SCOTTISH QUALIFICATIONS AUTHORITY

2001 Physics
Higher
Finalised Marking Instructions

Strictly Confidential

These instructions are **strictly confidential** and, in common with the scripts entrusted to you for marking, they must never form the subject of remark of any kind, except to Scottish Qualifications Authority staff. Similarly, the contents of these instructions must not be copied, lent or divulged in any way now, or at any future time, to any other persons or body.

Markers' Meeting

You should use the time before the meeting to make yourself familiar with the question paper, instructions and any scripts which you have received. Do **not** undertake any final approach to marking until **after** the meeting. Please note any points of difficulty for discussion at the meeting.

Note: These instructions can be considered as final only after the markers' meeting when the full marking team has had an opportunity to discuss and finalise the document in the light of a wider range of candidates' responses.

Marking

The utmost care must be taken when entering and totalling marks. Where appropriate, all summations for totals must be carefully checked and confirmed.

Where a candidate has scored zero marks for any question attempted, "0" should be entered against the answer.

Recording of Marks

The mark for each **question**, where appropriate, should be entered **either** on the grid provided on the back page of the answer book, **or** in the case of question/answer books, on the grid (if provided) on the last page of the book. Where papers assess more than one element, care must be taken to ensure that marks are entered in the correct column.

The **Total** mark for each paper or element should be entered (in red ink) in the box provided in the top-right corner of the front cover of the answer book (or question/answer book).

Always enter the **Total** mark as a **whole number**, where necessary by the process of rounding up.

The transcription of marks, within booklets and to the Mark Sheet, should always be checked.

4 June 2001

2001 Physics Higher
Section A
Finalised Marking Instructions

1.	A	11.	C
2.	A	12.	E
3.	E	13.	D
4.	C	14.	E
5.	D	15.	D
6.	C	16.	D
7.	B	17.	C
8.	B	18.	B
9.	D	19.	B
10.	A	20.	E

HIGHER LEVEL PHYSICS

INSTRUCTIONS

1. The marks awarded for each part as indicated in the marking scheme should be recorded in the right hand inner margin. The total mark awarded for each question should be recorded, in the outer margin, at the start of the answer for that question.

2. The fine division of marks shown in the marking scheme may be recorded within the body of the script beside the candidate's answer. If such marks are shown they must total to the mark in the inner margin.

3. Negative marks or marks to be subtracted should not be shown. An inverted vee may be used instead.

4. The number recorded should always be the mark awarded.
The number out of which a mark is scored SHOULD NEVER BE SHOWN AS A DENOMINATOR (½ will always mean one half mark and never 1 out of 2)

5. Make sure that "6" can be distinguished from "0" and a "1" from a "7"

6. Fractional marks, if awarded to individual questions, should be recorded in the right hand inner margin of the script.

7. Where square ruled paper is enclosed inside answer books it should be clearly indicated that this item has been considered. Marks should be transferred to the script inner margin and marked "G".

8. The individual question totals that are transferred to the grid on the cover of the answer book should be those shown in the outer margins of the answer book.

9. Fractional marks if awarded to individual questions should be recorded in the grid. The total, including fractional marks, should be shown at the bottom of the grid.

10. The total script mark, if necessary rounded up to the next whole number, should be transferred to the box at the top of the front page of the script.

11. Check all additions carefully by summing marks from the first page to the last page of the script then from the last to the first page.

GENERAL INSTRUCTIONS

a) No marks allowed for a description of the wrong experiment or one which would not work. Full marks should be given for information conveyed directly by a sketch.

b) Surplus answers: where a number of reasons, examples etc are asked for and a candidate gives more than the required number then wrong answers may be treated as negative and cancel out part of the previous answer.

c) Full marks should be given for a correct answer to a numerical problem even if the steps are not shown explicitly. The part marks shown in the scheme are for use in marking partially correct answers.

d) Where 1 mark is shown for the final answer to a numerical problem ½ mark may be deducted for an incorrect unit.

e) Where a final answer to a numerical problem is given in the form 3^{-6} instead of $3\text{x}10^{-6}$ then deduct ½ mark.

f) Deduct ½ mark if an answer is wrong because of an arithmetical slip.

g) No marks may be awarded in a part question after the application of a wrong physics principle (wrong formula, wrong substitution) unless specifically allowed for in the marking scheme.

h) In certain situations, a wrong answer to a part of a question can be carried forward within that part of the question. This would incur no further penalty provided that it is used correctly. Such situations are indicated by a horizontal dotted line in the marking instructions.
Wrong answers can always be carried forward to the next part of the question, over a solid line, without penalty.

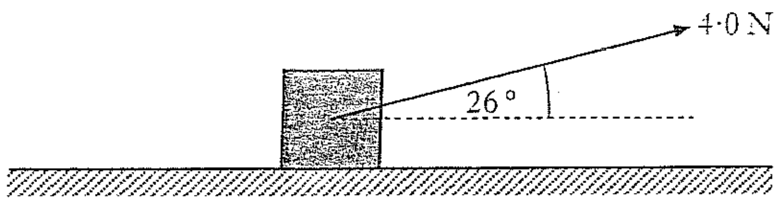
i) Where a triangle type "relationship" is written down and then not used or used incorrectly then any partial ½ mark for a formula should not be awarded.

j) In numerical calculations, if the correct answer is given then coverted wrongly in the last line to another multiple/submultiple of the correct unit then deduct ½ mark.

SECTION B

Write your answers to questions 21 to 29 in the answer book. *Marks*

21. (*a*) A box of mass 18 kg is at rest on a horizontal frictionless surface.
A force of 4·0 N is applied to the box at an angle of 26° to the horizontal.

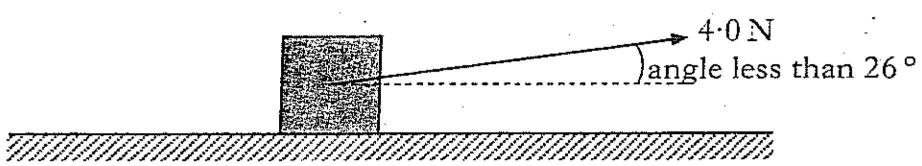


(i) Show that the horizontal component of this force is 3·6 N.

(ii) Calculate the acceleration of the box along the horizontal surface.

(iii) Calculate the horizontal distance travelled by the box in a time of 7·0 s. **5**

(*b*) The box is replaced at rest at its starting position.
The force of 4·0 N is now applied to the box at an angle of less than 26° to the horizontal.



The force is applied for a time of 7·0 s as before.

How does the distance travelled by the box compare with your answer to part (*a*)(iii)?

You must justify your answer. **2**

(7)

[Turn over

HIGHER LEVEL PHYSICS 2001 SECTION B
Maximum of (-0.5) per question for significant figures

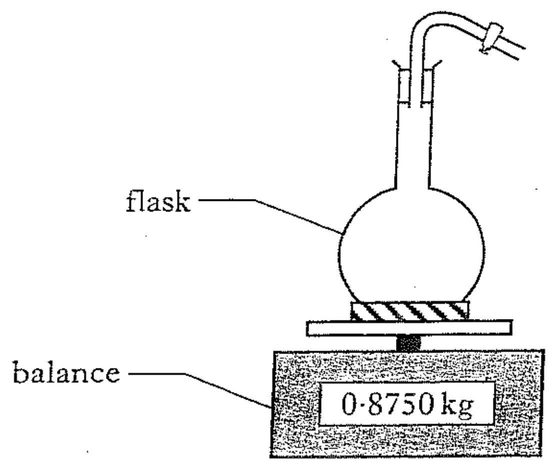
Answer and Mark Allocation	Notes	Inner Margin	Outer Margin
21. (a) (i) $F_h = F\cos\theta$ $\{\frac{1}{2}\}$ $= 4.0\cos 26°$ $\{\frac{1}{2}\}$ $= 3.59$ N / 3.6 N	must have both nos. in this line for $\{\frac{1}{2}\}$ Deduct $\{\frac{1}{2}\}$ if 3.59/3.6 missing	1	7
(ii) $a = F/m$ $\{\frac{1}{2}\}$ $= 3.6/18$ $\{\frac{1}{2}\}$ $= 0.2$ m s^{-2} $\{1\}$	deduct $\{\frac{1}{2}\}$ if wrong or missing unit	2	
(iii) $s = ut + \frac{1}{2}at^2$ $\{\frac{1}{2}\}$ $= 0.5 \times 0.2 \times 7^2$ $\{\frac{1}{2}\}$ $= 4.9$ m $\{1\}$	$v = u + at$ $= 0 + 0.2 \times 7$ $= 1.4$ m s^{-1} $\frac{1}{2}$ for both formulae $s = \frac{u+v}{2}t$ $= \frac{1.4}{2} \times 7$ ($\frac{1}{2}$) $= 4.9$ m (1)	2•	
(b) The distance travelled will be greater $\{1\}$ because horiz. unbalanced (component) of force is greater $\{\frac{1}{2}\}$, causing the acceleration to be greater $\{\frac{1}{2}\}$ {there **must** be an attempt at a reason (and not WP) to get first mark}	~~this answer must be consistent with (a)(i) to get the marks,~~ ~~i.e. if sin θ used in (i) then this answer must be opposite way round to the correct answer.~~ Accept calculation without final statement.	2•+	

[X069/301]

Page 3

Marks

22. (a) In an experiment to find the density of air, a student first measures the mass of a flask full of air as shown below.



The air is now removed from the flask and the mass of the evacuated flask measured.

This procedure is repeated a number of times and the following table of measurements is obtained.

	Experiment number					
	1	2	3	4	5	6
Mass of flask and air/kg	0·8750	0·8762	0·8748	0·8755	0·8760	0·8757
Mass of evacuated flask/kg	0·8722	0·8736	0·8721	0·8728	0·8738	0·8732
Mass of air removed/kg						

The volume of the flask is measured as $2{\cdot}0 \times 10^{-3}$ m^3.

(i) Copy and complete the **bottom row** of the table.

(ii) Calculate the mean mass of air removed from the flask **and** the random uncertainty in this mean. Express the mean mass and the random uncertainty in kilograms.

(iii) Use these measurements to calculate the density of air.

(iv) Another student carries out the same experiment using a flask of larger volume.

Explain why this is a better design for the experiment. 6

HIGHER LEVEL PHYSICS 2001 **SECTION B**

Maximum of (-0.5) per question for significant figures

Answer and Mark Allocation	Notes	Inner Margin	Outer Margin
22. (a) (i) Mass of air removed (kg): 0.0028, 0.0026, 0.0027, 0.0027, 0.0022, 0.0025	{1} for all correct (deduct {$\frac{1}{2}$} for each wrong/missing answer to a max. of {1} mark deducted)	1•	11
(ii) mean mass = (0.0028 + 0.0026 + 0.0027 + 0.0027 + 0.0022 + 0.0025)/6 = 0.0155/6 {$\frac{1}{2}$} for either of these two lines = 0.0026 {$\frac{1}{2}$} (kg) random uncertainty = (0.0028 - 0.0022)/6 {$\frac{1}{2}$} = 0.0001 {$\frac{1}{2}$} (kg)	Accept 0.00258, 0.002583 ($\frac{1}{2}$) for $\frac{\text{max - min}}{\text{number}}$ or $\frac{\text{range}}{\text{no. of results}}$	2•	
(iii) density = mass/volume {$\frac{1}{2}$} = 0.0026/2.0 x 10-3 {$\frac{1}{2}$} = 1.3 kgm^{-3} {1}	must use mean mass from (ii) ignore comments on random error	2	
(iv) greater mass difference {$\frac{1}{2}$} or mass of air => mass of air found more accurately/ more accurate calc^n of (density) {$\frac{1}{2}$} **OR** improved accuracy in volume {$\frac{1}{2}$} =>more accurate calculation of (density) {$\frac{1}{2}$}	Alternative: temp. more likely to be const. {$\frac{1}{2}$} => more accurate ~~mass~~/density {$\frac{1}{2}$} N.B. "rand. uncert. smaller" is wrong.	1•	
	Could get 2 x ½ for two of following • greater mass difference • improved accuracy in volume • temperature more likely to be constant One of above and improved accuracy in calculation of density (1) Measurements larger so more accurate (0)		

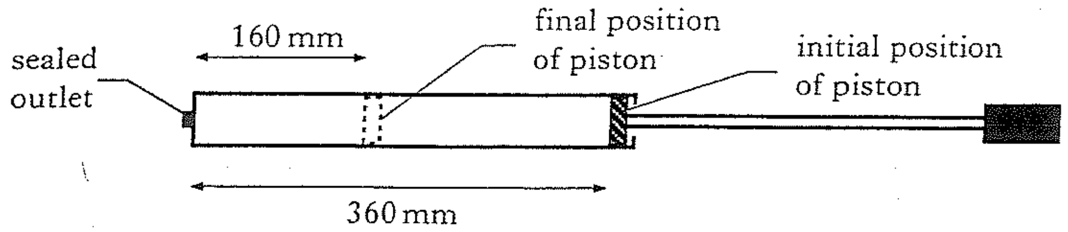
22. **(continued)**

Marks

(*b*) The cylinder of a bicycle pump has a length of 360 mm as shown in the diagram.

The outlet of the pump is sealed.

The piston is pushed inwards until it is 160 mm from the outlet.



The initial pressure of the air in the pump is $1{\cdot}0 \times 10^5$ Pa.

(i) Assuming that the temperature of the air trapped in the cylinder remains constant, calculate the final pressure of the trapped air.

(ii) State one other assumption you have made for this calculation.

(iii) Use the kinetic model to explain what happens to the pressure of the trapped air as its volume decreases. **5**

(11)

[Turn over

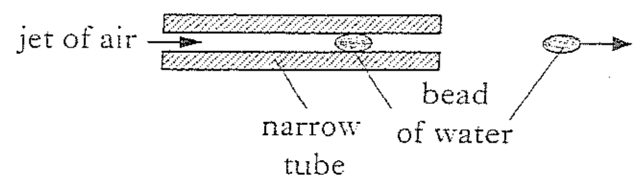
HIGHER LEVEL PHYSICS 2001 SECTION B
Maximum of (-0.5) per question for significant figures

Answer and Mark Allocation	Notes	Inner Margin	Outer Margin
22. (b) (i) $P_1V_1 = P_2V_2$ $\{\frac{1}{2}\}$ $\Rightarrow 1.0 \times 10^5 \times 360 = P_2 \times 160$ $\{\frac{1}{2}\}$ $\Rightarrow P_2 = 2.25 \times 10^5$ Pa {1}		2	
(ii) mass is constant {1} [or no molecules/gas escape(s)] [or diameter of cylinder constant] [or piston is airtight	or cross-sectional area constant volume $\propto$ length	1•	
(iii) V decreasing => more frequent collisions $\{\frac{1}{2}\}$ with the walls $\{\frac{1}{2}\}$ or piston => greater force $\{\frac{1}{2}\}$ => greater pressure $\{\frac{1}{2}\}$	~~independent~~ ~~$\{\frac{1}{2}\}$s (apart from last line)~~ O.K. if answered "other way round" but last $\{\frac{1}{2}\}$ only got if say "P actually increases since things happen other way round". Alternative: V decreasing, with walls ($\frac{1}{2}$) => more collisions per second $\{\frac{1}{2}\}$ => greater Δ momentum per second $\{\frac{1}{2}\}$ => greater force $\{\frac{1}{2}\}$ => greater pressure $\{\frac{1}{2}\}$	2	

Marks

23. Beads of liquid moving at high speed are used to move threads in modern weaving machines.

(a) In one design of machine, beads of water are accelerated by jets of air as shown in the diagram.



Each bead has a mass of $2{\cdot}5 \times 10^{-5}$ kg.

When designing the machine, it was estimated that each bead of water would start from rest and experience a constant unbalanced force of 0·5 N for a time of 3·0 ms.

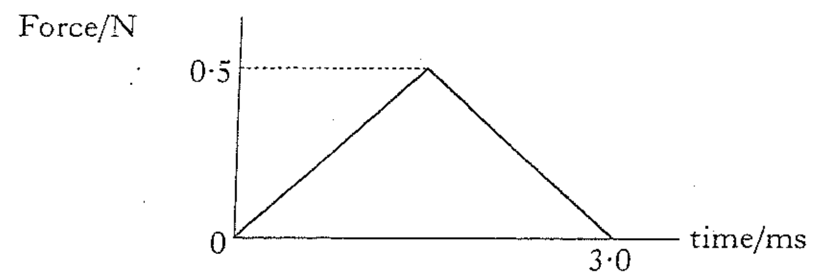
(i) Calculate:

(A) the impulse on a bead of water;

(B) the speed of the bead as it emerges from the tube.

(ii) In practice the force on a bead varies.

The following graph shows how the actual unbalanced force exerted on each bead of water varies with time.



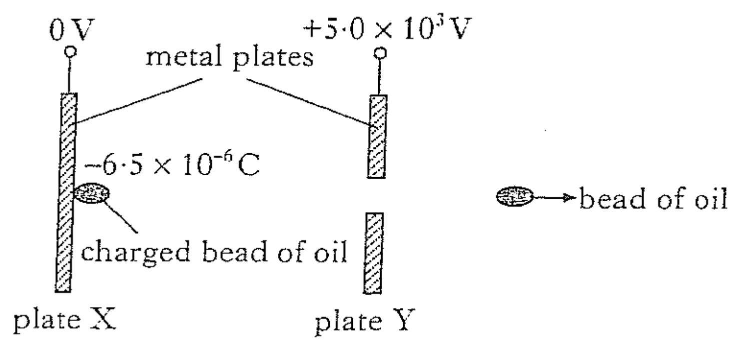
Use information from this graph to show that the bead leaves the tube with a speed equal to half of the value calculated in part (i)(B). 6

(b) Another design of machine uses beads of oil and two metal plates X and Y.

The potential difference between these plates is $5{\cdot}0 \times 10^3$ V.

Each bead of oil has a mass of $4{\cdot}0 \times 10^{-5}$ kg and is given a negative charge of $6{\cdot}5 \times 10^{-6}$ C.

The bead accelerates from rest at plate X and passes through a hole in plate Y.



Neglecting air friction, calculate the speed of the bead at plate Y. 3

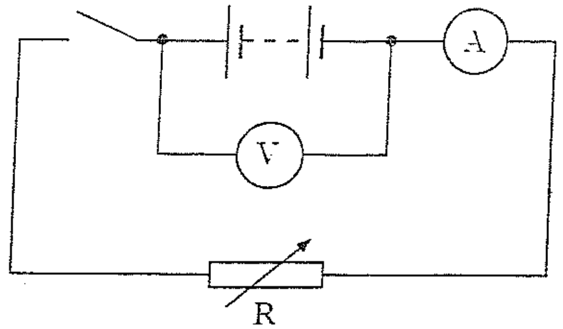
(9)

Maximum of (-0.5) per question for significant figures

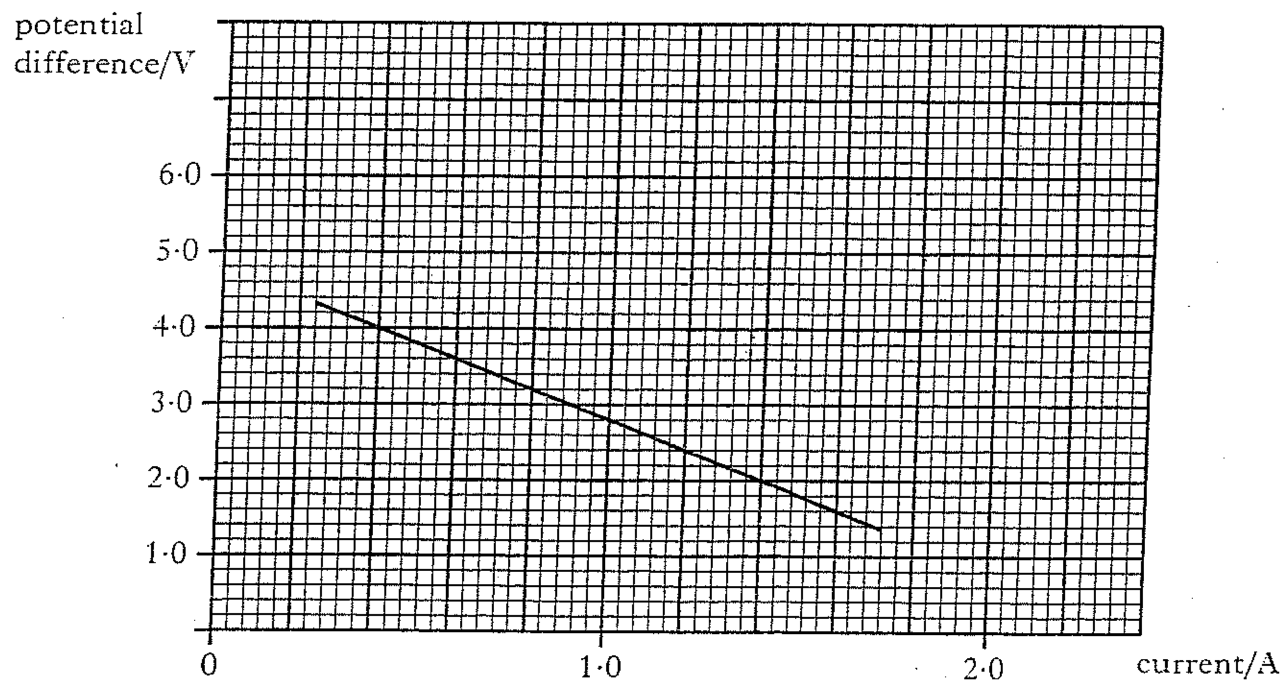
Answer and Mark Allocation	Notes	Inner Margin	Outer Margin
23. (a) (i) (A) impulse = Ft $\{\frac{1}{2}\}$ $= 0.5 \times 3.0 \times 10^{-3}\{\frac{1}{2}\}$ $= 1.5 \times 10^{-3}$ Ns (or kg m s^{-1}) {1}	$a = \frac{F}{m} = \frac{0.5}{2.5\times10^{-5}} = 20{,}000$ $\Delta p = m(v-u) = mat = 2.5\times10^{-5}\times2\times10^{4}\times3\times10^{-3} = 1.5\times10^{-3}$ Ns if 10^{-3} missing, unit error => lose $\{\frac{1}{2}\}$	2	9
(B) mv - mu = Ft $\{\frac{1}{2}\}$ $=> 2.5 \times 10^{-5} \times v = 0.5 \times 3.0 \times 10^{-3}\{\frac{1}{2}\}$ $(=> v = 1.5 \times 10^{-3}/2.5 \times 10^{-5})$ $=> v = 60$ ms^{-1} {1}	Could use, Δv = impulse/mass $\{\frac{1}{2}\}$ $= 1.5 \times 10^{-3}/2.5 \times 10^{-5}\{\frac{1}{2}\}$ = 60 m s^{-1} {1} Note: accept $F = \frac{mv}{t}$ but **not** $\frac{mu}{t}$ i.e.formula $\{\frac{1}{2}\}$ subst. $\{\frac{1}{2}\}$, answer {1} v = 0 is WP giving max of $\{\frac{1}{2}\}$ for formula	2•+	
(a)(ii) impulse = area under graph $\{\frac{1}{2}\}$ $= \frac{1}{2} \times 0.5 \times 3.0 \times 10^{-3}$ **OR** 7.5×10^{-4} $\{\frac{1}{2}\}$ this is **half** the impulse in part (i) $\{\frac{1}{2}\}$ ~~thus speed is half~~ $\{\frac{1}{2}\}$ and $v = \frac{\text{impulse}}{\text{mass}}$ $(\frac{1}{2})$ (or full recalculation method for v as in (B))	Alternative 1: av. force is const at half max. force $\{\frac{1}{2}\}$ => av. force = 0.25 (N) $\{\frac{1}{2}\}$ $=> v = 0.25 \times 3 \times 10^{-3}/2.5 \times 10^{-5}\{\frac{1}{2}\}$ $= 30\{\frac{1}{2}\}$ (m s^{-1}) Alternative 2: triangle has half area of rectangle $\{\frac{1}{2}\}$ (for the same time $\{\frac{1}{2}\}$) since impulse = area under graph $\{\frac{1}{2}\}$ impulse must be half $\{\frac{1}{2}\}$ $v = \frac{\text{impulse}}{\text{mass}}$ $(\frac{1}{2})$	2•+	
(b) $W = QV\{\frac{1}{2}\}$ $= 6.5 \times 10^{-6} \times 5000 \{\frac{1}{2}\}$ $= 0.0325$ $E_k = \frac{1}{2} mv^2 \{\frac{1}{2}\} = \{\frac{1}{2}\}$ QV $\{v = \sqrt{(2 \times 6.5 \times 10^{-6} \times 5000)/4.0 \times 10^{-5}}\}$ $(\frac{1}{2})$ $=> v = 40.3$ m s^{-1} {1}	Summary: $\{\frac{1}{2}\}$ for **each** formula; QV and $\frac{1}{2}$ mv^2 $\{\frac{1}{2}\}$ for full substitution $\{\frac{1}{2}\}$ for equating {1} for final answer If negative sign (for charge) used in formula, there is no penalty if it is 'dropped' in middle of calculation; BUT stop marking if -ve is inside square root (i.e. max of {2})	3•+	

Marks

24. (a) The following circuit is used to measure the e.m.f. and the internal resistance of a battery.



Readings of current and potential difference from this circuit are used to produce the following graph.



Use information from the graph to find:

(i) the e.m.f. of the battery, in volts;

(ii) the internal resistance of the battery. **3**

(b) A car battery has an e.m.f. of 12 V and an internal resistance of 0·050 Ω.

(i) Calculate the short circuit current for this battery.

(ii) The battery is now connected in series with a lamp. The resistance of the lamp is 2·5 Ω. Calculate the power dissipated in the lamp. **5**

(8)

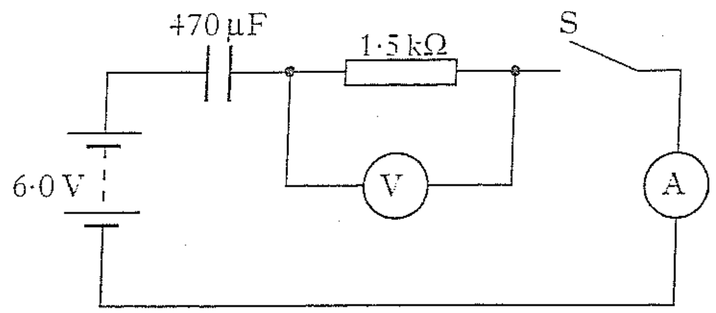
[Turn over

HIGHER LEVEL PHYSICS 2001 **SECTION B**
Maximum of (-0.5) per question for significant figures

Answer and Mark Allocation	Notes	Inner Margin	Outer Margin
24. (a) (i) emf = y-intercept $\{\frac{1}{2}\}$ = 4.8 $\{\frac{1}{2}\}$ (V) {tolerance is ±0.1 V}	"bare" 4.8 gets {1}	1•	8
(ii) r = - gradient $\{\frac{1}{2}\}$ = - (2.0 - 4.0)/(1.4 - 0.4) $\{\frac{1}{2}\}$ (or other corresponding points) = 2.0 Ω {1} (±0.2 Ω) r = grad. => − 2.0 Ω gets{1.5} if corrected to + 2.0 Ω gets {2}(bad form)	r = lost volts/I $\{\frac{1}{2}\}$ = subst. $\{\frac{1}{2}\}$ = 2.0 Ω {1} Alternative for (i) and (ii): E = V + Ir $\{\frac{1}{2}\}$ = 4 + 0.4r = 2 + 1.4r => 1.4r + 2 = 0.4r + 4 $\{\frac{1}{2}\}$ => r = 2 Ω {1} E = 4 + 0.4 x 2 $\{\frac{1}{2}\}$ = 4.8 (V) $\{\frac{1}{2}\}$	2•	
(b) (i) I_{max} = e.m.f./r_{int} $\{\frac{1}{2}\}$ = 12/0.05 $\{\frac{1}{2}\}$ = 240 A {1}	or E/r (or V/r, but stop marking if wrong subst.) V/R if value for e.m.f. used from (a) => max $\{\frac{1}{2}\}$ for formula	2•	
(ii) P = V^2/R $\{\frac{1}{2}\}$ {1} = $(11.76)^2$/2.5 $\{\frac{1}{2}\}$ = 55.3 W {1} (or 55.4) 55w [note - 12^2/2.5 = 57.6 W is WP, but can get $\{\frac{1}{2}\}$ for (implied) formula]	Alternative 1: P = VI $\{\frac{1}{2}\}$ = (11.76 x 4.706) {1} for either substitution; {0.5} for other = 55.4W {1} Alternative 2: P = I^2R $\{\frac{1}{2}\}$ {1} = $(4.706)^2$ x 2.5 $\{\frac{1}{2}\}$ = 55.4W {1}	3•+	
	(1) P = VI = 4.8 x 11.76 ($\frac{1}{2}$) = 56.4 W wrong I = V/R = 12/2.5 = 4.8 V =		

Marks

25. (*a*) The following diagram shows a circuit that is used to investigate the charging of a capacitor.



The capacitor is initially uncharged.

The capacitor has a capacitance of 470 µF and the resistor has a resistance of 1·5 kΩ.

The battery has an e.m.f. of 6·0 V and negligible internal resistance.

(i) Switch S is now closed. What is the initial current in the circuit?

(ii) How much energy is stored in the capacitor when it is fully charged?

(iii) What change could be made to this circuit to ensure that the **same** capacitor stores **more** energy? **5**

(*b*) A capacitor is used to provide the energy for an electronic flash in a camera.

When the flash is fired, $6{\cdot}35 \times 10^{-3}$ J of the stored energy is emitted as light.

The mean value of the frequency of photons of light from the flash is $5{\cdot}80 \times 10^{14}$ Hz.

Calculate the number of photons emitted in each flash of light. **3**

(8)

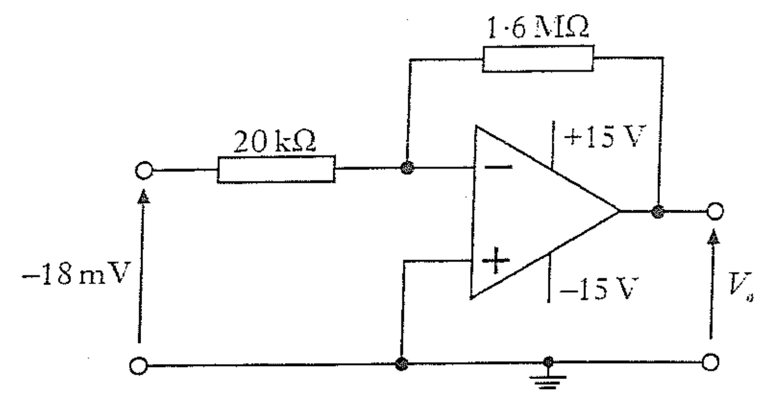
HIGHER LEVEL PHYSICS 2001 SECTION B

Maximum of (-0.5) per question for significant figures

Answer and Mark Allocation	Notes	Inner Margin	Outer Margin
25. (a) (i) $I = V/R$ $\{\frac{1}{2}\}$ $= 6.0/1500$ $\{\frac{1}{2}\}$ $= 4.0 \times 10^{-3}$ A {1}		2	8
(ii) $E = \frac{1}{2}CV^2$ $\{\frac{1}{2}\}$ $= \frac{1}{2} \times 470 \times 10^{-6} \times (6.0)^2$ $\{\frac{1}{2}\}$ $= 8.46 \times 10^{-3}$ J {1}	Alt: $Q = CV = 470 \times 10^{-6} \times 6.0$ $= 2.82 \times 10^{-3}$ (C) $\{\frac{1}{2}\}$ $E = \frac{1}{2}QV$ $\{\frac{1}{2}\}$ (i.e. both formulas needed for $\{\frac{1}{2}\}$) $= \frac{1}{2} \times 2.82 \times 10^{-3} \times 6$ $(\frac{1}{2})$ $= 8.46 \times 10^{-3}$ J {1}	2	
(iii) increase the supply voltage/ use a battery of higher e.m.f. etc. {1}	"**change** the supply voltage" gets {0} larger battery (0)	1•	
(b) energy of each photon = hf $\{\frac{1}{2}\}$ $= 6.63 \times 10^{-34}$ $\{\frac{1}{2}\}$ $\times 5.80 \times 10^{14}$ $\{\frac{1}{2}\}$ $= 3.85 \times 10^{-19}$ $\{\frac{1}{2}\}$ (J) **no dotted line here** no. of photons = $6.35 \times 10^{-3}/3.85 \times 10^{-19}$ $(\frac{1}{2})$ $= 1.65 \times 10^{16}$ $(\frac{1}{2})$	i.e. $\{\frac{1}{2}\}$ for 'h' (data value) $\{\frac{1}{2}\}$ for substitution $I = Nhf$ is incorrect	3•+	

Marks

26. (*a*) An op-amp is connected in a circuit as shown below.

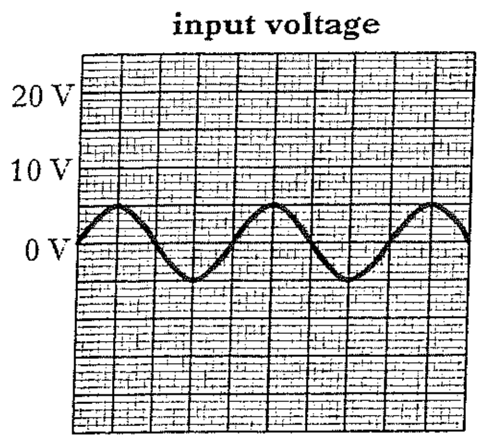


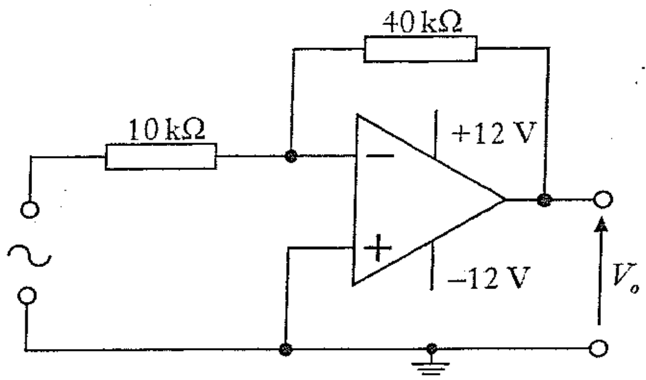
(i) In which mode is the op-amp operating?

(ii) A voltage of −18 mV is connected to the input. Calculate the output voltage V_o.

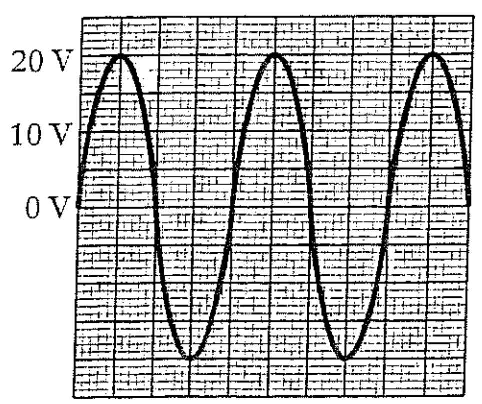
(iii) The supply voltage is now reduced from ±15 V to ±12 V. State any effect this change has on the output voltage. You must justify your answer. **4**

(*b*) A student connects an op-amp as shown in the following diagram. An alternating voltage of peak value 5·0 V is connected to the input as shown.





The sketch below shows the student's attempt to draw the corresponding output voltage.



State the **two** mistakes in the student's sketch. **2**

(6)

[Turn over

HIGHER LEVEL PHYSICS 2001 SECTION B
Maximum of (-0.5) per question for significant figures

Answer and Mark Allocation	Notes	Inner Margin	Outer Margin
26. (a) (i) inverting		1	6
(ii) $V_{out} = -V_{in} \times R_f/R_{in}$ $\{\frac{1}{2}\}$ $= 18 \times 10^{-3} \times 1.6 \times 10^6/20 \times 10^3$ $\{\frac{1}{2}\}$ $= 1.44$ V {1}	missing -ve is WP => {0} Method using gain = $R_f/R_{in} = 80$ is acceptable if final answer given as positive but if final answer is -ve => {0}	2	
(iii) no change $\{\frac{1}{2}\}$, since V_{out} not near saturation level/ op amp does not saturate/ V_o not near supply voltage $\{\frac{1}{2}\}$	Must jus but "output voltage does not saturate" is WP => {0} must be consistent with part (i)	1•+	
(b) not inverted {1}, should flatten {1} or square wave (at about ±10 V (or ±12 V) {1}, (due to saturation {of amplifier})	Can be shown by correct sketch.	2•	

29. (*a*) The following statement represents a nuclear reaction. *Marks*

$$^{239}_{94}\text{Pu} + {}^{1}_{0}\text{n} \longrightarrow {}^{137}_{52}\text{Te} + {}^{100}_{42}\text{Mo} + 3\,{}^{1}_{0}\text{n} + \text{energy}$$

The total mass of the particles before the reaction is $3{\cdot}9842 \times 10^{-27}$ kg and the total mass of the particles after the reaction is $3{\cdot}9825 \times 10^{-27}$ kg.

(i) State and explain whether this reaction is spontaneous or induced.

(ii) Calculate the energy, in joules, released by this reaction. **3**

(*b*) A radioactive source is used to irradiate a sample of tissue of mass 0·50 kg.

The tissue absorbs $9{\cdot}6 \times 10^{-5}$ J of energy from the radiation emitted from the source.

The radiation has a quality factor of 1.

(i) Calculate the absorbed dose received by the tissue.

(ii) Calculate the dose equivalent received by the tissue.

(iii) Placing a sheet of lead between the source and the tissue would have reduced the dose received by the tissue.

The half-value thickness of lead for this radiation is 40 mm.

Calculate the thickness of lead which would have limited the absorbed dose to one eighth of the value calculated in part (*b*)(i). **5**

(8)

[END OF QUESTION PAPER]

HIGHER LEVEL PHYSICS 2001 **SECTION B**
Maximum of (-0.5) per question for significant figures

Answer and Mark Allocation	Notes	Inner Margin	Outer Margin
29. (a) (i) induced, since neutron "added" {1}	{1 or 0}	1	8
(ii) $E = mc^2$ $\{\frac{1}{2}\}$ $= (3.9842 - 3.9825)$ $\{\frac{1}{2}\}$ $\times 10^{-27} \times (3.0 \times 10^8)^2$ $\{\frac{1}{2}\}$ $= 1.53 \times 10^{-13}$ $\{\frac{1}{2}\}$ (J)	$\{\frac{1}{2}\}$ for subtraction, $\{\frac{1}{2}\}$ for data	2	
(b) (i) $D = E/m$ $\{\frac{1}{2}\}$ $= 9.6 \times 10^{-5}/0.50$ $\{\frac{1}{2}\}$ $= 1.92 \times 10^{-4}$ Gy {1}		2	
(ii) $H = DQ$ $\{\frac{1}{2}\}$ $= 1.92 \times 10^{-4} \times 1.0$ $= 1.92 \times 10^{-4}$ Sv $\{\frac{1}{2}\}$ (= 0.19 mSv)		1	
(iii) $1 \longrightarrow \frac{1}{2} \longrightarrow \frac{1}{4} \longrightarrow \frac{1}{8}$ $\{\frac{1}{2}\}$ is three $\{\frac{1}{2}\}$ half values => thickness required = 120 mm {1}	for correct halving "chain"	2	

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