

Surname	Centre Number	Candidate Number
First name(s)		2



GCE AS

B490U10-1



S25-B490U10-1



MONDAY, 19 MAY 2025 – AFTERNOON

ELECTRONICS – AS component 1

Principles of Electronics

2 hours 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	10	
2.	9	
3.	12	
4.	9	
5.	5	
6.	12	
7.	15	
8.	11	
9.	6	
10.	6	
11.	14	
12.	11	
Total	120	

B490U101
01

ADDITIONAL MATERIALS

You will require a calculator, a ruler 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.

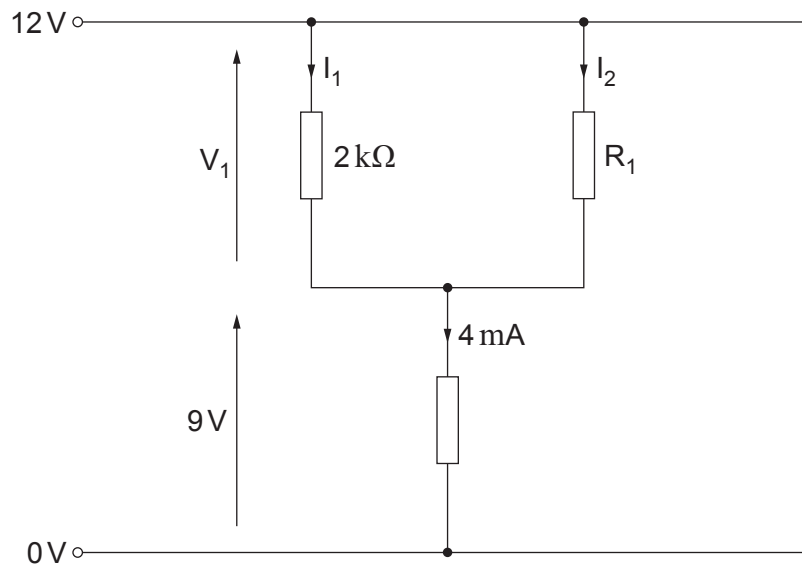
The assessment of the quality of extended response (QER) will take place in questions **4(b)** and **9**.



JUN25B490U10101

Answer **all** questions.

1. (a) Use the information given in the circuit diagram to calculate the values of the quantities listed.



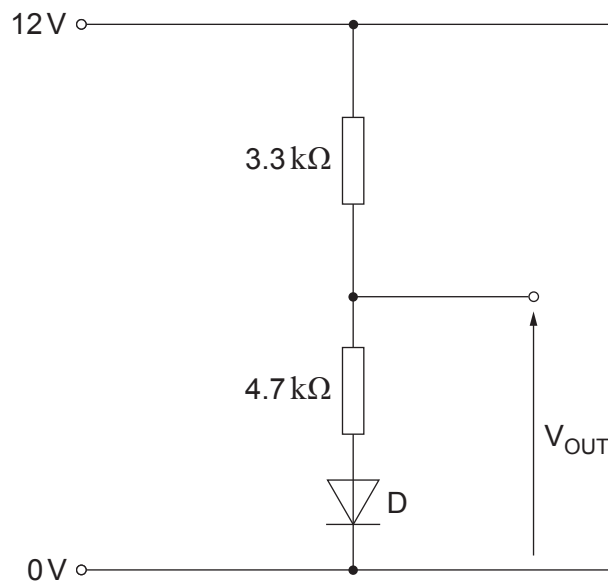
(i) V_1 [1]

(ii) I_1 [2]

(iii) R_1 [2]



(b) In the following circuit, D is a silicon diode.



(i) Calculate the voltage V_{OUT} .

[4]

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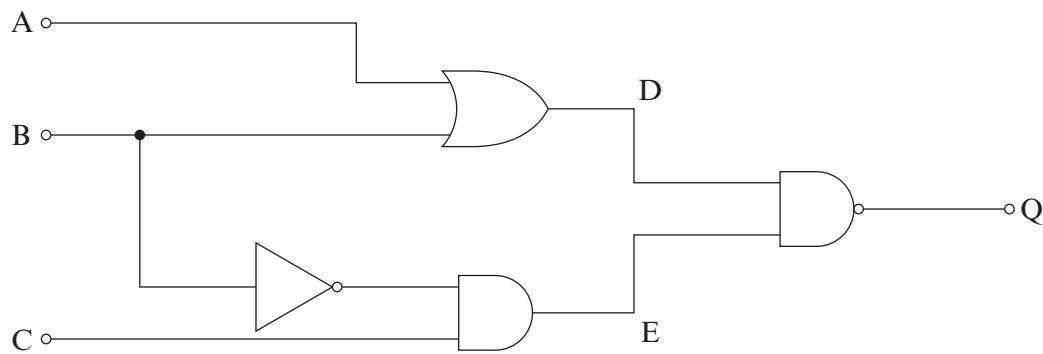
(ii) Diode D is reversed. What is the new value of V_{OUT} ?

[1]

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2. (a) The following diagram shows a logic system.



Complete the Boolean equations for D, E and Q in terms of inputs A, B and C.
No simplification is required.

[3]

D = ...

E = ...

Q = ...

- (b) The Boolean equation for a different 3-input logic system is:

$$Q = \overline{(C + A).C.\overline{B}}$$

Apply de Morgan's theorem to this equation and then simplify it.

[3]

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- (c) Another system produces the Karnaugh map shown below. Give the simplest Boolean equation for the output Q.

[3]

		BA			
DC		00	01	11	10
		00	01	11	10
00		1	0	1	1
01		0	0	0	1
11		0	0	0	1
10		1	0	0	1

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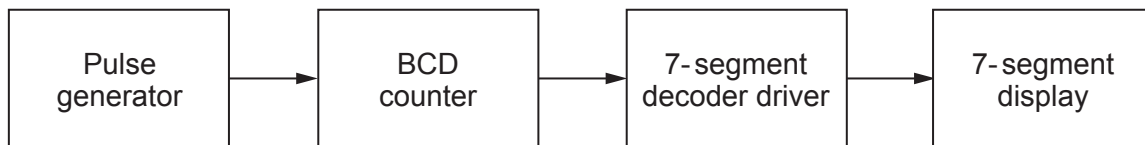
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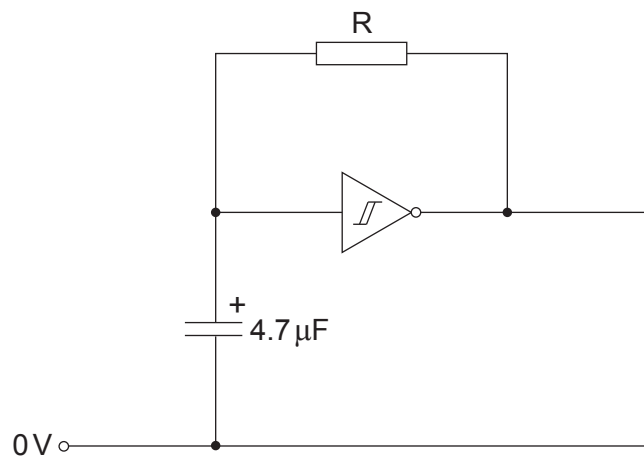
Q = ...



3. The block diagram for a timing system is shown below.



- (a) The following diagram shows an astable sub-system based on a Schmitt inverter that is used as the pulse generator.



The astable is required to produce a frequency of 0.5 Hz. Calculate the ideal value of the resistor. [3]

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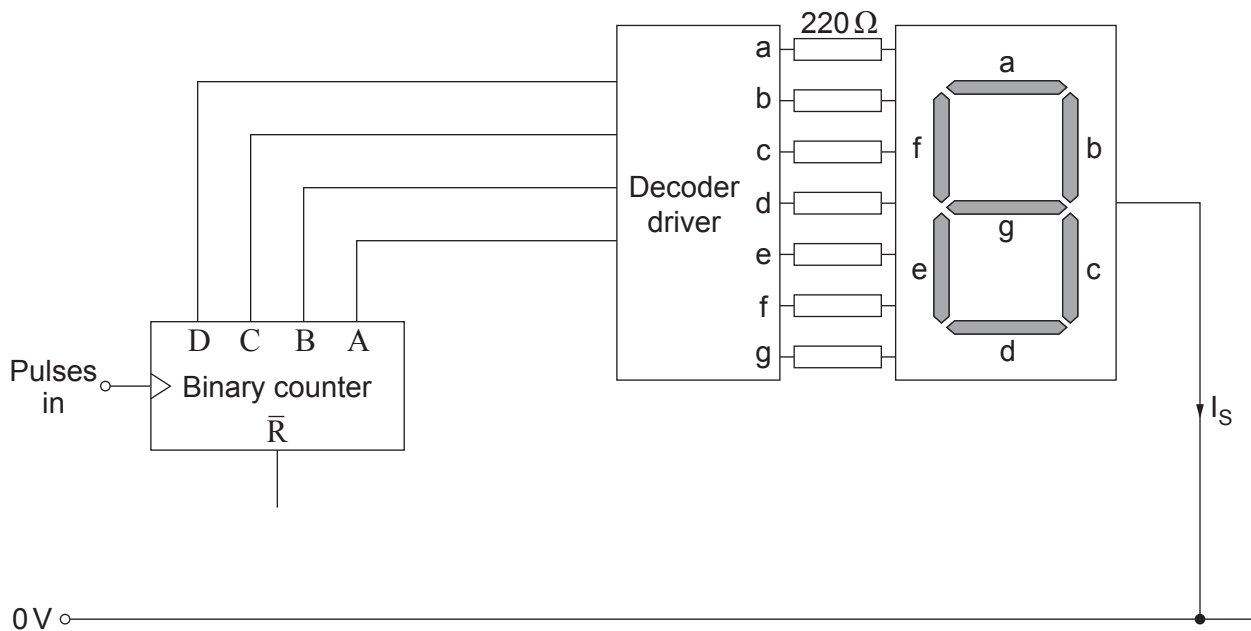
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- (b) On the circuit diagram below, show how a binary counter can be converted into a BCD counter by **adding** extra connections and components. [3]



- (c) (i) Each LED in the 7-segment display has a forward voltage drop of $2.1V$. The output of the decoder driver is $5V$ when logic 1. Calculate the current through LED 'a' when it is illuminated. [3]

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- (ii) What is the current, I_s , when the display is showing '2'? All resistors are $220\ \Omega$. [2]

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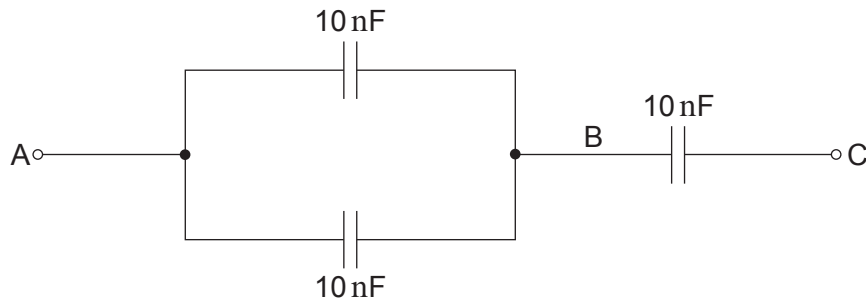
- (d) One of the LEDs in the 7-segment display fails to come on. The only number to be correctly displayed is '2'. Which segment (a–g) is faulty? [1]

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4. (a) Calculate the overall capacitance between A and C.

[3]



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- (b) A timer delay circuit is required, to meet the following specification:

- A pulse of 5 minutes duration, tolerance 5%, is produced.
- A pulse is triggered by the momentary press of a switch.

Design a 555-based monostable circuit to meet this specification. The circuit should run from a 9V battery and use a $3300\mu\text{F}$ capacitor. Include a suitable E24 series resistor in your design.

Discuss the effect of component tolerances on the operation of the circuit.

Explain your reasoning and show all calculations.

[6 QER]





5. A microcontroller system is required to clean the headlights of a tractor automatically. The specification states the following:

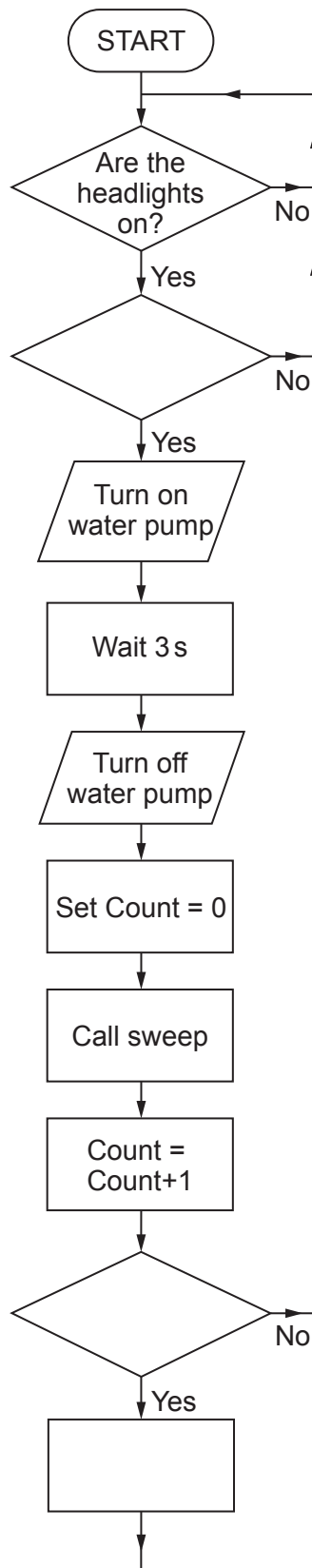
- Cleaning only takes place when the headlights are on.
- Cleaning only takes place when it is raining.
- A subroutine called 'sweep' is used to provide a single sweep of a wiper blade.
- Cleaning involves a 3 s squirt of water followed by 5 sweeps of the wiper blade.
- There is a delay of five minutes before cleaning can happen again.

An incomplete section of the program flowchart is shown opposite.

Complete the flowchart boxes **and** add any flow lines needed.

[5]



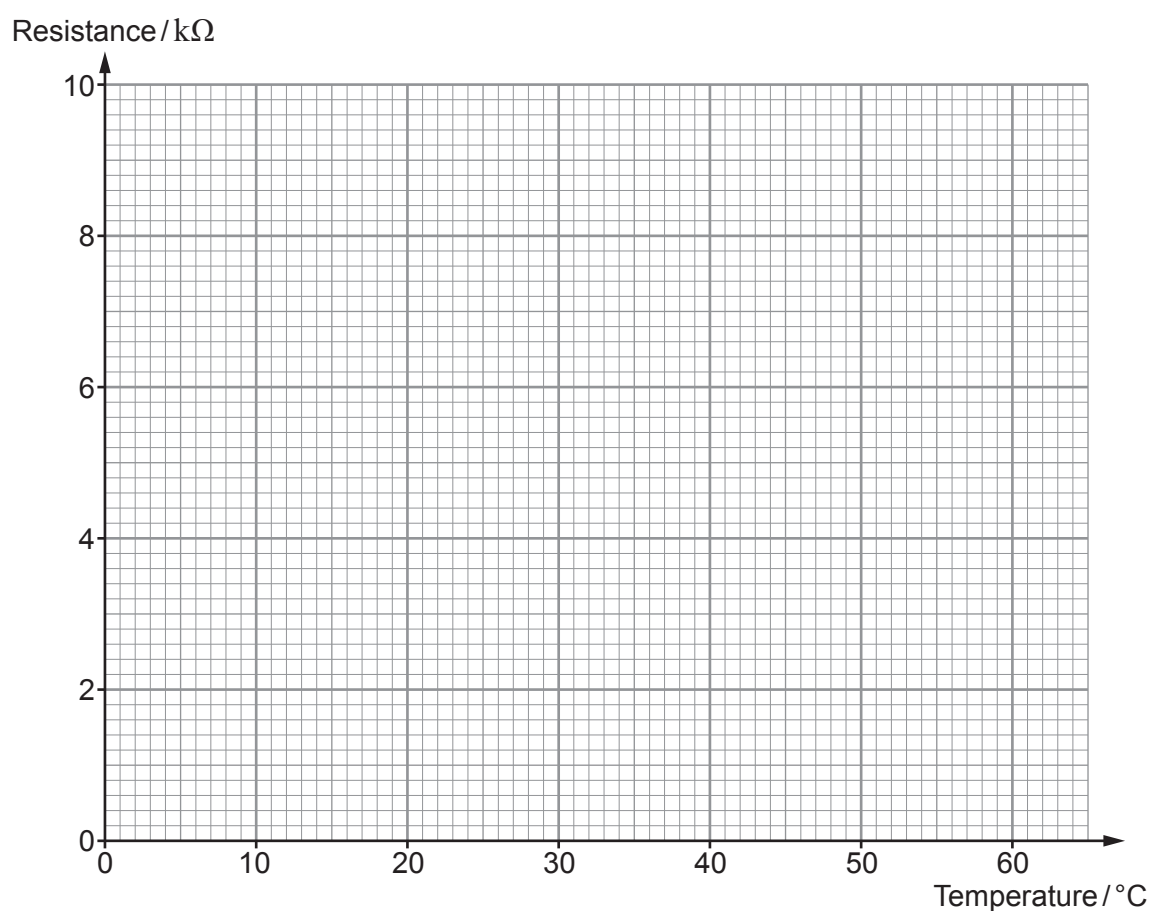


6. (a) The table below shows the results obtained when the resistance of a thermistor is measured at different temperatures.

Temperature / °C	Resistance / kΩ
0	8.8
10	5.4
20	3.7
30	2.4
40	1.6
50	0.9
60	0.4

- (i) Plot a graph of resistance against temperature on the grid below.

[3]

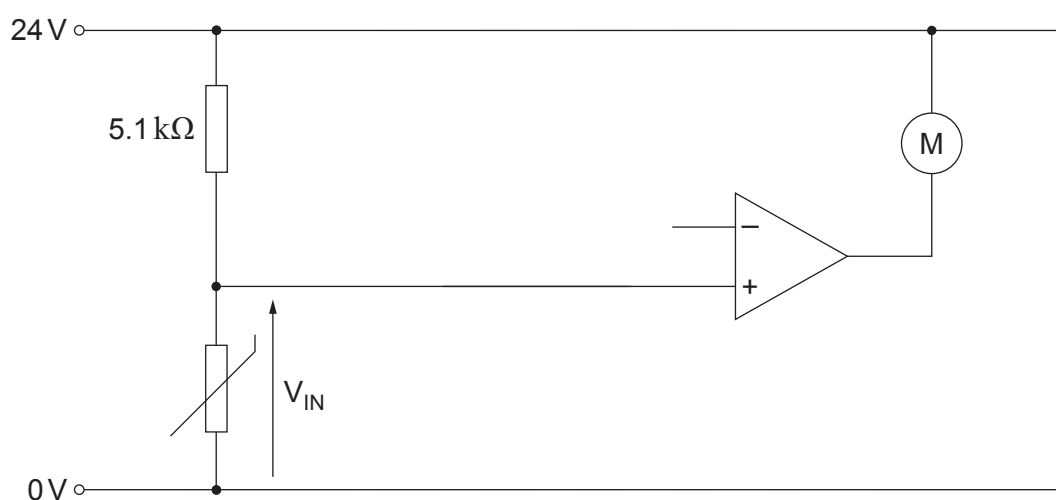


- (ii) Use the graph to determine the resistance of the thermistor at 25°C . [1]

- (b) A fan is used to help prevent a device from overheating.

The fan motor switches on automatically when the temperature exceeds 25°C . The temperature-sensing unit uses the thermistor from part (a), together with a $5.1\text{ k}\Omega$ resistor.

The incomplete circuit diagram for the system is shown below.



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

- A reference voltage sub-system for the comparator that can be adjusted.
- A component to protect the comparator from back emf.

[3]

- (ii) Calculate the value of V_{IN} at 25°C . [2]



- (c) The fan motor has a power rating of 500 mW and the comparator output can sink a current of 25 mA. The comparator output saturates at 23 V and 1 V.

Determine whether the system will operate as designed.

[3]

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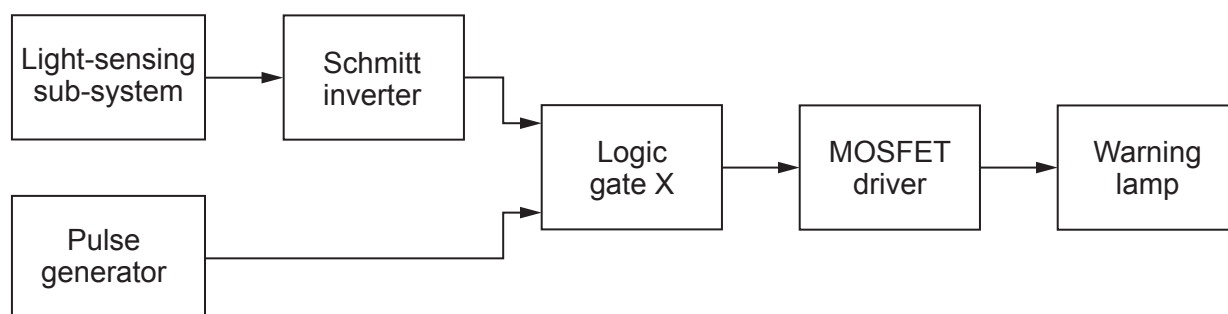
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7. A traffic cone has a warning lamp that flashes automatically at night. A design for the warning system is shown below.



- (a) (i) Design the light-sensing sub-system using an LDR and a resistor, to give an output voltage that rises with decreasing light intensity. [2]

5V ○ _____

0V ○ _____

- (ii) The LDR has a resistance of $9.6 \text{ k}\Omega$ at 40 lux. Calculate the value of the resistor that makes the light-sensing sub-system output 3.5V when the light intensity is 40 lux. [3]

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- (b) (i) Why is a Schmitt inverter used rather than a simple NOT gate in this circuit? [1]

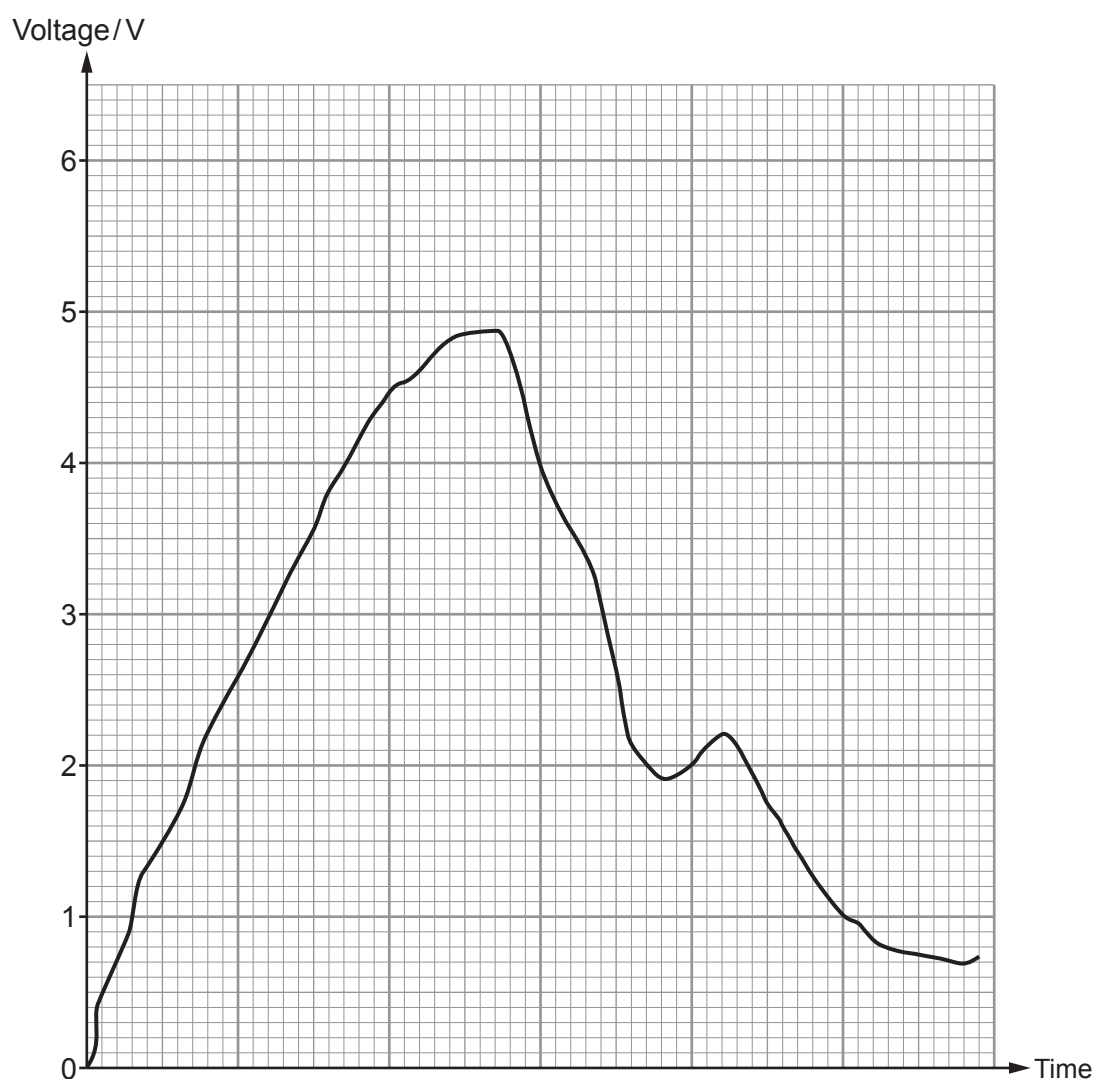
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- (ii) The data sheet for the Schmitt inverter is given below.

- Logic 0 = 0 V
- Logic 1 = 5 V
- The output changes from logic 1 to logic 0 when a **rising** input voltage reaches 3.5 V.
- The output changes from logic 0 to logic 1 when a **falling** input voltage reaches 1.5 V.

The output voltage of the light-sensing sub-system is shown on the graph below.
On the same graph, draw the resulting output signal produced by the Schmitt inverter. [3]

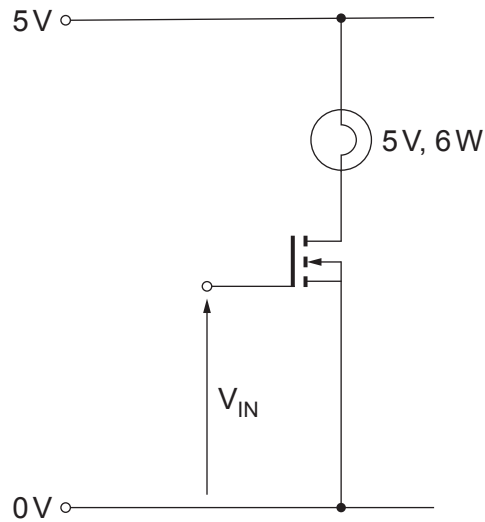


- (c) Identify the logic gate X.

[1]

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- (d) The MOSFET circuit is shown below.



The lamp is rated at 5V, 6W. Calculate:

- (i) the current through the lamp when fully lit

[2]

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- (ii) the minimum value of V_{IN} needed to saturate the MOSFET if the transconductance, g_M is 3.2 S.

[3]

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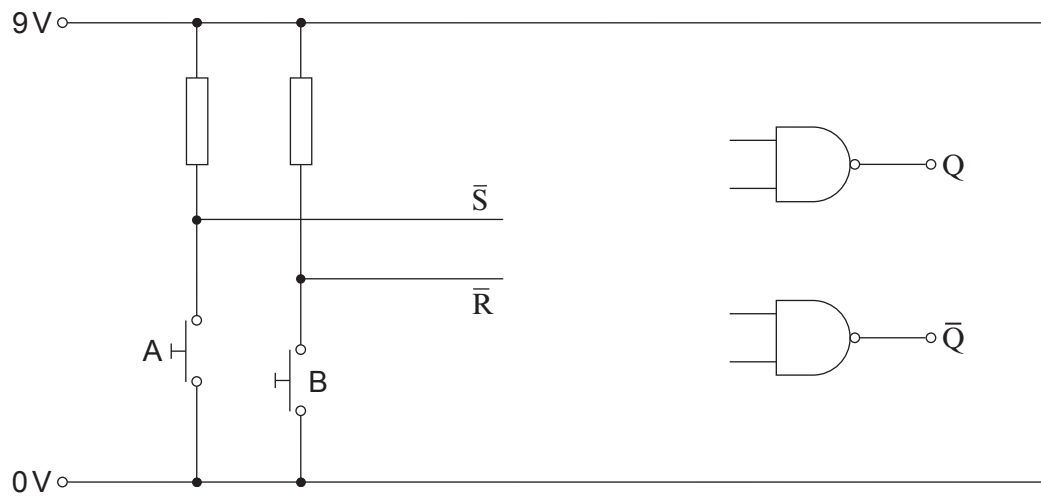


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8. (a) Complete the diagram to make a set-reset latch. [2]

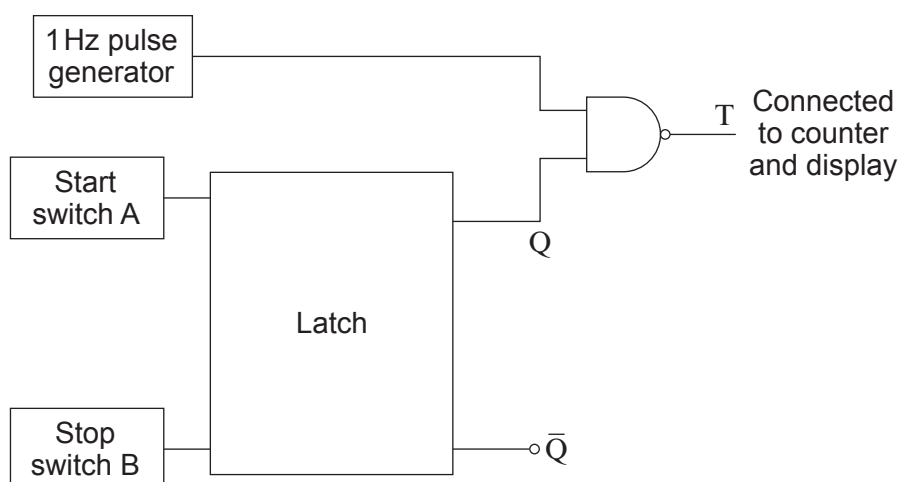


(b) Complete the table with the correct logic levels.
Output Q is initially low. [3]

Switch position		Logic levels		
A	B	$\bar{S}$	$\bar{R}$	Q
OPEN	OPEN			
CLOSED	OPEN			
OPEN	CLOSED			
OPEN	OPEN			



(c) The latch is used in a timer. Part of the system is shown below.



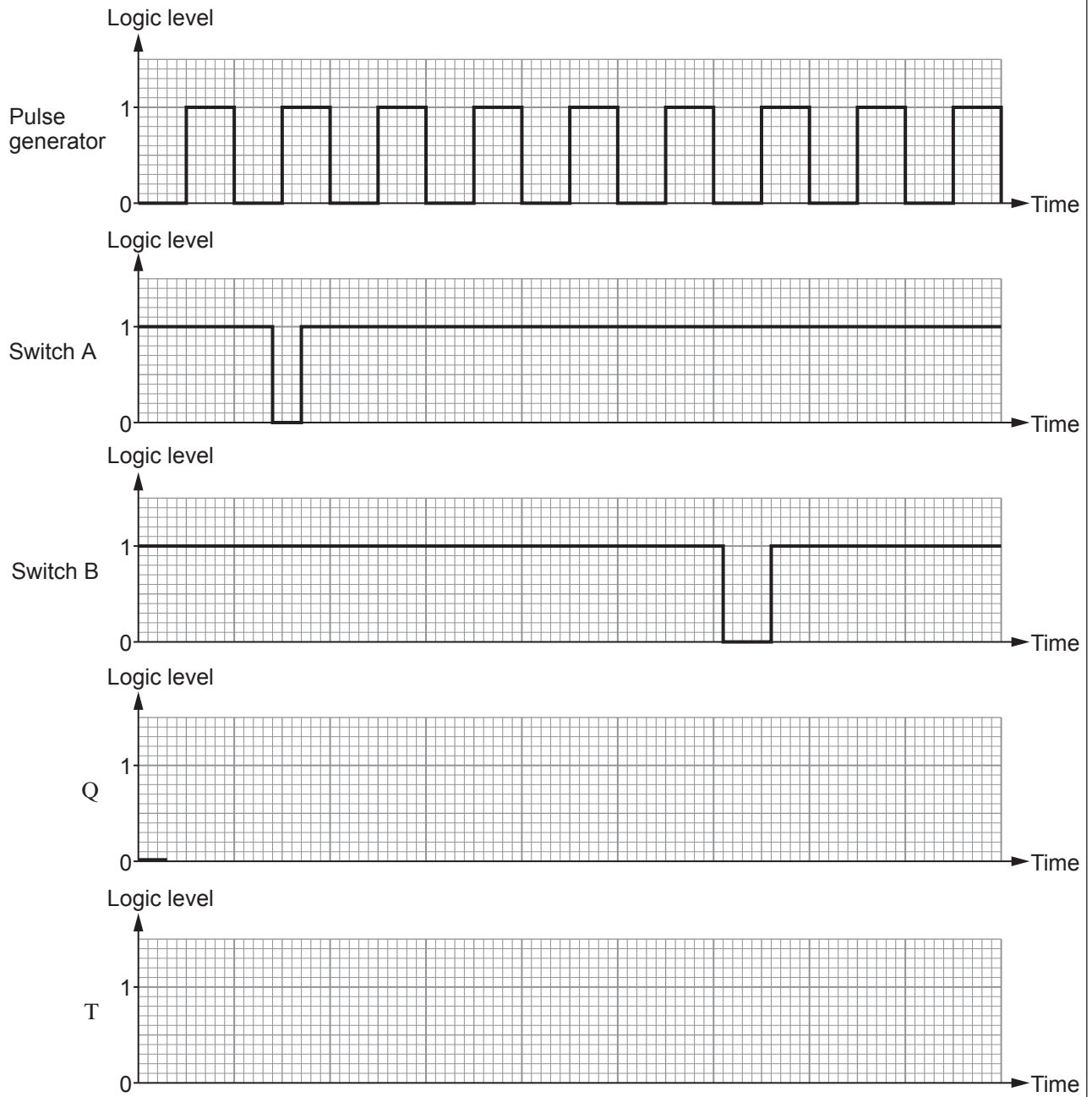
The timing diagrams opposite show:

- the output of the pulse generator
- the signal from switch A
- the signal from switch B.

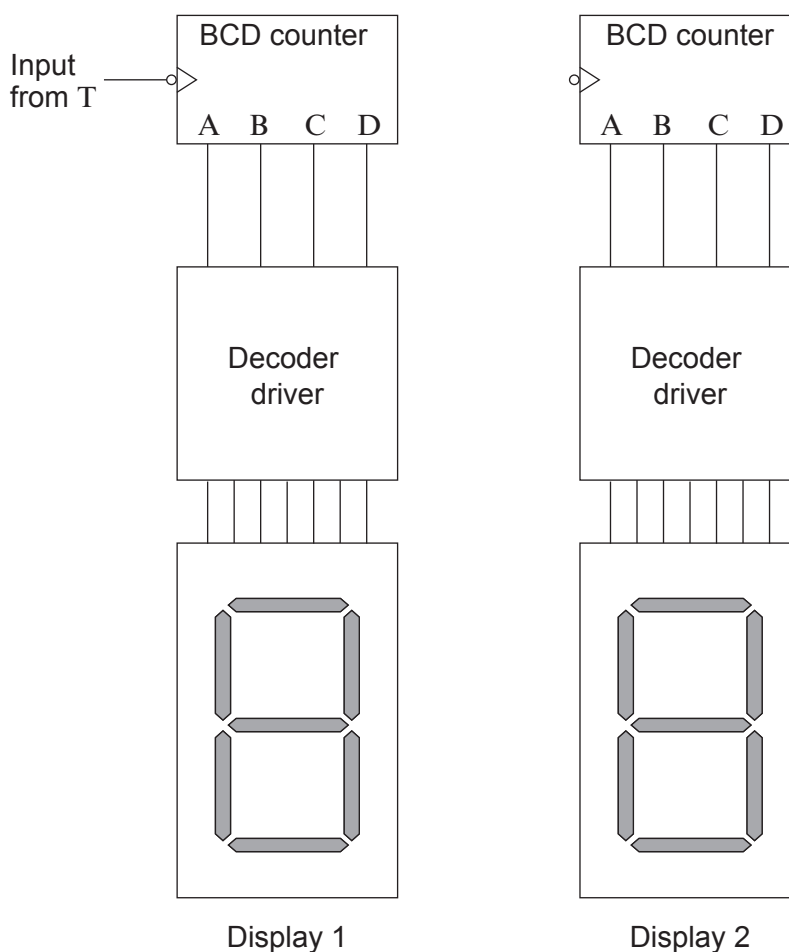
Complete the timing diagrams opposite to show the outputs Q and T.

[4]





(d) The incomplete 2-digit counter/display sub-system is shown below.



The counters are falling-edge triggered. D is the most significant bit.

(i) **Complete the diagram** so that the display can show a maximum of '99'. [1]

(ii) The timer counts for 47 s. Which display shows the number '7'? [1]

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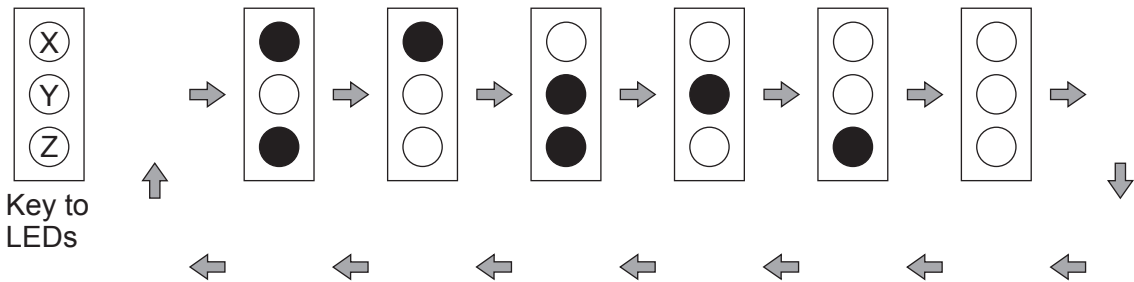


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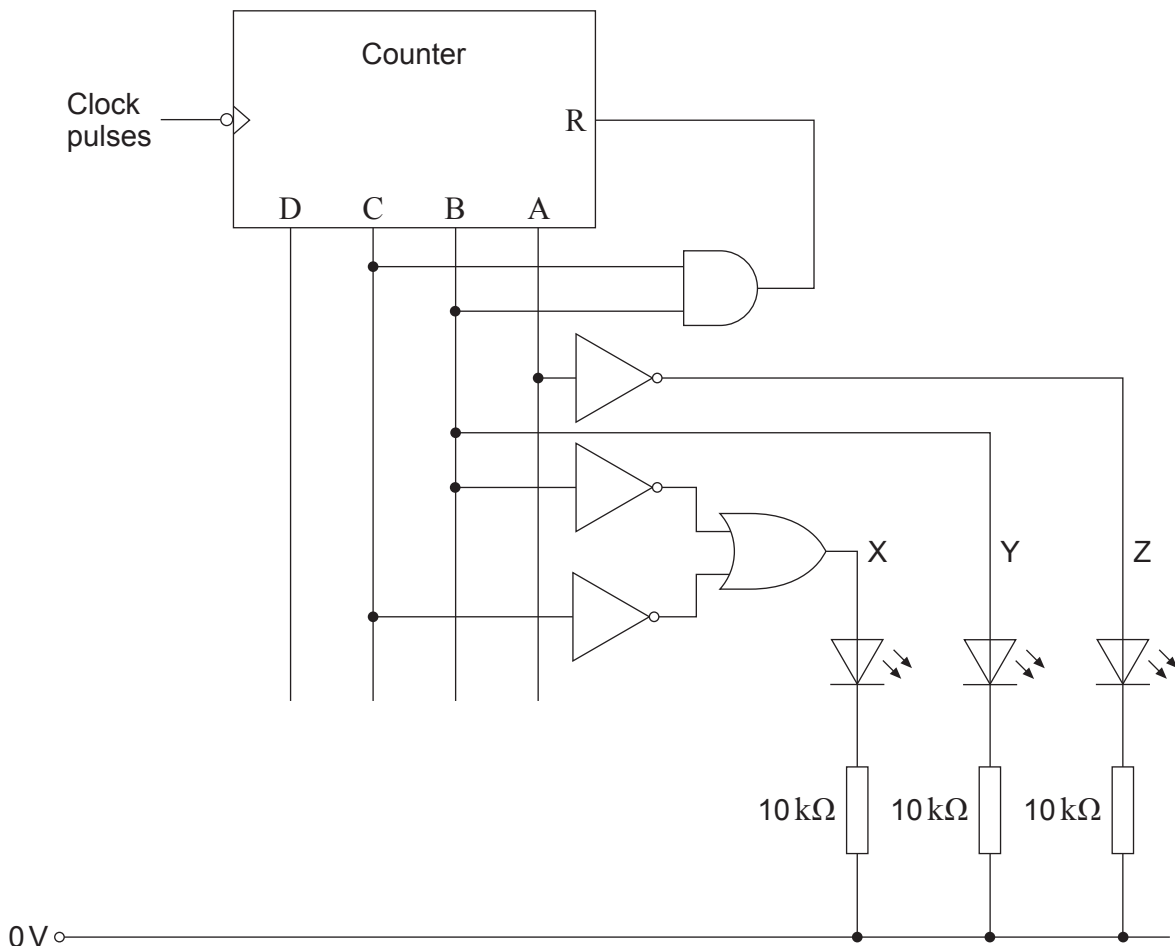
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- 9.



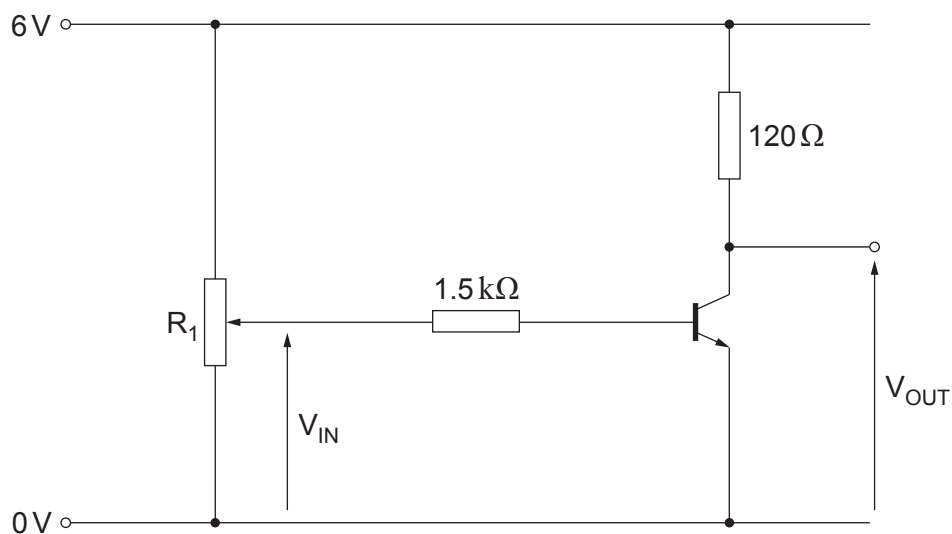
A student designs a combinational logic system attached to the outputs of a 4-bit counter to generate this light sequence.



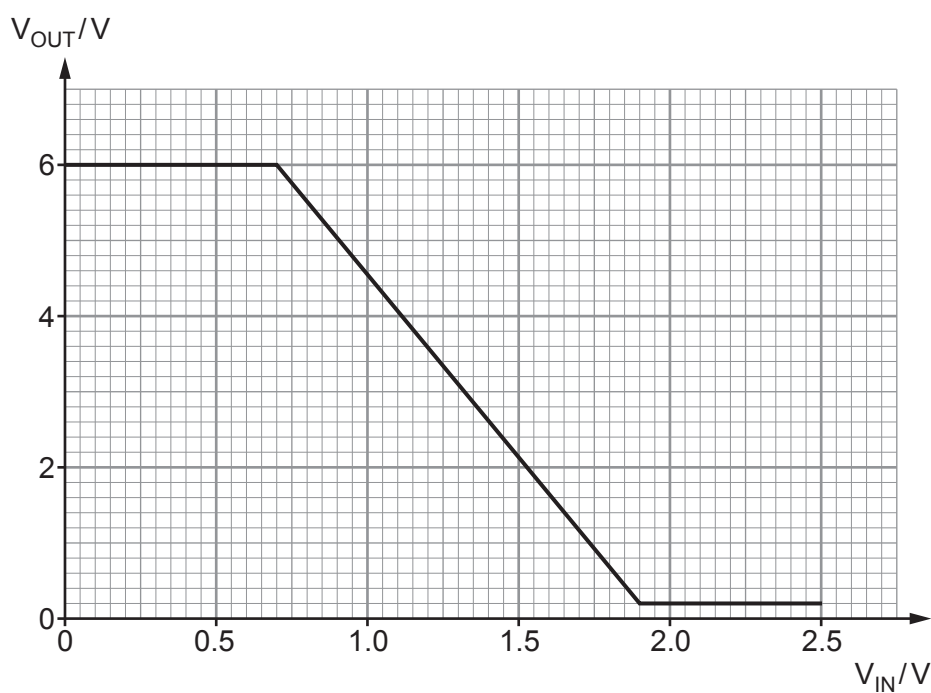
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10. The following circuit is used to investigate how a transistor can be used as a switch.



Results were obtained for values of V_{OUT} as V_{IN} was gradually increased from 0 to 2.5V. A graph of V_{OUT} against V_{IN} is plotted on the grid below.



- (a) Use the graph to determine the value of V_{IN} that will cause the transistor to just saturate. Use this value of V_{IN} to calculate the base current. [3]

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- (b) Calculate the collector current when the transistor is just saturated. Use your calculations to determine the current gain (h_{FE}) of the transistor.

[3]

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11. The table shows some properties for two op-amps, **M** and **N**. Both op-amps are connected to $\pm 20\text{ V}$ power supplies and saturate at $\pm 18\text{ V}$.

Property	M	N
Input impedance / Ω	4×10^9	5×10^8
Open-loop gain	3.5×10^5	1×10^6
Maximum output current / mA	20	12
Gain-bandwidth product / MHz	4.8	3.6
Slew rate / $\text{V}\mu\text{s}^{-1}$	5.0	7.5

- (a) (i) State which amplifier takes longer to reach saturation when a large step input signal is applied at the input. [1]

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- (ii) Calculate the bandwidth of amplifier **N** when configured to have a voltage gain of 200. [2]

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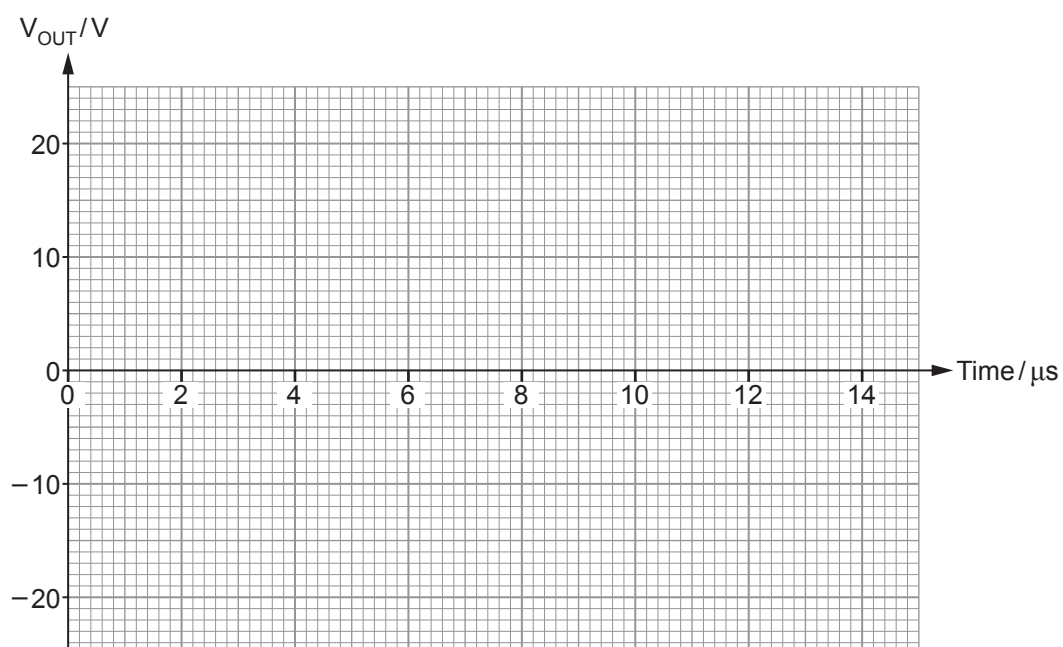
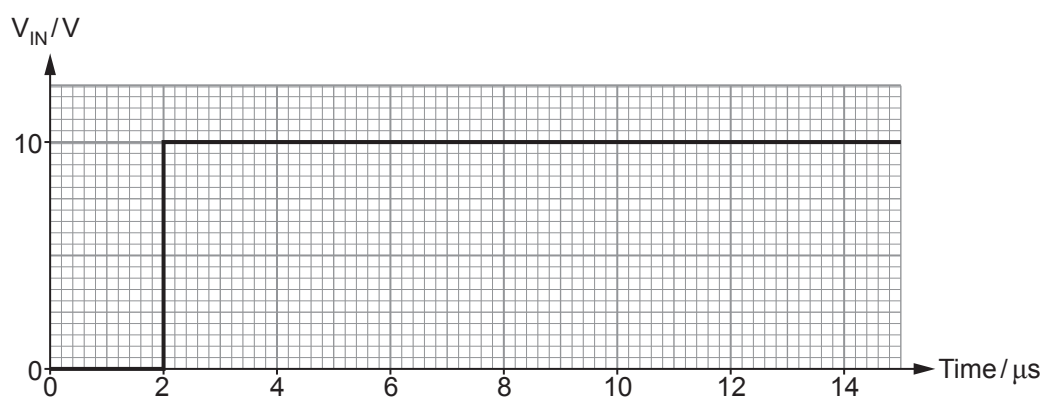
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- (b) Op-amp **M** is connected as a **non-inverting** voltage amplifier with a high gain. The first graph shows the signal applied to its input.

Complete the second graph to show the output signal.

[3]



(c) Op-amp **N** is used to make a voltage amplifier with gain -40 .

- (i) Design a suitable circuit for this amplifier. Your design should include a circuit diagram labelled with suitable resistor values. [5]

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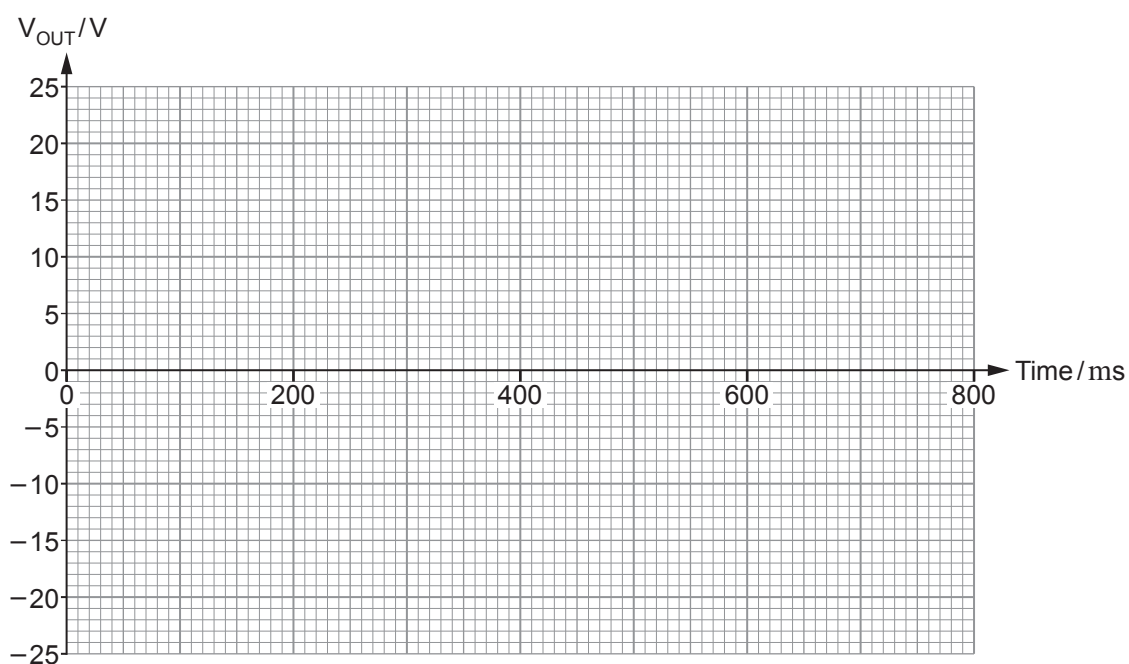
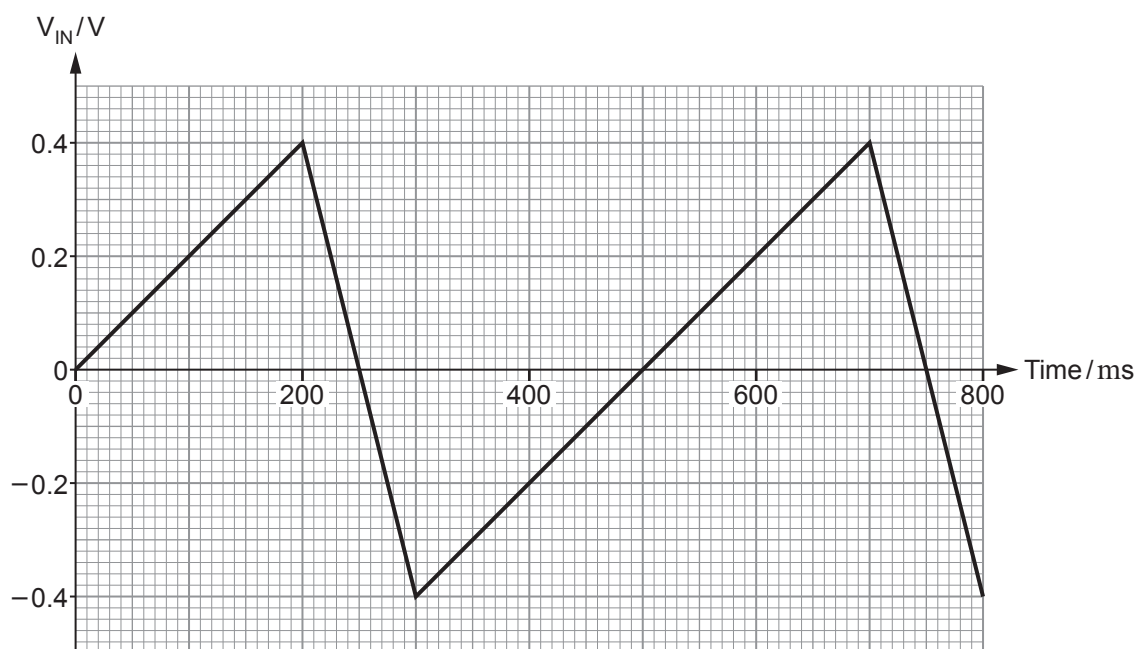
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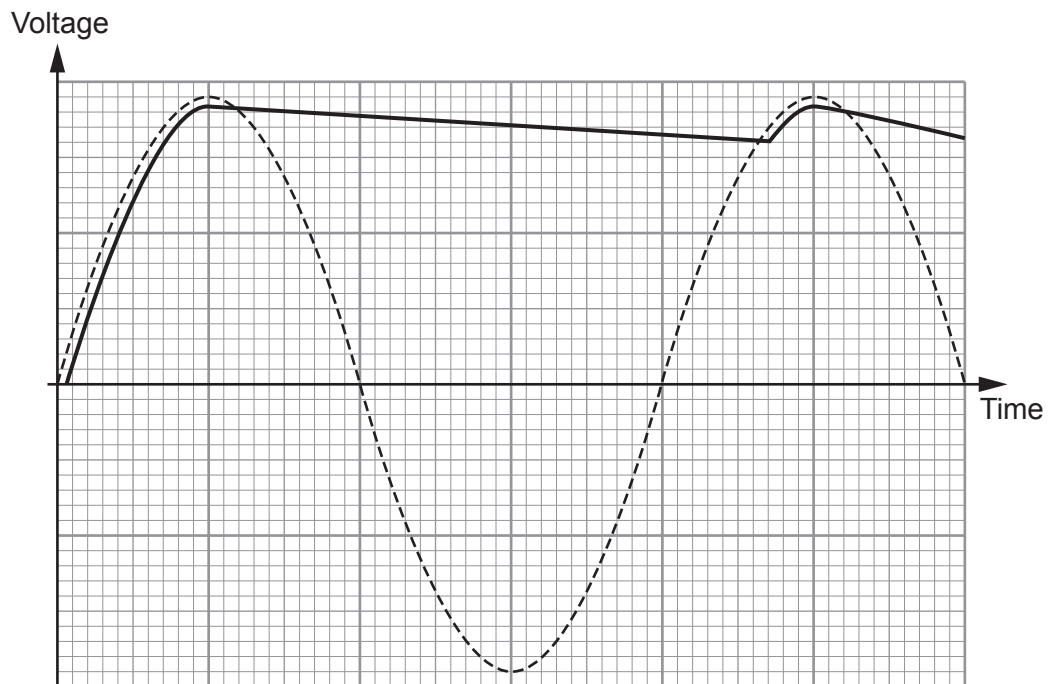
(ii) The signal V_{IN} is applied to the input.

Draw the output voltage V_{OUT} on the graph provided.

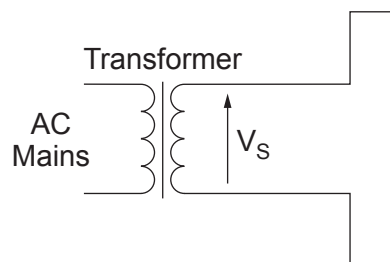
[3]



12. The graph below shows the output waveform across a load resistor, R_{LOAD} , produced by a diode rectifier. The dotted line shows the secondary AC voltage, V_s , from the transformer.



- (a) Complete the diagram to show the diode rectifier, smoothing capacitor, C , and load resistor, R_{LOAD} , needed to produce this output waveform. [3]



- (b) The secondary AC voltage, V_S , is 13 Vrms, 50 Hz. The load resistor has a value of $220\ \Omega$. Calculate:

(i) the peak voltage of V_S [2]

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(ii) the peak voltage across the load resistor **and** peak current through it [3]

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(iii) the value of smoothing capacitor to produce a ripple voltage of 3.7 V. [3]

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