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FORM TP 2009243

MAY/JUNE 2009

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 2 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of **SIX** questions.
2. Section A consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the spaces provided in this question paper.
3. Section B consists of **THREE** questions. Candidates must attempt **ALL** questions in this section. Answers for this section must be written in the separate answer booklet provided.
4. All working **MUST** be **CLEARLY** shown.
5. The use of non-programmable calculators is permitted, but candidates should note that the use of an inappropriate number of figures in answers will be penalised.

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}
	$\frac{1}{4\pi\varepsilon_0}$	=	9.0×10^{9} m F^{-1}
Elementary charge	e	=	1.60×10^{-19} C
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 due to gravity	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

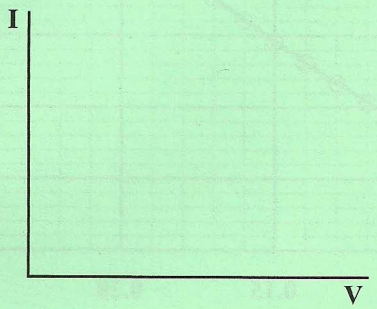
GO ON TO THE NEXT PAGE

SECTION A

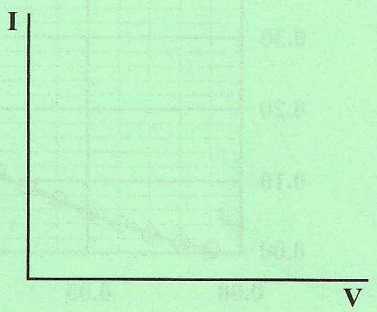
Answer ALL questions.

You MUST write your answers in the spaces provided in this answer booklet.

1. (a) Sketch graphs to show the I – V characteristics of EACH of the following devices: (i) a metallic conductor at constant temperature, (ii) a filament bulb



(i) Metallic conductor



(ii) Filament bulb

[2 marks]

(b) It is desired to test the I – V characteristics of a diode to be used in a circuit. Below the "turn on" voltage the current, I, is related to the voltage, V, by the relation, $I = kV^n$ where k and n are constants for the particular diode.

(i) Draw a potential divider circuit that could be used to examine the I - V characteristics of the diode.

[2 marks]

(ii) Describe how the readings would be taken.

_____

_____

_____

_____

[2 marks]

(c) Figure 1 shows the I - V characteristic that was obtained for a diode, operated at a temperature of 25°C.

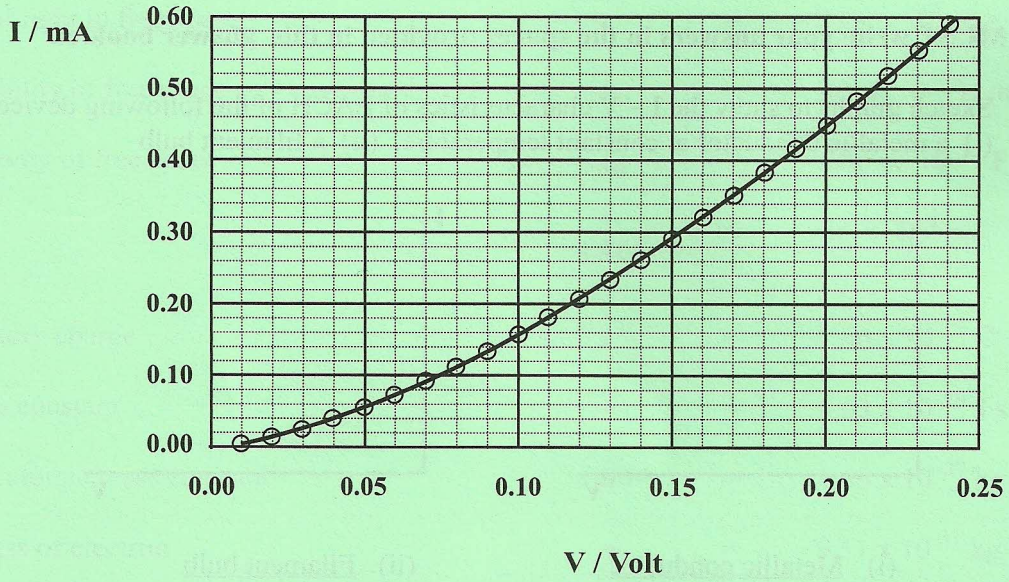


Figure 1 – I - V characteristic of a diode for small p.d.'s

(i) Use the data presented in Figure 1 to determine the value of n in the relation $I = kV^n$.

[3 marks]

(ii) Deduce the actual equation relating the current, I, to the voltage, V, for this diode.

[2 marks]

(iii) Calculate the d.c. resistance of the diode at I = 0.32 A.

[2 marks]

(iv) Suggest a better way of processing the data obtained in this experiment to determine the values of n and k.

[2 marks]

Total 15 marks

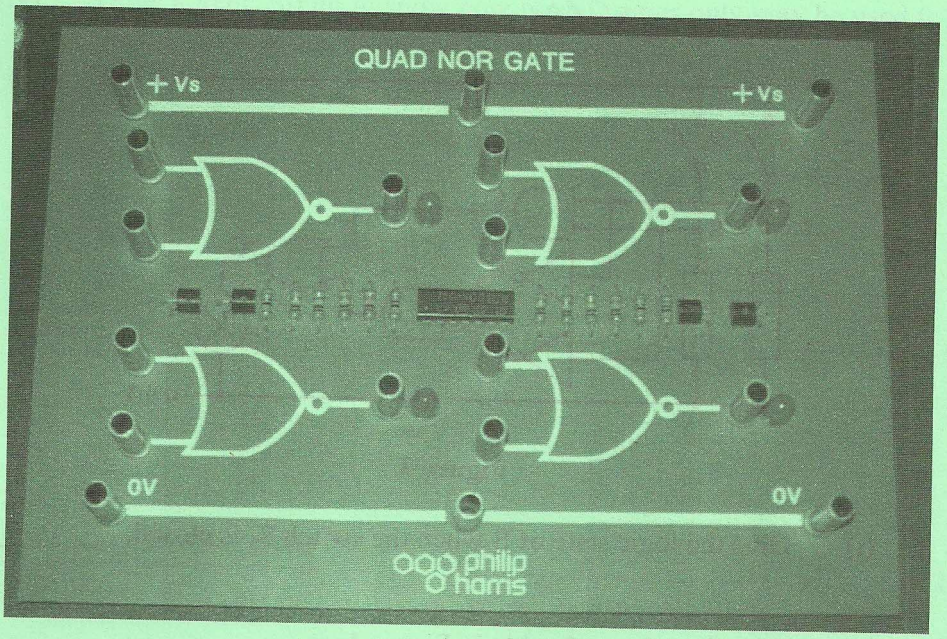
2. (a) (i) Complete the table to show the action of a NOR gate.

NOR truth table

A	B	OUT
0	0	
0	1	
1	0	
1	1	

[1 mark]

(ii) Draw a diagram to show how a NOR gate can be connected to function as a NOT gate. **[1 mark]**



(iii) The photograph above shows a circuit board with four NOR gates. Add connecting wires to the given diagram (Figure 2) to show how the NOR gates could be connected to form a NAND gate.

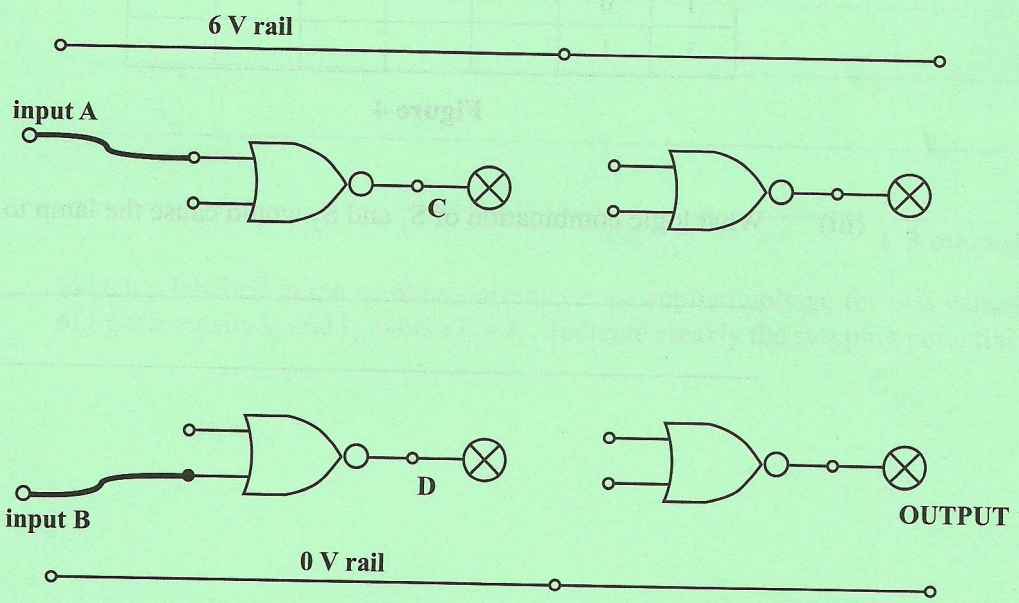


Figure 2: Quad NOR gate

[4 marks]

(b) Figure 3 shows a logic circuit designed to operate a lamp.

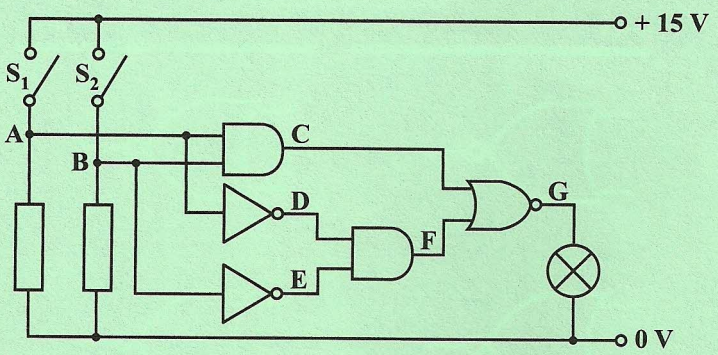


Figure 3

(i) Give the logic state of B when the switch S_2 is closed. _____

[1 mark]

(ii) Complete the truth table in Figure 4.

A	B	C	D	E	F	G
0	0					
0	1					
1	0					
1	1					

Figure 4

[5 marks]

(iii) What logic combination of S_1 and S_2 would cause the lamp to be ON?

_____

_____

[1 mark]

(iv) Draw a logic circuit to show how NAND gates only may be used to carry out the SAME function as the circuit of Figure 3.

[2 marks]

Total 15 marks

3. (a) (i) Einstein's photoelectric equation can be written as $K_{max} = hf - \phi$. Clearly explain EACH term used in this equation.

_____

_____

_____

_____

[3 marks]

(ii) Sketch a labelled graph of photocurrent versus applied voltage for two values of light intensity I_1 and I_2, where $I_2 > I_1$. Indicate **clearly** the stopping potential.

[2 marks]

(b) The following data are found for photoemission from calcium:

Stopping potential, V_s / V	**Wavelength, λ / nm**	**Frequency, f / Hz**
1.93	253.6	
1.51	279.5	
0.97	313.0	
0.50	365.5	
0.13	405.1	

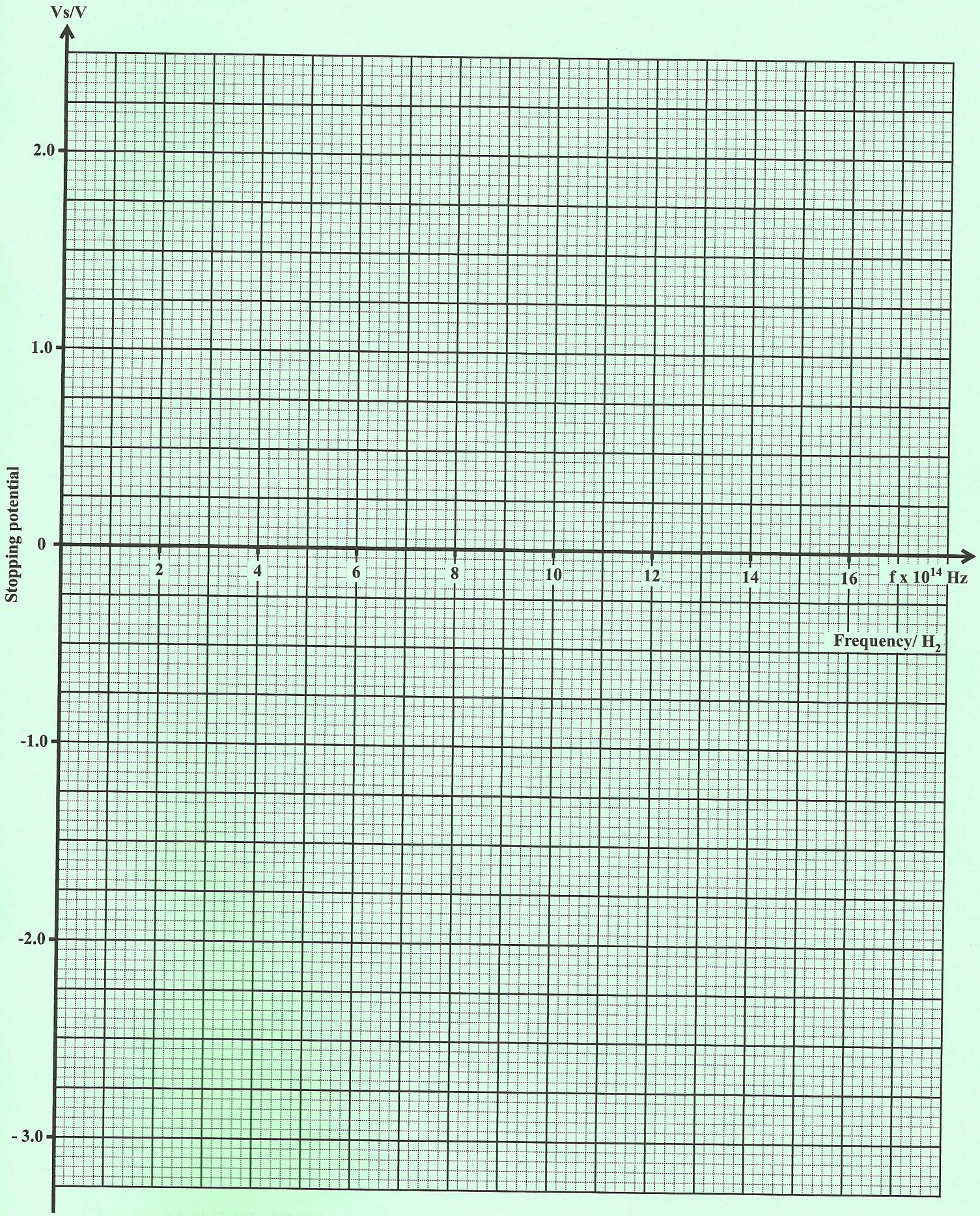
(i) Complete the table by filling in the values of frequency f. **[1 mark]**

(ii) On the grid on page 11, plot a graph of stopping potential V_s versus frequency f. Draw the BEST straight line through the points. **[3 marks]**

(iii) From your graph, determine

a) Planck's constant

[3 marks]


Vs/V
2.0
1.0
0
-1.0
-2.0
- 3.0
Stopping potential
2
4
6
8
10
12
14
16
f x 10^14 Hz
Frequency/ H2

b) the threshold frequency

[1 mark]

c) the work function of the metal.

[2 marks]

Total 15 marks

SECTION B

Answer ALL questions.

You MUST write your answers in the separate answer booklet provided.

4. (a) (i) Distinguish between 'magnetic flux density' and 'magnetic flux'.

(ii) State Faraday's law of electromagnetic induction.

(iii) State Lenz's law. **[4 marks]**

(b) Figure 5 shows a long solenoid which has a small copper disc mounted at its centre. The disc spins on an axle which lies along the axis of the solenoid. By means of brushes, one connected to the rim of the disc and the other connected to the axle, the millivoltmeter can display the e.m.f. generated.

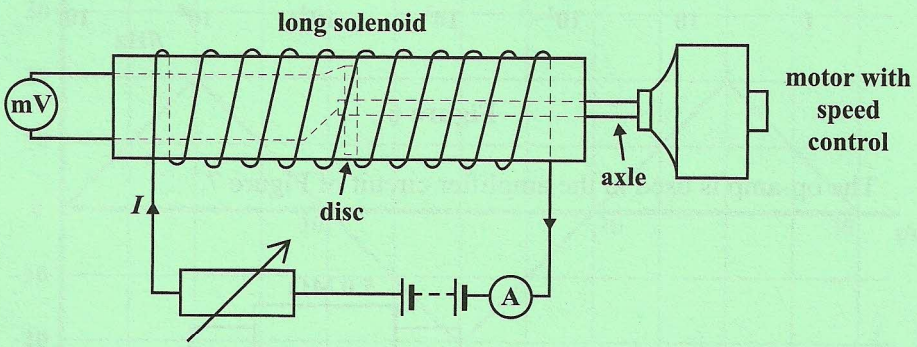


Figure 5

(i) Explain why an e.m.f. is generated between the axle and the rim of the disc when the disc rotates.

(ii) The disc has a diameter of 40 mm and rotates at 9.5 revolutions per second. The solenoid is 0.080 m long, has 160 000 turns, and carries a steady current of 5.0 mA. Calculate

a) the magnetic field within the solenoid

b) the magnetic flux cut every revolution

c) the potential difference maintained between the rim and the axle of the disc. **[8 marks]**

(c) The apparatus in Figure 5 could be used in an experiment to verify Faraday's law by changing the speed of the motor and measuring the corresponding e.m.f. Sketch a graph of the expected results and state how your conclusion would be made from the graph. Also state which factors must be held constant if the conclusion is to be valid. **[3 marks]**

Total 15 marks

5. Figure 6 shows the variation with frequency f of the voltage gain G, without feedback, of an ideal operational amplifier (op-amp).

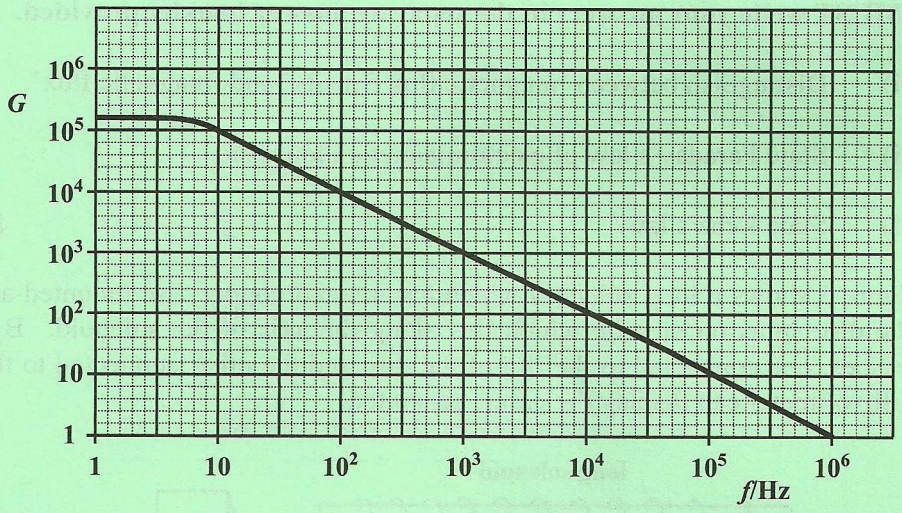


Figure 6

The op-amp is used in the amplifier circuit of Figure 7.

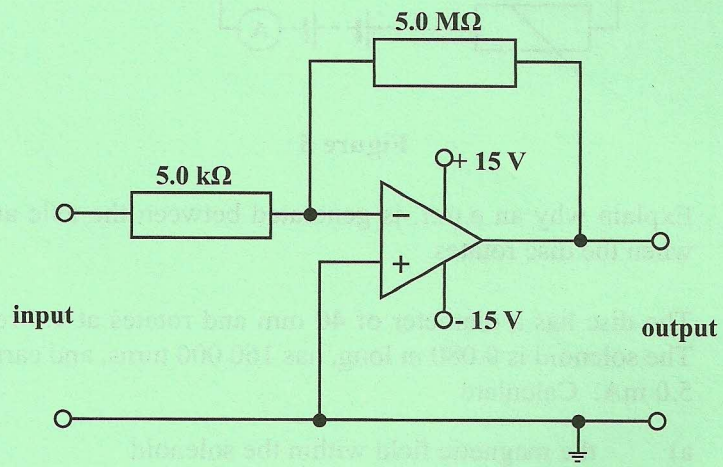


Figure 7

(a) (i) State the type of amplifier shown in Figure 6.

(ii) What is meant by 'negative feedback'?

(iii) Calculate the bandwidth of the amplifier. **[5 marks]**

(b) Calculate the peak output voltage for an input signal of peak value 0.01 V if the frequency is

(i) 500 Hz

(ii) 10 000 Hz **[4 marks]**

(c) The input of the amplifier in Figure 7 is connected to an audio frequency generator producing a signal like the one shown on the graph below. The amplifier is operated off a ±15 V supply.

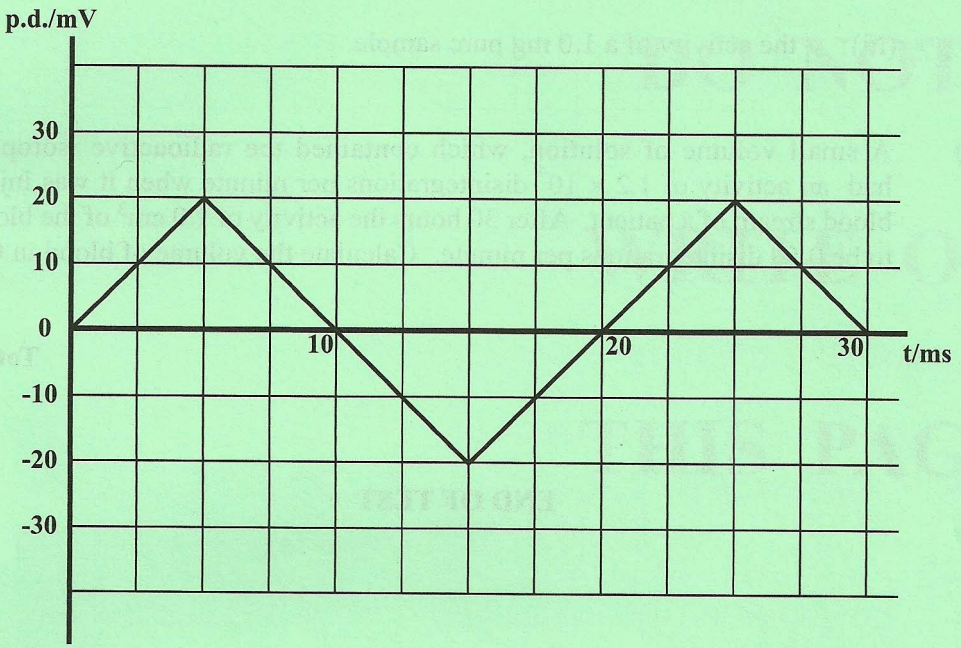


Figure 8

(i) What is the frequency of this signal?

(ii) Find the output of the amplifier when $t = 5$ ms.

(iii) Sketch a graph to show the shape of the output waveform from the amplifier.

[6 marks]

Total 15 marks

6. (a) Explain the terms 'decay constant' (λ) and 'half life' ($T_{\frac{1}{2}}$).

Derive an equation relating these two quantities, starting with the decay equation $N = No\ e^{-\lambda t}$. **[5 marks]**

(b) Sodium 24 (atomic mass 24 g mol^{-1}) is a radioactive isotope that beta-decays with a half life of 15.0 hours.

For this isotope, calculate

(i) the decay constant in units of s^{-1}

(ii) the number of atoms in a 1.0 mg sample

(iii) the activity of a 1.0 mg pure sample. **[5 marks]**

(c) A small volume of solution, which contained the radioactive isotope sodium 24, had an activity of 1.2×10^4 disintegrations per minute when it was injected into the blood stream of a patient. After 30 hours the activity of 1.0 cm^3 of the blood was found to be 0.50 disintegrations per minute. Calculate the volume of blood in the patient. **[5 marks]**

Total 15 marks

END OF TEST