INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

M99/430/S(3)M

MARKSCHEME

May 1999

PHYSICS

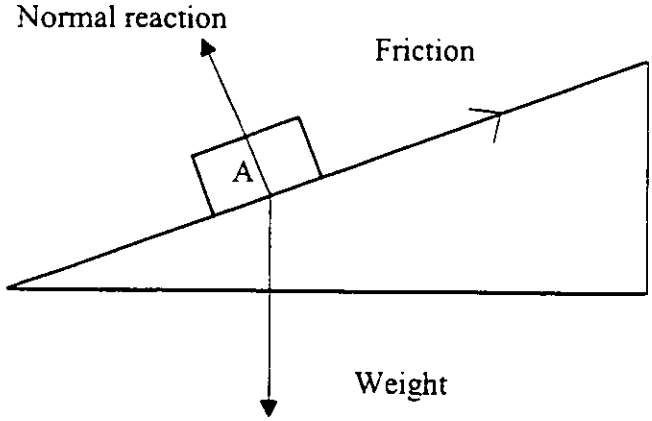
Standard Level

Paper 3

18 pages

OPTION A—MECHANICS

A1. **(a)** **(i)**



[1 mark] for each correct force and label. *[max 3 marks]*

(ii) $\mu = \tan\theta$ **[1]**
$= 0.6$ **[1]**
or from first principals
If candidates show that $\mu = \tan\theta$ then award 2 marks even if they get the value of μ incorrect. *[max 2 marks]*

(b) net force on block = $mg \sin 60 - \mu R$ **[2]**
i.e. *[1 mark]* for weight down the plane. *[1 mark]* for the friction
calculation of net force = 1.4 N **[1]**
acceleration $1.4 / .4 = 5.8\ m\,s^{-2}$ **[1]**
[max 4 marks]

A2. **(a)** -23.5×10^6 J **[1]**
[max 1 mark]

(b) From graph V at 3.8×10^6 $m = -17.0 \times 10^6$ J **[1]**
difference in V = energy = 6.5×10^6 J **[1]**
[max 2 marks]

(c) potential **[1]**
[max 1 mark]

(d) 23.5×10^6 J **[1]**
[max 1 mark]

(e) escape velocity = $\sqrt{2}V_{surface}$ **[1]**
$= 6.9 \times 10^3\ ms^{-1}$ **[1]**
[max 2 marks]

A3. **(a)** acceleration = v^2 / r **[1]**
$= 4.0\ ms^{-2}$ **[1]**
[max 2 marks]

(b) towards the centre of the circle **[1]**
[max 1 mark]

(c) friction between the tyres and the road **[1]**
[max 1 mark]

OPTION B — ATOMIC AND NUCLEAR PHYSICS

B1. **(a)** To explain the existence of isotopes or to explain why atomic masses do not have integer (whole) numbers [1]

[max 1 mark]

(b) **(i)** the radiation was very penetrating [1]
and was not affected by either E or B fields [1]

[max 2 marks]

(ii) conservation of momentum [1]
conservation of energy [1]

[max 2 marks]

(c) ${}^{1}_{0}n \rightarrow p^{+} + e^{-} + \tilde{\nu}$ [1]
proton, electron and anti-neutrino [1]
(accept only fully correct answers but allow *[1 mark]* if neutrino instead of anti-neutrino)

[max 2 marks]

B2. **(a)** 0.0035×930 MeV [1]
$= 5.21 \times 10^{-13}$ J [1]

[max 2 marks]

(b) increased KE of the nucleus [1]

[max 1 mark]

(c) no. of atoms of H in 1 kg $= 2 \times (1/18) \times 6 \times 10^{26}$ [1]
Energy available $= (1/18) \times 6 \times 10^{26} \times 10^{-1} \times 5.21 \times 10^{-13}$ [1]
$= 1.7 \times 10^{9}$ J [1]
time $= 1.7 \times 10^{9}$ J$/ 4 \times 10^{3}$ s [1]
$\approx$ 120 hours [1]
The calculation breaks down as follows for ECF marks:
calculating number of molecules in 1 kg *[1 mark]*
calculation of energy this yields *[2 marks]* (deduct *[1 mark]* if either or both % and division by 2 is omitted.)
calculation of time *[1 mark]*

[max 5 marks]

B3. Wave
energy is needed to eject electrons from the metal
in wave theory intensity measures energy [1]
light of low intensity has little energy so electrons would be expected to take some time to absorb enough energy to escape [1]
light of low frequency but large intensity will carry a large energy such light should therefore cause photo-emission [1]

Particle
particles will cause instantaneous emission [1]
If energy proportional to frequency then no dependence on intensity and a threshold frequency will also exist [1]
(look for valid points about both wave and particle models)

[max 5 marks]

OPTION C—ENERGY EXTENSION

C1. **(a)** any two valid examples [1] + [1]
with correct classification [1] + [1]
[max 4 marks]

(b) Energy in joules = $35000 \times 3600 \times 10^6$ [1]
power = $35000 \times 3600 \times 10^6 / 3600 \times 365 \times 24$ [1]
4000 kW. = 400 kW for one turbine [1]
[max 3 marks]

(c) Take up too much space
storage of electrical energy required
problems with variable wind speed
environmentally unsightly [2]
*Any two, **[1 mark]** each*

[max 2 marks]

C2. **(a)** For continuous work engine must work in a cycle [1]
this means that engine must be brought back to its original state [1]
to achieve this some energy must be ejected to a reservoir at a lower temperature [1]
(or could be answered by a suitable statement of the Second Law)

[max 3 marks]

(b) Efficiency = $1 - T_{cold} / T_{hot}$ [1]
= 50% [1]
*Deduct **[1 mark]** if not converted to K*

[max 2 marks]

(c) $0.2 = 1 - Q_{cold}/140$ [1]
Q_{cold} = 112 kW [1]
Energy ejected = 112 kWhr [1]
(or 4×10^8 J)

[max 3 marks]

(d) *These are the main points to look for:*

For the continuous conversion of heat into work the expansion of gas
cannot continue indefinitely [1]
to repeat the process the gas will have to be brought back to its initial condition [1]
this means that energy must be ejected from the gas. [1]
(*i.e.* look for good answer of why a cycle is needed for the continuous
conversion of heat into work)

[max 3 marks]

or the answer could be given in the terms of entropy but only award max of 2 out of 3
The gas absorbs energy from the surroundings when it expands thus reducing
the entropy of the surroundings [1]
to keep its temperature constant it must eject energy to the surroundings [1]
therefore the total entropy change is zero

OPTION D—MEDICAL PHYSICS

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

(b) **(i)** $Q_A / Q_B = (.60)^4 / (.30)^4 = 16$ [1]
FFR $\propto 1/Q$
to give the ratio = $\frac{1}{16}$ [1]
[max 2 marks]

(ii) Fluid flow 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. **(a)** 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]

(b) 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]

OPTION E — HISTORICAL PHYSICS

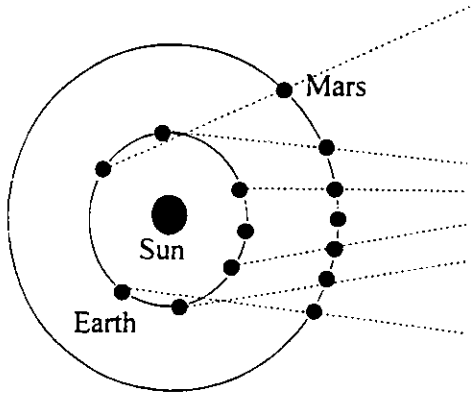
E1. **(a)** Although the stars appear to rotate about the Earth in a circular path against this backdrop the planets are at times seen to exhibit retrograde motion (or their motion wanders relative to the fixed stars) **[1]** **[1]**

[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 pertinent points)

[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) mass **[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.* ***[max 3 marks]***
(Answers should not just rely on conservation of momentum, reference to forces should be made.
*If only conservation of momentum or Newton **[1 mark]** then maximum 2 out of 3)*

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 mark]***, calculation of λ from $p = \frac{h}{\lambda}$ ***[1 mark]***

which is if the order of crystal lattice spacing **[1]**

[max 3 marks]

OPTION F — ASTROPHYSICS

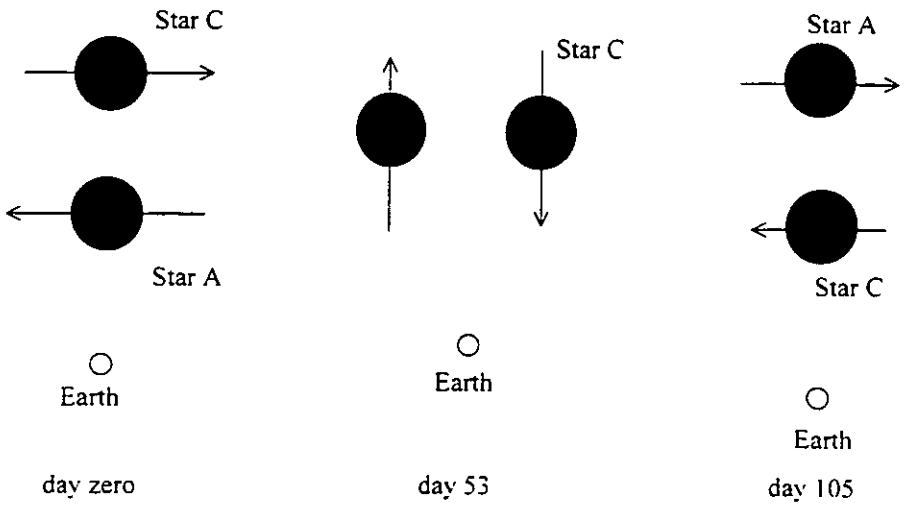
F1. **(a)** elements present in the corona [1]
temperature [1]
its velocity relative to earth [1]
[1 mark] for each correct

[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 sections 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]

OPTION G — RELATIVITY

G1. **(a)** **(i)** $t_{ac} = (100/1.5)$
$= 67$ s

[1]
[1]
[max 2 marks]

(ii) $230 : 67 = 3.4$

[1]
[max 1 mark]

(b) **(i)** the current is analogous to the motion of the earth through the ether

[1]
[max 1 mark]

(ii) the swimmer is analogous to light beams

[1]
[max 1 mark]

(c) the ether is assumed to be at absolute rest

[1]
[max 1 mark]

(d) 2 (or accept unity if candidates take the time to be from A to B and not the time there and back)

[1]

the motion of the earth does not affect the speed of light as measured by different observers

[1]

so there is no absolute reference frame

[1]
[max 3 marks]

G2. **(a)** $\Delta t = \gamma \Delta t$

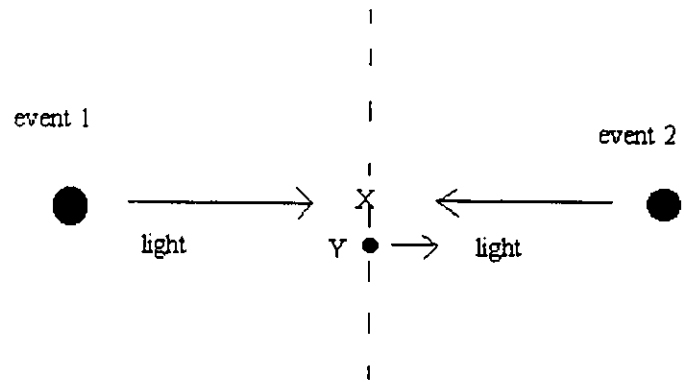
[1]

$\gamma = 1.01$

[1]

to give $v = 0.14c$

[1]
[max 3 marks]



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

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]

G3. **(a)** Space time is curved by the presence of mass [2]

[max 2 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]

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)

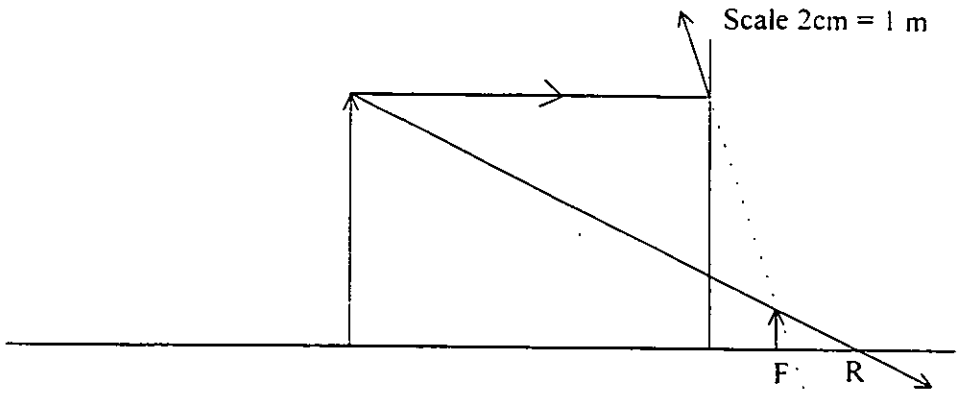
[max 3 marks]

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

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

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

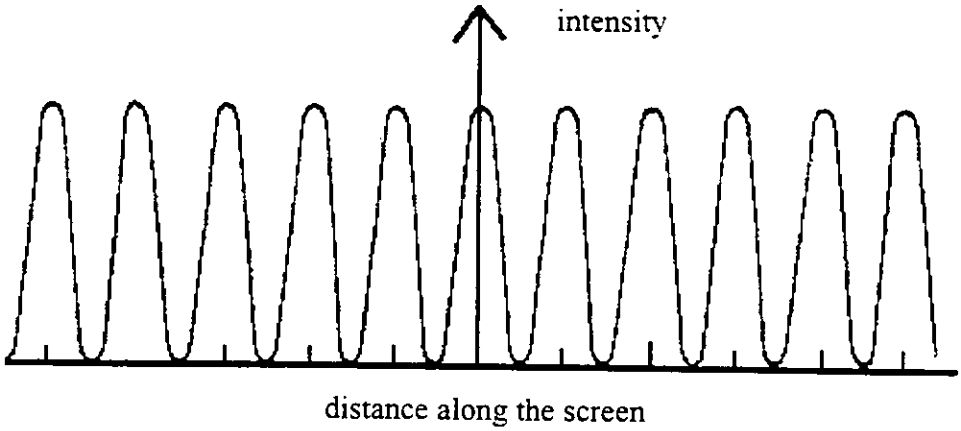
Or by scale drawing



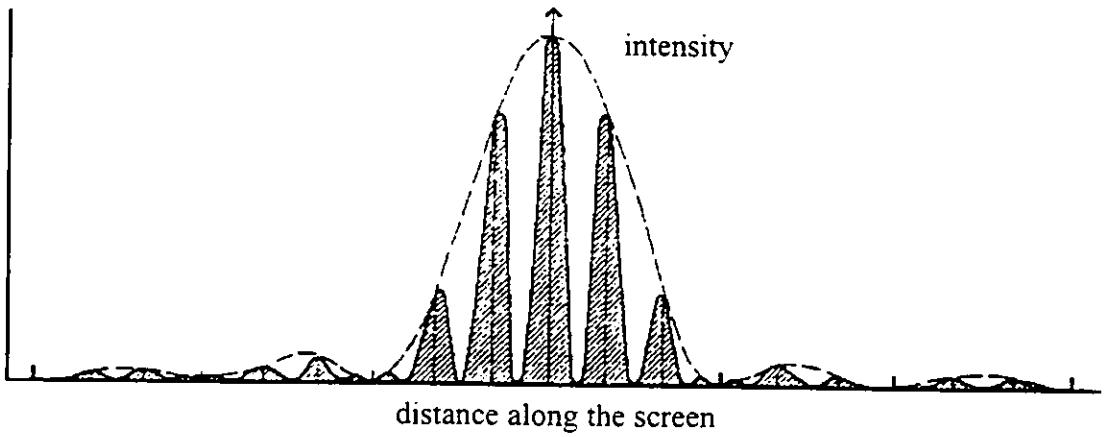
Scale **[1]**
F and R **[1]**
Rays **[1]**
Size and position **[1]**
[max 4 marks]

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

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



(b) secondary maxima [1]
diffraction envelope [1]



[max 2 marks]

(c) 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)** 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]

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