TEST CODE **02238020**

FORM TP 2005261

MAY/JUNE 2005

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 02 – Paper 02

2 hours 15 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **NINE** questions.
2. Section A consists of **THREE** questions. Candidates must attempt ALL questions in this section. Answers for this section must be written in this answer booklet.
3. Section B consists of **SIX** questions. Candidates must attempt **THREE** questions in this section, **ONE** question from **EACH** Module. Answers for this section must be written in the answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted.

LIST OF PHYSICAL CONSTANTS

Speed of light in free space	c	=	3.00×10^{8} m s^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
Elementary charge	e	=	1.60×10^{-19} C
The Planck's constant	h	=	6.63×10^{-34} J s
Unified atomic mass constant	u	=	1.66×10^{-27} kg
Rest mass of electron	m_e	=	9.11×10^{-31} kg
Rest mass of proton	m_p	=	1.67×10^{-27} kg
Acceleration of free fall	g	=	9.81 m s^{-2}
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Avogadro's constant	N_A	=	6.02×10^{23} per mole

SECTION A

Attempt ALL questions. You MUST write in this answer booklet. You must NOT spend more than 30 minutes on this section.

1. Figure I shows TWO flat circular coils with n turns, each of radius R, and separated by a disance a. Each coil carries a current I in the same direction.

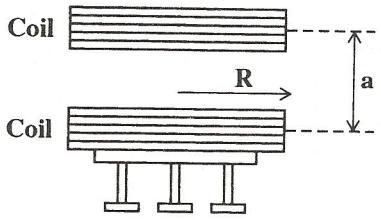

Figure I

The force of attraction between the TWO coils is given by $F = \frac{\mu_o n^2 I^2 R}{a}$ where μ_o is the permeability of free space.

In an experiment it is desired to measure the value of the permeability of free space, μ_o, by using the setup shown in Figure II. Initially, weights were added to the scale pan to suspend the coil. These weights were kept on during the experiment. The separation of the coils, a, was set to 1 cm. Each coil has n = 100 turns with radius R = 5.0 cm. The current through the coils was varied and weights were added to the scale pan to balance the scale.

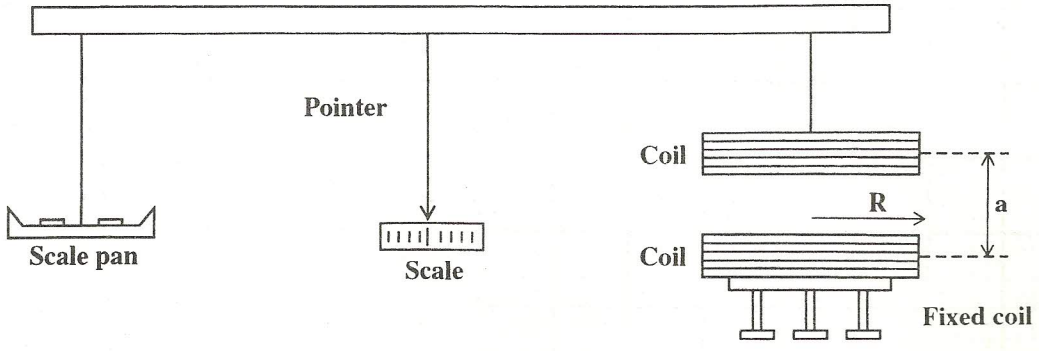

Figure II

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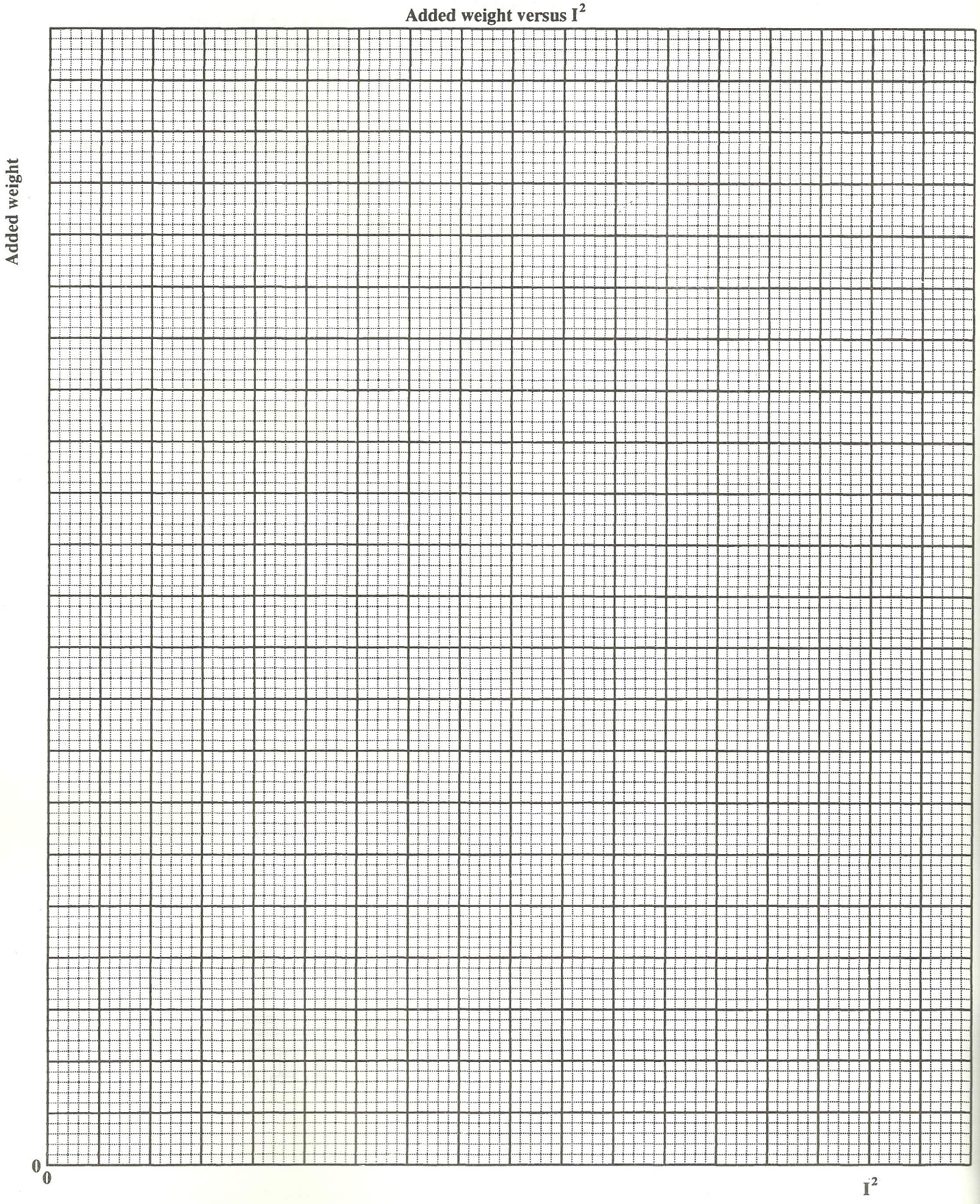
The following grid refers to question 1.



The following results were obtained.

Table 1

Added Weight, F, / N x 10^{-2}	**Current, I, / A x 10^{-2}**	**I^2 / A^2 x 10^{-4}**
1.0	4.0	
2.0	5.6	
3.0	6.9	
4.0	8.0	
5.0	8.9	

(a) Complete the third column of Table 1 **[1 mark]**

(b) On the grid provided on page 5 plot a graph of Added Weight, F, versus I^2.

[5 marks]

(c) Use your graph to determine a value for the permeability of free space, μ_o.

[4 marks]

Total 10 marks

2. The variation of the gain of an inverting amplifier at different frequencies may be investigated with the circuit shown in Figure III. The input and output signals are displayed on the screen of a double beam cathode ray oscilloscope. The input signal is provided by a signal generator.

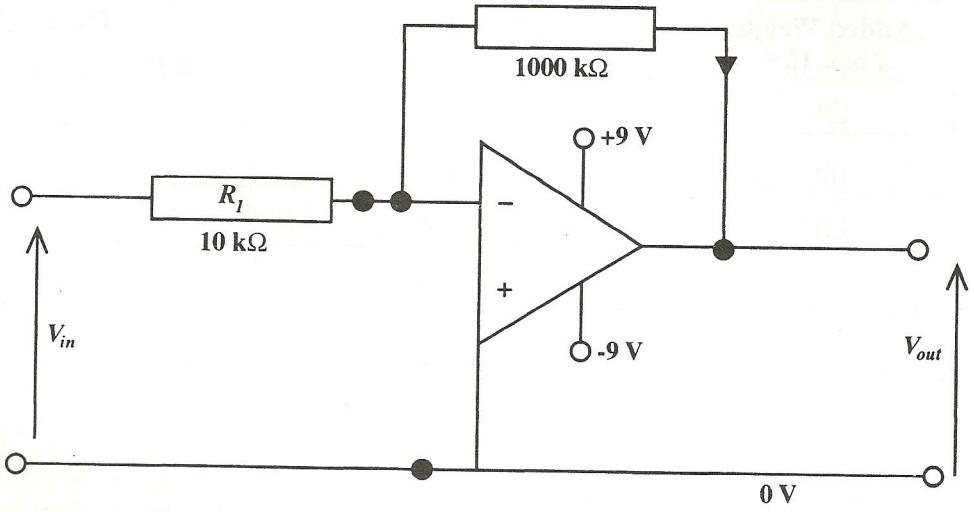


Figure III

(a) What is the gain of this amplifier at low frequencies?

_____

_____

[1 mark]

(b) At higher frequencies the gain may be lower than this theoretical value. It can be measured by use of the double beam oscilloscope. Figure IV below shows the output trace and the input trace at a higher frequency.

The gain setting of the c.r.o. for the output is 1V per division whilst that for the input trace is 10 mV per division.

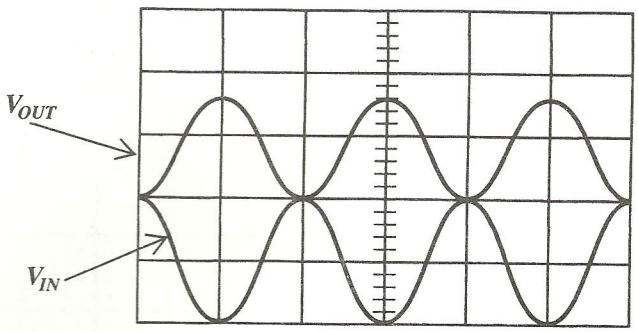
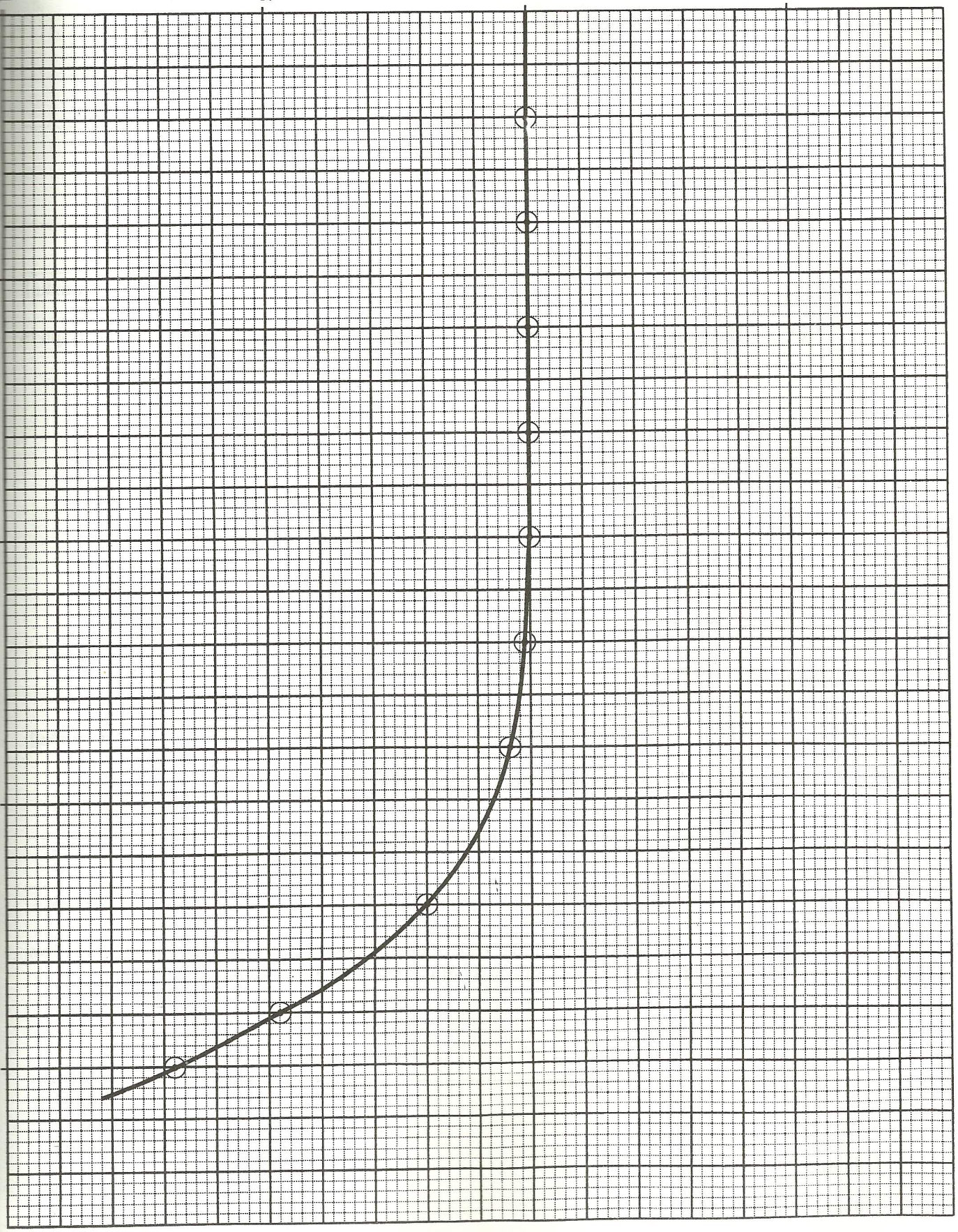


Figure IV


lg A
1.5
2
2.5
1
2
3
4
5
lg (E/E_a)

What is the gain, A, of the amplifier for this frequency?

[3 marks]

(c) The graph on page 8 shows the data collected in such an experiment. Use the graph to complete Table 2.

Table 2

lg(f/Hz)	lg A	f/HZ	A
2.00			
3.00			
4.00			
4.50			
5.00			

[3 marks]

(d) (i) What is the bandwidth of the amplifier?

[1 mark]

(ii) The value of the input resistance R_1 is changed to 1.0 kΩ. How will the low frequency gain and bandwidth of the amplifier change?

[2 marks]

Total 10 marks

3. In an experiment to determine the half life of a radioactive sample, the following data was obtained over a 10 hour period. The activity, A and time, t are related by the equation $A = A_o e^{-\lambda t}$

Table 3

Time/min	Activity (counts/min)	
60	3100	
120	2450	
240	1480	
360	910	
480	545	
600	330	

(a) After adding suitable data to the third column of Table 3, (there is no need to convert the minutes to seconds) plot a straight line graph on the grid on page 11.

State the equation of the line you plotted. **[6 marks]**

(b) Use the graph you plotted to determine the half-life of the sample.

[4 marks]

Total 10 marks

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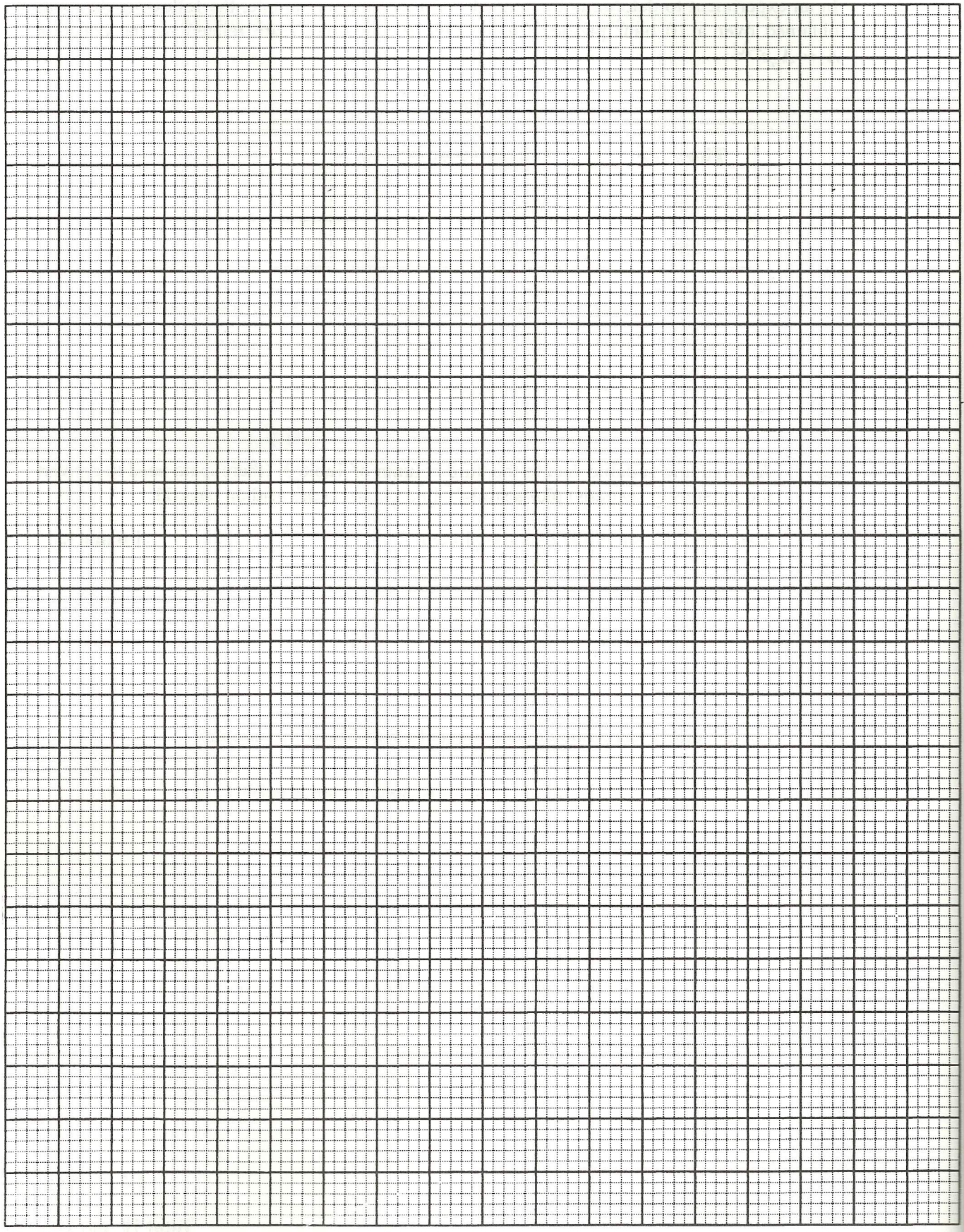

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SECTION B

You must attempt THREE questions from this section. Choose ONE question EACH from Module 1, 2 and 3. You MUST write your answers in the answer booklet provided.

MODULE 1

Answer EITHER Question 4 OR Question 5.

4. (a) (i) Explain CLEARLY the difference between 'e.m.f.' and 'terminal potential difference'.

(ii) Define the 'volt' and the 'coulomb'.

(iii) Write down Kirchhoff's laws for electrical networks and give the physical basis for EACH law.

[8 marks]

(b) In the circuit shown in Figure V, batteries A and B have negligible internal resistance. Battery C has an internal resistance of 3 Ω .

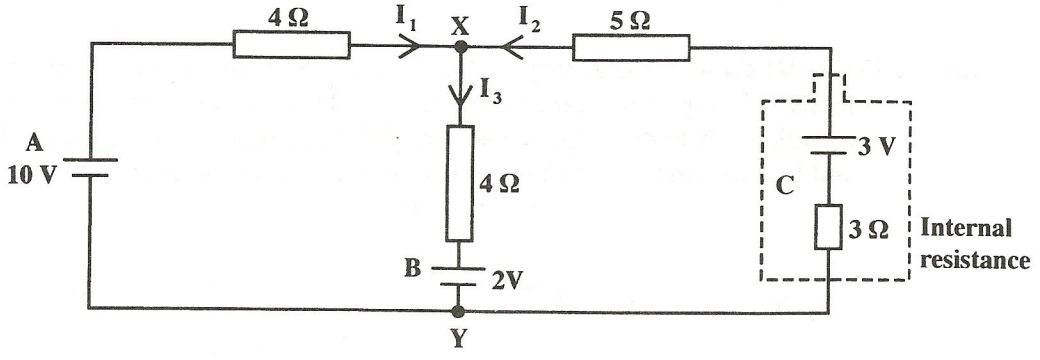

Figure V

Use the circuit in Figure V to find

(i) the currents I_1, I_2 and I_3

(ii) the potential difference between X and Y

(iii) the terminal p.d. of Battery C.

[12 marks]

Total 20 marks

5. (a) Explain the origin of the Hall effect. Include a diagram showing clearly the directions of the Hall voltage and other relevant quantities for a specimen in which electron conduction predominates. **[8 marks]**

(b) A Hall probe can be used to measure the magnitude of a magnetic field. A researcher has lost his instruction booklet and forgotten the calibration procedure. However, when he places the Hall probe inside a known magnetic field of 15 mT, he measures a Hall voltage of 130 mV. With the same Hall probe, he measures a Hall voltage of 1170 mV when it is placed in an unknown magnetic field.

Using this information, calculate the magnetic field strength of the unknown magnetic field. **[2 marks]**

(c) In the velocity selector of a mass spectrometer positive ions travelling at 1.6×10^5 m s^{-1} pass undeflected through a magnetic field of 0.15 T which is perpendicular to an electric field.

(i) Draw a labelled diagram to show the relationship between the two fields.

(ii) Write equations for the forces on the ions caused by the electric field and the magnetic field and hence calculate the field strength E of the electric field. **[5 marks]**

(d) Figure VI shows a metal strip 6.50 cm long, 0.850 cm wide which moves with constant velocity v through a uniform magnetic field B = 1.20 mT. The magnetic field is directed perpendicularly to the strip. A potential difference of 3.90 μV is measured between points C and D across the strip. Calculate the velocity, v, of the strip.

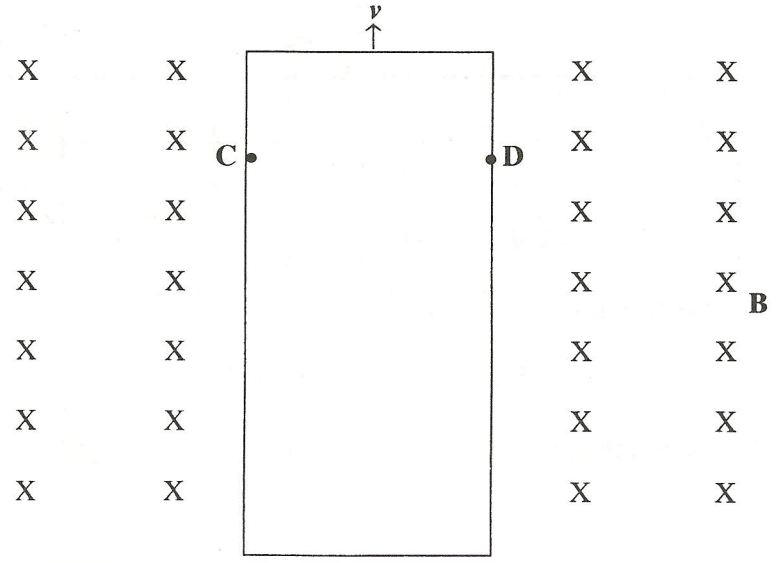

Figure VI

[5 marks]

Total 20 marks

MODULE 2

Answer EITHER Question 6 or Question 7.

6. (a) Draw a labelled diagram of a transformer suitable for transforming from 240 V a.c to 12 V a.c. Give details of the materials used in its structure and reasons for their choice.

[8 marks]

(b) A step up transformer connected to a 240-V r.m.s a.c line is to supply 18 kV r.m.s. for a neon sign as shown in Figure VII. To reduce shock hazard, a fuse is to be inserted in the primary circuit; the fuse is to blow when the current in the secondary circuit exceeds 10 mA.

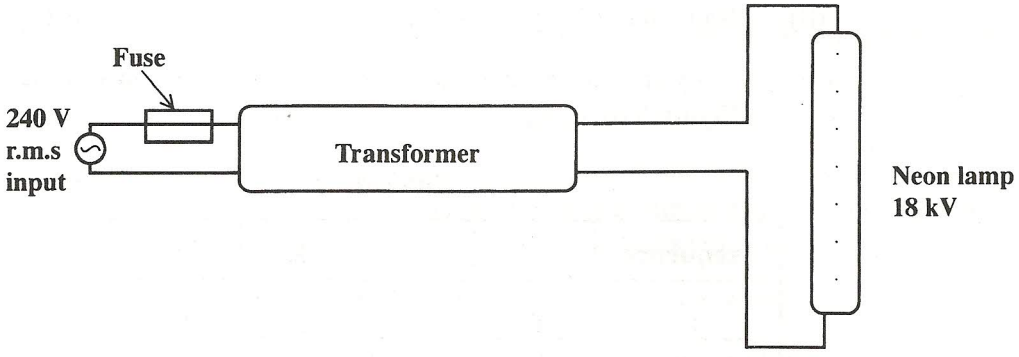

Figure VII

Calculate, assuming the transformer is ideal,

(i) the peak value of the primary voltage

(ii) the turns ratio $\frac{N_p}{N_s}$ of the transformer

(iii) the power that must be supplied to the transformer when the secondary current is 10 mA

(iv) the current rating of the fuse that is to be used in the primary circuit.

[8 marks]

(c) The transformer at a power station has an output of 15 MW at 60 kV. This power is transmitted to a sub-station some distance away along cables which have a total resistance of 12 Ω. What percentage of the power transmitted is lost in the cables?

[4 marks]

Total 20 marks

7. (a) Figure VIII shows a logic circuit with TWO inputs, I_1 and I_2, and TWO outputs X and Y.

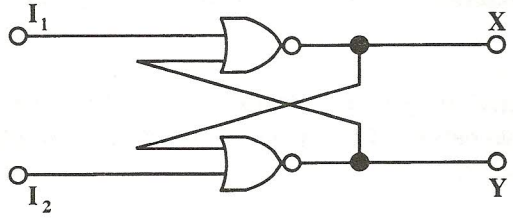

Figure VIII

(i) What is the name given to this type of circuit?

(ii) Name the logic gate used in the circuit and write out its truth table.

(iii) Copy and complete the sequential truth table to show the action of the circuit in Figure VIII.

Table 4

sequence	I_1	I_2	X	Y
1	0	1	1	0
2	0	0	1	0
3	1	0		
4	0	0		
5	0	1		
6	0	0		

(iv) By considering the role of feedback in this circuit and the condition for the type of gate in (a) (ii) to have a logic *0* output, explain why the output does not change when the input changes in the second step of the sequence (Row 2) as shown in Table 4.

[8 marks]

(b) The circuit of Figure VIII is incorporated in a burglar alarm as shown in Figure IX.

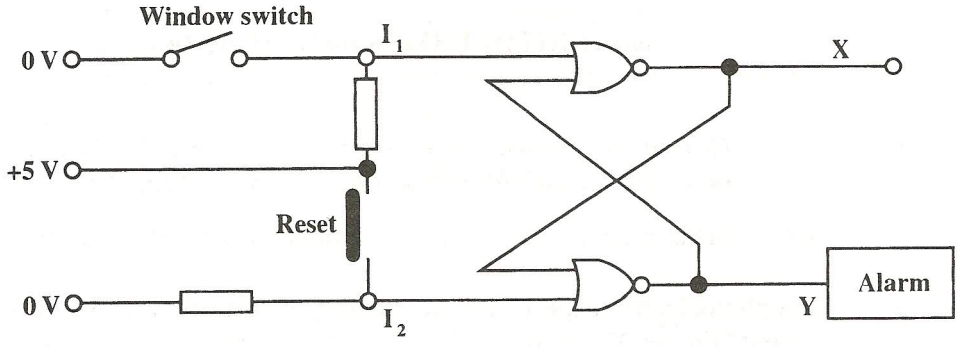

Figure IX

When the window is shut the switch is closed and I_1 is logic 0. When the window is opened $I_1 = 1$.

The input I_2 remains at logic 0 except when the reset switch is pressed.

(i) Before going to bed the householder closes the window and presses and releases the reset switch. Making reference to the sequential truth table in 7(a) (iii), explain how this "sets" the alarm so that it is ready to be triggered.

(ii) Why does the alarm sound when a burglar opens the window?

(iii) Explain why the alarm stays on even when the burglar closes the window.

(iv) How does the householder turn off the alarm? **[4 marks]**

(c) (i) Draw the circuit for a half-adder. Explain, with the aid of a truth table, what its function is and how it performs that function.

(ii) TWO half-adders can be connected to form a full-adder, Figure X. This circuit has THREE inputs.

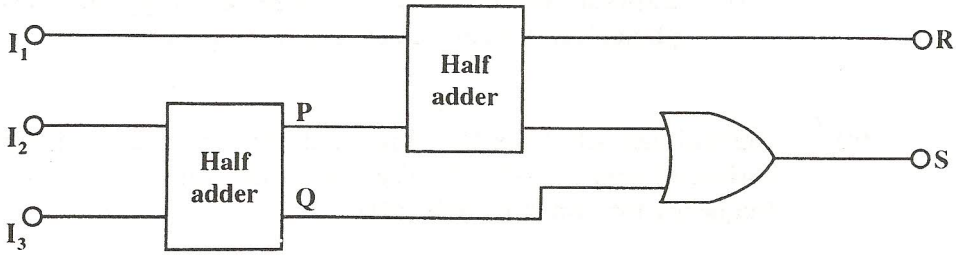

Figure X

Draw a table to show the outputs at points P, Q, R and S for the following input states:

A. $I_1 = 1$ $I_2 = 0$ $I_3 = 1$

B. $I_1 = 1$ $I_2 = 1$ $I_3 = 1$

[8 marks]

Total 20 marks

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MODULE 3

Answer EITHER Question 8 or Question 9.

8. (a) (i) Define the terms, 'work function', 'threshold frequency' and 'stopping potential' as applied in describing the photoelectric effect.

(ii) What property of light does the photoelectric effect display? **[4 marks]**

(b) In a photoelectric experiment the intensity of blue light incident on a metal surface is varied. Figure XI shows a plot of photocurrent versus applied voltage for different values of light intensity.

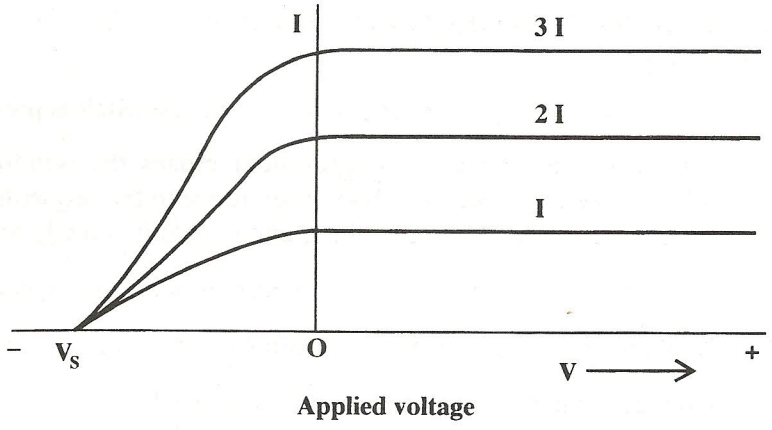

Figure XI

(i) What conclusions can be drawn from this plot?

(ii) Explain how the maximum kinetic energy and maximum velocity of the photoelectrons can be deduced from this plot.

[4 marks]

(c) Light of intensity 1.5×10^{-2} Wm^{-2} and wavelength 250×10^{-9} m is incident on an iron surface of area 1×10^{-4} m^2. The iron surface reflects 95% of the light. The threshold frequency for iron is 1.1×10^{15} Hz.

Calculate

(i) the intensity of light available for the photoelectric effect

(ii) the number of electrons emitted per second

(iii) the work function in electron volts for iron

(iv) the stopping potential for this radiation.

[12 marks]

Total 20 marks

9. (a) (i) Explain what is meant by 'nuclear fusion' and 'nuclear fission' and state which process is responsible for the energy release of the Sun.

(ii) Explain why a neutron would penetrate farther into a sample of matter than an alpha particle of the same energy.

(iii) The graph in Figure XII shows the binding energy per nucleon versus mass number (A) curve.

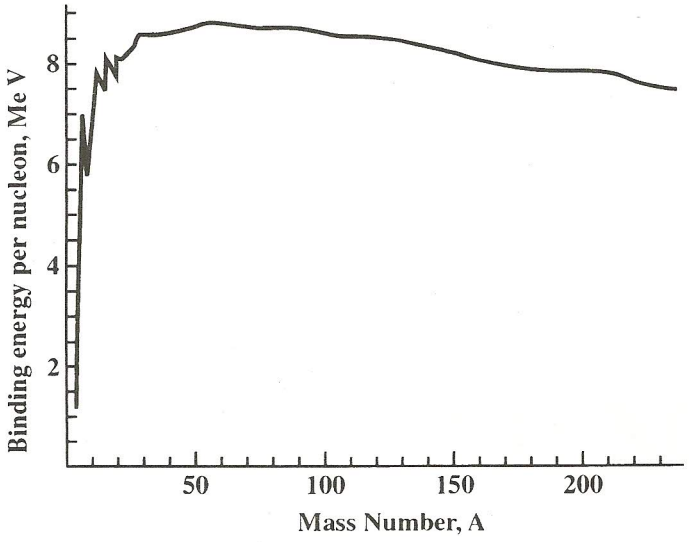

Figure XII

What does this curve indicate about the stability of nuclei and the processes by which nuclei achieve this stability? **[8 marks]**

(b) The fission of Uranium-235 can be represented by the nuclear equation

$$^{235}_{92}U \rightarrow {}^{140}_{54}Ce + {}^{94}_{38}Zr + {}^{1}_{0}n\,.$$

Atomic Masses:

$^{235}_{92}U$	235.0439 u	$^{140}_{54}Ce$	139.9054 u	[1 u ≡ 931.5 MeV]
$^{1}_{0}n$	1.00867 u	$^{94}_{38}Zr$	93.9063 u	

(i) How many atoms are contained in 1.0 kg of Uranium-235?

(ii) Using the masses above, calculate the energy, in joules, released by 1.0 kg of Uranium-235 by fission.

(iii) Using your answer to (ii) above, explain why nuclear fission is such a desirable source of energy. **[12 marks]**

Total 20 marks

END OF TEST