INTERNATIONAL BACCALAUREATE
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M03/430/S(3)M+

MARKSCHEME

May 2003

PHYSICS

Standard Level

Paper 3

20 pages

General Marking Instructions

After marking a sufficient number of scripts to become familiar with the markscheme and candidates' responses to all or the majority of questions, Assistant Examiners (AEs) will be contacted by their Team Leader (TL) by telephone. The purpose of this contact is to discuss the standard of marking, the interpretation of the markscheme and any difficulties with particular questions. It may be necessary to review your initial marking after contacting your TL. **DO NOT BEGIN THE FINAL MARKING OF YOUR SCRIPTS IN RED INK UNTIL YOU RECEIVE NOTIFICATION THAT THE MARKSCHEME IS FINALISED.** *You will be informed by e-mail, fax or post of modifications to the markscheme and should receive these about one week after the date of the examination. If you have not received them within 10 days you should contact your Team Leader by telephone. Make an allowance for any difference in time zone before calling.* **AEs WHO DO NOT COMPLY WITH THESE INSTRUCTIONS MAY NOT BE INVITED TO MARK IN FUTURE SESSIONS.**

You should contact the TL whose name appears on your "Allocation of Schools listing" sheet.

Note:
Please use a personal courier service when sending sample materials to TLs unless postal services can be guaranteed. Record the costs on your examiner claim form.

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Tel 44 29 20547820

1. Follow the markscheme provided, do **not** use decimals or fractions and mark in **RED**.

2. Where a mark is awarded, a tick (✓) should be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark.

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases write a brief annotation in the **left hand margin** to explain your decision. You are encouraged to write comments where it helps clarity, especially for moderation and re-marking.

4. Unexplained symbols or personal codes/notations on their own are unacceptable.

5. Record subtotals (where applicable) in the right-hand margin against the part of the answer to which they refer next to the mark allocation. Do **not** circle subtotals. **Circle the total mark for the question in the right-hand margin opposite the last line of the answer.**

6. Where an answer to a part question is worth no marks, put a zero in the right-hand margin.

7. For each Option: Add the totals for each question in the Option and write it in the Examiner column on the front cover.
   Total: Add the marks awarded and enter this in the box marked TOTAL in the Examiner column.

8. After entering the marks on the front cover check your addition to ensure that you have not made an error. Check also that you have transferred the marks correctly to the front cover. **We have script checking and a note of all clerical errors may be given in feedback to examiners.**

9. Every page and every question must have an indication that you have marked it. Do this by **writing your initials** on each page where you have made no other mark.

10. If a candidate has attempted more than the required number of Options within the paper, mark only the required number of Options in the order in which they are presented in the paper, **unless the candidate has indicated the Options s/he wants to be marked, on the front cover**.

11. A candidate can be penalised if he/she clearly contradicts him/herself within an answer. Make a comment to this effect in the left hand margin.

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

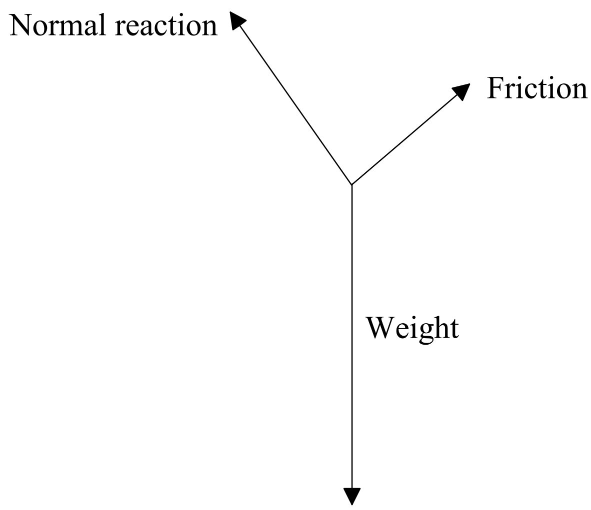
A1. (a) 20.0 kN *[1 max]*

(b) take moments about A: $N_B \times 9.5 = 15 \times 5.5 + 5 \times 3$;
to give $N_B = 10.3\,\text{kN}$;
and $N_A = 20 - 10.3 = 9.7\,\text{kN}$;

OR

take moments about B: $N_A \times 9.5 = 5.0 \times 6.5 + 15 \times 4.0$;
to give $N_A = 9.7\,\text{kN}$;
and $N_B = 20 - 9.7 = 10.3\,\text{kN}$; *[3 max]*

A2. (a)



*Award **[1]** for each correctly labelled force up to **[3 max]**.*
appropriate relative lengths; *[4 max]*

(b) (i) $R = Mg\cos 60 = 2.5\,\text{N}$;
$F_f = \mu R = 0.75\,\text{N}$; *[2 max]*

(ii) net force $= Mg\sin 60 - 0.75 = 3.6\,\text{N}$;
acceleration $= \dfrac{F}{m} = \dfrac{3.6}{0.5} = 7.2\,\text{m}\,\text{s}^{-2}$; *[2 max]*

A3. (a) (i) $V_{\text{surface}} = -6.3\ (\pm 0.3) \times 10^{7}\ \text{J kg}^{-1}$ ***[1 max]***

(ii) V_{h} is at $R = 42 \times 10^{6}$ m ;
$= -1.0\ (\pm 0.2) \times 10^{7}\ \text{J kg}^{-1}$; ***[2 max]***

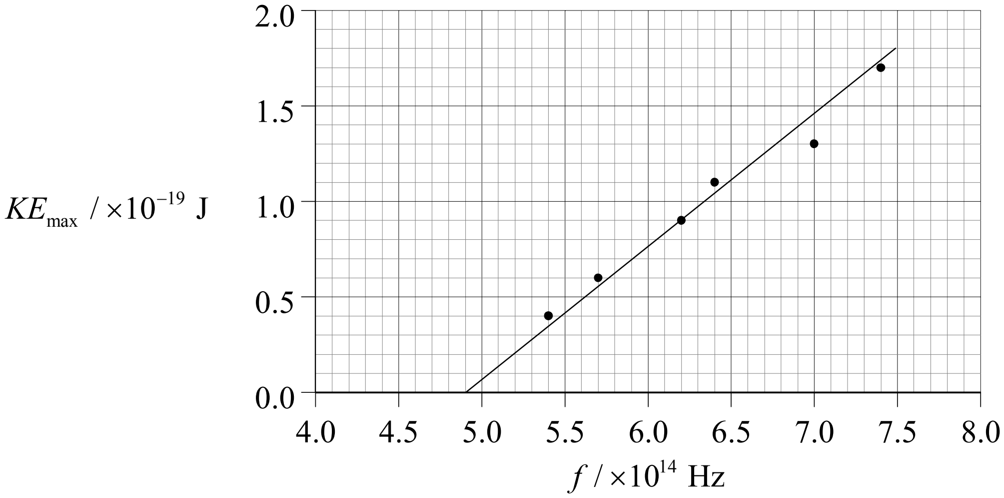
*Watch for $R = 3.6 \times 10^{7}$ m being used. If so award **[1]** and use ECF.*

(b) $\Delta V = 5.3\ (\pm 0.5) \times 10^{7}\ \text{J kg}^{-1}$;
Energy $= m\Delta V$;
$= 5.3 (\pm 0.5) \times 10^{11}$ J ; ***[3 max]***
*Award **[2]** if they calculate the PE of the satellite (10^{11} J).*

(c) *Any **two** of the following **[1]** each.*
the satellite has to be given a horizontal velocity (or has to have KE) to go into orbit;
rockets motors lifting rocket not 100 % efficient;
air resistance in initial stages of launch; ***[2 max]***

OPTION B — ATOMIC AND NUCLEAR PHYSICS EXTENSION

B1. (a)



sensible trend line ***[1 max]***

(b) (i) recognise that h = slope of the graph;

$$= \frac{1.8\times10^{-19}}{2.6\times10^{14}} = 6.9(\pm0.3)\times10^{-34}\ \text{J s};$$ ***[2 max]***

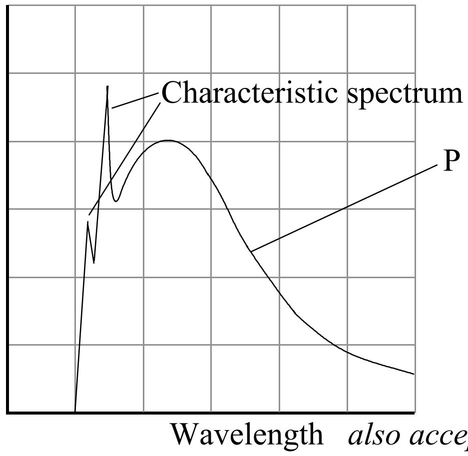
(ii) frequency intercept $= 4.8\times10^{14}$ Hz ;
therefore minimum energy $= hf$;
$= 4.8(\pm0.2)\times10^{14}\times6.9(\pm0.3)\times10^{-34} = 3.3(\pm0.5)\times10^{-19}$ J ; ***[3 max]***

*If the candidate uses a data booklet value (6.6) and not their graph value, then award **[2 max]**.*

(c) *A good answer should mention the following main points.*
light consists of photons;
if the photon energy is less than the work function an electron will not be ejected;
since each photon has energy hf if f is less than $\frac{\textit{work function}}{h}$ then an electron will not be ejected; ***[3 max]***

The candidate might use numerical values for work function and frequency which of course is consistent with the question and therefore acceptable.

B2. (a)



also accept "λ" **[3 max]**

*Award **[1]** for each label up to **[3 max]**.*
Only one characteristic spectrum peak needs to be labelled.

(b) $f = \dfrac{Ve}{h}$;

$= \dfrac{25\times10^{3}\times1.6\times10^{-19}}{6.63\times10^{-34}} = 6.0\times10^{18}\text{ Hz}$; ***[2 max]***

B3. (a) ${}^{54}_{25}\text{Mn} \to {}^{54}_{24}\text{Ar} + \beta^{+} + \nu$

A = 54;
Z = 24;
ν (name or symbol);
*Award **[1]** for each correct answer up to **[3 max]**.* ***[3 max]***

(b) charged vector boson ***[1 max]***

(c) (i) strong nuclear force (interaction) ***[1 max]***
Also accept just "strong".

(ii) meson ***[1 max]***

OPTION C — ENERGY EXTENSION

C1. (a) (i) fission ***[1 max]***

(ii) kinetic energy ***[1 max]***

(b) the two neutrons can cause fission in two more uranium nuclei producing four neutrons so producing eight *etc.*;
OWTTE; ***[1 max]***

(c) (i) the fuel rods contain a lot more U-238 than U-235;
neutron capture is more likely in U-238 than U-235 with high energy neutrons;
but if the neutrons are slowed they are more likely to produce fission in U-235 than neutron capture in U-238; ***[3 max]***

The argument is a little tricky so be generous. The candidate needs to know about there being two isotopes present in the fuel and something about the dependence of the fission and capture in the two isotopes on neutron energy.

(ii) control the rate at which the reactions take place;
by absorbing neutrons; ***[2 max]***

(d) *Look for* ***four*** *of the following main points and award* ***[1]*** *each.*
energy lost by the slowing of the neutrons and fission elements heats the pile;
this heat extracted by the molten sodium / pressurised water / other suitable substance;
which is pumped to a heat exchanger;
water is pumped through the heat exchanger and turned to steam;
the steam drives a turbine;
which is used to rotate coils (or magnets) placed in a magnetic field (or close to coils) which produces electrical energy; ***[4 max]***
Alternatively, award ***[4]*** *for a good answer,* ***[2]*** *for a fair answer and* ***[1]*** *for a weak answer.*

C2. (a) (i) on — gas is compressed ***[1 max]***
Correct answer and correct explanation.

(ii) ejected — pressure remains constant, volume reduced so temperature must go down ***[1 max]***
Correct answer and correct explanation.

(b) work done $= p\Delta V$;
$= -1.0 \times 10^5 \times 0.4 = -0.40 \times 10^5$ J (40 kJ); ***[2 max]***

Sign should be consistent with (a)(i) above-work "by" and + work here would get zero for (a)(i) but ***[2]*** *marks here.*

(c) area enclosed;
$\approx 0.6\ (\pm 0.2) \times 10^5$ J $(60\,\text{kJ} \pm 20\,\text{kJ})$; ***[2 max]***

(d) efficiency = work out/heat in;
$= \frac{60}{120} = 50\%\ (\pm 17\%)$; ***[2 max]***

OPTION D — BIOMEDICAL PHYSICS

D1. (a) mass of water carried out is proportional to surface area, $m \propto r^2$;
mass of sphere is proportional to volume therefore $M \propto r^3$;
therefore $\frac{m}{M} \propto \frac{r^2}{r^3} \propto \frac{1}{r}$; ***[3 max]***

(b) (i) for the sphere $\frac{k}{0.8} = 0.020$;
$k = 1.6 \times 10^{-2}$;
for the insect $\frac{m}{M} = \frac{1.6 \times 10^{-2}}{4.0 \times 10^{-3}} = 4$; ***[3 max]***

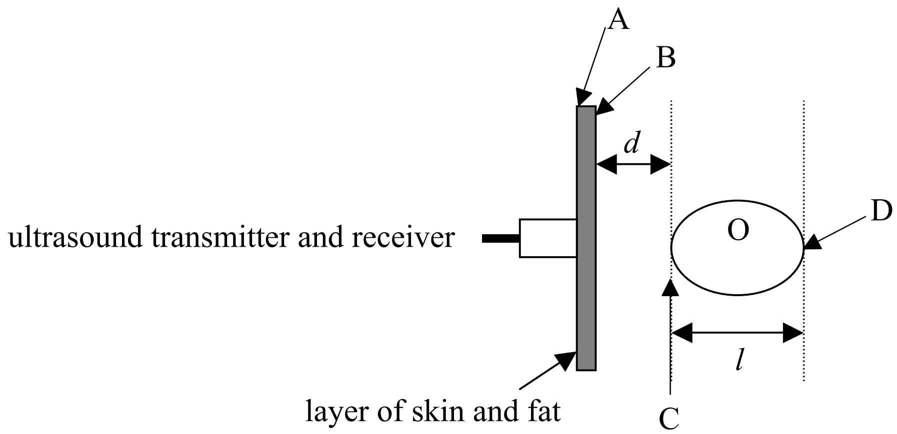
(ii) the constant k is the same for the sphere and the insect / the thickness of water carried out by insect and sphere is the same ***[1 max]***

(iii) if it carries out four times its body mass then it is unlikely to be able to get airborne again;
OWTTE; ***[1 max]***

D2. (a) 1 MHz → 20 MHz; ***[1]***

(b) (i) to ensure that no air is trapped between transmitter and skin;
otherwise nearly all the transmitted pulse will be reflected at the surface of the skin; ***[2]***

(ii)



A and B correct;
C and D correct; ***[2]***

(iii) pulse takes 50 μs to travel 2*d*;
therefore $d = \frac{ct}{2} = \frac{1.5\times10^{3}\times50\times10^{-6}}{2}$;
to give d = 38 mm;
similarly $l = \frac{1.5\times10^{3}\times175\times10^{-6}}{2} = 130\,\text{mm}$; ***[4]***
Allow for ECF here e.g. if “d” is marked as being between A and B.

(c) B-scan gives a three-dimensional image;
OWTTE; ***[1 max]***

(d) *advantage*:
non-ionising *(not as harmful as X-rays / OWTTE)*;

*Any **one** of the following:*
disadvantages:
small depth of penetration;
limit to size of objects that can be imaged;
blurring of images due to reflection at boundaries; ***[2 max]***

OPTION E — HISTORICAL PHYSICS

E1. (a) retrograde; ***[1]***

(b) (i) Mars rotates about the Earth;
but as it does so it also moves around epicycles; ***[2]***

(ii) the different angle of sight between Earth and Mars;
as they both rotate about the Sun with different periods; ***[2]***

E2. (a) *situation 1*: EE / GG;
situation 2: EG / GE; ***[2]***

(b) equal amounts of each type are produced in electrification by friction;
and the normal state of matter is neutral;
OWTTE;
Accept each cancels the other out. ***[2 max]***

(c)

	Hypothesis / theory	***Explanation***
Franklin	all matter contains an electrical fluid;	fluid is transferred from one object to another by friction; two objects with excess fluid or less fluid will repel and excess and less will attract;
Modern atomic theory	protons and electrons carry equal and opposite charges;	electrons are transferred during friction; two objects with excess or less electrons will repel and excess and less will attract; or electron transfer leaves on + the other object –; two like charges repel, unlike attract;

*Award **[1]** each for sensibly worded hypothesis and **[2]** each for an explanation in terms of the hypothesis which shows that they have an understanding of what is going on up to **[6 max]**.*

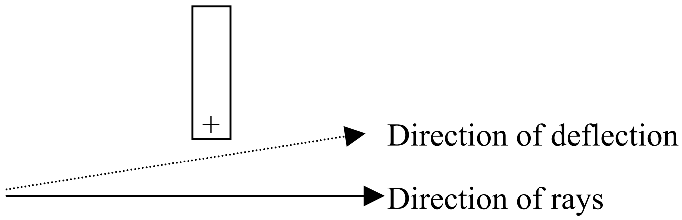
[6 max]

E3. (a) at right hand end of tube; ***[1]***

(b) (i) because they appear to originate from the cathode; ***[1]***

(ii) *Marked on the diagram.*
direction of cathode rays;
correct deflection of rays consistent with a magnet or charged rod;

e.g.



[2 max]

(iii) electrons; ***[1]***

OPTION F — ASTROPHYSICS

F1. (a) (i) spectral class;
Accept colour sequence. ***[1]***

(ii) absolute magnitude; ***[1]***

(b)

Star	*Type of star*
A	Main sequence ;
B	Super Red Giant;
C	White Dwarf;
D	Main sequence;

*Award **[1]** for each correct name.* ***[4]***

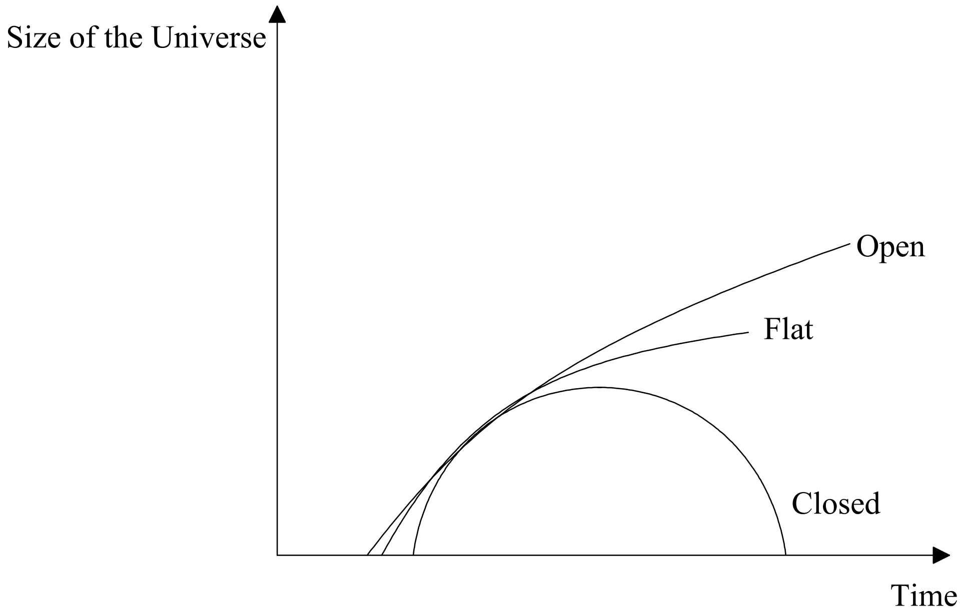
(c) B more luminous than A;
and has lower temperature than A;
so from the Stefan-Boltzmann law;
B has greater area (radius); ***[3 max]***

(d) use of $L = 4\pi b d^2$;
from the H-R diagram $L_B = 10^6 L_{Sun}$;
therefore $\frac{L_B}{L_{Sun}} = 10^6 = \frac{7.0\times10^{-8}\times d_B{}^2}{1.4\times10^3}$;
to give $d_B = 1.4\times10^8\ AU\ (\approx 700\,\text{pc})$; ***[4]***

No mark is awarded for the conversion from AU to pc.

(e) at this distance the parallax angle is too small to be measured accurately;
OWTTE; ***[1 max]***
Do not accept "it's too far away"

F2. (a)



*Award **[1]** for each correct label.* ***[3 max]***

(b)

Type of Universe	*Relation between* ρ *and* ρ_0
Open	$\rho < \rho_0$
Flat	$\rho = \rho_0$
Closed	$\rho > \rho_0$

*Award **[1]** for each correct entry.* ***[3 max]***

OPTION G — SPECIAL AND GENERAL RELATIVITY

G1. (a) *proper time:* the time interval measured by an observer of an event that happens at the same place according to that observer;

proper length: the length of an object as measured by an observer who is at rest relative to the object; ***[2]***

Do not look for precise wording but look for the understanding of the quantities in the sense of the words.

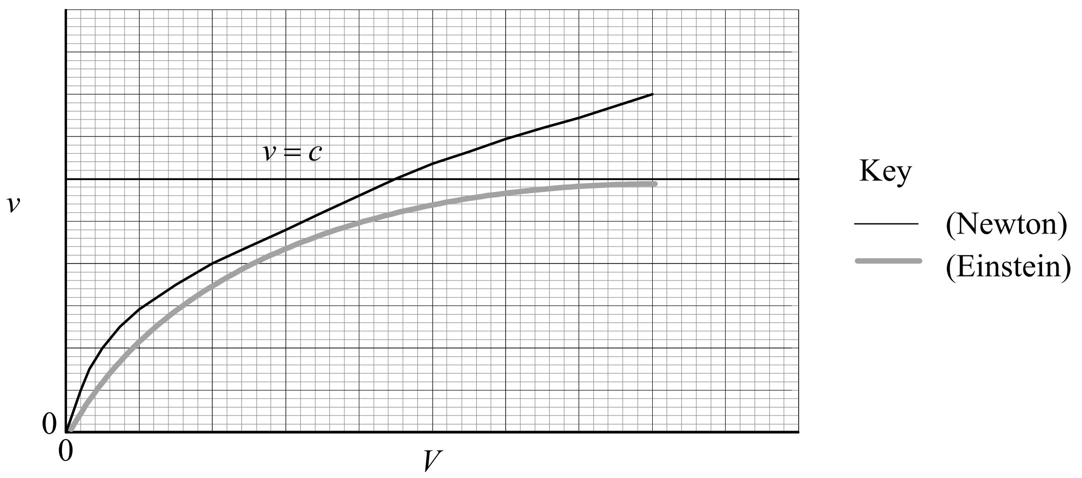
(b) (i) no they will not appear to be simultaneous;

Look for a discussion along the following lines.
Carmen sees Miguel move away from the signal from A and since Miguel receives the two signals at the same time;
and since the speed of light is independent of the motion of the source;
Carmen will see the light from A first / light from B will reach Carmen after light from A / *OWTTE*; ***[4 max]***

(ii) $\gamma = 2$;
to give $u = 0.87c\ (2.6 \times 10^{8}\ \mathrm{m\,s^{-1}})$; ***[2]***

(iii) both measure the correct distance;
SR states that there is no preferred reference system / laws of physics are the same for all inertial observers;
OWTTE; ***[2 max]***

G2. (a)



correct general shape;
asymptotic to c; ***[2 max]***

(b) as the speed of the electrons increases SR predicts that the mass of the electrons will increase;
SR also predicts that at speed c the mass will be infinite;
so effectively the electrons can never reach the speed of light; ***[3]***

Look for an answer that shows that mass increases and why the electrons cannot travel at the speed of light. They might quote $m = \gamma m_0$ *and this is fine.*

(c) (i) $\gamma = \dfrac{1}{\sqrt{1-\dfrac{v^2}{c^2}}} = \dfrac{1}{\sqrt{1-0.97^2}}$

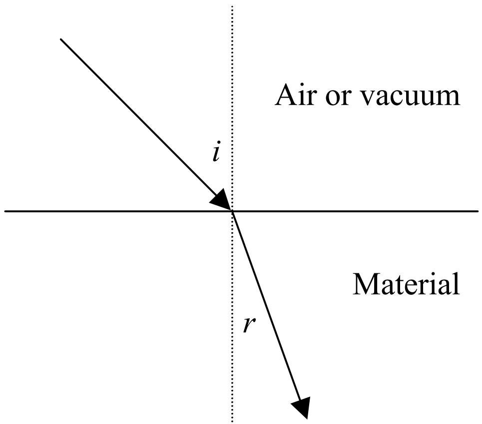
to give $\gamma = 4.1$;
$m = \gamma m_0 = 4.1 \times 0.51 = 2.1\,\mathrm{MeV\,c^{-2}}$;
Accept $m = 3.7 \times 10^{-30}$ *kg .*

could also solve from KE = 1.5 MeV;
rest mass $= 0.51\,\mathrm{MeV\,c^{-2}}$;
therefore total mass $= 2.1\,\mathrm{MeV\,c^{-2}}$; ***[3 max]***

(ii) $E = mc^2$;
= 2.1 MeV;
Accept 3.20×10^{-13} *J.* ***[2]***

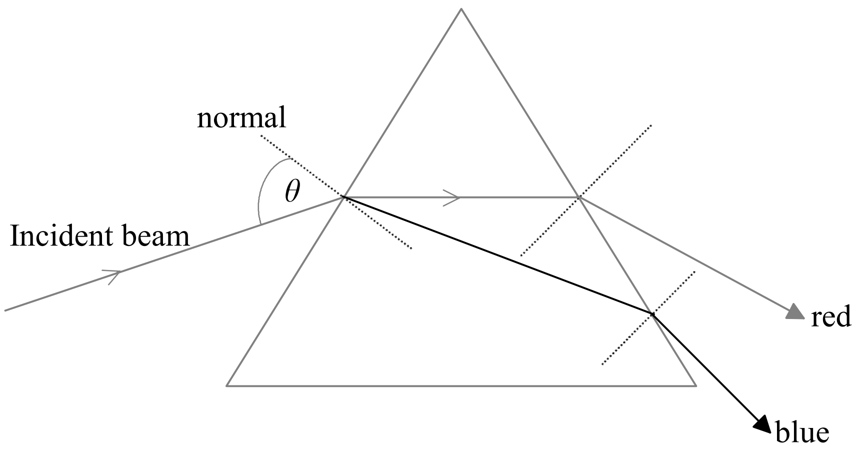
OPTION H — OPTICS

H1. (a)



definition consistent with diagram $n = \frac{\sin i}{\sin r}$;
with i in air or vacuum; ***[2]***

(b) (i)



refraction at first surface;
refraction at emergent surface;
deviation greater than red light; ***[3]***

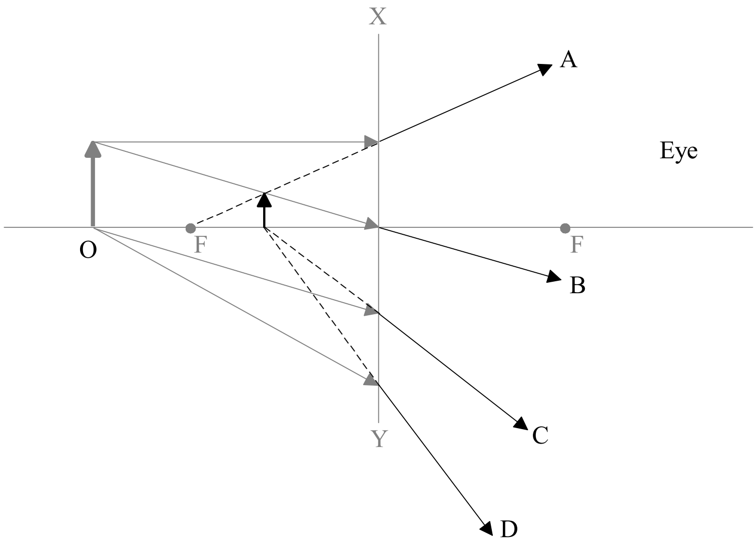
If the refraction's are correct but the angle of refraction is less than that for red light award ***[2]****.*

(ii) less — refraction angle is greater therefore $\sin i \ / \ \sin r$ is smaller; ***[1]***

H2. (a) focal point: the point on the principal axis to which rays parallel to the principal axis are brought to a focus after refraction by the lens / it is a point on the PA from which rays will be parallel to the PA after refraction by the lens; ***[2 max]***

*Look for a precise definition to gain **[2 max]** – award **[1]** for an inexact definition. Use discretion.*

(b) (i)



correct ray A;
correct ray B;
correct rays C and D;
correct location of the image; ***[4 max]***

*If a correct diagram is given for a **convex** lens award **[1]** but then use ECF for the rest of the question.*

(ii) anywhere to the right of the lens; ***[1]***

(c) virtual;
because any two rays from any one point of the object are not brought to a focus by the lens;
OWTTE; ***[2 max]***
*Virtual with incorrect explanation award **[1]** with no explanation **[0]**.*

(d) *Award marks either by calculation or drawing.*

calculation:
use $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ with $f = -50$;
to give $v = -30.0$ cm;
to give $m = \frac{-30}{75} = -0.4$;
Only penalise once for incorrect sign.

drawing:
suitable scale;
correct rays;
correct measurement; ***[3 max]***

(e) no effect on linear magnification;
only effect on appearance is that image will be fainter; ***[2]***