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M02/430/S(3)M+

MARKSCHEME

May 2002

PHYSICS

Standard Level

Paper 3

22 pages

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.
- 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 mark scheme then award the mark.
- Mark positively. Give candidates credit for what they have achieved, and for what they have got correct, rather than penalising them for what they have not achieved or what they have got wrong.
- Remember that many candidates are writing in a second language. 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 penalised. However, if the incorrect answer is used correctly in subsequent parts then **follow through** marks should be awarded. Indicate this with **"ECF"**, error carried forward.
- Units should always be given where appropriate. Omission of units should only be penalised once. Indicate this by **"U-1"** at the first point it occurs. 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**.

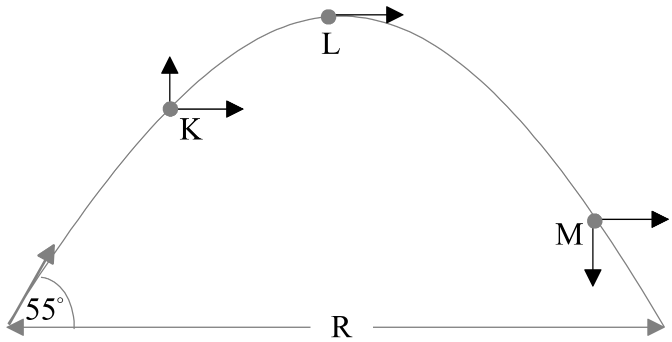
e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

Indicate the mark deduction by **"SD-1"**. 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)



horizontal components constant and equal (within reason) to that at the origin; *[1]*
vertical component at K "up" and < at the origin; *[1]*
vertical component at M "down" and magnitude > at K and < at the origin; *[1]*
*Deduct **[1]** for vertical component at L.*

[3 max]

(b) at maximum height, $v_{vert} = 0$; *[1]*
This need not be explicitly stated as it is implied by the following equation.
$v_{vert} = 0 = 20\sin 55 - gt$; *[1]*
$\Rightarrow\ t = \frac{20\sin 55}{g} = 1.67\,\text{s} = 1.7\,\text{s}$ *(2 significant digits)*; *[1]*

[3 max]

(c) projectile is in the air for 2×1.67 s; *[1]*

Alternatively, $y = 0 = 20\sin 55\, t - \frac{1}{2}gt^2$ *gives time of flight.*

hence $R = v_{horiz}\, t_{total}$; *[1]*
$= 20\cos 55 \times 2 \times 1.67 = 38.4\,\text{m} = 38\,\text{m}$ *(2 significant digits)*; *[1]*
[3 max]

A2. (a) (i) *They should show at least implicit understanding that*
the amount of work that needs to be done to get to infinity is finite; *[1]*
and the projectile must have a greater amount of KE than this (at the surface); *[1]*

Some acceptable statements:
the projectile must have sufficient KE (at the surface) so that it can - get to "infinity" / always move to greater *r* / always be capable of receding;
as $r \to \infty, v > 0$;
if the total energy at any radius > 0, then the trajectories are hyperbolas (projectile $\to \infty$);

[2 max]

(ii) we require that $\Delta KE = \Delta U_g$ from $r \to \infty$; **[1]**

*Award **[1]** for any attempted use of conservation of energy.*

hence $\frac{1}{2} m v_{esc}^2$ *(not required: $U_f - U_i = mV_f - mV_i$)* $= \frac{GMm}{r}$; **[1]**

Sufficient here is the realisation that the KE at the surface must be at least enough to provide the required PE. It's not the intention that they get bogged down with negative signs.

$\Rightarrow v_{esc} = \sqrt{\left(\frac{2GM}{r}\right)}$; **[1]**

[3 max]

(b) $v_{esc} = \sqrt{\left(\frac{2GM}{r}\right)}$

$= \sqrt{\left(\frac{2G \times 2 \times 10^{15}}{5 \times 10^3}\right)}$; **[1]**

$= 7.31 = 7\,\text{m s}^{-1}$ *(1 significant digit)*; **[1]**

[2 max]

(c) (i) for a circular orbit: $\frac{mv^2}{r} = \frac{GMm}{r^2}$; **[1]**

$\Rightarrow v = \sqrt{\left(\frac{GM}{r}\right)} = \sqrt{\left(\frac{G \times 2 \times 10^{15}}{5 \times 10^3}\right)}$ **[1]**

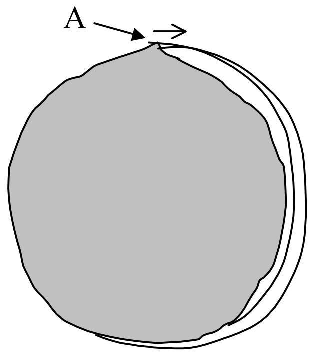
$= 5.17 = 5\,\text{m s}^{-1}$ *(1 significant digit)*; **[1]**

of course a candidate may realize that $v_{esc} = \sqrt{2} \times v_{orbit}$

[3 max]

(ii) *"Any path" that describes $\geq \frac{1}{4}$ circle is OK*

i.e. any path that is more than just a "parabolic" trajectory;



[1 max]

OPTION B — ATOMIC AND NUCLEAR PHYSICS EXTENSION

B1. (a) *Essential points:*

each series arises from transitions from higher energy states to a **particular** lower energy state; ***[1]***

for the higher energies (smaller wavelengths), the energy levels become closer together (the energy level differences become smaller) → crowding of the wavelengths at the short wavelength end of a series; ***[1]***

Main (other) points:

there is a **minimum energy** transition for each series and therefore a **maximum wavelength**; ***[1]***

there is a **maximum energy** transition for each series and therefore a **minimum wavelength**; ***[1]***

Other points for which a mark can be given:

Lyman series: final state $n = 1$;

Paschen series: final state $n = 3$;

Hydrogen atom energy levels vary as: $E_n \sim \frac{1}{n^2}$, and hence become closer together for transitions from higher energies (larger n);

[4 max]

(b) any spectral line in the visible / Balmer series; ***[1]***

the third line; ***[1]***

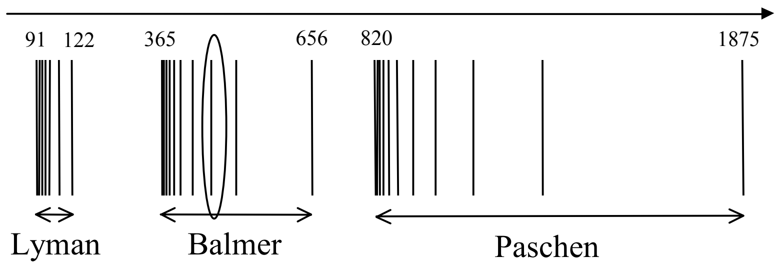


Diagram 2

[2 max]

(c) $E = hf = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E}$, for a photon of energy E. ***[1]***

$\frac{hc}{E} = \frac{hc}{(3.4 - 0.54) \times 1.6 \times 10^{-19}}$; ***[1]***

Note that we are not concerned here with "double negatives"

$= 434 \times 10^{-9}$ m $= 434$ nm $= 430$ nm *(2 significant digits)*;

*Allow **[1]** (max) if conversion from eV has been omitted, but otherwise correct.*

[2 max]

B2. (a) *Any **one** of the following.*
photoelectric effect, Compton effect, line spectra, blackbody (cavity / thermal) radiation, pressure of light

[1 max]

(b) "particle diffraction" - electron *or* neutron
Also accept,
"explanation of the Bohr model" (in terms of simple de Broglie standing wave condition in two dimensions);
and even "success of Quantum Mech.";

[1 max]

(c) the "extent" to which the wave nature of a particle is exhibited depends on the wavelength
Or this could be expressed in terms of diffraction:
the exhibition of a "wave nature" is through diffraction, the "extent" of which depends on the wavelength; ***[1]***
$\lambda = \frac{h}{p}$, (any use of this); ***[1]*** ***[1]***
and for a ("macroscopic") ball, p >> … >> h, so λ is very, very small;
hence the "wave nature" / diffraction effects, are not observable
Accept
would require an impossibly small "slit" to produce measurable diffraction

[3 max]

B3. (a) (i) e^+ : positively charged "electron" ; positron; ***[1]***
v : (electron) neutrino; ***[1]***
[2 max]

(ii) the positron must eventually annihilate (*allow* "collide") with an electron
[→ gamma radiation]

[1 max]

(iii) high temperatures → high kinetic energies for the "gas" particles; ***[1]***
and high kinetic energies are required to "overcome" the Coulomb (*or* electro-static; *etc.*) repulsion between the nuclei; ***[1]***

[2 max]

(b) the helium-3 nuclei are doubly charged; ***[1]***
(→ "4× the repulsion")
hence more kinetic energy is required, hence a greater temperature; ***[1]***
[2 max]

OPTION C — ENERGY EXTENSION

C1. (a) $e = \dfrac{(T_{HOT} - T_{COLD})}{T_{HOT}}$; ***[1]***

$\approx \dfrac{(2400 - 300)}{2400}$; ***[1]***

The mark is for a reasonable estimate of T_{COLD} : 270 – 400 K

= 88 %; ***[1]***

(= 90% (1 significant digit))

[3 max]

(b) *Any* ***two*** *of the following up to* ***[2 max]***.

T_{HOT} is never attained (it is < 2400 K) *by the "working fluid"*
incomplete combustion
T_{COLD} is at the higher temperature of the exhaust gasses
frictional energy losses
not an ideal (Carnot cycle) heat engine
Note an unqualified "energy losses" will receive ***[0]***.

[2 max]

(c) $e = \dfrac{W}{Q_{HOT}} \Rightarrow Q_{HOT} = \dfrac{35\text{ kJ/s}}{0.2}\ (= 175\text{ kW})$; ***[1]***

the energy released to the atmosphere = $Q_{COLD} = Q_{HOT} - W$; ***[1]***

$35\text{ kJ/s}\left(\dfrac{1-0.2}{0.2}\right) = 140\text{ kJ/s} = 140\text{ kW}$; ***[1]***

or "by proportion": 35 kW $= \dfrac{1}{5}$ energy consumed $\Rightarrow \dfrac{4}{5}$ = 140 kW = 140 kJ/s

[3 max]

(d) degraded thermal energy is:
at a "lower temperature"
or "less ordered" / more "spread out" (over a large number of molecules)
or of "lower quality" ***[1]***

To achieve the second mark, these have to be qualified along the lines of:
"harder" to extract useful work from
or "harder" to transform into work
or becomes "less available" to do useful work; ***[1]***

[2 max]

(e) *Award* ***[1]*** *for any sensible statement along the lines of:*
entropy change is a measure of energy degradation / is directly related to Q_{COLD}, the amount of degraded energy.

Award ***[1]*** *for any additional qualification:*
in irreversible processes the amount of degraded energy, $Q_{COLD} > 0$, just as the entropy change > 0;
entropy is high when energy is "disordered" / spread over many molecules;
the greater the degradation of the energy, the greater the entropy change;
the greater amount of degraded energy the greater the entropy change;

[2 max]

C2. *Award any* ***two*** *of the following advantages of solar radiation, up to* ***[2 max]****.*
lack of "emissions"
possible on a small scale
possible in remote areas
abundant in many developing countries
other nontrivial / reasonable points

Award any ***two*** *of the following for disadvantages of solar radiation, up to* ***[2 max]****.*
requires special sites / lack of suitable sites
unreliable / depends on local weather conditions
periodic generation / needs a storage system to provide energy over 24 hours
takes up large areas / aesthetics
direct conversion to electrical energy expensive
other nontrivial / reasonable points

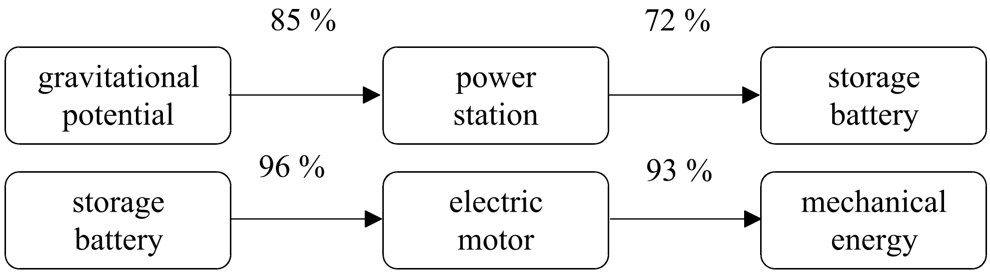
[4 max]

C3. (a) the efficiency that the second law refers to is of energy conversion to **useful work**. ***[1]***
It is essential that this be recognised.

Additional points
this is not the case here, no useful work is produced. ***[1]***
or here only thermal energy is produced.
or all the energy is degraded. *(i.e. the "real" efficiency is in fact 0 %)*
or all energy forms must ultimately end up as (degraded) thermal energy.

[2 max]

(b) relevant efficiencies:



[2]

overall efficiency $= 85 \times 72 \times 96 \times 93 = 55\ \%$;
Award ***[1]*** *for omission of* ***one*** *factor and* ***[0]*** *for omission of* ***two*** *factors*
Accept if some include one (or two) "transformers" in the chain; efficiency factors ~99%.

[2 max]

OPTION D — BIOMEDICAL PHYSICS

D1. (a) *Award* ***[2 max]*** *for three* **or** *four correct labels,* ***[1]*** *for two correct labels and* ***[0]*** *if only one label is correct.*

Label 1 = aorta   Label 2 = arteries *or* arterioles

Label 3 = capillaries   Label 4 = veins *or* venules

Accept "artery" for Label 1 but then need "arterioles" for Label 2.

The answers to (b) and (c) below rest on the "conservation of matter" and the incompressibility of blood.

(b) the same blood flow rate Q; ***[1]***
must be carried by a greater cross sectional area of vessels, hence blood velocity must be reduced; ***[1]***
[2 max]

(c) heart output $= \text{Area} \times v_{\text{average}}$; ***[1]***

$\Rightarrow v_{\text{average}} = \dfrac{100\,(\text{cm}^3\,\text{s}^{-1})}{8\,\text{cm}^2} = 12\,\text{cm}\,\text{s}^{-1} = 10\,\text{cm}\,\text{s}^{-1}$ *(1 significant digit)*; ***[1]***

[2 max]

D2. (a) mass of water $\propto L^2$; ***[1]***
normal body mass $\propto L^3$; ***[1]***

$\Rightarrow \text{ ratio} = \dfrac{\text{mass of water}}{\text{normal body mass}} \propto \dfrac{L^2}{L^3} = \dfrac{1}{L}$

[2 max]

(b) $\dfrac{\text{ratio human}}{\text{ratio fly}} \approx \dfrac{L_{fly}}{L_{human}}$; ***[1]***

This assumes the "proportionality constants" are equal which, given the totally different nature of the animals, is stretching things a bit! If any candidate makes an explicit (sensible) reference to this aspect they should be rewarded, with up to ***[1]*** *subject to the* ***[3 max]***.

$L_{fly} \approx 10\,\text{mm}$ *(accept ~5 – 20 mm)*; ***[1]***
$L_{human} \approx 1700\,\text{mm}$ *(accept ~ 1500 – 2000 mm)*; ***[1]***

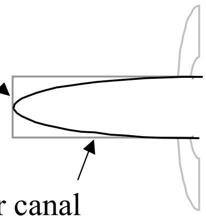
$\Rightarrow \text{ratio fly} \approx \text{ratio human} \times \dfrac{L_{human}}{L_{fly}} = \dfrac{1\,\% \times 1700}{10} = 170\,\%$ *(accept ~75 – 400 %)* ***[1]***

(accept a maximum of 2 significant digits);

[3 max]

D3. (a) 20 Hz to 20 kHz; *(Accept* 35 Hz ± 15 Hz $\rightarrow$ 19 kHz ± 1 kHz *.)* ***[1 max]***

(b) (i) *Accept representations other than displacement amplitude, e.g. pressure amplitude.*
Accept different ways of representing the varying amplitude.



[1 max]

(ii) $\frac{\lambda}{4} = 2.7\,\text{cm} \;\; \Rightarrow \; \lambda = 10.8\,\text{cm}$; ***[1]***

$f = \frac{c}{\lambda}$; ***[1]***

$\frac{343}{0.108} = 3200\,\text{Hz}$ *(2 significant digits)*; ***[1]***

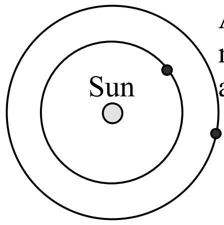
[3 max]

(c) *The details are complex; look for a general understanding and (as usual), reward other correct observations and any meaningful / relevant diagrams, particularly if labelled.*
it is here that the vibrations of the sound wave are transformed into electrical impulses; ***[1]***
sound passing down the cochlea causes a membrane to vibrate; ***[1]***
(The membrane is of varying thickness and under a varying tension and so)
different parts of the membrane respond to different frequencies; ***[1]***
thus the nerve cells attached to the membrane (fine hairs) are mainly stimulated at certain positions for a given sound frequency; ***[1]***

[4 max]

OPTION E — HISTORICAL PHYSICS

E1. (a) (i) all planetary paths **must** be shown as *(or somehow indicated to be)* circles



Allow a single planet shown and even the addition of an epicycle.

[1 max]

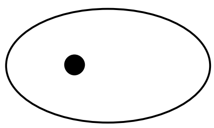
(ii) Sun and Stars' motion is apparent; ***[1]***
due to the spin of the Earth in the "opposite" sense; ***[1]***
[2 max]

(b) (i) *Award **[1 max]** for any **one** of the following.*
phases of Venus; ***[1]***
varying brightness of planets; ***[1]***
"rough" features on the Sun and Moon (hence they are not "perfect spheres"); ***[1]***
Sun rotates; ***[1]***
Jupiter has moons; ***[1]***

(ii) in a geocentric model, the Earth is at the centre of "all heavenly motion"; ***[1]***
why an explanation of the stated observation fails in such a model; ***[1]***
The first two observations above are "inexplicable" / have no natural explanation and the last three are philosophically not acceptable in such a model.

[2 max]

(c) orbits were ellipses not circles; ***[1]***
with the Sun at one focus; ***[1]***



A good diagram can be a full description and receive full marks.

[2 max]

(d) (i) an empirical relationship is a rule or set of rules that allow certain events / observations to be predicted but with no underlying physical principle.
or an empirical relationship provides a "numerical" agreement … .
or guess a formula which fits the facts … .

[1 max]

(ii) Newton's Laws of Motion; ***[1]***
Newton's Law of Gravity; ***[1]***
[2 max]

E2. (a) "heat" as a "substance" means that it is a physical material that flowed out of hot bodies; some sort of fluid; ***[1]***
"Caloric" with no explanation would receive ***[0]****.*

[1 max]

(b) many believed at the time that heat was (at least related to) the **microscopic random motion** of the molecules of the hot material; ***[1]***
Just use of "motion" would not be adequate for the mark.

[1 max]

(c) he noticed that in the boring of cannons he could **generate an unlimited amount of heat**; (so long as boring continues) ***[1]***
especially with blunt tools where there was very little "cutting" occurring and hence very little "releasing" of the "heat fluid" / Caloric; ***[1]***

[2 max]

(d) energy required $= mc\Delta T = mgh$; ***[1]***

$\Rightarrow \Delta T = \dfrac{gh}{c}$, and for $h = 1\,\text{m}$

$\Rightarrow \Delta T = \dfrac{9.8}{4200} = 0.0023$ K (per metre) $= 0.002\,\text{K}$ *(1 significant digit)*; ***[1]***

[2 max]

E3. the **photon-electron interaction is a one-to-one**, "billiard-ball" type "collision"; ***[1]***
there is a minimum amount of energy required to knock out the electron (the work function) – either the photon has enough energy or it has not; ***[1]***
for the photon, $E = hf$, hence a minimum $E \Rightarrow$ a minimum f; ***[1]***

[3 max]

OPTION F — ASTROPHYSICS

F1. (a) (i) Deneb would be bluish and Antares A reddish; ***[1]***
Accept Deneb is white / whitish / violet etc..
because Deneb is at a higher (surface) temperature; ***[1]***

at higher temperatures a greater proportion of the energy is radiated in the blue part of the visible spectrum; ***[1]***
Accept any sensible reference to temperature.

[3 max]

(ii) Antares A is brighter than Deneb *(accept – about the same brightness)*; ***[1]***
because it has a smaller apparent magnitude; ***[1]***
[2 max]

(iii) Deneb is further away than Antares A; ***[1]***
Deneb's absolute magnitude is smaller ⇒ Deneb's luminosity > Antares A, but it looks fainter; ***[1]***
Do not accept "because the parallax angle is too small to measure" for the second mark.

[2 max]

(b) $d = \frac{1}{0.006}$ pc; ***[1]***

$= 3.26 \times 9.46 \times 10^{15} \times \frac{1}{0.006} = 5.1 \times 10^{18}$, *accept* 5×10^{18} m *(1 significant digit)*; ***[1]***

[2 max]

(c) $L = \sigma A T^4$; ***[1]***

$\frac{L_A}{L_B} = 40$ *(forming the ratio)*; ***[1]***

$= \frac{A_A \times 3000^4}{A_B \times 15000^4} \Rightarrow \frac{A_A}{A_B} = 5^4 \times 40 = 25000$; ***[1]***

*Deduct only **[1]** if inverse ratio obtained* (4×10^{-5}).

[3 max]

F2. (a) when one star is approaching (the Earth), the other is receding; ***[1]***
⇒ a red and (simultaneously), a blue shift; ***[2]***
When the motion is perpendicular (to the line of sight) there is no wavelength shift. This occurs every half cycle – ***[1]*** *is given for this at (b).*

[3 max]

(b) 20 days *(accept 21 days)* ***[1 max]***

F3. (a) whichever direction you look, the line-of-sight should eventually fall upon a star surface; ***[1]***
assuming
the universe was infinite; ***[1]***
and/or
unchanging in time (existed forever, *etc.*); ***[1]***
Accept either one for ***[1]***

[2 max]

(b) there is a finite time since the Big Bang; ***[1]***
(hence if you go back far enough in time (if you look far enough out in distance), eventually there'll be no stars)
and the universe is not unchanging in time – it is expanding; ***[1]***
(hence the most distant stars/ galaxies are strongly red-shifted, out of the visible part of the spectrum)
Light from distant stars may not have reached us yet. Stars themselves die.
For ***[2]*** *accept* ***either*** *of the above* ***with*** *an attendant* ***explanation****.*

[2 max]

OPTION G — SPECIAL AND GENERAL RELATIVITY

G1. (a) to measure the speed of the Earth through the ether / to investigate the existence of the ether / investigate influence of Earth's motion on speed of light / OWTTE ***[1 max]***

(b) null result / no detectable velocity ***[1 max]***

(c) to rule out the possibility of an "accidental" null result – at any one time the speed of the Earth, by chance, could be zero; ***[1]***
if a null result was obtained (⇒ speed = 0), at one time (of the year) / in one orientation, then it couldn't be so at a later time / in another orientation; ***[1]***

For full marks, candidates should be aware that rotation of apparatus was expected to produce a ***shift*** *in the fringe pattern.*

[2 max]

(d) reference must be made to either (or both) of the hypotheses – "constancy of the speed of light" *or* "all experiments performed in an inertial frame of reference (= "all physical laws") must produce the same results"; ***[1]***
⇒ time differences / phase shifts between the arms do not change with season / orientation. *i.e.* result is independent of orientation / *etc*.; ***[1]***
[2 max]

G2. (a) (i) travel time to Alpha Centauri (Earth's frame) $= \dfrac{4.2}{0.95} = 4.4(2)$ y ***[1 max]***

(ii) $\gamma = \dfrac{1}{\sqrt{\left(1 - \dfrac{v^2}{c^2}\right)}} = 3.2$; ***[1]***

$\Delta t_{\text{astro}} = \dfrac{4.42}{\gamma}$; ***[1]***

= 1.3(8) y *(Astro's measure a proper time)*; ***[1]***
[3 max]

(b) (i) time passed on Earth's clocks = 2 × 4.42 = 8.8(4) y; ***[1]***

(ii) time passed on astronauts' clocks = 2 × 1.3(8) = 2.7(6) y; ***[1]***
[2 max]

(c) (i) *Just saying this is the "Twin Paradox" is not acceptable –* ***[0]*** *marks.*
essential point: (on first appearances), any time difference should be "reversible"; ***[1]***
the (implicit) assumption being that descriptions of the events from the two frames of reference are completely equivalent; ***[1]***
[2 max]

(ii) the two frames of reference are not equivalent; ***[1]***
*and some reasonable (not necessarily "perfect") explanation of why would also receive **[1]**.*
the astronauts must have accelerated in order to have "stopped" and returned *or* accelerations tell us who was "really" moving / their frame of reference was non-inertial
or the astronauts had to switch from one inertial frame to another; ***[1]***

[2 max]

G3. (a) *Answers can be in terms of*:
the photon energy, hence frequency, reducing with distance or increasing wavelength with distance; ***[2]***
*The bare statement that this is "red shift" would receive **[0]** while "gravitational red shift" would receive **[1]**.*

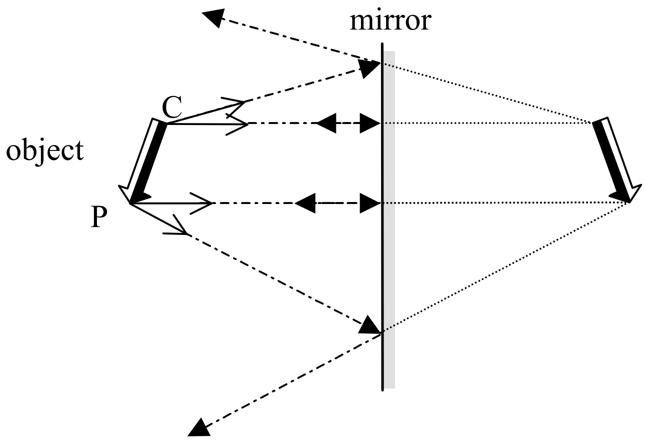
[2 max]

(b) *Award **[1]** for identifying any **one** experiment and **[1]** for a brief description.*
[Pound - Rebka] – sending γ rays down a tower and measuring the frequency change, Δf *[positive]*.
[Hafele and Keating] – flying atomic clocks around the world and measuring the Δt relative to clocks at rest with respect to the Earth.
atomic clock sent in a rocket up to 10^4 km and measuring Δt, as above.

[2 max]

OPTION H — OPTICS

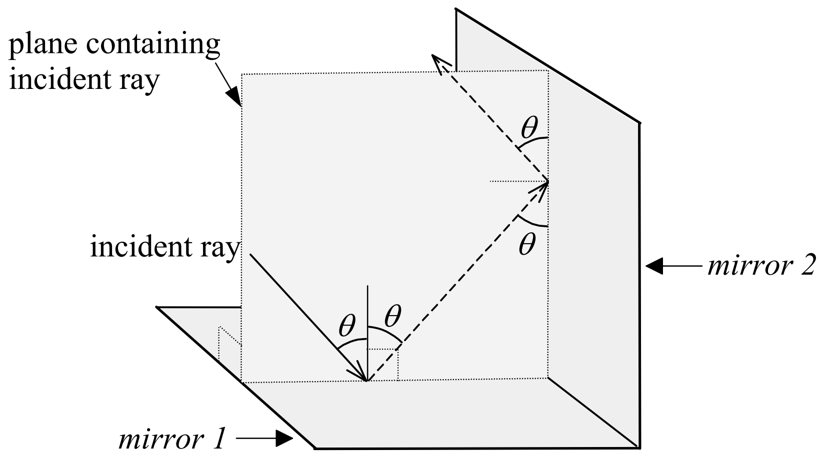
H1. (a) properly extended rays; ***[2]***
Allow for some error / variation.
correct orientation; ***[1]***
(image of "C" closer to the mirror than of "P" and black / white "reversal")



If path of rays is extended to mirror but not reflected, you can still award full marks so long as image orientation and location are correct.

[3 max]

(b) (i) reflected path; ***[1]***
geometric argument based on
angle of incidence = angle of reflection; ***[1]***
and some geometry (alternate angles are equal; complementary angles = 90°; *etc.*); ***[1]***



[3 max]

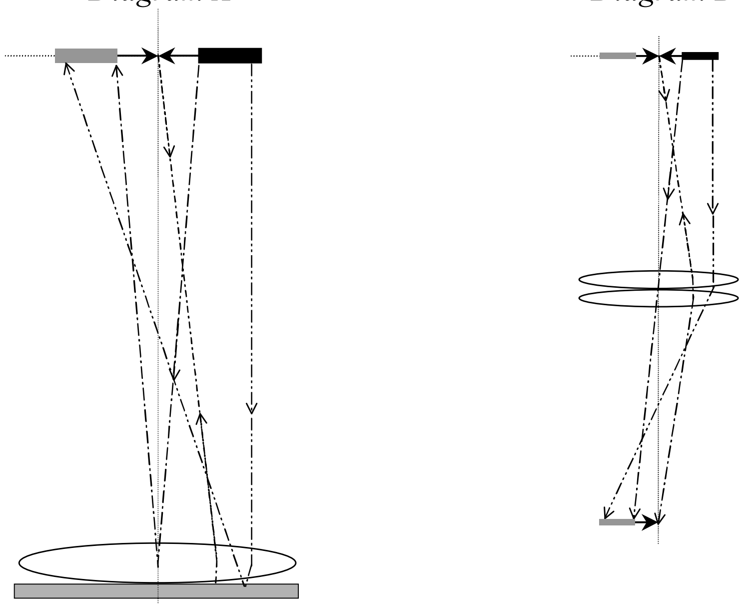
(ii) *Award **[1 max]** for any **one** of the following.*
rear vehicle / bicycle reflectors
"cats-eyes" reflectors on roads
"corner reflectors" on the Moon
or any other applications

H2. (a) *Given the open-ended nature of the question, the markscheme cannot be too rigid. The following can serve as a guide:*

- *general understanding of situation (even if poorly expressed);* ***[2]***
- *general quality of ray diagram (ruled lines, accuracy, care taken);* ***[1]***
- *discussion of role of mirror or other relevant detail;* ***[1]***
- *each correctly drawn ray;* ***[2]***

The answer could be along the lines that the mirror acts as a second identical lens plus a reflection (see Diagram B).

Diagram A *Diagram B*



[4 max]

(b) image is real ***[1 max]***

(c) *Allow* magnification = 1 *(accept same size)*, 0 ("no magnification") or -1 (implying inverted) ***[1 max]***

(d) the image will move **closer** to the lens ***[1 max]***

H3. (a) $d \sin \theta = n\lambda$ *(for maxima)*; **[1]**

$\Rightarrow d \sin \theta = 1 \times \lambda$ for $\theta = 0.50^{\circ}$ *(the scale can easily be read to 2 significant figures)*; **[1]**

$\Rightarrow d = \dfrac{434 \times 10^{-9}}{\sin 0.50} = 5.0 \times 10^{-5}$ m (= 0.050 mm); **[1]**

Using $\theta = 0.25^{\circ}$ to get 9.95×10^{-5} m gets [1] max.

[3 max]

(b) *Award **[1]** per feature shown on the diagram below, up to **[3 max].***

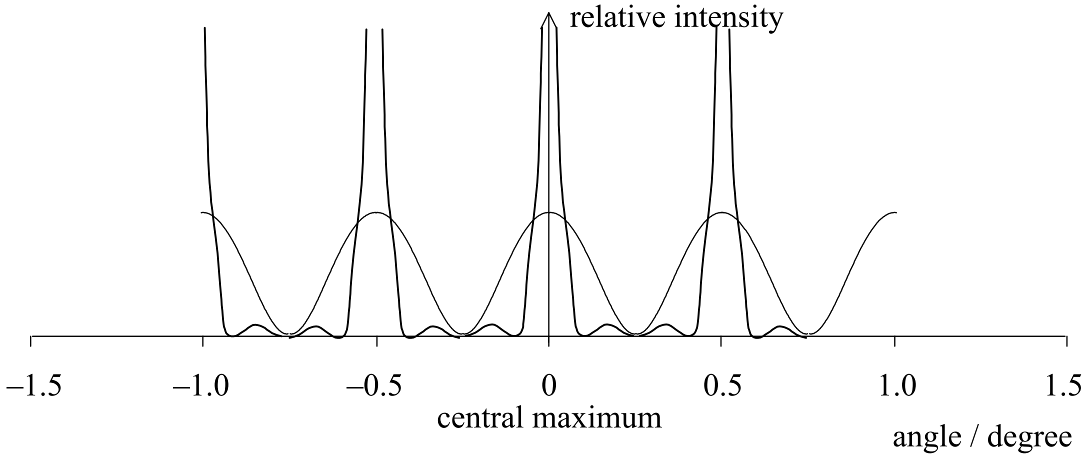
narrower "lines"; **[1]**

maxima in the same positions; **[1]**

greater intensity *(clearly, correct scaling is not required)*; **[1]**

secondary, much smaller, maxima *(there should be two but this is not critical)*; **[1]**

*It is not necessary to show **all** maxima as long as the candidate clearly shows he/she knows what's up e.g. see below*



[3 max]