Cambridge Assessment

A Level

Physics

Session: 1994 June
Type: Mark scheme
Code: 9240

MS11 (UK)

University of Cambridge
Local Examinations Syndicate

GCE Examinations June 1994

MARKING SCHEME
for
PHYSICS

This marking scheme is a working document prepared for use by Examiners. All Examiners are required to attend a Coordination meeting to ensure that the Marking Scheme is consistently interpreted and applied in the marking of candidates' scripts.

UCLES will not enter into any discussion or correspondence about any Marking Scheme. It is acknowledged that there may be different views about some matters of emphasis or detail of a Marking Scheme. It is also recognised that, without the benefit of attendance at a Coordination meeting, there may be different interpretations of the application of a Marking Scheme.

University of Cambridge
Local Examinations Syndicate
International Examinations

GCE ADVANCED LEVEL EXAMINATIONS
MARKING SCHEME JUNE 1994

JUNE 1994

PHYSICS

GCE

9240

Paper 9240/01

Question Number	*Key*	*Question Number*	*Key*
1	D	26	C
2	B	27	C
3	D	28	C
4	C	29	A
5	D	30	D
6	C		
7	A		
8	D		
9	C		
10	D		
11	B		
12	C		
13	D		
14	A		
15	B		
16	D		
17	A		
18	A		
19	A		
20	B		
21	C		
22	C		
23	B		
24	B		
25	A		

A Level Physics (9240) **MARKING SCHEME**

This marking scheme is the initial draft. It must be used only after it has been amended or confirmed as at the Examiners' meeting.

General Instructions

Mark all scripts in red. Team leaders' comments will be in green.
Put a mark of some sort on every page which has any writing on it to show that it has been seen - even if it is zero or a dash.
Tick the point in the candidate's work where you finally decided that the candidate had done enough to earn the sub-mark shown alongside in the margin.
Use crosses to indicate incorrect work.
Annotate papers where difficulty in marking has been found. Comments, underlining and ringing of crucial parts of answers are all useful when any script needs to be re-marked.

Conventions for Marking Numerical Questions

Check answers on mark scheme before co-ordination meeting.
Explanation - candidates are told in the rubric that 'all working should be shown'. Sub-marks in the mark scheme are however mainly for candidates who do not obtain the correct answer. A correct answer, obtained from a valid starting point, will obtain full credit if intermediate steps are given or are not necessary. Some better candidates can jump many steps in their logic and this should not be penalised. One mark may be deducted if there is a severe lack of explanation.
Wrong physics - no credit is given for correct substitution, or subsequent arithmetic, in a physically incorrect equation.
Error carried forward - answers to later parts of questions that are consistent with an earlier incorrect part gain full credit.
Units of answer omitted or incorrect - deduct one mark.
Arithmetic error - deduct one mark. Follow through the figures and give full subsequent credit if no further errors are made.
Transcription error - deduct one mark; allow follow through.
Answer correct but not worked out - deduct one mark. (i.e. count as an arithmetic error. You may use your discretion about whether to deduct this mark or not. For example, no mark would be deducted for quoting an angle as 2π rad.)
Significant figure error. Deduct a maximum of one mark on the script overall. (Accept 4 sig. fig. or 2 sig. fig. from 3 sig. fig. data but not one or five. When you have made this deduction please indicate by writing *SF* adjacent to the question number in the mark grid on the front page.

Rubric Infringement (Paper 3 only)

Candidates are required to answer 4 questions from Section A and 2 questions from any part of Section B. If they answer more than this number, mark all the questions answered and allow the best to count within the rubric.

Marks Check and double-check to ensure accuracy

During Marking

Ensure that sub-marks for each part of a question are put in the right-hand margin.
Add up the sub-marks for each question, starting at the beginning of the question, and put the total for each question in a ring at the end of the question.
Transfer this total to the mark grid on the front page.
Total the script by adding the marks in the mark grid.

After Marking

Check that every page of the script has been marked.
Check that all parts of all questions have been marked.
Add up all the sub-marks, starting at the back of the script, and check that this total agrees with the total in the mark grid on the front page.
Check that the candidate's name and number are the same on the mark sheet and the script.
Transfer the mark from the script to the mark sheet and complete the lozenges.
VITAL. Check that the total as marked in the lozenges agrees with the total mark shown on the script.

..../2..

Co-ordination Procedures

These notes are intended to supplement the instructions provided in "Examiner's Instructions".

Examiners should receive some scripts on the day after the examination is set. Please familiarise yourself with the questions and the marking scheme by doing some preliminary marking in pencil before the co-ordination meeting. During the co-ordination meeting amendments will be made to the mark scheme and it is important that these amendments are incorporated in your copy of the mark scheme. At the co-ordination meeting it will not be possible to deal with every possible answer to a question: the principles used in establishing the mark scheme are important facts to be determined and you will be expected to use your own judgement when marking. It is important that answers worthy of merit do score appropriate marks.

Exchange scripts

As soon as possible after co-ordination, send 10 marked scripts to your team leader. When selecting these scripts:

a) do not send any very poor scripts,

b) as far as possible, select scripts from several centres,

c) ensure that the sample includes examples from as many questions as possible.

These scripts should be marked in red and should be well annotated. You should indicate your thinking behind the awarding of marks where the total is less than the maximum permitted.

Keep a record of all the mark totals for these scripts.

Enclose a stamped and self-addressed envelope with the scripts.

When these exchange scripts are returned to you, go through them carefully. It may be necessary for your to correct your marking on any other scripts which you have already marked.

Your team leader may at this stage ask to see additional scripts from you.

The Chief Examiner may find it necessary to circularise all Examiners if common answers have not been discussed at the co-ordination meeting. This will hopefully be done before scripts are returned from team leaders.

Batch 1 scripts

When batch 1 scripts have been completed - by the specified date, or earlier

a) send mark sheets to Cambridge - first class,

b) send marked scripts to team leader,

c) send the mark distribution sheet to the team leader.

Batch 2 and Batch 3 scripts

On completion send scripts and mark sheets to Cambridge under separate cover.

Conclusion

Please let your team leader know immediately if you anticipate any difficulty in keeping to deadlines.

Do not hesitate to use the telephone to contact a team leader if you have any doubts as regards procedures or marking points. Whenever possible, contact should be made during cheap rate periods.

All examiners are asked to send to the Chief Examiner their comments for inclusion in the final report. The report has to be written immediately after the marking period and therefore reports from each Examiner should be sent as soon as marking is completed.

GCE ADVANCED LEVEL EXAMINATIONS
MARKING SCHEME JUNE 1994

1 (a) (i) Define *linear momentum.*

Mass × velocity (1) — 1

(ii) State whether linear momentum is a vector or a scalar quantity.

vector (1) — 1 [2]

(b) State the principle of conservation of momentum.

The momentum (of a system) before a collision equals the momentum after the collision if no external forces act (on the system) (1) — 1 [1]

(c) The principle can be applied in different types of interaction. These are illustrated by the following examples.

(i) Inelastic collision: a piece of plasticine of mass 0.20 kg falls to the ground and hits the ground with a velocity of 8.0 m s^{-1} vertically downward. It does not bounce but sticks to the ground. Calculate the momentum of the plasticine just before it hits the ground.

Momentum of plasticine $= 0.20\,\text{kg} \times 8.0\,\text{ms}^{-1}$
$= 1.6\,\text{Ns}$ (1) — 1
OR $1.6\,\text{kgms}^{-1}$

State the transfers of momentum and of kinetic energy of the plasticine which occur as a result of the collision.

Momentum is transferred to the Earth (1) — 1

Kinetic energy is lost as internal energy (heat) (1) — 1 [3]

(ii) Elastic collision: a neutron of mass 1.00 u travelling with velocity 6.50 × 10^5 m s^{-1} collides head on with a stationary carbon atom of mass 12.00 u. The carbon atom moves off in the same direction with velocity 1.00 × 10^5 m s^{-1}. Calculate the velocity of the neutron after the collision. State what happens to the total kinetic energy as a result of this collision.

Momentum before = momentum after
$(1 \times 6.50 \times 10^5) = (12 \times 1.00 \times 10^5) + (1 \times v)$ (1) — 1
$(6.5 - 12) \times 10^5 = v$
$v = -5.5 \times 10^5\,\text{ms}^{-1}$ (1) — 1

Kinetic energy total is constant (1) — 1 [3]

(iii) There is a third type of interaction: this happens when two strong magnets are held stationary with the north pole of one pushed against the north pole of the other. On letting go, the magnets spring apart. It is apparent that the kinetic energy of the magnets has increased. Explain how the law of conservation of momentum applies in this case.

Zero momentum at start 1

Magnets have equal and opposite momentums (1) 1

giving zero momentum total at end (1) [2] 11

2 (a) Define the term *gravitational field strength*.

Force per unit mass (1) 1

[1]

(b) State the numerical value and the unit of the gravitational field strength of the Earth at its surface.

9.8 (1) $N\,kg^{-1}$ (1) [2] 2

(c) Why is it incorrect to call g (= $9.8\,m\,s^{-2}$) 'gravity'?

Gravity provides a force (1) and g is an acceleration (1) 2

OR g is a gravitational field strength (1) not a force (1) [2]

(d) This part of the question is about the rotation of the Moon in a circular orbit around the Earth. You will need to use the following astronomical data.

Radius of the Moon's orbit = 3.84×10^8 m

Mass of the Moon = 7.35×10^{22} kg

Time for Moon to complete one orbit around the Earth = 2.36×10^6 s

Calculate

(i) the speed of the Moon in its orbit around the Earth,

circumference of orbit $= 2\pi \times 3.84 \times 10^8 = 2.41 \times 10^9$ m (1)

speed $= \frac{\text{circumference}}{\text{period}} = \frac{2.41 \times 10^9\,m}{2.36 \times 10^6\,s} = 1020\,m\,s^{-1}$ (1) 2

(ii) the acceleration of the Moon,

acceleration $= \frac{v^2}{r} = \frac{(1020)^2}{3.84 \times 10^8}$ (1)

$= 2.72 \times 10^{-3}\,m\,s^{-2}$ towards Earth (1) 2

(iii) the force the Earth exerts on the Moon,

Force $= ma = 7.35 \times 10^{22} \times 2.72 \times 10^{-3} = 2.00 \times 10^{20}$ N (1) 1

(iv) the gravitational field strength of the Earth at the Moon. [6]

$g = \frac{F}{m} = 2.72 \times 10^{-3}\,N\,kg^{-1}$ (1) 1

11

3 (a) A filament lamp is marked 240 V 60 W. Calculate

(i) the current through the lamp when it is working normally, [1]

$$I = \frac{P}{V} = \frac{60\,W}{240\,V} = \frac{1}{4}A \quad (1)$$

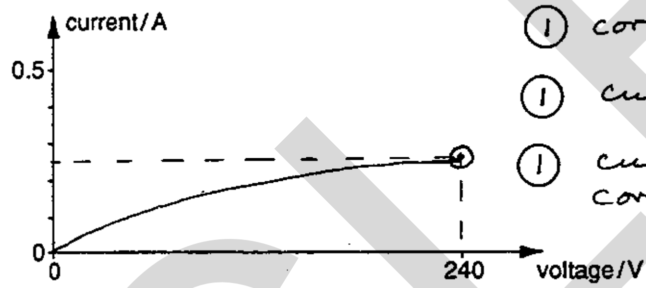
1

(ii) the resistance of the lamp when it is working normally. [1]

$$R = \frac{V}{I} = \frac{240\,V}{\frac{1}{4}\,A} = 960\,\Omega \quad (1)$$

1

(iii) The resistance of the lamp is found to be less when it is not lit than when it is working normally. Sketch the current-voltage characteristic of the filament lamp on the axes in Fig. 3.1.



(1) correct point
(1) curve
(1) curve correct way

[3] 3

Fig. 3.1

(b) A lighting circuit includes four lamps connected as shown in Fig. 3.2. The resistance of each lamp *should* be 120 Ω when it is not lit.

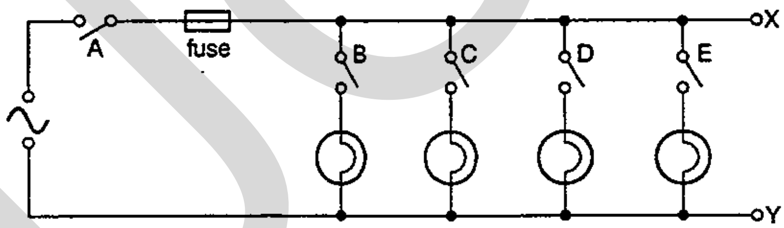


Fig. 3.2

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GCE ADVANCED LEVEL EXAMINATIONS
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A fault is discovered in the circuit, so switch A is turned off and the fuse is removed for safety. A resistance meter is connected between the points X and Y and the following readings are obtained for different switch positions.

Switches A	B	C	D	E	Resistance meter reading/Ω
off	off	off	off	off	14 600 000
off	off	off	off	on	120
off	off	off	on	on	60
off	off	on	on	on	40
off	on	on	on	on	0.2

(i) If there were no fault in the circuit, what would the resistance meter read when switches B, C, D and E are on and A is off?

4 lamps in parallel so total resistance = $\frac{R}{4}$ (1)

= 30 Ω (1) — 2

(ii) Why does the resistance meter not read infinity when all the switches are off?

(14 600 000 Ω is) the resistance of the insulation (1) — 1

(iii) Suggest what the fault in the circuit may be.

Bulb B is at fault. (1) In the circuit containing B there is a short circuit (1) [5] — 2

10

4 The three graphs in Fig. 4.1 are load-extension graphs for strands of three different materials X, Y and Z. Each strand is of cross-sectional area 1.0 mm².

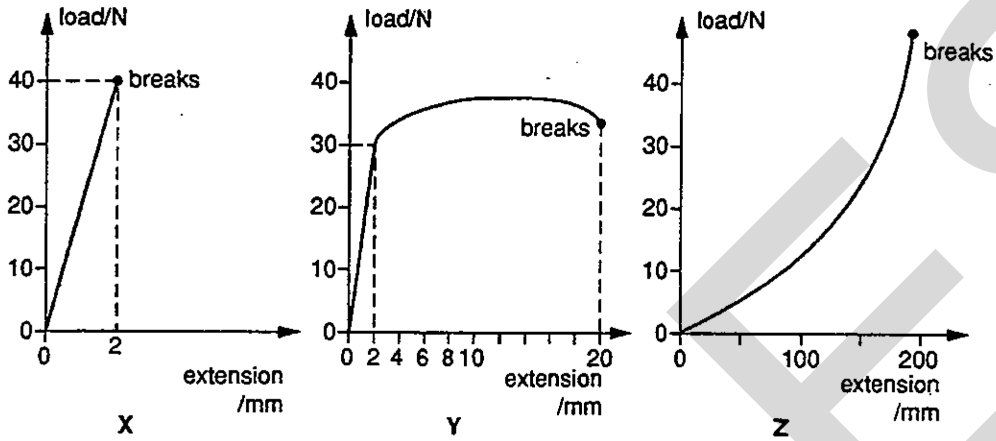


Fig. 4.1

(a) Which material is

(i) ductile, Y

(ii) brittle, X ⓶ for 3 correct ⓵ for 1 correct — 2

(iii) polymeric? Z [2]

(b) Name a possible substance for each of the three materials. ⓵ each — 3

e.g. X GLASS Y COPPER Z RUBBER [3]

(c) (i) Deduce the strain energy stored in the strand of material Y for an extension of 2.0 mm. [2]

Strain energy $= \frac{1}{2}Fx = \frac{1}{2} \times 30 \times 0.002$ ⓵

$= 0.030$ J ⓵ — 2

(ii) Estimate how much additional work would have to be done on this strand in order to break it. [2]

Area under graph ⓵

Approx $0.018\text{ m} \times 34\text{ N} = 0.6 (\pm 0.1)$ J ⓵ — 2

9

5 A fixed mass of gas in a heat pump undergoes a cycle of changes of pressure, volume and temperature as illustrated in the graph, Fig. 5.1. The gas is assumed to be ideal.

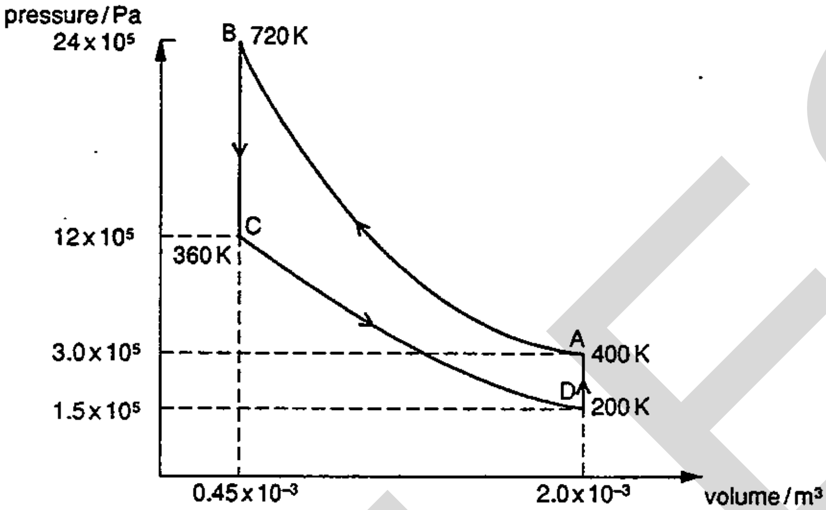


Fig. 5.1

The table below shows the increase in internal energy which takes place during each of the changes A to B, B to C and C to D. It also shows that in both of sections A to B and C to D, no heat is supplied to the gas.

	Increase in internal energy /J	*Heat supplied to gas* /J	*Work done on gas* /J
A to B	1200	0	
B to C	−1350		
C to D	−600	0	
D to A			

(a) Using the first law of thermodynamics and necessary data from the graph, complete the table. You will find it helpful to proceed in the following order.

(i) work done on gas for A to B and C to D — 1200 J ; −600 J (1) — 1

(ii) work done on gas for B to C and D to A — ZERO : ZERO (1) — 1

(iii) heat supplied to gas for B to C — −1350 J (1) — 1

(iv) increase in internal energy for D to A — 1350 + 600 − 1200 (1) = 750 J (1) — 2

(v) heat supplied to gas for D to A — 750 J (1) — 1 [6]

(b) Calculate P, the coefficient of performance of the heat pump, given that

$$P = \frac{\text{Heat delivered by gas (during change B to C)}}{\text{Net work done on gas}} = \frac{1350}{600}$$ [1] — 1

$= 2.25$ (1)

7

6 Fig. 6.1 shows a typical arrangement for a domestic hot-water tank. The water can be heated by an immersion heater and the tank has lagging around the walls and over the top.

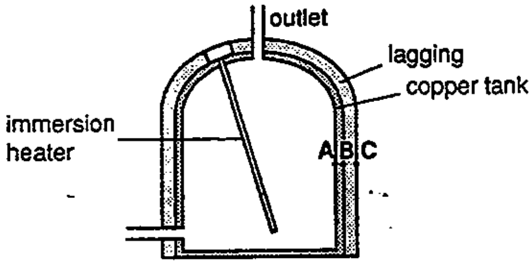


Fig. 6.1

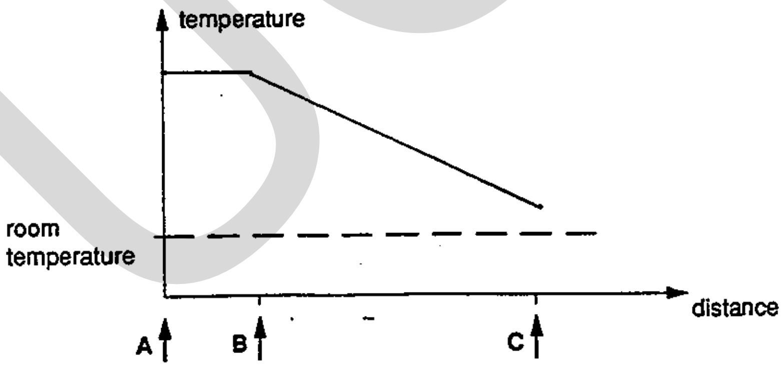
(a) Why is convection important in heating the water?

Conduction is ineffective as water is a bad heat conductor OR Convection allows circulation of water (so whole tank is heated) (1) [1] — 1

(b) Why is the bottom of the tank not lagged?

The water is cold here (1) so little conduction or convection takes place from bottom (1) [2] — 2

(c) Sketch a graph on the axes below to show how the temperature is likely to vary along the line of points ABC shown in Fig. 6.1. Assume the tank surface is flat in this region. [3]



(1) for very small or zero temperature drop across AB
(1) for large temperature drop across lagging
(1) for outer surface above room temperature — 3

6

7 (a) What is meant by

(i) the *decay constant* λ of a radioactive material,

Ratio of rate of change of number of particles to number of particles present i.e. λ in $\frac{dN}{dt} = -\lambda N$ (1)

(ii) the *half-life* $t_{\frac{1}{2}}$?

The (average) time taken for half the atoms present to decay (1) [2] — 2

(b) The decay constant and the half-life are related by the equation

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}.$$

The half-life of $^{60}_{27}Co$ is 5.26 years.

(i) What do the numbers 27 and 60 represent?

27 The number of protons (1)

60 The number of protons + neutrons (1) [2] — 2

(ii) Calculate the decay constant of $^{60}_{27}Co$. [1]

$\lambda = \frac{0.693}{T_{\frac{1}{2}}} = \frac{0.693}{5.26\,y} = 0.132\, y^{-1}$ (1) $(= 4.18 \times 10^{-9}\, s^{-1})$ — 1

(iii) Calculate the activity of 1.00 gram of $^{60}_{27}Co$. [3]

(60 grams of $^{60}_{27}Co$ contain 6.02×10^{23} atoms.)

Activity $= \frac{dN}{dt} = \lambda N$

$= 4.18 \times 10^{-9} \times \left(\frac{6.02 \times 10^{23}}{60}\right)$ (2)

$= 4.19 \times 10^{13}$ Bq (1)

OR 4.19×10^{13} counts per s — 3

8

GCE ADVANCED LEVEL EXAMINATIONS
MARKING SCHEME JUNE 1994

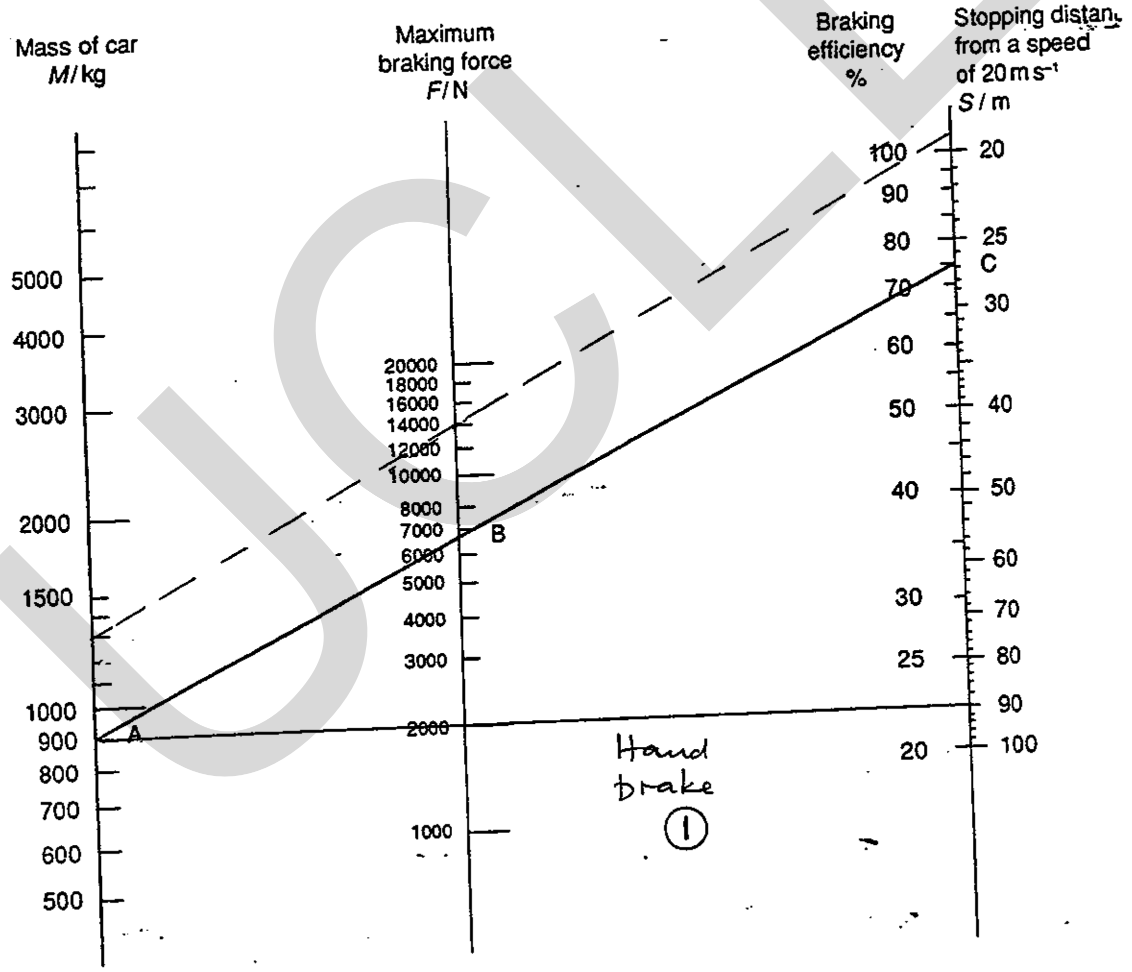
8 When a car has a brake test, two sets of measurements are made:

1. the maximum braking force on the wheels produced by operating the foot brake,
2. the maximum braking force produced by operating the hand brake.

Typical data for a car of mass 900 kg are as follows.

	Maximum braking force /N
1. Foot brake	6700
2. Hand brake	2000

In order to determine whether or not the brakes are satisfactory, the data are applied to a chart (called a nomogram) like the one shown in Fig. 8.1. This chart has three vertical lines, marked with scales.



Brake efficiency and stopping distance from 20 m s⁻¹

Fig. 8.1

The central vertical line is for the maximum braking force.
The left line is for the mass of the car.
The right hand line is for the braking efficiency and also for the stopping distance from an initial speed of 20 m s^{-1}. The braking efficiency E is defined by the equation

$$E = \frac{\text{deceleration of car}}{\text{acceleration of free fall}} \times 100.$$

As an example of the use of this chart for the car of mass 900 kg, the figures in the table show a maximum braking force for the foot brake of 6700 N. The point A corresponding to the mass and the point B corresponding to the braking force are joined to give a straight, sloping line. This line is extended to cut the braking efficiency scale at the point C, and shows that in this particular case the stopping distance S from a speed of 20 m s^{-1} is about 27 m.

(a) Read from the chart the braking efficiency corresponding to point C.

75 % (1) ..... [1] — 1

(b) Using the definition of braking efficiency given above, find the deceleration corresponding to this value of braking efficiency. Give your answer in m s^{-2}. [2]

$$\frac{75}{100} = \frac{\text{deceleration}}{g} = \frac{\text{deceleration}}{9.8\ \text{m s}^{-2}} \quad (1)$$

$$\therefore \text{deceleration} = 7.35\ \text{m s}^{-2} \quad (1)$$

2

(c) Show, by calculation from the equations of motion, that the deceleration you obtained in (b) gives a stopping distance of 27 m to 2 sig. fig. from an initial speed of 20 m s^{-1}. [3]

$$v^2 = u^2 + 2as \quad (1)$$

$$0 = 20^2 + 2 \times 7.35 \times s \quad (1)$$

$$s = \frac{400}{2 \times 7.35} = 27.2\ \text{m} \quad (1)$$

3

(d) (i) Draw a line on the chart to represent the results of the hand brake test on the car of mass 900 kg. [1]

Correct line drawn as shown

(ii) Using the hand brake alone,

1. what would be the stopping distance from a speed of 20 m s^{-1}, [1]

90 m (± 2 m) (1)

2. what is the braking efficiency? [1]

22% (± 1%) (1)

3

(e) Now consider a car of mass 1300 kg. Read from the chart in Fig. 8.1 corresponding pairs of values of the maximum braking force and stopping distance from 20 m s^{-1}, and tabulate them below.

e.g.

Maximum braking force/N	Stopping distances from 20 m s^{-1}/m
3000	88
4000	66
5000	53
6000	44
7000	37
8000	33
10 000	26·5
12 000	22·5

Allow ±1 m
(1) for each correct 2 pairs of values
Max 3 [3] 3

Plot a graph of these values on the grid on page 17. (See over) [3] 3

(f) Use the chart to estimate the braking efficiency for the car of mass 1300 kg if the maximum braking force were 14 000 N. Comment on your answer.

105 (± 3) % (1)

This is possible (1) but unlikely (1). Use of the word efficiency is dubious. (1) This implies frictional force greater than weight (1) Max 2 from these reasons. [3] 3

18

GCE ADVANCED LEVEL EXAMINATIONS
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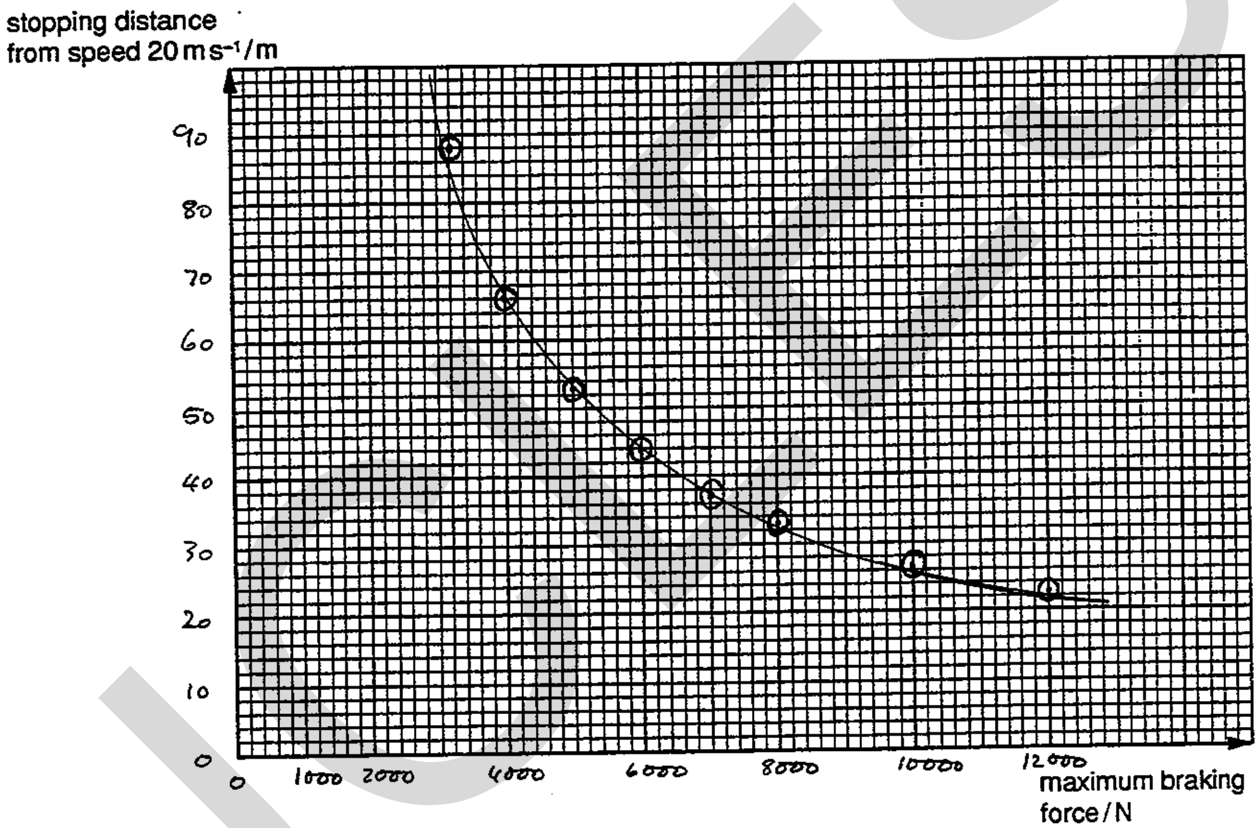

Graph.

Axes & scales (1)

Points accurate (1)

line smooth & reasonable fit (1)

PHYSICS CONSTANTS

PHYSICS (9240 Papers 0, 1, 2, 3)
PHYSICAL SCIENCE (9272 Papers 1, 2, 3, 4)

speed of light in a vacuum,	c	$= 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of a vacuum,	μ_0	$= 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of a vacuum,	ϵ_0	$= 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$ $\approx (1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
electronic charge,	e	$= -1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant,	h	$= 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant,	u	$= 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron,	m_e	$= 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton,	m_p	$= 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant,	R	$= 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	L	$= 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant,	k	$= 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant,	G	$= 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall,	g	$= 9.81\,\mathrm{m\,s^{-2}}$

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During marking Ensure that sub-marks for each part of the question are put in the right-hand margin. N.B. Nothing else should be written in this margin. Add up the sub-marks for each question, starting at the beginning of the question, and put the total for each question in a ring at the end of the question. Also, transfer this total to the mark grid on the front page.
Total the script by adding the marks in the mark grid.
After marking Go through the script, checking that every page has been marked or seen.
Check that all parts of all questions have been marked.
Add up the sub-marks for each individual question, starting at the front of the script, and check that this total agrees with the total in the mark grid on the front page.
Check that the candidate's name and number are the same on the mark sheet and on the script.
Transfer the mark from the script to the mark sheet and complete the lozenges.
VITAL Check that the total, as marked in the lozenges, agrees with the total mark shown on the script.

<u>Co-ordination procedures</u>

These instructions are intended to supplement the instructions provided in "Examiner's Instructions".
Examiners should receive some scripts, or photocopies of scripts, shortly after the examination has been taken. Please familiarise yourself with the questions and the marking scheme by doing some preliminary work in pencil before the co-ordination meeting. During the co-ordination meeting, amendments will be made to the marking scheme and it is important that these amendments are incorporated in your copy of the Scheme. At the co-ordination meeting it will not be possible to deal with every conceivable answer to a question - the principles used in establishing the marking scheme are the important facts to be determined and you will be expected to use your own judgement, based on these principles. It is important that answers worthy of merit do score appropriate marks and conversely, poor work is not unduly credited.

Exchange scripts

As soon as possible after co-ordination, send 10 marked scripts to your Team Leader. When selecting scripts,
(a) do not send any very poor scripts,
(b) as far as is possible, select scripts from several centres,
(c) ensure that the sample includes examples from all questions.
These scripts should be marked in red and should be well annotated. You should indicate your thinking behind the awarding of marks where the total is less than the maximum permitted.
Keep a record of all mark totals for these scripts.
Enclose a stamped and self-addressed envelope with the scripts.
When these exchange scripts are returned to you, please go through them carefully. It may be necessary for you to correct your marking on any other scripts which you have already marked.

Section A

Answer four questions from this section.

1 (a) State what is meant by *angular velocity*. [2]

1 (a) angle turned through per unit time/second . . Allow θ/t, $\frac{d\theta}{dt}$, rate of change of angle . ①

in a particular direction . . . . ①

no credit for bald rad s^{-1}

(b) A stone is tied to one end of a cord and then made to rotate in a horizontal circle about a point C with the cord horizontal, as shown in Fig. 1.1.

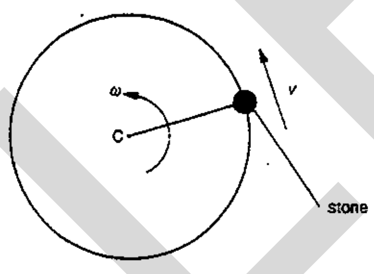


Fig. 1.1

The stone has speed v and angular velocity ω about C.

(i) Write down a relation between the speed v, the length r of the cord and the angular velocity ω.

(ii) Explain how v can be made to vary when ω is constant.

(iii) Explain why there needs to be a tension in the cord to maintain the circular motion.

(iv) Write down an expression for the acceleration of the stone in terms of v and r. Hence, if the stone has mass m, show that the tension T in the cord is given by

$$T = mv\omega.$$

[8]

(b) (i) *Relation*: $v = r\omega$ OR $r = v/\omega$ OR $\omega = v/r$ . . . . ①

(ii) (v varies at constant ω if) r varies alter length of string . . . . ①

charity mark for "no force, flies off tangentially" OR "cord provides centripetal force"

(iii) linear velocity changes continuously (allow "speed" here) . . . . ①

for full credit direction needs to be mentioned once only: and particle accelerates towards centre of circle . . . . . ①

so force required towards centre of circle provided by tension in cord . . . . ①

(iv) acceleration $a = v^2/r$. a must be the subject . . . . . ①

so, force $F (= ma) = mv^2/r$. [F=ma: charity '1' if all else fails] . . . ①

but $v = r\omega$ so $T = mvr\omega/r$, $\underline{T = mv\omega}$ . . . . ①

The third mark is for a clear indication of the path from $\frac{mv^2}{r} \rightarrow mv\omega$

(c) On one particular ride in an amusement park, passengers 'loop-the-loop' in a vertical circle, as illustrated in Fig. 1.2.

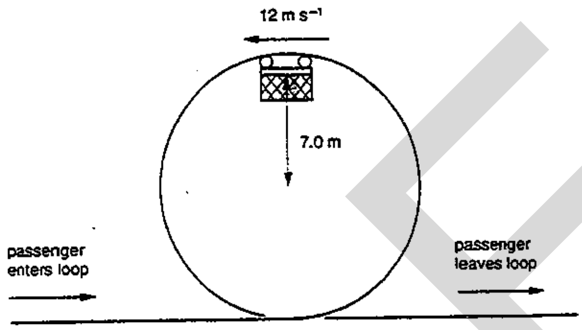


Fig. 1.2

The loop has a radius of 7.0 m and a passenger, mass 60 kg, is travelling at 12 m s^{-1} when at the highest point of the loop. Assume that frictional forces may be neglected.

(i) Calculate, for the passenger when at the highest point,
  (1) the centripetal acceleration,
  (2) the force the seat exerts on the passenger.

(ii) The passenger now moves round and descends to the bottom of the loop. Calculate
  (1) the change in potential energy of the passenger in moving from the top of the loop to the bottom,
  (2) the speed of the passenger on leaving the loop.

(iii) Operators of this ride must ensure that the speed at which the passengers enter the loop is above a certain minimum value. Suggest a reason for this. [10]

no e.c.f. from b(iv)

(i)(1) acceleration = v^2/r = $12^2/7$ = $\underline{20.6 \text{ ms}^{-2}}$ [Allow 1, 2 or 3 sig fig.] . (1)

(2) force = $mv^2/r - mg$ . . mg missing 0/2, +mg 1/2 . . . . . . (1)

= (60 x 20.6) - (60 x 9.8) = $\underline{648 \text{ N}}$ . . . . (1)

allow ECF

(ii)(1) $\Delta E = mgh$ . . . . good start mark . . . . . . (1)

= 60 x 9.8 x 14 = 8230 J . . . . (1)

(2) Initial K.E. + initial P.E. = Final K.E. — 0/2 if initial KE ignored

$(\frac{1}{2}m \times 12^2) + (m \times 9.8 \times 14) = \frac{1}{2}mv^2$ — 0/2 for $v = 16.6 + 12$

$\underline{v = 20.5 \text{ ms}^{-1}}$ . . . . (2)

(iii) If car is not to fall inwards (at top of loop) . . . . (1)

$g < v^2/r$ — must make reference to v^2/r + g for 3/3

$\underline{\text{hence}}$, minimum value for the speed . . . . (2)

2/3 for min. speed because there must be a reaction force between car and rail
1/3 for KE at bottom > increase in PE on reaching top
1/3 for centrifugal force > mg 0/3 for "it wouldn't reach top"

2 (a) Define *capacitance* and the *farad*. [2]

2 (a) Capacitance = charge / potential or Q/V or charge/voltage . . . . (1)

Farad = coulomb / volt OR coulomb per volt . . . . (1)

not CV^{-1} unless C and V explained

If reference to units, without ratio, allow if ratio clear when defining capacitance

(b) In the circuit of Fig. 2.1, the capacitor has capacitance C and the resistor has resistance 20 kΩ. The milliammeter has negligible resistance.

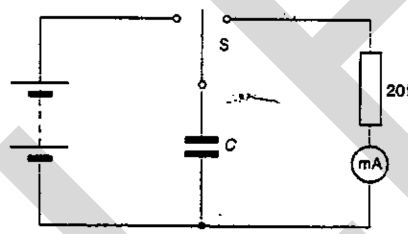


Fig. 2.1

The switch S enables the capacitor to be charged by the battery and then discharged through the resistor. The variation of the current i in the resistor with time t during discharge is shown in Fig. 2.2.

(i) Read from the graph the current i in the resistor at the following times:

(1) t = 10.0 s,

(2) t = 30.0 s.

(ii) Hence calculate the potential difference across the capacitor at each of the times listed in (b)(i).

(iii) Using your readings in (b)(i), or otherwise, estimate the charge which has flowed from the capacitor between the times t = 10.0 s and t = 30.0 s.

(iv) Hence, estimate the capacitance of the capacitor. [10]

(b) (i)(1) 1.46 mA (allow ± 0.01 mA) . . . . (1)

(2) 0.78 mA (allow ± 0.01 mA } unit error : deduct once only . . . . (1)

(ii) p.d. across C = iR or $V = iR$ . . . . good start mark . . . (1)

at t = 10 s, $V = 1.46 \times 10^{-3} \times 20 \times 10^{3}$ = 29.2 V . . . . . . (1)

at t = 30 s, $V = 0.78 \times 10^{-3} \times 20 \times 10^{3}$ = 15.6 V . . . . . . (1)

(iii) assume the graph is linear OR reference to area . . } . . . . . . (1)

OR charge = (average) current x time OR $Q = it$ }

= $\frac{1}{2}(1.46 + 0.78) \times 10^{-3} \times 20$ = <u>22.4 mC</u> . . . . (2)

Incorrect area, max 1/3 for initial explanation

Counting squares (→ 21mC) 3/3

(iv) $C = \Delta Q/\Delta V$ (allow $C = Q/V$)

= $(22.4 \times 10^{-3})/(29.2 - 15.6)$ = 1650 μF (ECF) . . . . (2)

0/2 if uses average voltage

> (c) Describe how you would use the graph of Fig. 2.2 to show that the current in the resistor during the discharge of the capacitor follows an equation of the form
>
> $x = x_0 \exp(-t/CR)$. [3]

(c) Any valid method: e.g. plot graph of $\ln i$ against t . . . . (1)
gives a straight line . . . . (1)
either gradient $(-1/CR)$ or intercept $\ln i_0$. (1)

accept x or i

3/3 for read i_0, i + t at least twice, finds CR constant (once: 1/3). 0/3 for mere i, t substitution into formula

1/3 for finding time to halve twice

1/3 finding time to halve more than twice

> (d) (i) Use the values of the resistance and the capacitance to calculate the time constant τ for the discharge of the capacitor.
>
> (ii) Hence calculate the current in the resistor at time $t = 2\tau$. [2]

(d) (i) time constant = CR

= $1650 \times 10^{-6} \times 20 \times 10^{+3}$ = 33 s . . . . (1)

(ii) $i = 2\ e^{-2}$ = 0.27 mA . . . . (1)

extrapolation of graph 0/1 $e^{-2} = \frac{1}{9}$ 0/1

> (e) (i) Read from Fig. 2.2 the time at which the current i is 0.74 mA.
>
> (ii) Comment on your answers to (d)(i) and (e)(i). [3]

(e) (i) time = 31.5s (allow ± 0.5s) . . . . (1)

(ii) Should be same as answer to (d)(i) . . . . (1)
because $2\ e^{-1} = 0.74$ . . . . (1)

If states "about same", there must be some supporting statement for any credit.

3 (a) A long bar magnet hangs from one end of a spring, as shown in Fig. 3.1.

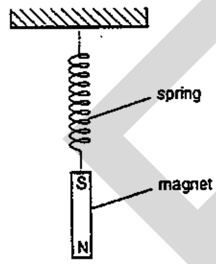


Fig. 3.1

The magnet is displaced vertically downwards and then released. The subsequent vertical displacement x is found to vary with time t as shown in Fig. 3.2.

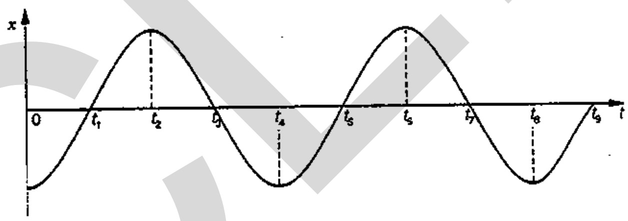


Fig. 3.2

(i) State two times, apart from $t = 0$, at which the magnet is stationary.

(ii) State two times at which the magnet is moving vertically upwards with maximum speed.

(iii) State two times at which the magnet is moving vertically downwards with maximum speed. [3]

3 (a) (i) **Two times** e.g. t_2, t_4, t_6, t_8 . . . . ①

(ii) **Two times** e.g. t_1, t_5, t_9 . . . . ①

(iii) **Two times** e.g. t_3, t_7 . . . . ①

e.c.f. in (iii) if consistent with (ii)

(b) The north pole of the magnet is now placed inside a coil of wire, as shown in Fig. 3.3.

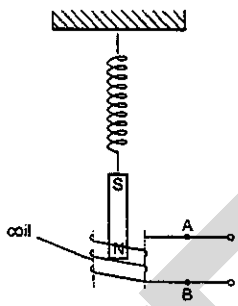


Fig. 3.3

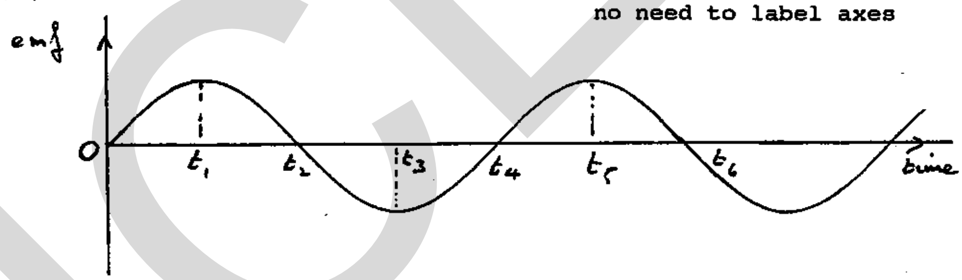
The terminals of the coil are connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.) which may be assumed to have infinite input resistance.

(i) Sketch a graph to show how the induced e.m.f. in the coil will vary with time t when the magnet oscillates in the coil. Mark relevant times (for example, t_1, t_2, t_3) on the t-axis of your graph.

(ii) Use the laws of electromagnetic induction to explain the shape of your graph. [7]

(b) (i)

no need to label axes



(constant amplitude and period) , at least one cycle.

Graph: reasonable shape allow π phase change . . . . (1)

correct frequency clear i.e. 1 time marked . . . . . . (1)

at least two times marked correctly . . . . (1)

(ii) emf ∝ rate of change of flux (linkage) {1}

so no emf when magnet stationary {1}

maximum emf when speed is maximum {1}

(By Lenz's law,) emf "opposes" change {1}

so current reverses as direction of motion changes {1}

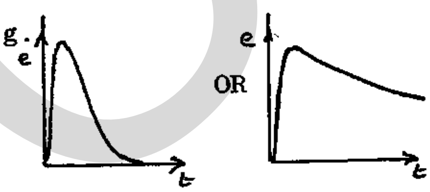
1 each to MAX (4)

> (c) A high resistance resistor is now connected in parallel with the c.r.o. between the points A and B (see Fig. 3.3).
>
> (i) Draw a second graph to show how the e.m.f. will vary with time *t*.
>
> (ii) Explain, in terms of the principle of conservation of energy, why this graph is different from your first graph.
>
> (iii) Describe, with the aid of a sketch graph, the changes which would occur in the shape of the graph drawn in (c)(i) if the resistance of the resistor has been reduced to a very low value. [10]

(c) (i) Graph: Sinusoidal wave with same frequency as (b) . . . . ①
(axes need not be labelled)
amplitude decreasing . . . . ①
progressively (both at (+)ve & (-)ve peaks) . . . . . . ①

(ii) There is a current in the resistor . . . . ①
so energy dissipated / lost (as heat) in resistor . . . . ①
this energy comes from motion of magnet . . . . ①
so maximum speed of magnet decreases . . . . ①
and hence maximum emf becomes smaller . . . . ①
('max' once only for 2/2.)

(iii) Graph:

e.g. 

little or no oscillation ①
reasonable shape . . . . ①
Give full credit if initial rise not shown

Allow 2/2 if oscillates and decay significantly greater than (i)
but -1 if period different to that in (i).
-1 if period varies

> 4 (a) Describe, with the aid of a labelled diagram, the basic structure of a cathode-ray tube in a cathode-ray oscilloscope (c.r.o.). [4]

4 (a) Diagram / labels / description: (envelope &) vacuum . . . . . . ①

electron gun – or filament and anode . . . . ①

deflection plates – 2 sets indicated . . ①

fluorescent (Phosphor / ZnS) screen . . . . . . ①

> (b) In one type of c.r.o., the electrostatic deflection system consists of two parallel metal plates, each of length 2.0 cm, with a separation of 0.50 cm, as shown in Fig. 4.1.

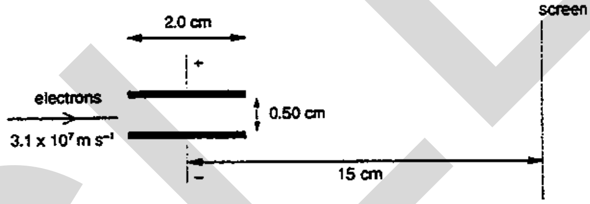


Fig. 4.1

> The centre of the plates is situated 15 cm from a screen. A potential difference of 80 V between the plates provides a uniform electric field in the region between the plates. Electrons of speed 3.1×10^7 m s^{-1} enter this region at right angles to the field. Calculate
> (i) the time taken for an electron to pass between the plates,
> (ii) the electric field strength between the plates,
> (iii) the force on an electron due to the electric field,
> (iv) the acceleration of the electron along the direction of the electric field,
> (v) the speed of the electron at right angles to its original direction of motion as it leaves the region between the plates. [9]

(b) (i) time = $s/v = (2.0 \times 10^{-2})/(3.1 \times 10^{7})$ = $\underline{6.45 \times 10^{-10}\ \text{s}}$ . . . ①

(ii) $E = V/d$ . . . . good start mark . . . . ①

$= 80 / 0.5 \times 10^{-2}$ = $\underline{1.6 \times 10^{4}\ \text{Vm}^{-1}}$ (NC^{-1}) . . . . ①

(iii) $F = qE$ . . . . good start mark . . . ①

$= 1.6 \times 10^{-19} \times 1.6 \times 10^{4}$ (ECF) = $\underline{2.56 \times 10^{-15}\ \text{N}}$ . . . . ①

(iv) $a = F/m$ . . . . good start mark . . . . ①

$= (2.56 \times 10^{-15})/(9.11 \times 10^{-31})$ (ECF) = $\underline{2.81 \times 10^{15}\ \text{ms}^{-2}}$ . . . . . ①

(v) $v = at$ or $v = u + at$ . . . . good start mark unless $u = 3.1 \times 10^{7}\ \text{ms}^{-1}$ ①

$= 2.81 \times 10^{15}$ (ECF) $\times 6.45 \times 10^{-10}$ (ECF) = $\underline{1.81 \times 10^{6}\ \text{ms}^{-1}}$ . . . . . . ①

(c) Hence, by considering your answer to (b)(v) and the original speed of the electron, estimate the deflection of the electron beam on the screen. [2]

(c) Deflection = $(v/V) \times 15$ Full credit for calculating time to screen (where distance = 14 OR 15 cm OR 16 cm) then $v_y \rightarrow 0.82$ cm

= <u>0.88 cm</u> . . . . (2)

allow ½ for $\tan\theta = v_y/v_x$ OR $\theta = 3.34°$

(d) (i) Figure 4.2 represents the front of the screen of the c.r.o.

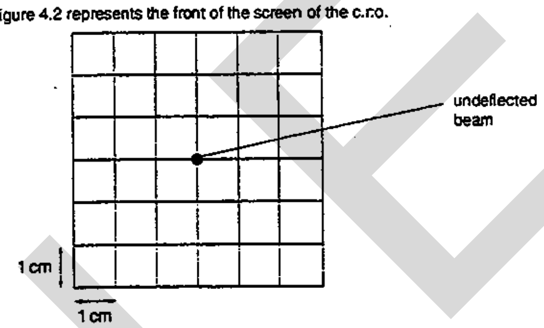


Fig. 4.2

Copy Fig. 4.2 on to your paper and mark on your diagram the position of the deflected beam of electrons.

(ii) Draw similar sketch diagrams to show the trace on the screen if the p.d. across the plates is

(1) varying sinusoidally with r.m.s. value 80 V,

(2) a half-wave rectified sinusoidal voltage of r.m.s. value 80 V. [5]

(d) (i) Correct deflection upwards . . . . (1)

(ii)(1) Vertical line, correctly centred . . . . (1)

length approx. 2.5 cm i.e. $2\sqrt{2}$ × length in (c) . . . . (1)

(2) Vertical line extending from centre upwards /downwards . . (1)

length one half that in (1) . . . . (1)

If it shows a time base { allow ½ for peak-to-peak in (ii)(1)
{ allow ½ for peak in (ii)(2)

5 (a) The wavelength of the monochromatic light from a lamp is to be determined by means of a double-slit interference experiment.

(i) Outline the experiment. State what measurements are taken and explain how these measurements are used to calculate the wavelength.

(ii) Give approximate values for the separation of the two slits and the width of one of these slits.

(iii) Explain briefly the parts played by diffraction and by interference in the production of the observed fringes. [10]

Do not accept laser

5 (a) (i) Diagram showing lamp, single & double slits, screen (or travelling microscope) . . . (1)

either indicate on diagram or define terms in equation { measure double slit - screen distance D, fringe separation x and distance between double slits d . . . . (1)

then $\lambda = xd/D$ . . . . (1)

Any further detail e.g. measure across several fringes & count number of fringes to get x . . . . (1)

(ii) Values: separation of slits, say 2mm - 0.2 mm . . . . . . (1)

slit width, say 0·5mm - 0.01mm . . . . (1)

(iii) Diffraction at slit(s) . . . . (1)

giving rise to an interference pattern . . . . (1)

where beams from slits overlap (not just "on screen") . . . . (1)

Further detail e.g. max where { path difference = $n\lambda$ / constructive interference . . . . (1)

or reference to minimum

(b) (i) State what is meant by the *photoelectric effect*.

(ii) Give three of the experimental observations associated with this effect. [5]

(b) (i) ejection of electrons from a surface . . . . (1)

when a photon / light / em wave } is incident on the surface (Do not accept "radiation") . . . . (1)

(ii) Observations; e.g. (maximum) energy of electron depends on frequency
OR: Range of energies up to a maximum

rate of ejection depends on intensity

no time delay

no electrons ejected below certain frequency

cut-off frequency depends on metal

1 mark each to MAX (3)

(c) (i) A lamp is placed above a metal surface which contains atoms of radius 2.0×10^{-10} m. Each electron in the metal requires a minimum energy of 3.2×10^{-19} J before it can be emitted from the metal surface, and it may be assumed that the electron can collect energy from a circular area which has a radius equal to that of the atom. The lamp provides energy at a rate of $0.40\ \mathrm{W\,m^{-2}}$ at the metal surface.

Estimate, on the basis of wave theory, the time required for an electron to collect sufficient energy for it to be emitted from the metal.

(ii) Comment on your answer to (c)(i). [5]

(c) (i) Area of collection = $\pi \times (2.0 \times 10^{-10})^2 = 1.26 \times 10^{-19}\ \mathrm{m^2}$ (wrong area - treat as A.E -1)

Energy collected per second = $0.40 \times 1.26 \times 10^{-19}$ J

$= 5.03 \times 10^{-20}$ J

Time required = $(3.2 \times 10^{-19})/(5.03 \times 10^{-20})$ = 6.4 s . . . . (3)

(ii)

Not instantaneous release, . . (1)

so wave theory inappropriate or light behaves as particle etc. (1)

6 (a) Explain how a physical property of a substance which varies with temperature may be used for the measurement of temperature. [2]

6 (a) Find value of property at two fixed temps. & unknown temp. . . (1)

Calculate temp. assuming linear change of property with temp.

OR formula quoted . . . . (1)

(b) (i) Describe the principal features of one type of liquid-in-glass thermometer.

(ii) Discuss the relative advantages and disadvantages of a liquid-in-glass thermometer and a resistance thermometer which may be used in the same temperature range. [7]

(b) (i) ("Large") bulb and capillary stem . . . . (1)

scale marked on stem . . . . (1)

reason given for any particular feature e.g. narrow bore . . (1)

(ii) Discussion of:
- linearity }
- thermal capacity } not to be awarded unless qualified
- physical size } as regards detail of thermometer
- speed of response }
- ease of use
- remote reading etc
- accuracy/precision
- cost
- robustness

For any factor, must make reference to both thermometers
Or state as "advantage" Or use comparative ("cheaper" etc).

1 mark for each factor, MAX (4)

(c) A resistance thermometer is placed in a bath of liquid at 0 °C and its resistance is found to be 3740 Ω. At 100 °C, its resistance is 210 Ω. The bath is now cooled until the resistance of the thermometer is 940 Ω.

(i) What is the temperature of the bath, as measured using the resistance thermometer?

(ii) The reading taken at the same time on a mercury-in-glass thermometer placed in the bath is 40 °C. Suggest a reason for the difference between this reading and the value calculated in (c)(i). [3]

(c) (i) $t = \dfrac{R_x - R_o}{R_{100} - R_o} \times 100$ good start mark (1)

½ for answer 21 °C

n.b. no back-credit to (a) allowed here

$t = \dfrac{940 - 3740}{210 - 3740} \times 100\,°C = \underline{79\,°C}$ . . . . (1)

(ii) Change in resistance with temperature is non-linear . . . (1)

Or: thermometers only agree at fixed points.

(d) (i) What do you understand by the absolute (thermodynamic) scale of temperature?

(ii) The pressure p of an ideal gas of density ρ is related to the mean square speed $<c^2>$ of its molecules by the expression

$$p = \tfrac{1}{3}\rho<c^2>.$$

Deduce an expression for the thermodynamic temperature T of the gas in terms of the mean kinetic energy $<E_K>$ of a molecule at that temperature. [5]

(d) (i) Theoretical temperature scale (Not depend on physical property OR) {OR "IDEAL GAS" SCALE} . . . . (1)

{with only one fixed point i.e. triple point of water (OR: TWO FIXED POINTS (0 K & TRIPLE POINT)) } . . . (1)
{OR at 0 K, atoms have zero energy / KE OR KELVIN TEMP ∝ KE

(ii) Derivation: $\rho = Nm/V$ and $pV = nRT$ . . . . (1)

for 1 mole, $pV = \tfrac{1}{3}Nm<c^2> = RT$ . . . . (1)

$R/N = k$ and $E_k = \tfrac{1}{2}m<c^2>$, so $E_k = \tfrac{3}{2}kT$ or $\tfrac{3}{2}\tfrac{R}{N}T$ (OR $T = \ldots$) . (1)

(allow 1/3 for a bald quote of the result)

Any fudging of algebra or n/N etc, max 1/3 for correct answer

(e) Explain, in terms of the energies of atoms, conditions under which it is possible to increase the total energy of the atoms of a substance without any change of temperature of that substance. [3]

(e) Only the potential energy can change . . . . (1)

{ Bond breaking
{Changing separation of atoms changes potential energy . . . . (1)

as in melting OR evaporating OR solidifying OR condensing . . (1)

1/3 for bald "change of state" or specific case

OPTION S

SOUND AND MUSIC

7 (a) (i) Distinguish between the *intensity* and the *loudness* of a sound.

(ii) Hence compare the loudness of two sound waves, each of intensity 0.01 W m^{-2}, having frequencies 3 kHz and 20 kHz. [6]

7 (a) (i) *Intensity*: (sound) power incident per unit area / Rate of flow of energy per unit area . . . . . . (1)

normal to the area . . . . (1)

Loudness: Subjective judgement (of intensity) . . . . . . (1)

which depends on individual OR pitch OR timbre (1)

(ii) 3 kHz: sound would be loud / very loud . . . . (1)

20 kHz: not heard OR beyond threshold of hearing . . . . (1)

allow ½ for "louder at 3kHz"

(b) A musical instrument may be tuned with the aid of a tuning fork. Explain, with the use of a diagram, how tuning of a named instrument is possible, even though the note produced by the tuned instrument does not have the same tone as the vibrating fork. [4]

(b) Tuning fork produces sinusoidal wave /single frequency . . . . . (1)

(Named) instrument produces fundamental & overtones . . . . . . (1)

Diagram to illustrate waveform . . . . (1)

Fundamental (or overtone) usually tuned to the fork . . . . (1)

(c) Briefly discuss the physical principles by which the following instruments may be tuned to a note from another instrument:

(i) a wood-wind instrument, such as a recorder,

(ii) a stringed instrument, such as a guitar. [5]

(c) (i) Alter length of tube . . . . (1)

because $f = c/2l$. or $l = \lambda/2$ or antinode at each end . (1)

detail of how length altered . . . . (1)

(ii) Alter tension . . . . (1)

because $f = \frac{1}{2l}\sqrt{\frac{T}{m}}$. or . $l = \lambda/2$ or "NODE AT BOTH ENDS" . . . (1)

8 (a) What is meant by a *stationary* wave? [2]

8 (a) Wave (which has modes/antimodes) along which there is no transfer of energy . . . . (1)

formed by interference of two waves travelling in

opposite directions <u>Or</u> incident and reflected waves . . . . (1)

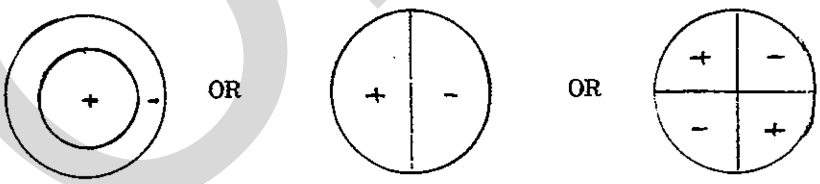
(b) A drum consists of a circular membrane (skin) which is kept under tension. (i) Describe the vibration of the membrane when it is vibrating at its fundamental frequency. (ii) Draw a diagram to illustrate one mode of vibration other than the fundamental mode. [4]

(b) (i) Max. amplitude at centre, zero amplitude at edge . . . (1)

only one antinode OR diagram with explanation . . . . . (1)

(ii)

cross-sectional diagrams acceptable



etc

. . . (2)

(allow 1/2 if nodal line marked but no +/-)

(c) Distinguish between the sounds produced by a drum when its circular skin is struck (i) gently at its centre, (ii) forcefully at its edge. [4]

(c) (i) Fundamental only OR very low intensity overtones . . . (1)

low amplitude fundamental OR not loud sound . . . . . (1)

(ii) Many (high frequency) overtones . . . . (1)

(very) loud sound produced . . . . (1)

(d) (i) Briefly describe a steel drum as used in a steel band.

(ii) In what way does the length of the drum affect the sounds produced? [5]

(d) (i) Top has areas with different shapes OR thicknesses OR tensions . . (1)

Frequency produced depends on area struck . . . . (1)

and position of striking on the area . . . . (1)

(ii) Longer drum, lower frequencies predominate . . . . . . (1)

so produces a "deeper" sound . . . . (1)

9 (a) (i) What do you understand by the *acoustic properties* of a room?

(ii) Discuss the importance of reflecting and of absorbing materials in determining acoustic properties. [6]

9 (a) (i) *acoustic properties*: Reverberation time . . . . ①

{areas of high/low intensity} . . . . . ①
{ distribution of sound energy }

(ii) Factors such as: Absorption to reduce *T*

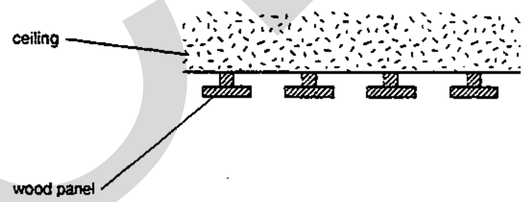
Reflection to increase *T*
<u>OR</u> cause dead spots

Effect must be { Focussing etc 1 mark for each to MAX ④
related to property {
Shape effects

(b) Explain why, on the basis of acoustic design,

(i) the seating in a theatre is usually cloth-covered rather than plain wood,

(ii) a ceiling covered with decorative wood panelling, as shown in Fig. 9.1, affects reverberation time.



Side view

Fig. 9.1

(iii) the double-glazed panel shown in Fig. 9.2 is a better sound insulator than that shown in Fig. 9.3.

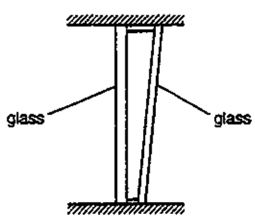


Fig. 9.2

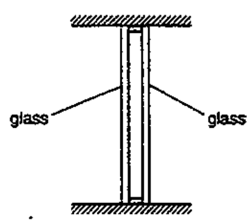


Fig. 9.3

[9]

(b) (i) acoustic properties depend on size (1)
& distribution of audience (1)
seats covered in cloth have approx. same absorption as a person (1)
so acoustics vary little with audience size (1)

(ii) Sound waves enter spaces between slots (1)
where the energy is absorbed (1)
so reducing reverberation time (1)

(iii) Less possibility of standing waves (1)
because spacing varies (1)
Less possibility of coupling (1)
because panes have different thicknesses (1)
and no different resonant frequencies (1)

1 each to MAX (9)

OPTION C

COMMUNICATIONS

10 (a) Write brief notes comparing a resistor and an inductor as circuit components. [3]

10 (a) Resistor dissipates power (1)

Inductor comes into effect only when current varying (1)

Inductor does not dissipate power (1) . 1 each to MAX (3)

Inductor stores energy (1)

(b) An inductor of inductance 5.0 mH is connected in series with a capacitor of capacitance 20 μF and a variable frequency sinusoidal supply, as shown in Fig. 10.1.

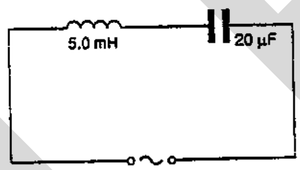


Fig. 10.1

(i) When the frequency of the supply is 250 Hz, the r.m.s. current in the circuit is 230 mA. Calculate

(1) the reactance of the inductor,

(2) the r.m.s. p.d. across the inductor,

(3) the r.m.s. p.d. across the capacitor. [5]

(ii) By reference to the current in the inductor and in the capacitor, state the phase of the p.d. across

(1) the inductor,

(2) the capacitor.

Hence, using the values of p.d. calculated in (i), calculate the r.m.s. p.d. across the supply. [4]

(iii) The frequency of the supply is now increased until the current in the circuit is a maximum. The supply voltage remains constant.

(1) At what frequency will this maximum current occur?

(2) What, in practice, will limit the size of this maximum current? [3]

(b) (i)(1) $X_L = 2\pi fL$ . . . . good start . . . (1)

$= 2\pi \times 250 \times 5 \times 10^{-3} = \underline{7.85\ \Omega}$ . . . . (1)

(2) $V_L = iX_L = 230 \times 10^{-3} \times 7.85 = \underline{1.81\ V}$ . . . . (1)

(3) $V_C = i/(2\pi fC)$ . . . . good start . . . (1)

$= (230 \times 10^{-3})/(2\pi \times 250 \times 20 \times 10^{-6}) = \underline{7.32\ V}$ . . (1)

(ii)(1) p.d. leads current by 90° (π/2) . . . . (1)

(2) p.d. lags behind current by 90° (π/2) . . . . (1)

[If phases incorrect in (1) and (2) allow ½ for correct consistent calculation of supply p.d.]

Supply p.d. = 7.32 - 1.81 = 5.51 V   allow ecf from (1) and (2). (2)

(iii)(1) $f = \frac{1}{2\pi\sqrt{LC}}$ . . . . good start . . . . (1)

"Resonant freq." bald 0/2.

$= \frac{1}{2\pi\sqrt{(5\times10^{-3}\times20\times10^{-6})}}$ = 503 Hz . . (1)

(2) Resistance (in the circuit) . . . . (1)

UNIVERSITY OF CAMBRIDGE
Local Examinations Syndicate
International Examinations

9240/03

GCE ADVANCED LEVEL EXAMINATIONS
MARKING SCHEME JUNE 1994

> 11 A sinusoidal signal of frequency 1.0 kHz and amplitude 0.50 V is to be transmitted by means of a carrier wave of frequency 100 MHz and amplitude 50 V. The carrier wave is to be either amplitude modulated (AM) or frequency modulated (FM).
>
> (a) What do you understand by a *carrier wave*? [2]

11 (a) Wave with frequency (much) higher than frequency of information

to be transmitted . . . . (1)

Clear, labelled diagram 2/2.

on which the information can be superposed . . . . (1)

> (b) Describe, giving numerical values where possible, the form of the carrier wave when it is
>
> (i) amplitude modulated,
>
> (ii) frequency modulated, the variation of the carrier wave frequency being at a rate of 8.0 kHz per volt of the modulating wave. [8]

(b) (i) Frequency constant . . . . (1)

amplitude varies between 49.5 V (1) and 50.5 V (1) . . (2)

50V → 51V or 49V → 50V allow ½

with a frequency of 1000 Hz. . . . . (1)

(ii) Amplitude constant . . . . (1)

frequency varies between 99.996 MHz (1) & 100.004 MHz (1) (2)

with a frequency of 1000 Hz (1)

> (c) (i) By reference to an amplitude modulated wave, explain what is meant by *bandwidth*.
>
> (ii) Explain the implications of bandwidth for radio reception. [5]

(c) (i) AM wave spectrum consists of carrier frequency + sidebands (1) or diagram

Good labelled diagram 3/3 MAX.

Bandwidth is range of frequencies in spectrum (1)

Diagram / further detail to illustrate (1)

(ii) Each broadcast requires a band of frequencies (1)

which must not overlap (1)

Ignore "noise"

Limits numbers of broadcasts in a waveband (1)

Bandwidth determines quality of sound broadcast (1)

1 mark for each point to MAX (5)

12 (a) What is meant by a *digital* signal? [2]

12 (a) Series of pulses . . . . (1)

having {discrete / two levels only} . . . . (1)

(b) The variation in light output from an optical fibre is sampled every millisecond and this output is converted into a 4-bit number, the most significant bit coming first. A series of consecutive 4-bit numbers is given below:

0001 0010 0100 0110 1010 1100 1010 0110 0010

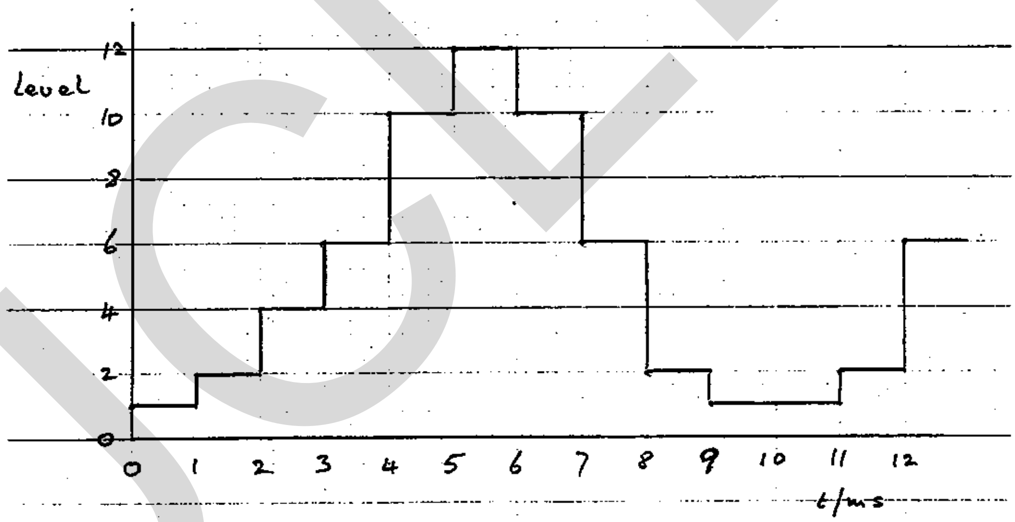
0001 0001 0010 0110

(i) Plot a graph showing the variation with time of the output.

(ii) Estimate the frequency at which the pulses of light are being transmitted along the fibre. [8]

(b) levels are 1 2 4 6 10 12 10 6 2

1 1 2 6



Graph: axes labelled . . . . (1)

easy scales to read . . . . (1)

Accept points at any 1 ms <u>intervals</u>

correct values -1 each error . . . . (3)

stepped line drawn <u>OR</u> acceptable smooth curve . . . (1)

(ii) Period 10 ms OR 9 ms

Frequency 100Hz OR 110 Hz . . . . (2)

(c) An optical fibre transmission system consists of a transmitter, an optical fibre of length 30 km and a receiver. The minimum detectable power leaving the fibre and entering the receiver is 1.0×10^{-8} W.

(i) Calculate the minimum power entering the fibre from the transmitter, given that the power P is related to the distance x along the fibre by the expression

$$P = P_0 e^{-ax},$$

where P_0 and a are constants and the value of a is $0.15\ \text{km}^{-1}$.

(ii) List two possible sources of power loss associated with an optical fibre. [5]

(c) (i) $P = P_0 e^{-ax}$

$1.0 \times 10^{-8} = P_0 e^{-0.15 \times 30}$

P_0 = <u>9.0×10^{-7} W</u> . . . . (3)

(ii) *Loss*: e.g. absorption

scatter /scratches — 1 mark each to MAX (2)

impurities

jointing etc.

OPTION M

MEDICAL PHYSICS

13 (a) Describe the mechanisms by which radiation causes damage to the cells of living matter. Hence explain the probable effects on a cell of such damage. [7]

13 (a) Radiation causes lesions /disruptions . . . . (1)

in DNA molecules . . . . or C – C bonds . . . . (1)

or causes ionisation of water molecules . . . . (1)

and ions react with DNA molecules . . . . (1)

Cell dies /death . . . . (1)

or is unable to replicate or shortens life expectancy . . . . (1)

or {replication is faulty i.e mutation . . . . (1)
{causes cancer
{changed cell function

(b) On the basis of your account in (a), explain why the extent of radiation damage depends on
(i) the type of radiation to which the cells are exposed,
(ii) the total dose of radiation,
(iii) the dose rate of the radiation. [8]

(b) (i) Damage depends on density of ionisation (per unit length) . (1)

and track density depends on type of radiation . . . . . . (1)

<u>hence</u> damage depends on type of radiation OR

discussion of relative effects of α, β, γ radiations . . (1)

charity 1/3 for α radiation causes more ionisation so more damage

(ii) Greater dose gives more ionisation per unit volume . . . (1)

so damage increases with increasing dose . . . . (1)

no reference to unit volume – max ½ .

(iii) Repair mechanism requires time to operate . . . . (1)

High dose rate, less time for repair . . . . (1)

(so) damage increases with increasing dose rate charity . . (1)

14 A student complains that he is not able to see clearly any object unless it is more than 75 cm from his eyes. The normal near point is taken as being 25 cm from the eye.

(a) (i) Name the student's eye defect.

(ii) State what is meant by the *near point* of the eye. [2]

14 (a) (i) Long sight / hypermetropia . . . . (1)

(ii) *Near point*: point closest to eye at which the eye can focus on an object . . . . (1)

allow "distance"

(b) (i) Copy Fig. 14.1 on to your answer sheet.

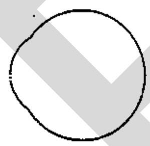


Fig. 14.1

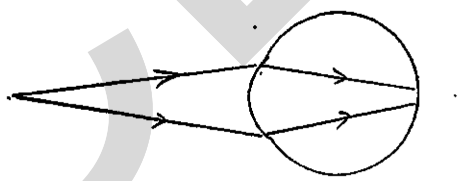
On this, draw a ray diagram to illustrate the paths of two rays of light from a point object at the normal near point, showing how they would reach the retina of the student's eye.

(ii) Draw a second ray diagram to show how a lens may be used to correct the defect for an object set at 25 cm from the eye.

(iii) Calculate the power of this correcting lens. [9]

(b) (i)

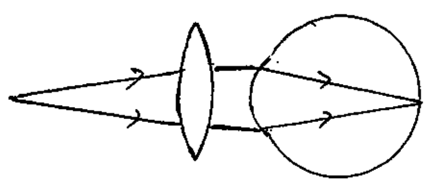
If eye lens included & refraction all at lens OR cornea 1/2
No arrowheads -1 (once only)



Rays diverge from near point to surface of eye . . . . . (1)

then converge to point behind retina . . . . (1)

(ii)



Convex lens used . . . . (1)

Correct refraction at lens and cornea . . . . (1)

to focus rays on to the retina . . . . (1)

concave lens used - 0/3

(b)(iii) $1/u + 1/v = 1/f$ . . . . (1)

and power = $1/f$ . . . . (1)

$1/(0.25) - 1/(0.75) = 1/f$

Power = 2.67 D . . . . (2)

incorrect sign in equation, max 2/4

> (c) Some animals are able to change the curvature of the cornea so that they are able to see clearly both in air and in water. Explain why a change in curvature is necessary. [4]

(c) Focussing depends to great extent on refraction at cornea . . (1)

$\Delta\mu$ for water-cornea boundary < $\Delta\mu$ for air cornea-boundary } . . (1)
OR $\mu_{air} < \mu_{water}$

(so) less refraction when in water . . . . (1)

and greater curvature in water to compensate . . . . (1)

> 15 (a) (i) What do you understand by *basal metabolic rate* (BMR)?
> (ii) Why is the BMR of a child greater than that of an adult? [3]

15 (a) (i) Rate of energy expenditure OR Rate per unit mass . . . . (1)
to maintain body {at rest / functions . . . . (1)

(ii) greater energy requirement for growth . . . . (1)
(OR greater surface area/mass ratio (only if BMR defined as "rate per unit mass")

> (b) A flight of stairs consists of 60 steps, each of height 20 cm. A man of mass 80 kg claims to be able to run up the steps in 5.5 s. Make suitable calculations so that you can decide whether the claim is justified. [5]

(b) Power = Energy/time . . . . good start . . . . . (1)

= mgh/t . . . . (1)

= (80 x 9.8 x 60 x 0.2)/5.5 = 1700 W . . . . (1)

This is unlikely . . . . (1)

unless he is an athlete because rate is usually about 1 kW . (1)

If calculates number of steps per second + comment, allow 2/5. Other 3 marks transferred to (c)(i)

> (c) When climbing the steps in (b), the body muscles are able to work with an efficiency of 17%.
> (i) Calculate the amount of energy wasted.
> (ii) Given that the specific latent heat of vaporisation of sweat is 2400 kJ kg^{-1}, what mass of sweat must evaporate in order to dissipate this waste energy? [4]

(c) (i) Energy wasted = mgh x (83/17)

= 45.9 kJ . . . . (2)

(ii) mass to be evaporated = (ECF) 45.9/2400 kg = 19.1 g . . . . . . (1)

> (d) Discuss why, in practice, the mass of sweat excreted is likely to differ from that calculated in (c)(ii). [3]

(d) Likely to be more . . . . (1)

because some sweat will not evaporate . . . . (1)

but some heat loss by convection OR respiration OR radiation . (1)

and this would reduce mass to be excreted . . . . (1)

If nonsense answer in (c)(ii), then charity 1/4 for comment on "nonsensical"

OPTION T

PHYSICS OF TRANSPORT

16 (a) Explain how a motive force is provided by a propeller. [4]

16 (a) Momentum of {fluid etc. / air} changed by propeller . . . . (1)

this change requires a force to be exerted on the air . . . . (1)

1st mark only if conservation of momentum

by Newton's 3rd law (OR Newton 2nd law for above) . . . . (1)

equal & opposite force exerted on the propeller . . . . (1)

(b) The propellers on an aircraft engine are of length r. Show that P, the kinetic energy delivered per unit time to the air behind the propeller, is given approximately by the expression

$$P = \tfrac{1}{2}\pi r^2 v^3 \rho,$$

where v is the speed of the air leaving the propeller and ρ is the density of air. For this part of the question, assume that the aircraft is stationary and that the air in front of the propeller is also stationary. [4]

(b) Volume of air moved per second = $\pi r^2 v$ . . . . (1)

Mass of air moved per second = $\pi r^2 v \rho$ . . . . (1)

no reference to time, maximum ¾

Kinetic energy = $\tfrac{1}{2}mv^2$ . . . . (1)

Hence K.E. per second = $\tfrac{1}{2}\pi r^2 v^3 \rho$ . . . . (1)

(c) On take-off, the instruments in the aircraft indicate that the engine, rotating at 45 revolutions per second, is providing a torque of 2.0×10^3 N m to the propeller. The blades of the propeller are 0.90 m long.

(i) Show that the power supplied to the propeller is 0.57 MW.

(ii) Calculate the speed of the air behind the propeller, assuming that all the power is supplied to the air and that the density of air is 1.3 kg m^{-3}. You may assume the formula given in (b).

(iii) Hence calculate the thrust provided by the propeller. [7]

(c) (i) Power = torque x angular speed . . . . good start . . (1)

requires evidence of substitution for 2/2

$= 2.0 \times 10^3 \times 45 \times 2\pi =$ 0.57 MW . . . . (2)

(ii) $0.57 \times 10^6 = \tfrac{1}{2} \times \pi \times 0.9^2 \times v^3 \times 1.3$

$r = 0.45$ m : −1

$v^3 = 3.45 \times 10^5$

$v =$ 70.1 ms^{-1} . . . . (2)

(iii) Power = thrust x speed . . . . good start . . . (1)

Thrust = $(0.57 \times 10^6)/70.1$ = 8130 N (ECF) . . . . (1)

Accept calculation based on change of momentum of air.

17 (a) An aircraft is flying horizontally with constant velocity. The forces A, B, C and D acting on the aircraft are illustrated in Fig. 17.1.

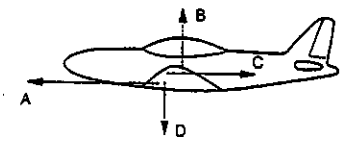


Fig. 17.1

(i) Identify each of the forces. [4]
(ii) Discuss the equilibrium of the aircraft under the action of these forces. [3]
(iii) Briefly discuss the purpose of the tailplane. [2]
(iv) Describe the effect on the path of the aircraft of a loss of engine power. [3]

17 (a) (i) A - thrust /propulsive force . . . . (1)

B - lift . . . . (1)

C - drag /air resistance . . . . (1)

D - weight . . . . (1)

(ii) A = C and B = D . . . . (1)

couples due to B & D and due to A & C . . . . (1)

must be equal and opposite . . . . (1)

"no net turning effect" ½

(iii) moment, couple / resultant force } on tailplane when at angle to airflow . (1)

returns tailplane in line with airflow,

maintaining stability . . . . (1)

(iv) resultant couple on plane . . . . (1)

makes aircraft go "nose-down" . . . . (1)

so aircraft glides downwards . . . . (1)

(b) A second design of aircraft has forces as illustrated in Fig. 17.2.

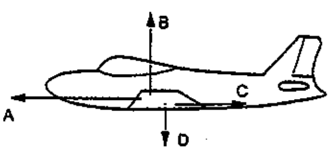


Fig. 17.2

Explain why this design is potentially more dangerous than that illustrated in Fig. 17.1. [3]

(b) If thrust is lost . . . . (1)

resultant couple makes aircraft go "nose-up" . . . . (1)

which could lead to a stall . . . . (1)

18 (a) When an object is placed in water, it experiences an upthrust.

(i) What is meant by an *upthrust*?

(ii) Explain how an object made of material which is more dense than water may be designed so that it will float in water. [4]

18 (a) (i) *Upthrust*: Force upwards (on object) . . . . (1)

due to weight of fluid displaced . . . . (1)
allow "water" or "liquid"

(ii) Object is hollow OR diagram to illustrate . . . . (1)

so that {density / weight} of water displaced > {mean density / weight} of material . (1)
OR =

(b) A boat may capsize if it is not stable.

(i) What is meant by *stability*?

(ii) Explain, with the aid of a diagram, how the stability of a partially submerged submarine is achieved. [6]

(b) (i) *Stability*: Object returns to its {original / equilibrium} position . . (1)

after being displaced . . . . (1)

(ii) Diagram showing: positions of centre of gravity }
centre of buoyancy } . . . (2)
not essential → {metacentre} }

force at centre of gravity . . . . (1)

force through C of B (& metacentre) . . . . (1)

For stability, metacentre must be above centre of gravity (1)
OR restoring couple rights boat.

(c) Discuss the problems involved in maintaining the stability of a submarine whether it is partially or totally submerged. [5]

(c) When submerged - tanks are flooded . . . . (1)

Position of centre of gravity rises . . . . (1)

Position of centre of buoyancy rises . . . . (1)

Must ensure metacentre remains above C of G . . . . } . . . . (1)
OR couple due to upthrust and weight must always right boat }

PHYSICS CONSTANTS

PHYSICS (9240 Papers 0, 1, 2, 3)
PHYSICAL SCIENCE (9272 Papers 1, 2, 3, 4)

speed of light in a vacuum,	c	$= 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of a vacuum,	μ_0	$= 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of a vacuum,	ϵ_0	$= 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$ $\approx (1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
electronic charge,	e	$= -1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant,	h	$= 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant,	u	$= 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron,	m_e	$= 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton,	m_p	$= 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant,	R	$= 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	L	$= 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant,	k	$= 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant,	G	$= 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall,	g	$= 9.81\,\mathrm{m\,s^{-2}}$

Marking Scheme for thermistor investigation.

Circuit set up (no help) 2

Limited help (i.e. **one** error only), deduct one mark.
Limited help means that the candidate has only made a small error. This could be connecting a meter in the wrong place in the circuit. If most of the circuit has been constructed by the supervisor then both marks are lost.

Do not penalise apparatus failures or accidental breakages.

Justification of sig. figs for R 1

Generally we will accept R to 3 or 4 s.f. if V and I are measured to 3 s.f..
If either V or I are measured to only 2 s.f., then accept R to either 2 or 3 s.f..

Stirring/Time allowed for thermistor to arrive at water temperature. 2

Allow one mark for 'place thermometer bulb near thermistor', or stirring.
The second mark is reserved for some indication of allowing time to elapse before the reading is taken.

Observations:

Readings 5

One mark for each set of readings taken, to a maximum of 5.
Deduct one mark if the interval between each temperature reading is below 10 ^oC or is more than 20^oC. Check R and 1/T. (-1) each error. Lg instead of ln, -1. Ln incorrect, -1.
Deduct one mark if temperature readings are not given in ^oC.

Check calculation for R. If R has been miscalculated see 'special cases' below.

Unit of 1/T (either in table or on graph) 1

Presentation of results:

General presentation (R0)	1
Column headings (R1)	1
Consistency (R2) (I, V, θ ONLY)	2
Significant figures (R3) ($\ln(1/R)$ and $1/T$)	2

Graphical work:

Axes (G1)	2
Plotting of points (G2)	2
Line of best fit (G3)	1
Gradient (G4)	2
Intercept (G5)	1

Analysis:

A1	$\ln(1/R) = -B/T + \ln A$	1
A2	Value of A (ignore sig. figs.)	1
A3	Value of B (ignore sig. figs.)	1
	(ECF for A and B from graph)	
A4	Unit of A stated as Ω^{-1} (dependent on correct value of A)	1
A5	Unit of B stated as Kelvin (dependent on correct value of B)	1

Special cases.

If a candidate misreads the values of current from the milliammeter (e.g. 2.4 A or 0.24 A instead of 24 mA), then mark as scheme, but deduct a mark from R4, and then ECF.

If the candidate calculates R incorrectly (e.g. by using R = VI or R = I/V) then −1.

Allow subsequent working (as ECF) for the value of A and value of B (with units).

Others will be discussed at the co-ordination meeting.

IF wrong variables have been plotted then G3 = G4 = G5 = A4 = A5 = 0.

IF $\ln(R) = B(1/T) - \ln A$, or correct alternatives, then ALLOW FULL CREDIT

Marking scheme for falling ball experiment

Basic procedure:

It must be clear from the account of the experiment, or from the recorded readings, that each of the procedures has been followed:

Distance between tapes **equal to** or **greater than** 0.5m (from candidates recorded value)	1
Use of set square and/or plumb-line to make tube vertical	1
Use of magnet to raise balls to repeat experiment	1
Suggested improvement (e.g. use longer tube/ensure constant temp./use light beams & electronic timer) Improvement must relate to the **use of apparatus**. Do not allow vague statements, such as 'I would do the experiment more carefully'.	1
Valid reason given for improvement	1
Any further good experimental procedure.	1

Measurements and calculations:

Repeated readings for time of fall We need at least **two** times of fall for at least one ball used by the candidate.	1
Averaged correctly (SF same as T, or one better)	1
Diameter of largest ball measured correctly (see value supplied by centre) Allow error of 0.02 mm.	1

Do not penalise lost balls/breakages/faulty equipment. Centres should have spare sets of apparatus available.

Observations:

Results 5
(Allow one mark for each set of readings to a maximum of five marks)
(If d not tabulated, only r, then -1) Ignore 4th SF in times.

Check one calculation for v and r^2. If either incorrect then see 'special cases' below.

Quality of results 1
(as judged by scatter of points on the graph)

Presentation of results:

General presentation (R0)	1
Column headings (R1)	1
Consistency (R2)	2
Significant figures (R3)	2

Graphical work:

Suitable graph (G0)	2
Axes (G1)	2
Plotting of points (G2)	2
Smooth curve (G3 - replace 'line' by 'curve' for (a) to (d))	1

Analysis:

Statement is not valid (points show curved trend)	1
Since graph of v against r^2 is not a straight line	1
OR	
Statement is valid (points must lie on a good straight line)	1
Since graph of v against r^2 is a straight line through the origin	1
OR	
Statement is valid for small balls only	1
Since graph of v against r^2 is a straight line through the origin for small balls	1

(For lg/lg treatment, then $1.9 < n < 2.1$ for both marks)

Special cases.

If a candidate misreads the values of time from the stopwatch (e.g. 0.456s instead of 45.6s), then mark as scheme, but deduct two marks from the 'readings' marks (and ECF).

If the candidate has only had time to perform the experiment using fewer than five balls, then mark as scheme, but deduct the last two marks for the analysis (e.g. if only three balls were used, then 2 marks would be lost for results, and 2 marks would be lost for analysis - penalty -4). Line of best fit mark lost also.

If v or r^2 has been calculated incorrectly, then both analysis marks are lost (since it will not be possible for candidates to establish a 'trend').

Presentation of results

R0 General presentation (one mark).

Any one of the following will lose this mark.

a) Generally scruffy presentation (e.g. *many* crossings out).

b) Presentation of results is poor (e.g. recorded readings 'go on for several pages' rather than being given in a table of results).

Ideally we would expect all the values to be in a single table. However, allow two tables to be given - one for measured values and one for calculated values.

If the table of results is split (perhaps the candidate has turned the page over), then allow if it can be followed easily. If you have to count the entries, or do some calculation to correlate the entries, then deduct this mark.

We will not penalise use of tippex if the candidates' work can be clearly seen (i.e. the previous working does not show through and make it difficult to read the new information).

Ignore any working that has been crossed out by the candidate.

R1 Column headings in table of results (one mark).

Any one of the following errors will lose this mark.

a) Column of results has no heading, or wrong heading

Allow use of conventional symbols, or abbreviations, if the meaning is clear (e.g. if the quantity being measured is potential difference, then allow the use of 'V', 'p.d.', or 'pot. diff.').

b) Units of quantity tabulated not given, or incorrect.
Allow units of quantities plotted on graph if omitted from table.

If the quantity being measured is current, then allow 'I/mA', 'I (mA)' and 'I in mA'. The quantity and/or the units may be written in words.

We will *not* allow 'I mA', or just 'mA' (with no quantity indicated), or $\frac{I}{mA}$.

Ignore units of logarithmic quantities. Ignore units in body of table.

R2 Consistency of presentation (two marks).

It is expected that all recorded raw readings will be given to the same degree of accuracy (e.g. if one length can be measured to the nearest mm then all lengths should be given to the nearest mm).

Deduct one mark each time an inconsistency is found in *each column* of results. (This means that if there are several inconsistencies in a single column of results then only one mark would be lost. There must be inconsistencies in two columns of results for both these marks to be lost)

Do not apply R2 to calculated values.

R3 Significant figures in calculated quantities (two marks).

Calculated quantities must be given to the same number (or one better) of significant figures (not decimal places) as the measured quantity of least accuracy.

Deduct one mark each time an inconsistency is found in *each* row of results. (This means that if there are several inconsistencies in a single row of results then only one mark would be lost. There must be inconsistencies in two rows of results for both these marks to be lost)

```
e.g  if V and I are given to 2 and 3 SF,
     then R must be given to 2 or 3 SF.

e.g  if length of fall in question 2 is given to 1 SF,
     then allow V to 1 or 2 SF.
```

Graphical work

G0 Plotting a suitable graph (two marks).

These two marks can be awarded if the candidate plots a graph from which the required result can be obtained. If an unsuitable graph is plotted, then candidates could possibly score all the marks **G1** to **G5**, but would get no credit for any analysis that follows.

G1 Axes (two marks).

Any one of the following errors will lose a mark.
Two or more errors will lose two marks.
The criteria apply to one axis. If both axes or scales are at fault, then both marks are lost. The 'axes mark' must not fall below zero.

a) An unlabelled axis., or wrongly labelled axis.

b) Unconventional scale direction.

c) Graph occupies less than half the page in either direction (i.e. if a scale can be doubled, then -1. If both scales can be doubled then -2).

d) Awkward scale markings (e.g. 10 small squares on the graph paper corresponds to a labelling of 3).

e) More than 3 large squares between scale markings.

f) Holes in the scale (e.g. scale markings of 0, 1, 3, 4, 5)

g) Scale is too short (i.e. the scale should be such that all the readings can be plotted on the graph).

Do not penalise axes lines that have been drawn in thick pencil, or if they have been omitted completely.

Allow graph paper to be attached to graph if done well.

G2 Plotting of points (two marks).

Check 2 plotted points that are "off trend." Circle and ✓ if correct. If incorrect plot found, check all plotted points.
Any one of the following errors will lose a mark.
Two or more errors will lose two marks.

a) Misplot (i.e. the plot is out by one small square, or greater. Could be due to rounding of readings or scale reading error). A second misplot loses both marks.

b) Omitted plot. Two omitted plots loses two marks.

c) Edited plots (plotted point erased because it is not close to the line of best fit). Two edited plots loses two marks.

d) Very thick plots (half square thickness or greater).

e) Very scruffy alterations to plotted points.

A point which cannot be seen (e.g. fine dot not ringed, or line obscures the plot) will lose one mark. Two points that cannot be seen will lose two marks.

All plotted points <u>must</u> be on the squared paper, and not in the margin areas.

If plotted values are not given then both plotting marks are lost.

G3 Line of best fit (one mark).

Any of the following errors will lose this mark.

a) Hairy/wobbly/bad join/point-to-point/kinked line, or more than one line drawn.

b) Line drawn is not one of best fit. The line should have been drawn so that there is a reasonable balance of points about the line.

c) Very thick line (greater than half square thickness).

d) Line drawn from fewer than five readings plotted (i.e. failure to plot data from all five observations will lose this mark).

If less than five observations have been made, then the line of best fit mark will be lost.

e) Straight line is drawn through points showing a 'curved trend'.

G4 Measurement of gradient (two marks).

Any one of the following will lose a mark. Two errors will lose both marks. Allow ECF in subsequent working if the gradient has been calculated incorrectly.

a) Hypotenuse in the triangle used to find the gradient of the line is less than half the length of the line drawn by the candidate.

b) Gradient calculated as 'increase in x/increase in y'.

c) 'Δx' inaccurate by one small square, or greater.

d) 'Δy' inaccurate by one small square, or greater.

If there is no working shown when the gradient is calculated (i.e. the vertices of the triangle are not given, or the triangle is not drawn on the graph paper), then deduct one mark.
If plots are used which are taken from the table of results or are not points on the line, then deduct one mark.

G5 **Measurement of intercept (one mark).**

Any one of the following errors will lose this mark.
Allow ECF in subsequent working if the intercept has been read incorrectly.

a) Value is misread.
Allow value to be given to the nearest 'small-square'.

b) Value is read from the wrong axis.

c) Candidates work has obscured the value of the intercept.

Intercept <u>must</u> be on the graph grid (not in the margin area).

Allow ECF using the candidate's gradient value

if uses $y = mx + c$ to calculate the intercept