dark lines; ***[1]***

(ii) dark lines formed by the absorption of photons;
the absorbed photons have specific/discreet wavelengths;
indicating discreet differences in energy;
which can only be explained by existence of energy levels; ***[3 max]***

(c) $E = 13.6\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = 12.1 \text{ eV};$

$12.1\text{eV} = 12.1 \times 1.6 \times 10^{-19} \text{ J} = \frac{hc}{\lambda};$

$\lambda = 102 \text{ nm}$ ***or*** $103 \text{ nm};$ ***[3]***

*Award **[3]** for a bald correct answer.*

B2. (a) neutrino/ν;
positron / e^+ / ${}^{0}_{+1}e$ / β^+; ***[2]***

*Award **[1 max]** for wrongly stating electron and antineutrino. Both needed for the ECF.*
Order of answers is not important.

(b) $\lambda = \left(\frac{\ln 2}{1.3 \times 10^9} =\right) 5.31 \times 10^{-10} \text{ yr}^{-1};$

$0.15 = e^{\left[-5.31 \times 10^{-10} \times t\right]};$

$t = 3.6 \times 10^9 \text{ yr};$ ***[3]***

*Award **[3]** for a bald correct answer.*

or

$(0.5)^n = 0.15;$

$n = \frac{\log(0.15)}{\log(0.5)} = 2.74 \text{ half-lives};$

$2.74 \times 1.3 \times 10^9 = 3.6 \times 10^9 \text{ yr};$

*Award **[3]** for a bald correct answer.*

(c) the count rate/activity of a sample;
the mass/number of atoms in the sample; ***[2]***

B3. *Look for these points*:
idea that total energy released in the decay is fixed;
beta particle energies are less than this value/continuous;
the neutrino is postulated to account for this "missing" energy; ***[3]***

Option C — Digital technology

C1. (a) (i) laser light reflected from pits/lands results in constructive interference/is read as binary 0;
light reflected from the edge of a pit/land suffers destructive interference/is read as binary 1;
recognition of depth of pit as quarter wavelength; ***[2 max]***
Accept answers where the 0 and the 1 are interchanged.
Look for these points within a diagram if drawn.

(ii) *information in digital form*:
is more secure / can be encrypted;
can be edited/manipulated;
can be accessed quickly;
can be sent electronically;
can be copied/deleted easily;
is less noisy;
can be stored in large quantities in little physical space; ***[1 max]***

(b) number of bits is $44100 \times 32 \times 80 \times 60 = 6.77 \times 10^9$;
number of megabytes is $\frac{6.77 \times 10^9}{8 \times 10^6} = 846 \approx 850$; ***[2]***

C2. (a) the ratio of the number of electrons emitted to the number of photons incident; ***[1]***

(b) number of electrons $= 4.2 \times 10^6 \times 0.78 \times 30 \times 10^{-3} = 98280$;
charge $= 98280 \times 1.6 \times 10^{-19} = 1.57 \times 10^{-14}$;
$V = \frac{1.57 \times 10^{-14}}{12 \times 10^{-12}} = 1.3\,\text{mV}$; ***[3]***
*Award **[3]** for a bald correct answer.*

(c) image is digital so it can be easily manipulated/edited/stored;
CCD has a larger quantum efficiency so image can be obtained in a shorter time;
CCD has a more uniform response to light of different wavelengths;
CCD can obtain images of bright and faint objects at the same time; ***[1 max]***

C3. (a) infinite input impedance/resistance;
infinite open loop gain;
zero output impedance; ***[2 max]***

(b) $G = 26 = 1 + \frac{R}{4}$;
$R = 100\,\text{k}\Omega$; ***[2]***
*Award **[2]** for a bald correct answer.*

(c) (i) $V_{\text{OUT}} = -7.8\,\text{V}$; *(minus sign required)* ***[1]***

(ii) $V_{\text{OUT}} = 9.0\,\text{V}$; ***[1]***

C4. (a) a larger cell size would require a larger power from base stations/mobile phones;
and this would imply greater health risks; ***[2]***

or

signal strength decreases with distance/is attenuated by buildings;
if cells are too large then signal strength will become too weak;

(b) (the cellular exchange allocates a) range of carrier frequencies within the same cell;
by allocating different time slots using time division multiplexing; ***[2]***

Option D — Relativity and particle physics

D1. (a) a point in spacetime / something happening at a particular time and a particular point in space; ***[1]***

(b) (i) $t = \frac{6.0}{3.0\times10^{8}} = 2.0\times10^{-8}\,\text{s}$; ***[1]***

(ii) for either formula to be used one of the time intervals must be a proper time interval;
the two events occur at different points in space and so neither observer measures a proper time interval;
the proper time interval is that of the photons; ***[2 max]***

(c) (i) $\gamma = \frac{1}{\sqrt{1-0.80^{2}}} = \frac{5}{3} = 1.67$;
$l = \frac{L}{\gamma} = \frac{6.0}{1.67} = 3.6\,\text{m}$; ***[2]***
*Award **[2]** for a bald correct answer.*

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

(iii) vT ***or*** $0.80\,cT$; ***[1]***

(iv) $cT = 0.80\,cT + 3.6$;
$T = \frac{3.6}{0.20\times3.0\times10^{8}} = 6.0\times10^{-8}\,\text{s}$; ***[2]***
*Award **[2]** for a bald correct answer.*

D2. (a) photon / graviton / Z / Higgs; ***[1]***

(b) (i) K^0 has a strangeness of +1, its antiparticle has strangeness –1 and so are different;
the antiparticle is s, $\bar{d}$ and so is different; ***[1 max]***

(ii) strangeness is violated in this decay;
this can only happen with the weak interaction; ***[2]***

(iii) Z^0 / Z; ***[1]***

(iv) $R = \left(\frac{h}{4\pi mc} = \right) \frac{6.6\times10^{-34}}{4\times\pi\times1.6\times10^{-25}\times3.0\times10^{8}}$;
$R \approx 10^{-18}$ m; ***[2]***
*Award **[2]** for a bald correct answer.*

(c) (i) the K^0 consists of a quark and an antiquark of opposite colours/colour anticolour pair;
and so cancel out; ***[2]***

(ii) baryon number / quark number / energy; ***[1]***

Option E — Astrophysics

E1. (a) (i) the apparent magnitude/log scale of apparent brightness/measure of apparent brightness of a star at a distance of 10 pc / a (logarithmic) measure of the luminosity of a star; ***[1]***

(ii) temperature/colour; ***[1]***

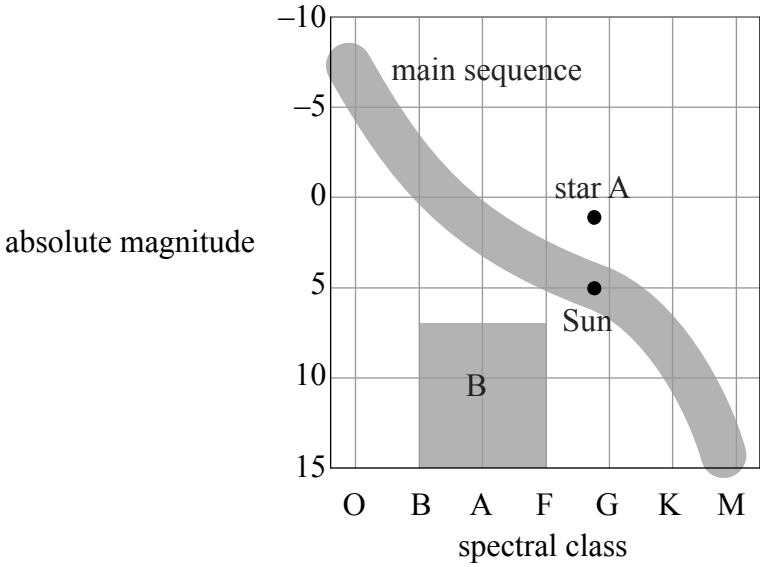
(iii) star A has higher luminosity/brightness/mass at the same temperature/class / star A is near the red giant region;
(so it must be larger in radius) ***[1]***

(b) (i) $\frac{L_A}{L_B} = \frac{\sigma 4\pi R_A^2 T_A^4}{\sigma 4\pi R_B^2 T_B^4}$;

$\frac{L_A}{L_B} = 0.60^4 \times 270^2$ ***or*** look for 3 or more sig fig *eg* 9.45×10^3;

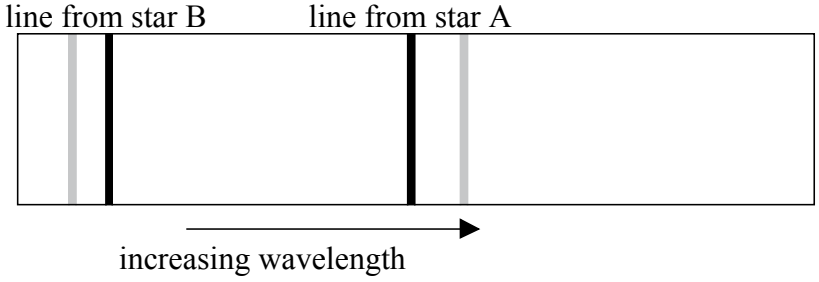
$\left(\frac{L_A}{L_B} = 9.4\times10^3\right)$ ***[2]***

(ii)



anywhere in the grey box; ***[1]***

(c)



*Award **[1]** for each correct line.* ***[2]***
The shifted lines are light grey in the diagram above. Ignore magnitude of shift.
*Award **[0]** if more than two lines are drawn unless it is clear which lines are to be marked.*

E2. (a) (i) the star expands and contracts/pulsates / radius oscillates / *OWTTE*; ***[1]***

(ii) average absolute magnitude/$M = \left(-2.83\log_{10} 7.2 - 1.81\right) = -4.24$;
average apparent magnitude/$m = 4.0$;
$d = 10\times10^{(m-M)/5} = 10\times10^{(4.0+4.2)/5} = 436 \approx 440$ pc; ***[3]***
Answer very sensitive to rounding. Allow 436 to 445 pc.
*Award **[3]** for a bald correct answer.*
*Allow ECF **[2 max]** for 164 pc obtained by assuming (7.2 – 1.81) is in brackets.*

(b) measure period and average apparent brightness/magnitude of the Cepheid to determine its distance;
measuring the apparent brightness of the star gives the luminosity (since distance is now known) from $L = 4\pi d^2 b$; ***[2]***

or

measure period of Cepheid to determine its (average) luminosity;
compare the apparent brightness of the star and Cepheid to find L using $L \propto b$;

E3. (a) (i) a universe whose density is equal to the critical density; ***[1]***

(ii) the mutual gravitational attraction would slow the expansion down; ***[1]***

(iii) the density of the universe needs to be determined;
this involves many uncertainties related to measurement of distances/volume;
this involves many uncertainties related to presence of dark matter; ***[2 max]***

(b) light from galaxies is observed to be red-shifted/to have a longer wavelength than that emitted;
indicating that the distance between galaxies is getting bigger/galaxies move away from each other/from us; ***[2]***
*Award **[1 max]** if galaxies are not mentioned.*

or

the presence of the cosmic microwave background radiation;
is evidence of cooling of the universe/increase in wavelength/red-shift due to expansion;

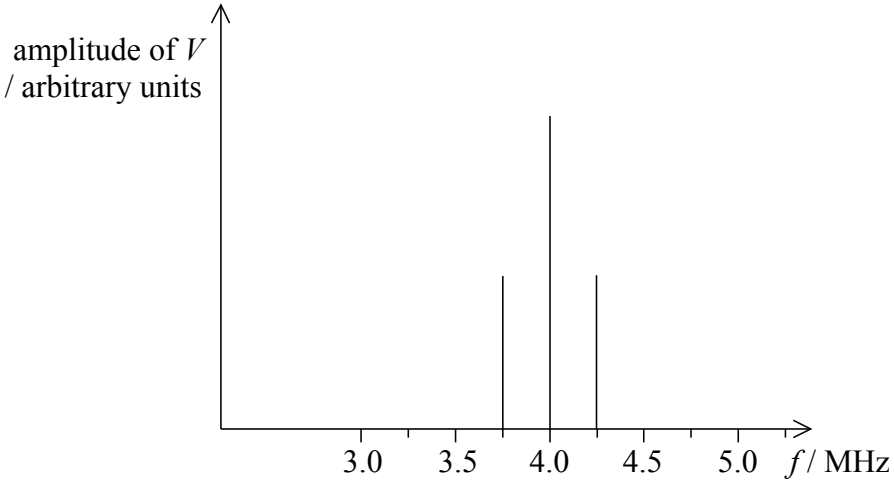
Option F — Communications

F1. (a) (i) (24 full waves in $6\,\mu s$ so) 4 MHz; ***[1]***

(ii) (period is time from peak to peak of envelope *i.e.* $4\,\mu s$ so) 0.25 MHz; ***[1]***

(iii) $\left(\frac{\text{max} - \text{min}}{2} = \frac{3.2 - 0.8}{2}\right) = 1.2$ V; ***[1]***

(b) three lines at the correct frequency;
sidebands shorter length; ***[2]***



F2. (a) (i) *X*: analogue-to-digital converter;
Y: parallel-to-serial converter; ***[2]***

(ii) the bits arrive at the serial-to-parallel converter one after the other/ sequentially (*OWTTE*) and are registered;
the bits are then simultaneously (*OWTTE*) fed in to the DAC; ***[2]***

(b) need a larger sampling frequency;
in order to see variation of signal on a shorter time scale;
need a greater number of bits (in each digitized sample);
in order to make the vertical step size smaller / in order to reduce the quantization error; ***[4]***

F3. (a) less noise/attenuation per unit length/crosstalk;
greater bandwidth/security (though encryption); ***[1 max]***

(b) attenuation/loss of energy depends on wavelength;
and is least for infrared wavelengths; ***[2]***

(c) (i) $10\log\frac{P_{\text{signal}}}{P_{\text{noise}}} = 25 \Rightarrow P_{\text{signal}} = 4.2\times10^{-6}\times10^{2.5}$;
(=1.3 mW) ***[1]***

(ii) $\text{loss in dB} = 10\log\frac{25}{1.3}$;
$\text{loss} = 12.8 \text{ dB}$;
$L = \frac{12.8}{0.30} = 43 \text{ km}$; ***[3]***
*Award **[3]** for a bald correct answer.*

Option G — Electromagnetic waves

G1. (a) the light from the sources must be coherent / phase difference must be constant *(allow "in phase")* / the electric fields must have the same polarization; ***[1]***

(b) fringe spacing $= \frac{1.60\,\text{m} \times 410\,\text{nm}}{0.30\ \text{mm}}$;

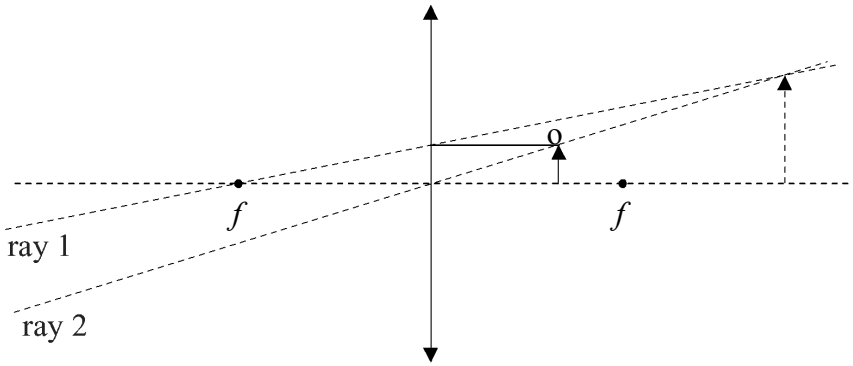
2.2 mm; ***[2]***

*Award **[2 max]** for a response that makes use of $n\lambda$ in the double slit formula*
*Award ECF **[1 max]** if answer is for a value of n greater than 1.*
*Award **[2]** for a bald correct answer.*

(c) sharper fringes / *OWTTE*;
brighter;
same spacing; ***[3]***

G2. (a) the near point is the closest position of an object from the eye that can be clearly focused / objects placed closer than the near point cannot be focused clearly by the eye / *OWTTE*; ***[1]***

(b)



ray 1 correct;
ray 2 correct;
virtual rays converge/image shown; ***[3]***
Ignore arrows on any lines drawn.

(c) $M = \left(\frac{\theta_i}{\theta_o} = \right)(-)\frac{v}{u}$;

$= \frac{D}{\frac{fD}{f+D}} = \frac{D(f+D)}{fD}$;

$\left(M = 1 + \frac{D}{f}\right)$ ***[2]***

Check for correct manipulation.

(d) (i) $M = \left(1 + \frac{25}{6} = \right) 5.2$; ***[1]***

(ii) $\frac{1}{v} = \frac{1}{2.8} - \frac{1}{3.4}$;
$v = 16\,\text{cm}$; ***[2]***
*Award **[2]** for a bald correct answer.*
*Award **[1]** for ECF giving $v = 1.5\,cm$.*

(iii) magnification of objective $= \left(\frac{16}{3.4} = \right) 4.7$;
overall magnification $= \left(5.2 \times 4.7 = \right) 24$; ***[2]***
*Award **[2]** for a bald correct answer.*
*Award **[2 max]** for ECF from (d)(i) and (d)(ii).*

G3. blue/short wavelength light is scattered most in the atmosphere;
at sunset, sunlight passes through a greater thickness of atmosphere;
so the Sun/sky/clouds appear redder due to removal of blue / *OWTTE*; ***[3]***