

Surname	Centre Number	Candidate Number
First name(s)		2



GCE A LEVEL

A490U10-1



TUESDAY, 20 MAY 2025 – AFTERNOON

ELECTRONICS – A level component 1

Principles of Electronics

2 hours 45 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	6	
2.	20	
3.	12	
4.	6	
5.	9	
6.	9	
7.	22	
8.	16	
9.	11	
10.	7	
11.	10	
12.	12	
Total	140	

ADDITIONAL MATERIALS

You will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question 7(c)(ii).



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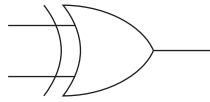
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Answer **all** questions.

1. (a) Name this logic gate.

[1]



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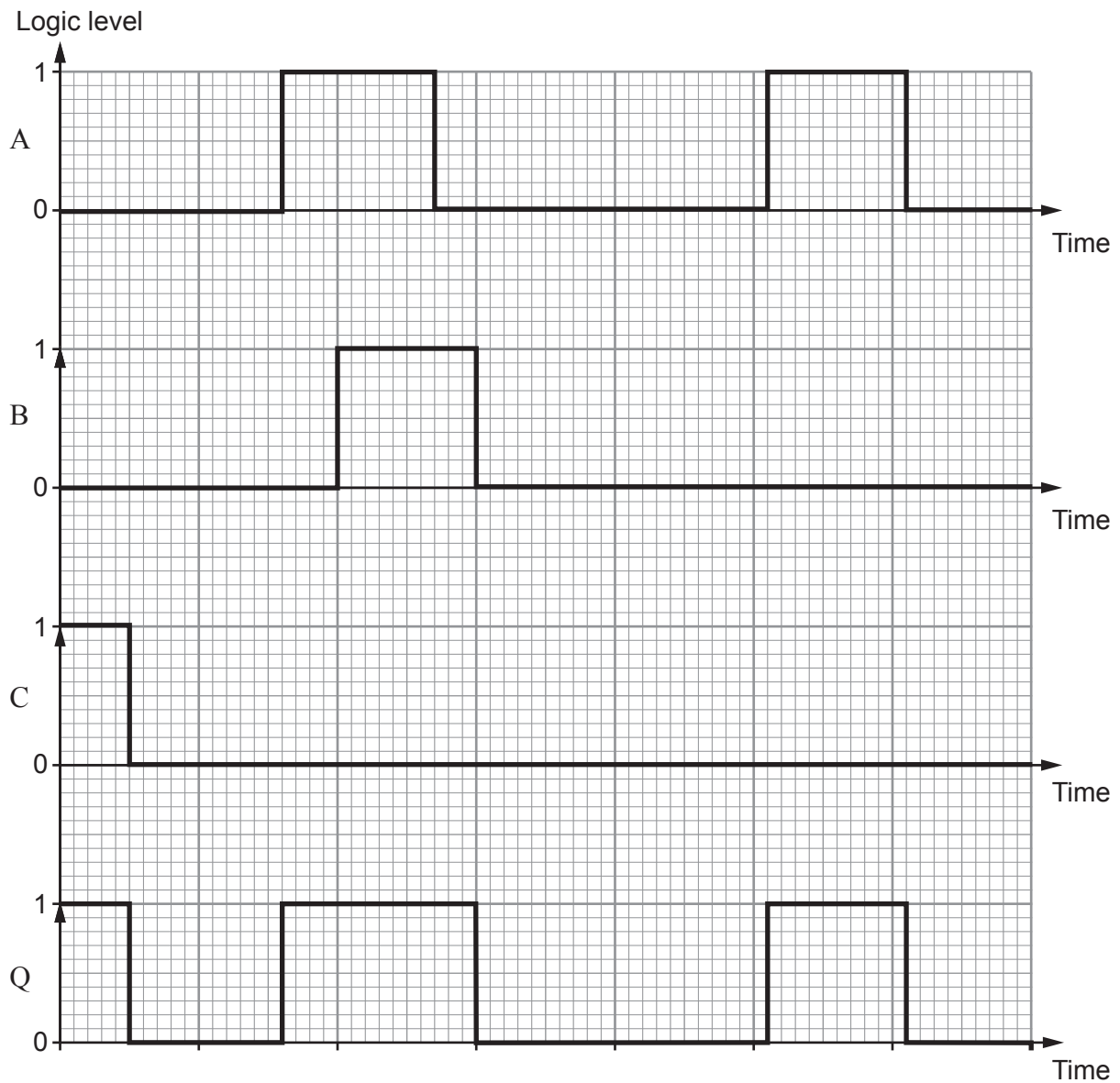
- (b) Complete the truth table below for a 3-input NOR gate.

[1]

C	B	A	Q
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	



- (c) (i) The graphs show the signals applied to the inputs A, B and C of a 3-input logic gate and the resulting output Q. Identify the type of logic gate. [1]

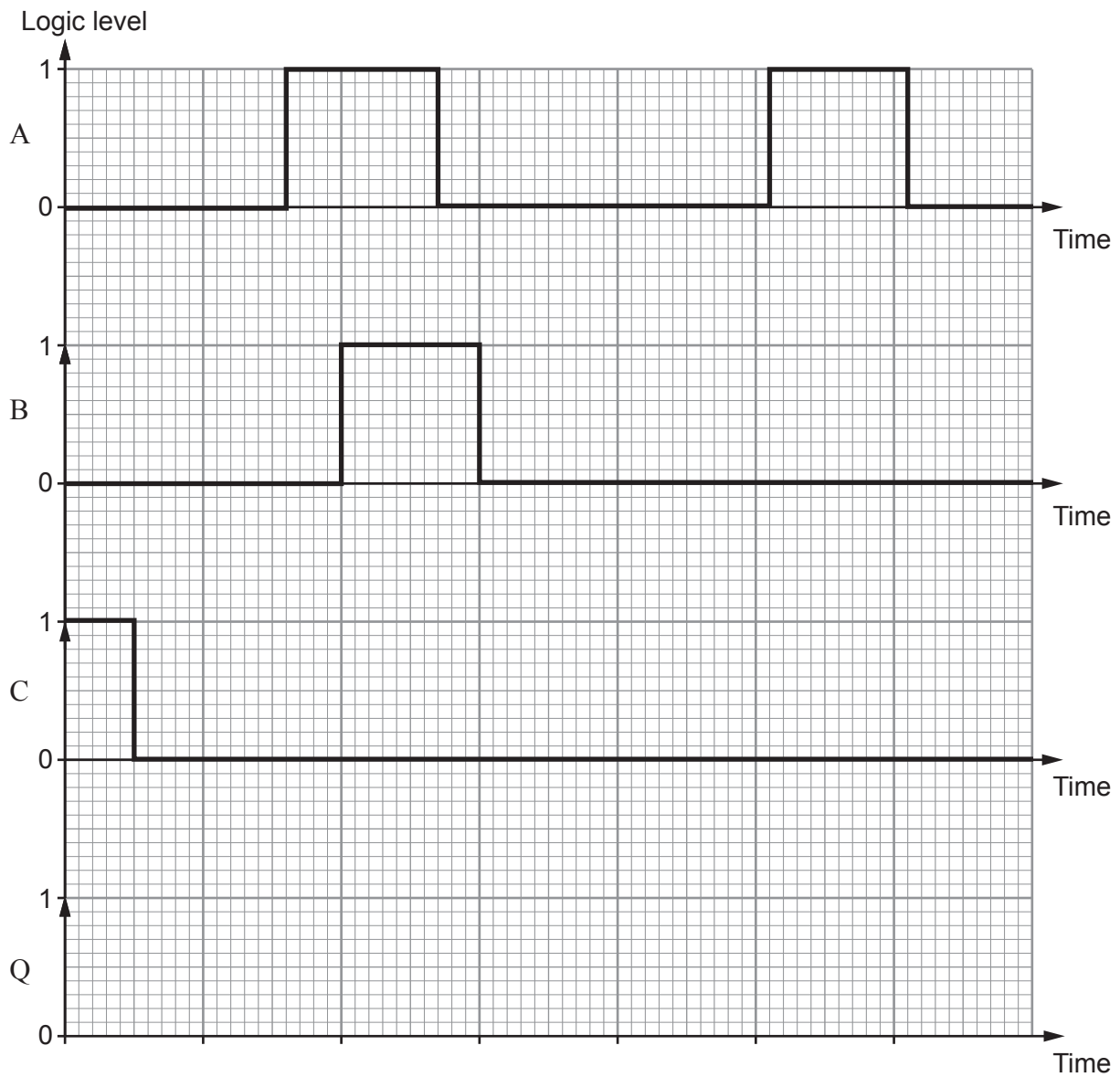


Type of logic gate:

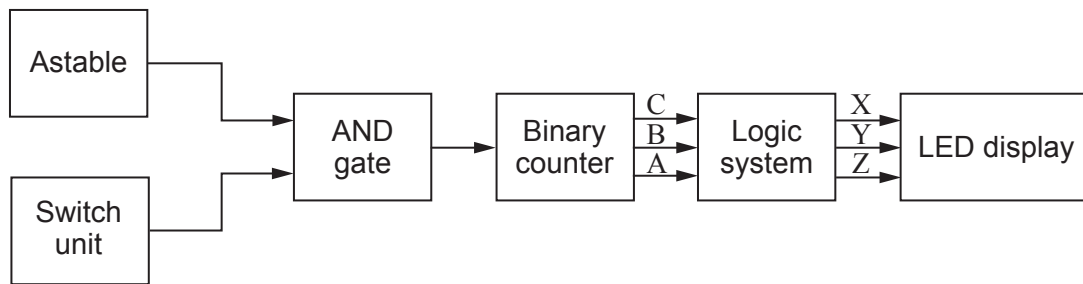


- (ii) The same input signals are now applied to a 3-input XOR gate.
Draw the output, Q, on the graph below.

[3]



2. A student wants to make a light display for a scooter. Below is the block diagram for the system.



- (a) From the truth table below, derive the simplest Boolean expressions for the outputs X and Y of the logic system. [4]

C	B	A	X	Y	Z
0	0	0	1	0	0
0	0	1	0	1	0
0	1	0	0	0	1
0	1	1	1	1	0
1	0	0	1	0	1
1	0	1	0	0	0
1	1	0	0	0	1
1	1	1	1	0	0

(i)

.....

X = ...

		BA			
C		00	01	11	10
	0				
	1				

(ii)

.....

Y = ...

		BA			
C		00	01	11	10
	0				
	1				



- (iii) The Boolean equation for Z is $Z = \overline{A}.B + \overline{A}.C$.
From this equation, draw the circuit that generates output Z using AND, OR and NOT gates. [3]

A ○—

B ○—

—○ Z

C ○—

- (iv) **Redraw** the circuit using NAND gates only. [3]

A ○—

B ○—

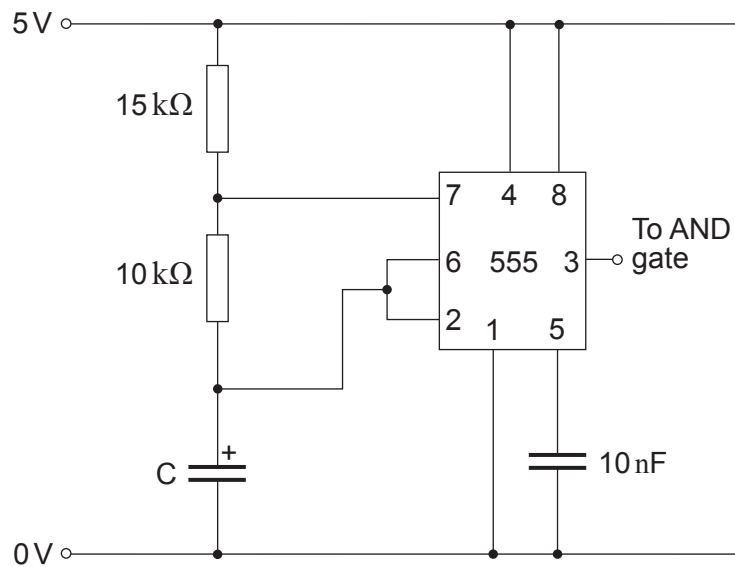
—○ Z

C ○—

- (v) **Cancel** any redundant NAND gates. [2]



(b) Here is the circuit for the astable sub-system.



- (i) Calculate the ideal value for the capacitor C that would give a frequency of 0.5 Hz. [3]

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- (ii) Calculate the mark and space times for the output of this astable.
Use the graph below to **sketch the output signal**.

[5]

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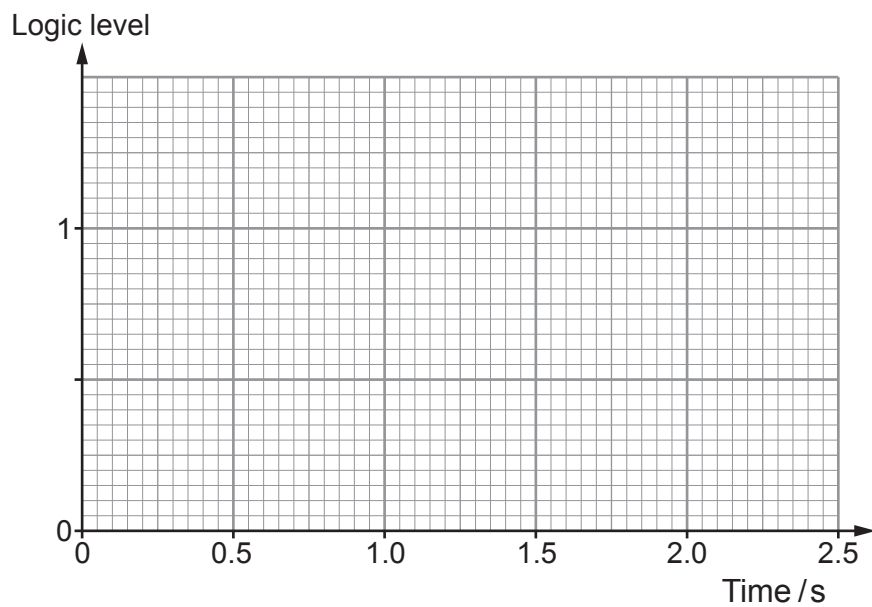
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3. (a) Simplify the following expressions.

[3]

(i) $A.1$

(ii) $B + 0$

(iii) $B.A + B$

(b) Use de Morgan's theorem and Boolean algebra to simplify the following Boolean expression.

[5]

$$\overline{A.B + C.B}$$

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(c) The Karnaugh map for a logic system is shown below.
Derive the simplest Boolean equation for the output Q of the logic system. You should identify and label on the Karnaugh map any groups that you create.

[4]

		B A			
D C		00	01	11	10
	00	0	0	1	1
	01	0	1	0	0
	11	0	1	0	0
	10	1	0	1	1

Q = ...

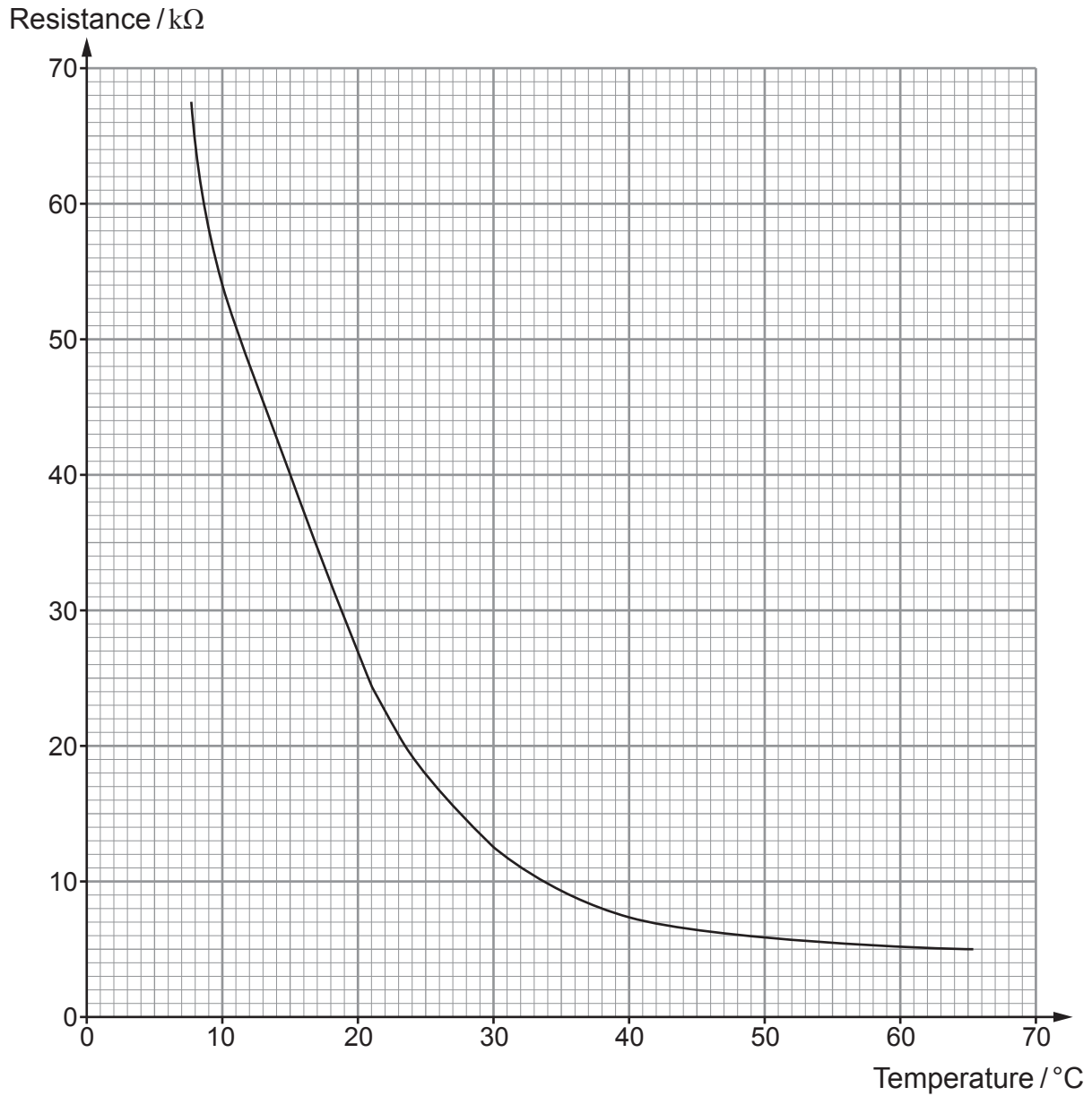


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4. A water cooler uses a thermistor and a comparator to control the cooling motor. When the water is too warm, the motor turns on. Below is a graph showing the behaviour of the thermistor.



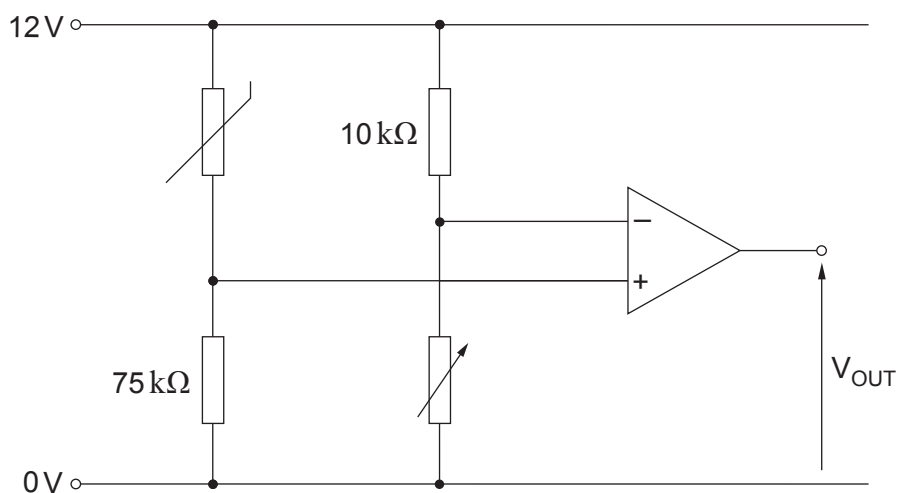
- (a) What is the resistance of the thermistor when the temperature is 15°C ?

[1]

.....



The comparator circuit is shown below. The op-amp saturates at 0V and +11V.



- (b) The variable resistor is set at $14\text{ k}\Omega$. Calculate the resistance of the thermistor that switches the output of the op-amp to $+11\text{ V}$. Use this to determine the temperature at which the system switches on the cooling motor. [5]

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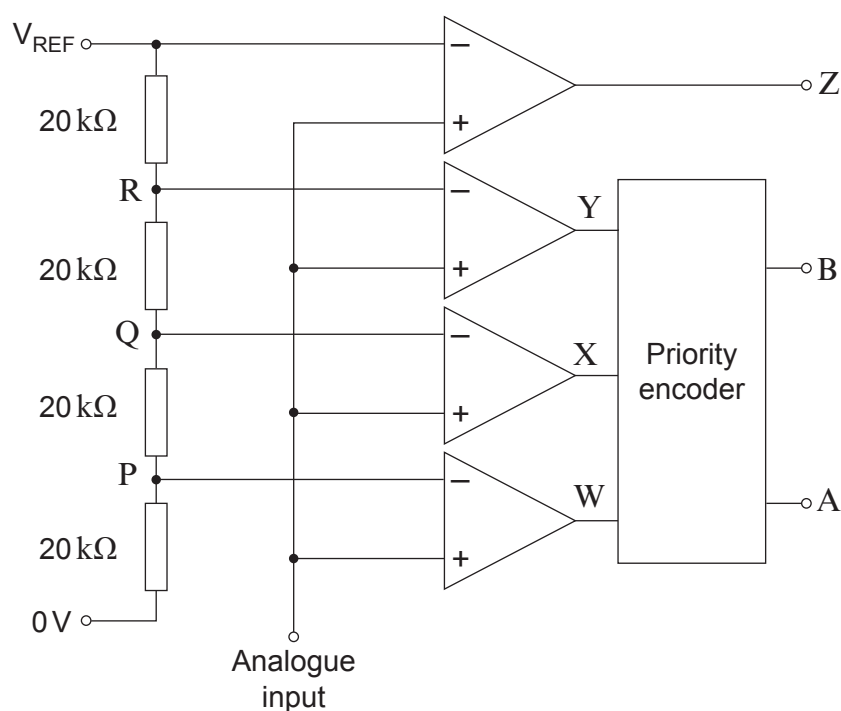
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5. The circuit diagram below shows an ADC. $V_{REF} = 5V$ and the op-amps saturate at $+10V$ and $0V$.



- (a) (i) Calculate the voltages on the resistor chain at P, Q and R. [2]

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Voltage at P = ... Voltage at Q = ... Voltage at R = ...

- (ii) What is the purpose of the output Z? [1]

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.....

- (iii) Determine the resolution of the ADC. [2]

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- (b) The priority encoder produces Gray code output as shown in the table below.
Logic 0 = 0V, Logic 1 = 10V

Voltage at W/V	Voltage at X/V	Voltage at Y/V	Outputs B A	
0	0	0	0	0
10	0	0	0	1
10	10	0	1	1
10	10	10	1	0

Design the priority encoder for this ADC. Give the **simplest** Boolean equation for outputs A and B in terms of W, X and Y and **draw the circuit** in the space below. [4]

A = ...

.....

B = ...

.....

W ○ —

— ○ A

X ○ —

— ○ B

Y ○ —

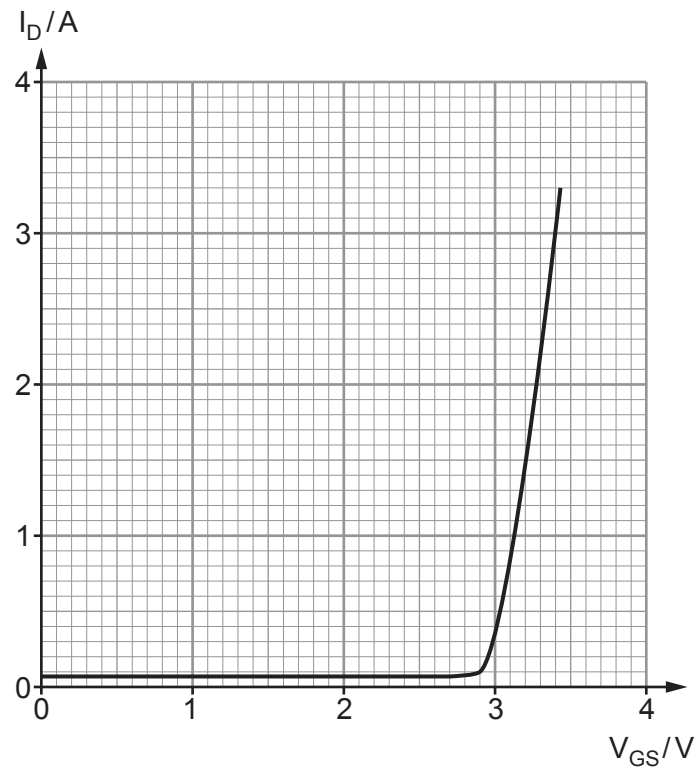


6. Diodes, transistors and MOSFETs are made from semiconductor materials.

- (a) On the axes below, sketch the current-voltage characteristic of a silicon diode when forward-biased. Label any significant voltages. [2]



- (b) Below is the graph of the drain current against the gate-source voltage for a MOSFET.



- (i) Use the graph to determine the transconductance, g_M . [3]

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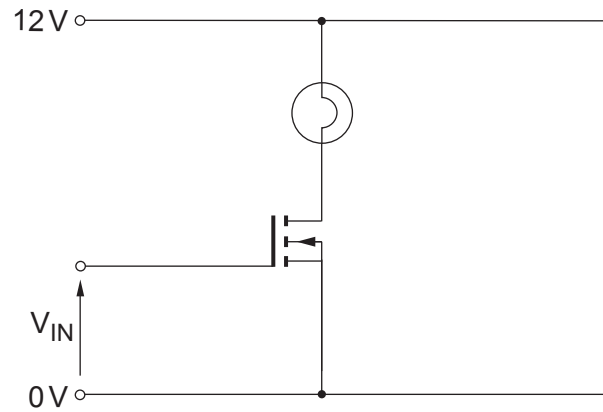
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$g_M =$



- (ii) Another MOSFET with a transconductance of 5.5 S and $r_{\text{DSon}} = 0.2\Omega$ is used in the circuit below. Calculate the drain current I_{D} when $V_{\text{IN}} = 3.8\text{ V}$ **and** use your answer to calculate the power dissipated by the MOSFET. [4]



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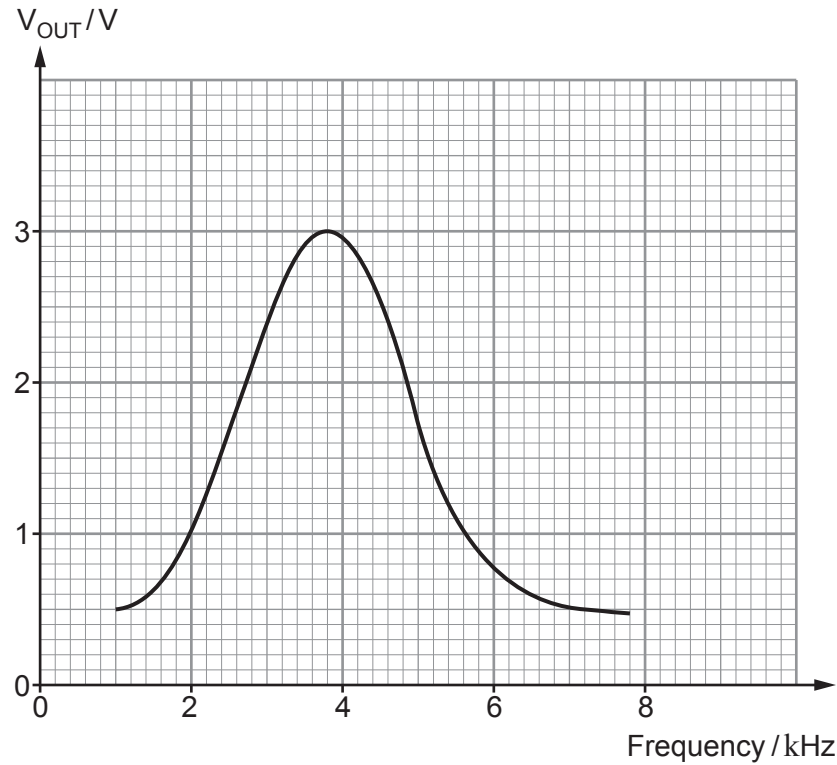
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7. (a) (i) The graph below shows the frequency response for a band-pass filter. Determine the resonant frequency and bandwidth of the filter. Use your answers to calculate the Q-factor. [5]



Resonant frequency = ... kHz

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Bandwidth = ... kHz

Q-factor = ...

- (ii) State the meaning of Q-factor and describe how it affects bandwidth. [2]

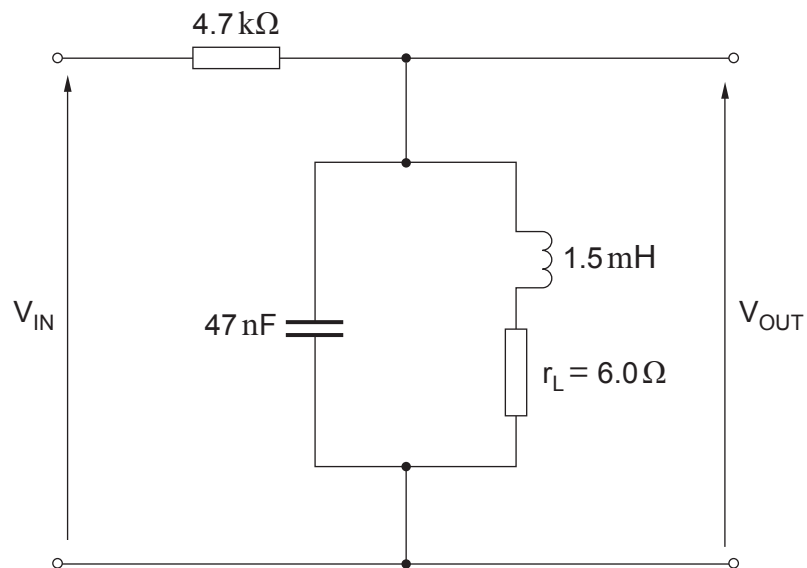
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- (b) The circuit for another band-pass filter is shown below.



- (i) Calculate the resonant frequency of this filter. [3]

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- (ii) Calculate the value of dynamic resistance (R_D) **and** use this to calculate the value of V_{OUT} at resonance when $V_{IN} = 9\text{ V}$. [4]

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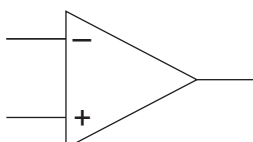
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- (i) Draw the circuit for a voltage follower based on the op-amp below. Label the input and output. [2]



0V ○————○

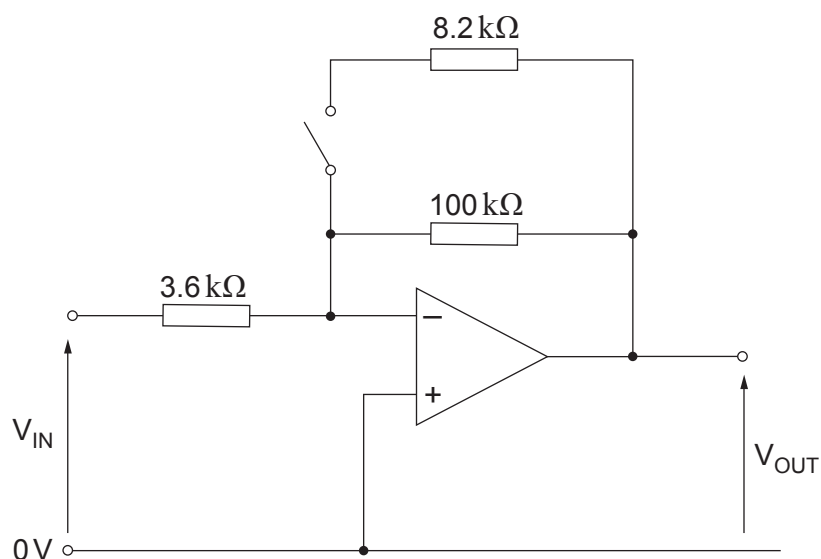
- the issues associated with linking the band-pass filter to another sub-system without the voltage follower
- the properties of the voltage follower
- how these properties solve the issues.

[6 QER]





8. Below is the circuit for an inverting amplifier with two voltage gain settings. The amplifier saturates at ± 10 V.



- (a) (i) What is the input impedance of the amplifier? [1]

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- (ii) What are the **two** possible voltage gains for the amplifier? [5]

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Voltage gain with switch open = ...

Voltage gain with switch closed = ...

- (iii) Calculate V_{OUT} when $V_{IN} = 0.1$ V and the switch is open. [2]

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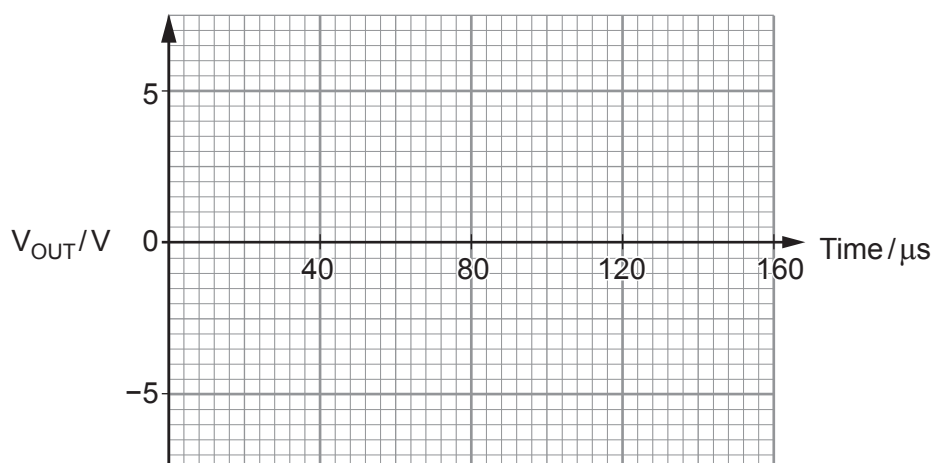
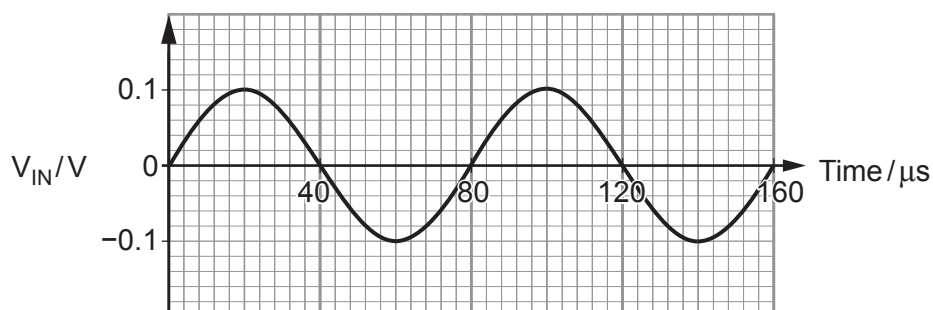
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- (b) The signal shown on the graph is now applied to the input of the amplifier. The switch remains open.

(i) Draw the output on the graph below.

[3]



(ii) Calculate the frequency of V_{IN} .

[2]

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.....

(iii) Calculate the lowest value of slew rate that will ensure that V_{OUT} is not distorted.

[3]

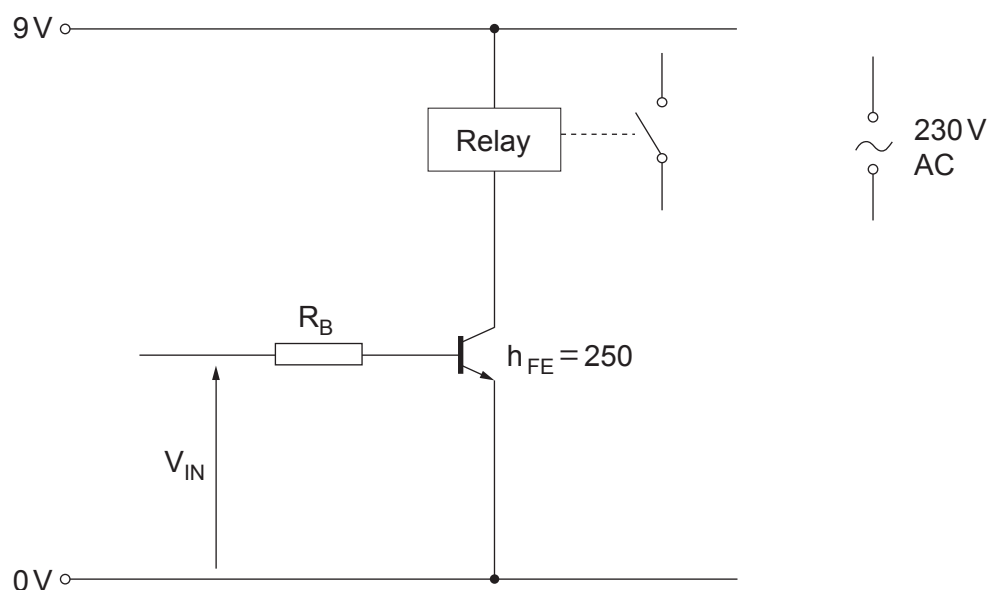
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9. A system is required to switch on a mains lamp when the light level drops below a certain value.



- (a) The input voltage V_{IN} is 3.2V when the transistor is just saturated. The relay coil has a resistance of 120Ω .

Calculate the ideal value for R_B and then give its preferred value from the E24 series.

[6]

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Preferred value = ...

- (b) **Complete the circuit diagram** by adding:

- the sensing sub-system
- a component to protect the transistor
- the mains lamp circuit.

[5]

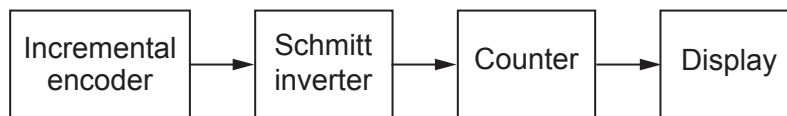


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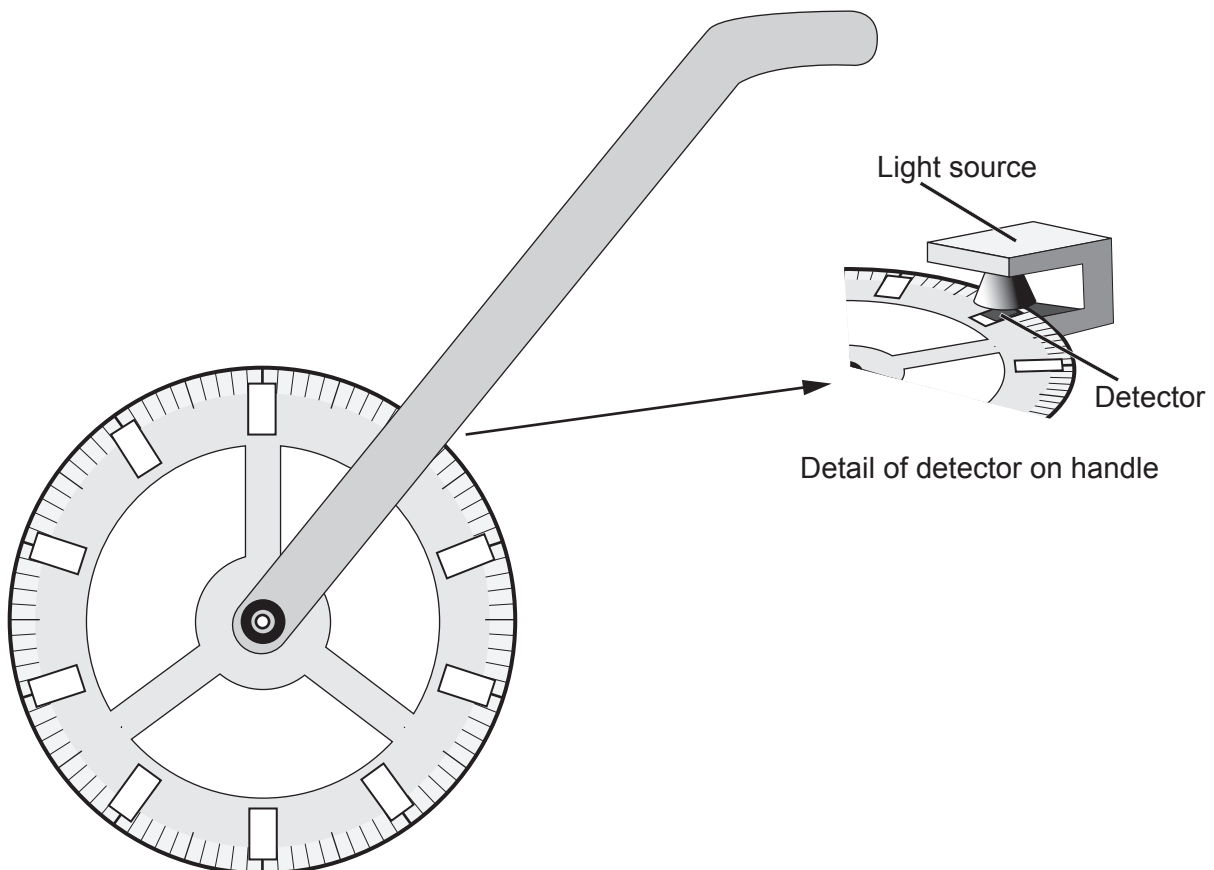
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10. A trundle wheel is a device used in the construction industry to measure distances. Here is the block diagram for the system.



The incremental encoder consists of a disc, a light source and a photodiode detector. The disc has 10 slots and covers 1 m in one complete revolution.



- (a) (i) If the counter counts to 80, how many metres have been covered? [2]

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- (ii) What is the smallest distance that can be measured? [1]

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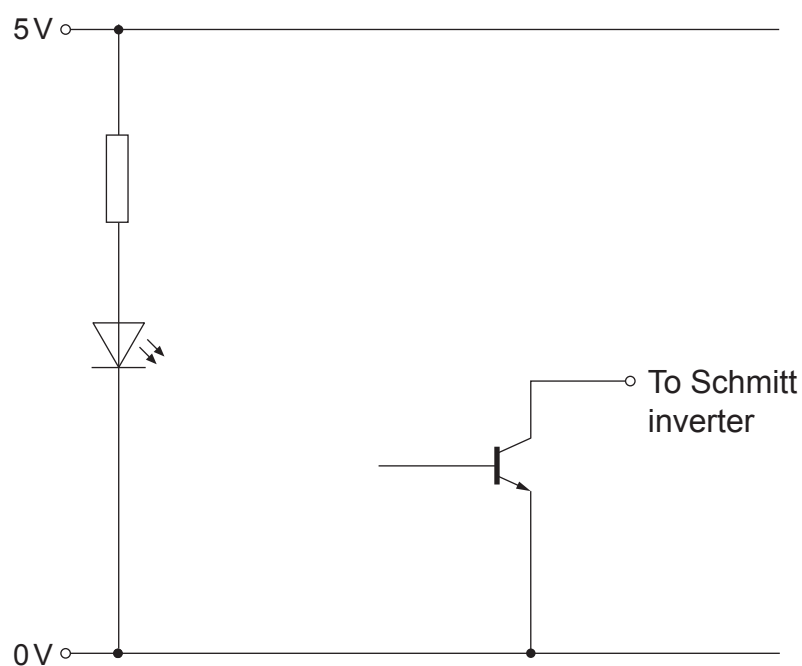


- (b) (i) What is the purpose of the Schmitt inverter? [1]

.....

.....

- (ii) Complete the design of the circuit below for the photodiode detector based on a transistor by adding a photodiode and any resistor(s) required. The LED light source has been completed for you. [3]



11. Space waves are used for communications with satellites.

- (a) (i) State a property of space waves that makes them suitable for this application. [1]

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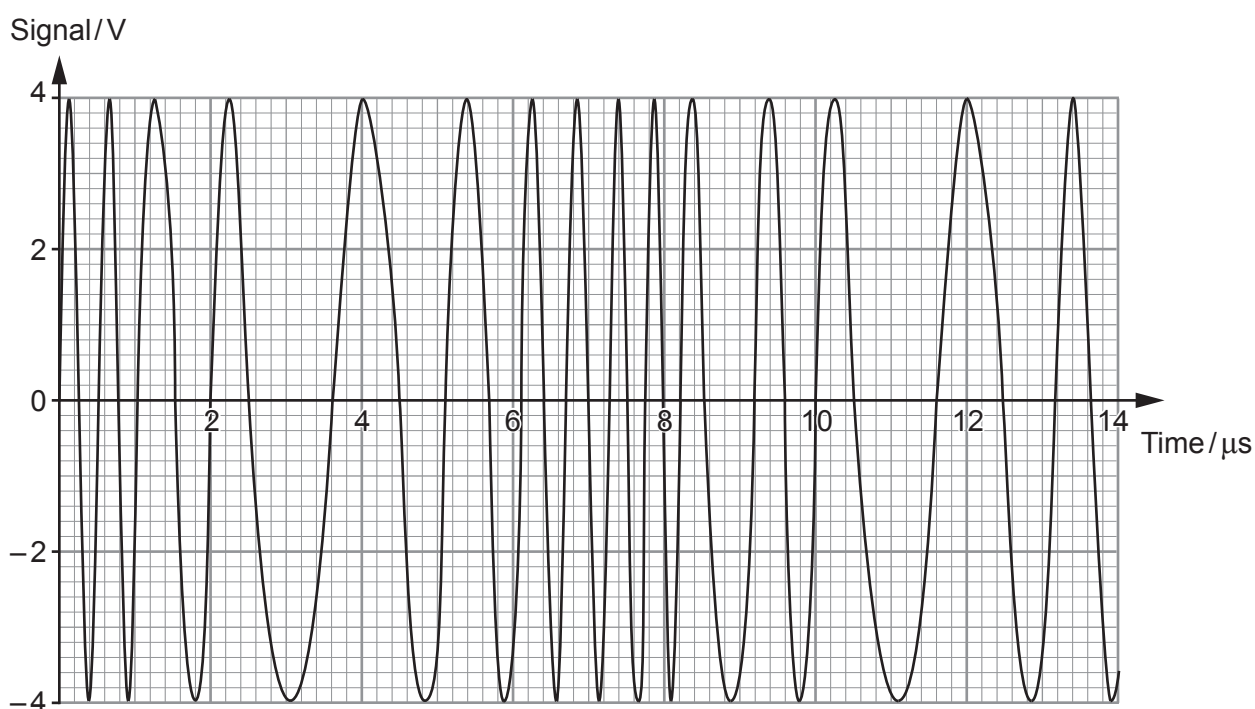
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- (ii) What is the wavelength of a space wave with a frequency of 200 GHz?
(The speed of electromagnetic waves = $3 \times 10^8 \text{ m s}^{-1}$) [2]

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- (b) The graph shows a radio wave that has been frequency modulated by a single frequency.



Calculate:

- (i) the signal frequency [2]

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.....



(ii) the carrier frequency.

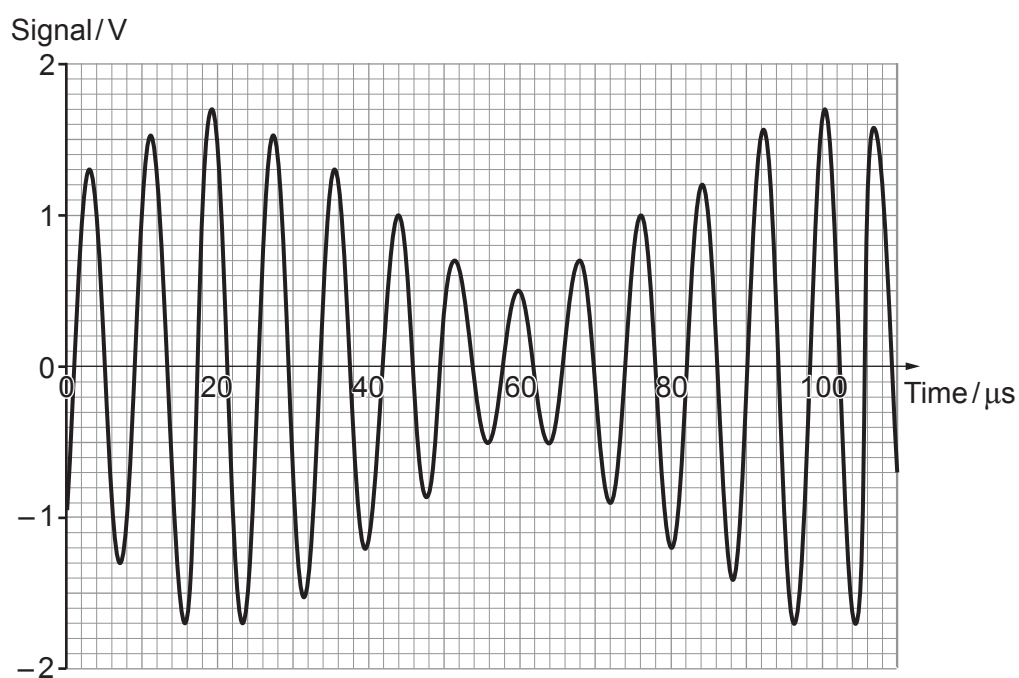
[2]

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(c) The graph below shows an amplitude modulated signal that has been modulated by an audio signal that is a single sine wave.



Determine the depth of modulation of the modulated signal.

[3]

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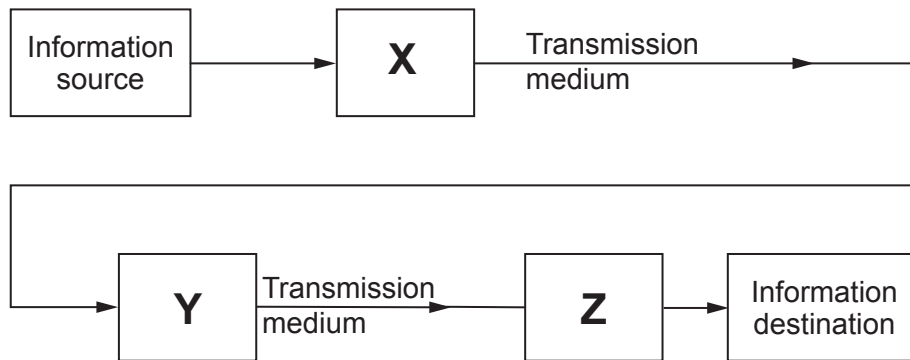
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12. A block diagram for a simple digital communications system is shown below.



- (a) Identify the function of the blocks **X**, **Y** and **Z**.

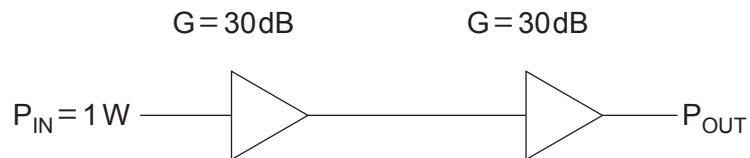
[3]

X = ...

Y = ...

Z = ...

- (b) A different communications system has two amplifiers 20 km apart, as shown below. The attenuation is 3.1 dB km^{-1} between the amplifiers.



- (i) Define attenuation, describe its effect on SNR and explain why it is an issue.

[3]

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- (ii) Show by calculation that the output power for the system is approximately 0.6 W. [4]

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- (iii) The communications engineer wants to increase the power at the output to 0.8 W. They decide to add an additional amplifier. What is the gain of this amplifier in dB? [2]

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END OF PAPER



[illegible]