INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL -
BACHILLERATO INTERNACIONAL

MARKSCHEME

May 1999

PHYSICS

Higher Level

Paper 3

17 pages

OPTION D—MEDICAL PHYSICS

D1. **(a)** Blood pressure depends on both hydrostatic pressure [1]
hydrostatic pressure depends on height (depth) [1]
so when horizontal height has little effect on pressure [1]
[max 3 marks]

(i) $Q_A / Q_B = (.60)^4 / (.30)^4 = 16$ [1]
FFR $\propto 1/Q$ [1]
to give the ratio $\frac{1}{16}$ [1]
[max 3 marks]

(ii) Fluid/low rate 16^x in A (Poiseville) [1]
Radius double therefore velocity flow 4^x [1]
[max 2 marks]

(iii) they will dilate [1]
to increase the blood flow rate to the muscles [1]
[max 2 marks]

D2. **(i)** body surface of adult is about 4 × that of a baby [1]
so rate of heat loss is greater [1]
but adult mass is about 8 × greater (accept 6 - 30) [1]
so ratio of heat loss relative to body mass for an adult is
about half that of a baby (or other value consistent with estimate) [1]
[max 4 marks]

(ii) same clothing (or other valid assumption *e.g.* same shape,
same skin colour) [1]
[max 1 mark]

D3. **(a)** sound vibrations do not reach the inner ear [1]
[max 1 mark]

(b) hearing aids are only effective over a range of about 200-5000 Hz [1]
this is range of a normal conversation [1]
sound from a Hi-Fi system covers a much greater range [1]
[max 3 marks]

(c) rel intensity = $10 \log (I / 10^{-12}) = 40$ [1]
to give $I = 10^{-8}$ W m^{-2} [1]
[max 2 marks]

D4. **(a)** absorption **[1]**
Comptom scattering (accept scattering) **[1]**
or pair production

[max 2 marks]

(b) **(i)** recognition that μ is the slope of the graph **[1]**
measurement of slope = -0.2 mm^{-1} **[1]**

[max 2 marks]

(ii) $x_{½} = \left(\frac{\ell n\,(2)}{\mu}\right)$ **[1]**

= 3.5 mm **[1]**

[max 2 marks]

(c) **(i)** x-rays cause ionisation of the molecules of living cells (or
break molecular bonds) **[1]**
the ions formed can react with other molecules in the cell **[1]**
thereby causing damage **[1]**

[max 3 marks]

e.g. the ions could react with DNA and upset genetic coding **[1]**
or any other suitable example- candidate might choose a large dosage

[max 1 mark]

OPTION E — HISTORICAL PHYSICS

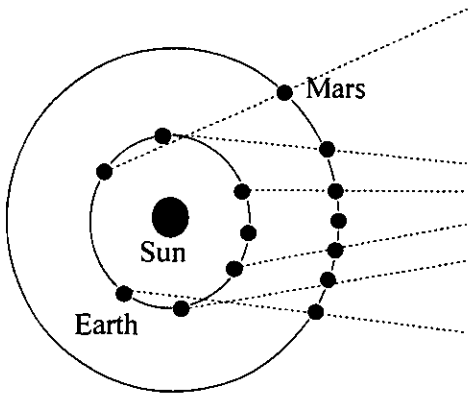
E1. **(a)** Although the stars appear to rotate about the Earth in a circular path **[1]**
against this backdrop the planets are at times seen to exhibit retrograde motion **[1]**
(or their motion wanders relative to the fixed stars)

[max 2 marks]

(b) Ptolemy's model regarded the Earth as being at the centre of the solar system **[1]**
Copernicus proposed a heliocentric system **[1]**
the moon alone rotated about the Earth **[1]**
(Accept Ptolemy used a system of epicycles *i.e.* look for 3 pertinent differences)

[max 3 marks]

(c) *Diagram:* **[2]**



Explanation:
The direction which Mars is seen from earth varies as the Earth and Mars move round the Sun **[1]**
this variation in angle will produce the observed retrograde motion **[1]**

[max 4 marks]

The marks for this section need not be split [2] and [2] for the diagram and explanation. The diagram, which might be the candidate's own diagram, is meant to aid the explanation. Essentially look for something that shows clearly that as the Earth and Mars move around the Sun the angular direction of Mars as viewed from the Earth will change and so produce the observed retrograde motion.

E2. **(a)** Latin was the universal language of scholars of the time **[1]**

[max 1 mark]

(b) linear momentum **[1]**

[max 1 mark]

(c) *Answers to this will be open-ended so look for a good understanding of conservation of linear momentum in conjunction with Newton's Third Law. Answers should not just rely on conservation of momentum, reference to forces should be made.*
If only conservation of momentum or Newton then max [2] out of 3 ***[1 mark]***

[max 3 marks

E3. **(a)** Energy of photon = $mc^2 = hc / \lambda$ **[1]**
therefore $p = mc = h / \lambda$ **[1]**
de Broglie hypothesised that all particles would have an associated wavelength given by $p = \frac{h}{\lambda}$ **[1]**
[max 3 marks]

(b) appropriate method of calculation to give $\lambda = 3.9 \times 10^{-11}\ m$ **[2]**
(essentially, calculation of momentum **[1]**
calculation of λ from $p = \frac{h}{\lambda}$) **[1]**
which is if the order of crystal lattice spacing **[1]**
[max 3 marks]

E4. **(a)** Kelvin's approach was macroscopic **[1]**
Boltzmann's was microscopic **[1]**
[max 2 marks]

(b) **(i)** two gases separated by a sliding door, one warm, one cool **[1]**
demon opens door every time a fast molecule in the cool gas approaches and lets it through to the warm gas. **[1]**
[max 2 marks]

(ii) the warm gas gets warmer and the cool gas gets cooler **[1]**
therefore energy is transferred spontaneously from cold to hot
OR the entropy of the cold gas has decreased **spontaneously**
[max 1 mark]

(iii) Energy would have to enter from outside in order for the demon to operate the door therefore, the system is no longer closed. **[1]**
[max 1 mark]

E5. **(a)** **(i)**

electric charge	✓
strangeness	
energy	
mass	
baryon number	✓

Award ***[1 mark]*** for electric charge and ***[1 mark]*** for baryon number. **[2]**
Deduct ***[1 mark]*** for each incorrect ✓ but do not give a minus mark!
e.g. ✓✓ of which one is wrong gets ***[1 mark]*** ✓✓✓ of which two are wrong gets ***[0 mark]***
[max 2 marks]

(ii) Look for something along the lines that it is not always possible to know the details of what is happening in an interaction but if we know of quantities that are conserved then it is possible to predict the outcome OR predict what interactions will take place and which will not. **[2]**
[max 2 marks]

OPTION F — ASTROPHYSICS

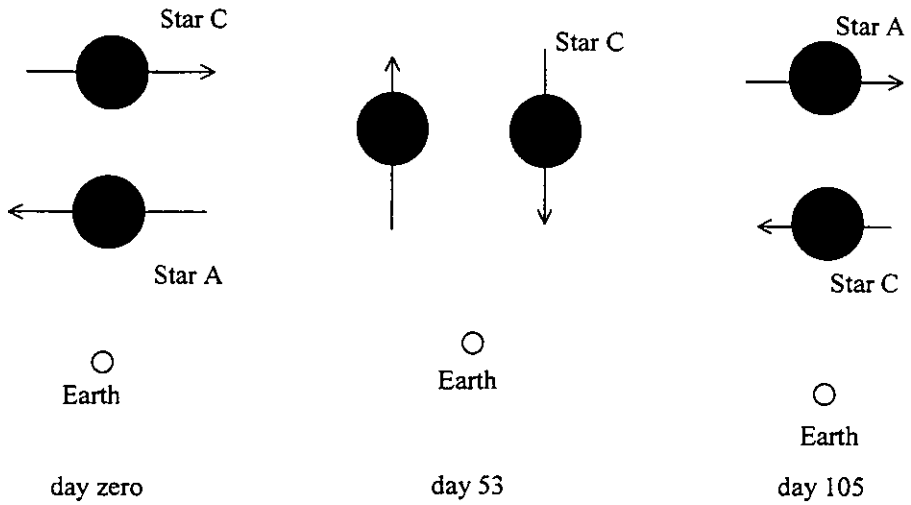
F1. **(a)** elements present in the corona **[1]**
temperature **[1]**
its velocity relative to earth **[1]**
[1 mark] for each correct

[max 3 marks]

(b) **(i)** this is a binary system **[1]**
consisting of two stars of the same spectral class **[1]**
that are orbiting in a visual plane with the earth **[1]**

[max 3 marks]

(ii)



The diagram should show the correct orientations of the binary system with respect to the earth for each of the three spectra.
diagram of system showing movement of individual stars **[1]**
position consistent with each spectrum **[1]**

Day 1- Star C is blocked (or moving sideways relative to the Earth) from view by star A so only A's spectrum is observed **[1]**
Day 53- Star C moving towards the earth so spectrum is blue shifted **[1]**
Star A moving away so its spectrum is red shifted **[1]**
Day 105- Star A is blocked by C (or moving sideways relative to the Earth) so only C's spectrum is seen (or both spectrums overlap) **[1]**

The diagram should be taken in conjunction with the explanation and discretion used to award up to ***[6 marks]***. If a candidate does not give a diagram but gives a completely accurate explanation then award the full ***[6 marks]***.
Essentially award ***[2 marks]*** for each correct explanation of the three spectra.

[max 6 marks]

F2. **(a)** Consider shells of equal thickness D at radius R from the Earth **[1]**
the volume of a shell is $4\pi R^2$ D **[1]**
therefore the number of stars is proportional to R^2 **[1]**
or some other plausible argument to show that number of stars is proportional to R^2.
If candidates just quote this then award 2/5.
but intensity varies as $1/R^2$ **[1]**
therefore everywhere in the universe is equally bright **[1]**
[max 5 marks]

(b) Any 3 of :
the universe is expanding **[1]**
is finite **[1]**
the stars are not uniformly distributed **[1]**
the universe is eternal **[1]**
(accept light absorbed on the way)
[max 3 marks]

F3. **(a)** **(i)** Red giant (Super red giant) **[1]**
[max 1 mark]

(ii) more massive **[1]**
[max 1 mark]

(b) **(i)** could contract to become a neutron star **[1]**
or a black hole **[1]**
[max 2 marks]

(ii) the original mass of the star **[1]**
[max 1 mark]

F4. **(i)** 1.65×10^6 ly = 1.65×10^6 /3.26 pc = 0.51 Mpc **[1]**
v =Hd
to give v = 25.3 km s^{-1} **[1]**
[max 2 marks]

(ii) Use $\Delta\lambda/\lambda \approx V/c$ **[1]**
$\Delta\lambda = (25.3 \times 10^3 \times 500) / 3 \times 10^8 = .04$ nm **[1]**
therefore $\lambda = 5.04 \times 10^{-9}$ m **[1]**
[max 3 marks]

OPTION G — RELATIVITY

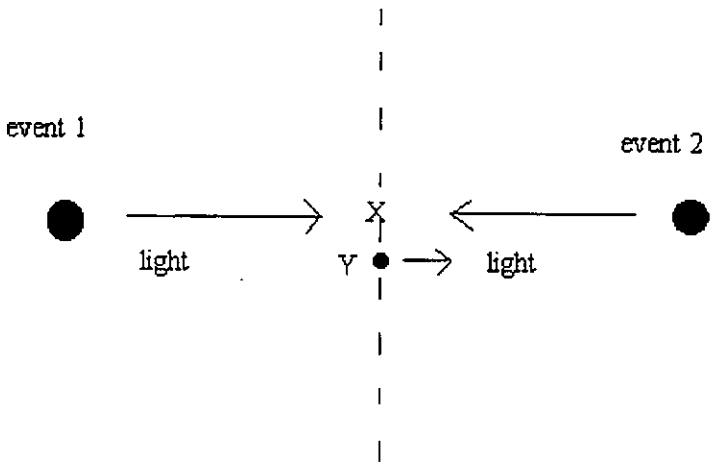
G1. **(a)** **(i)** $\Delta t' = \gamma \Delta t$ **[1]**

$\gamma = 1.01$ **[1]**

to give $v = 0.14c$ **[1]**

[max 3 marks]

(b)



These are the key things to look for in the explanation and diagram.

(i) light from events 1 and 2 takes the same time to reach X **[1]**

but because of the relative motion of Y if he is moving

towards event 2 and because the speed of light is the same for X and Y **[1]**

then light from 2 will reach him before light from 1 **[1]**

therefore Y will see event 2 before event 1 **[1]**

[max 4 marks]

(ii) No, there is no preferred reference system **[1]**

or yes, for a particular observer

[max 1 mark]

G2. **(a)** Space time is curved (warped) by the presence of mass **[2]**
objects moving near large masses change their path because of the warped space. **[1]**
[max 3 marks]

(b) the frequency of light is affected by a gravitational field **[1]**
e.g. if light leaving the surface of the earth is compared with light emitted from an identical source at a height above the earth's surface then it will be observed to have a lower frequency **[1]**
[max 2 marks]

(c) The Pound-Rebka experiment
Measuring the frequency shift of γ rays **[1]**
from sources at different levels within a building **[1]**
OR atomic clocks in rockets and at the earth's surface
OR redshift form light emitted from atoms at the surface of the sun.
[max 2 marks]

(d) calculation of frequency = 10^{15} Hz **[1]**
use of $\Delta f/f = g\Delta h/c^2$ to give 10 Hz **[1]**
this is far two small to be detected since the frequency bandwidth of the emitted light would be greater than 10 Hz **[1]**
[max 3 marks]

G3. *(Note that answers to this question can be given in terms of energy)*

(a) **(i)** Use $E_k = mc^2 - m_0c^2$ **[1]**
calculation of E_k **[1]**
to give $m = 12.3 \times 10^{-31}$ kg (0.69 MeV/c^2) **[1]**
[max 3 marks]

(ii) use $m = \gamma m_0$ **[1]**
to give $v = .67c$
i.e. for working, for correct answer. **[2]**
[max 3 marks]

(iii) Use $E = mc^2$ **[1]**
to give $E = 1.1 \times 10^{-13}$ J (0.69 MeV)
[1]
[max 2 marks]

(iv) $p = mv$ **[1]**
$= 12.3 \times 10^{-31} \times .67 \times 3 \times 10^8 = 2.5 \times 10^{-22}$ Ns (0.46 MeV/c) **[1]**
[max 2 marks]

(b) use $v = v^1 = \dfrac{(u+v)}{1+\dfrac{uv}{c^2}}$ **[1]**

to give 2.78×10^8 ms^{-1} **[1]**
[max 2 marks]

OPTION H — OPTICS

H1. **(a)** diagram to show the formation of image in a plane mirror **[1]**
the image is not there because of the diverging rays **[1]**
diagram of eye to show that the eye converges the rays to see the image as if it were a real object at virtual image position **[1]**
(Note: that to get the full marks candidates must mention or show that the eye forms the image)

[max 3 marks]

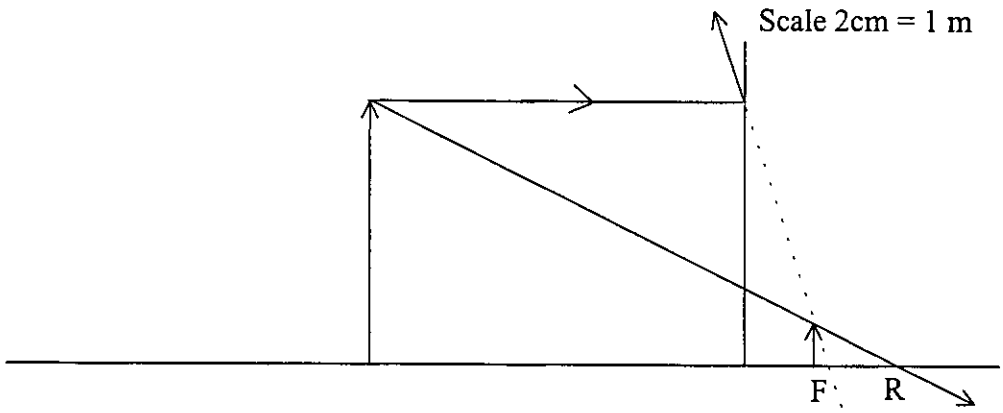
(b) **(i)** they have a wide field of view **[1]**
[max 1 mark]

(ii) images are smaller in convex mirrors / or distortion **[1]**
[max 1 mark]

(c) **(i)** focal length = 0.5 m **[1]**
use $1/d_o + 1/d_i = -1/f$ **[1]**
to give $d_i = -0.42$ m
(either minus sign or stated behind the mirror) **[1]**
size = (1.8 x .42) / 2.5 = 0.30 m **[1]**
[max 4 marks]

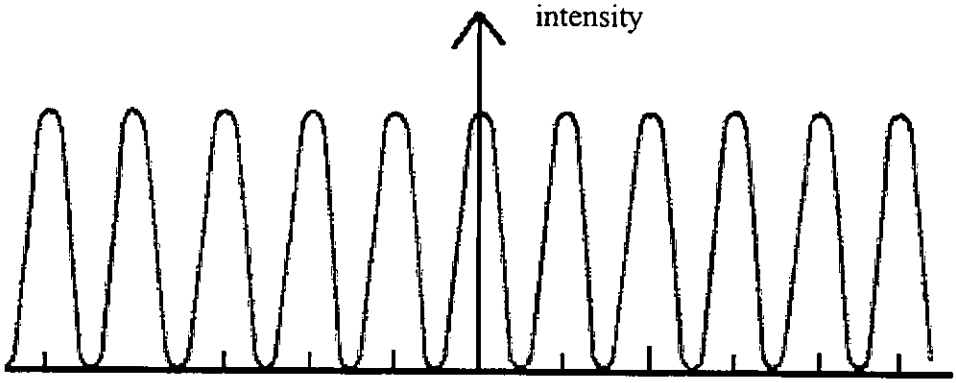
(ii) virtual **[1]**
[max 1 mark]

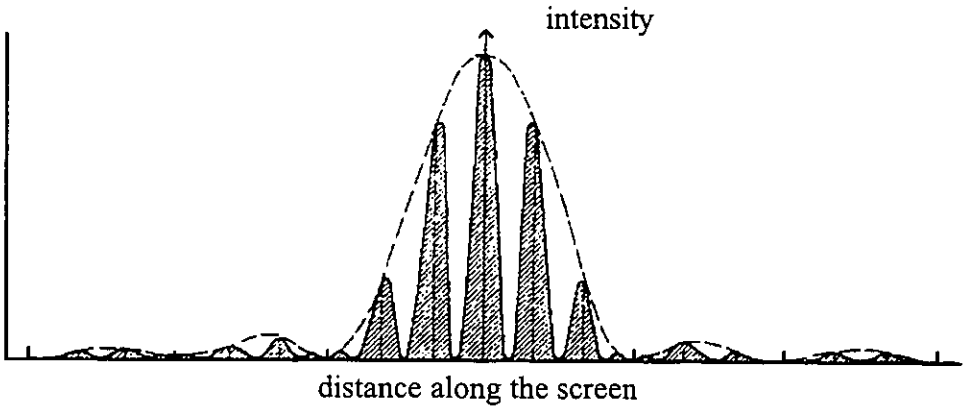
Or by scale drawing



Scale **[1]**
F and R **[1]**
Rays **[1]**
Size and position **[1]**
[max 4 marks]

H2. **(i)** fringes of near equal intensity **[1]**
and equal separation **[1]**
[max 2 marks]





(ii) secondary maxima **[1]**
diffraction envelope **[1]**
[max 2 marks]

(iii) In the first diagram diffraction maxima is very wide **[1]**
in the second diagram diffraction effects at the slits modifies the
intensity pattern **[1]**
[max 2 marks]

H3. **(a)** **(i)** the lights are not resolved by the eye **[1]**
as the car gets closer the angle that the lights subtend at the eye gets larger **[1]**
so that the separation of the maximum of the diffraction pattern
produced by each light at the retina increases **[1]**
until the Rayleigh criterion is eventually satisfied. **[1]**
(The Raleigh criterion need not be mentioned by name)

Or something along the following lines
each light produces a diffraction pattern on the retina **[1]**
these patterns will overlap so that they may not be resolved **[1]**
as the car gets nearer the patterns separate **[1]**
until the Rayleigh criterion is eventually satisfied. **[1]**
[max 4 marks]

(b) **(i)** separation of headlights 1.5 m (allow 0.5 - 2.0 m) **[1]**
wavelength of light = 500 nm (allow between 400 - 700 nm) **[1]**
diameter of pupil = 5 mm (allow between 1 - 10 mm) **[1]**
[max 3 marks]

(ii) if d = distance of car then angle subtended at the eye = 1.5 /d **[1]**
Rayleigh criterion $\propto = 1.22\,\lambda / b$ **[1]**
$1.22 \times 5 \times 10^{-7} / 5 \times 10^{-3} = 1.5$ /d,d = 12 km **[1]**
[max 3 marks]

H4. **(a)** light reflected from the water surface is **partially** polarised **[1]**
polaroid will cut out this light **[1]**
therefore only light transmitted from the bottom of the pond
will reach the eye **[1]**
(or therefore cutting out the glare from the surface) ***[max 3 marks]***

n= tan θ (Brewster angle) θ = 52° **[1]**
[max 1 mark]