Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A490U10-1

S24-A490U10-1

TUESDAY, 21 MAY 2024 – AFTERNOON

ELECTRONICS – A level component 1

Principles of Electronics

2 hours 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**13**	
2.	**11**	
3.	**15**	
4.	**7**	
5.	**11**	
6.	**14**	
7.	**14**	
8.	**15**	
9.	**7**	
10.	**15**	
11.	**12**	
12.	**6**	
Total	**140**	

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01

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 **12**.

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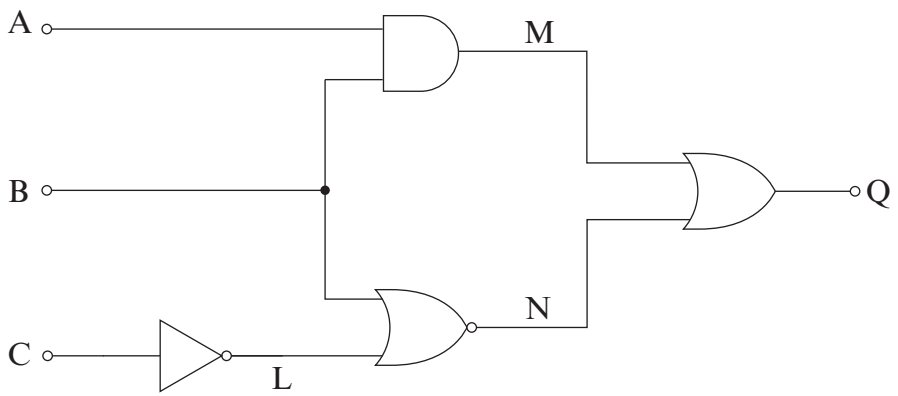
Answer **all** questions.

1. A logic circuit is shown below.



(a) Complete the truth table for the circuit. [4]

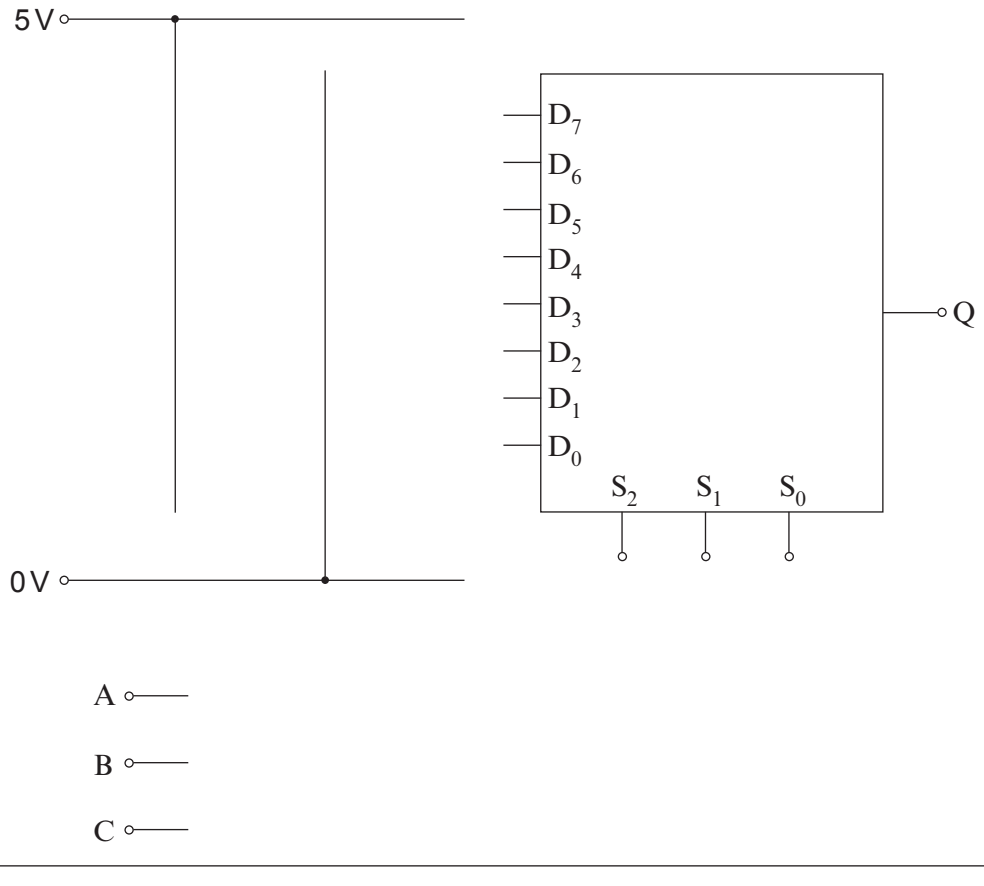
C	B	A	L	M	N	Q
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

Examiner only

(b) (i) Redraw the circuit using NAND gates only. [4]

(ii) **Cross out all** redundant gates. [2]

(c) Use a multiplexer to design a circuit to produce the same output as the truth table in part (a). [3]



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13

Turn over.

Examiner only

2. (a) Simplify the following expressions. [3]

(i) $A.0$

.....

(ii) $B + 1$

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(iii) $B.C + \overline{B}$

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(b) Using de Morgan's theorem simplify the following equation to its simplest form. [4]

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

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(c) Complete the truth table for the following Boolean equation. [2]

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

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	

Examiner only

(d) Write the Boolean expression for the output Q shown in the truth table below.
[Do not attempt to simplify the equation.] [2]

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

Q = ...

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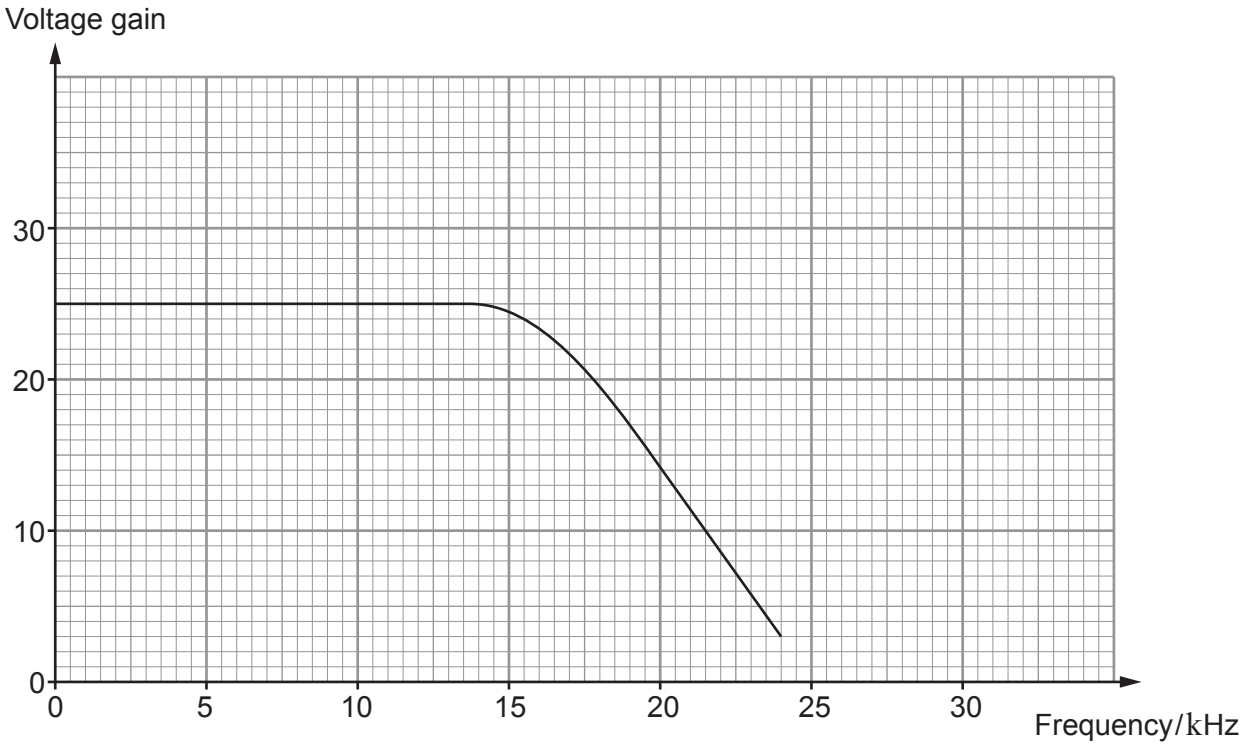
3. (a) A non-inverting amplifier has the frequency response shown in the graph below.



(i) Use the graph to determine the gain-bandwidth product of this amplifier. [4]

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Examiner only

(ii) Draw the circuit below for the non-inverting amplifier to meet these requirements. Include all component values. [4]

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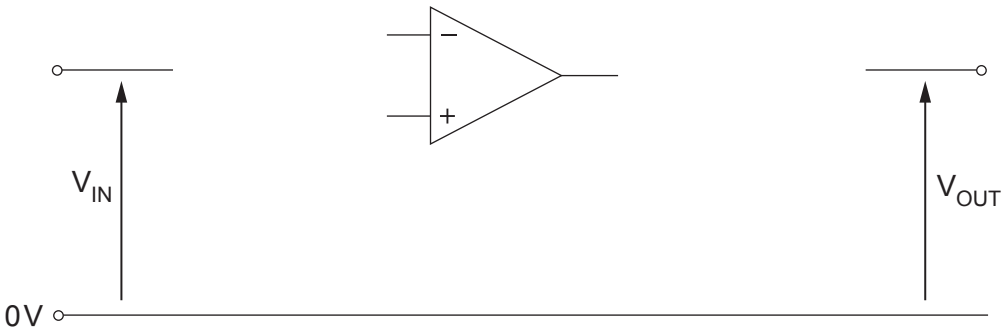

(b) The maximum gain of the amplifier is now set to 35. The op-amp has a power supply of ±15 V, saturates at ±14 V and has a slew rate of $5\,V\,\mu s^{-1}$.

(i) Determine the maximum input voltage that avoids clipping distortion for this circuit. [2]

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(ii) Calculate the minimum time taken for the output to change from +10 V to – 4 V. [2]

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(iii) Calculate the maximum frequency that avoids slew rate distortion in this circuit for a sinusoidal signal with a peak output voltage of 8 V. [3]

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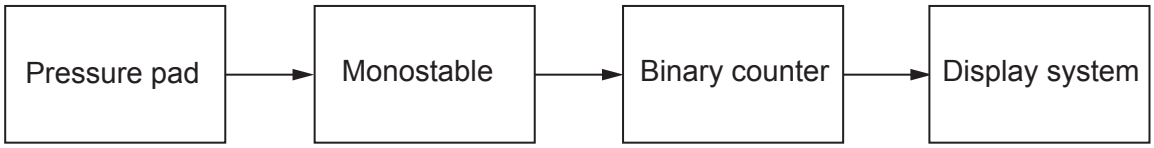
4. This is the block diagram for a system to count the number of passengers entering a 15-seater minibus.



(a) An incomplete circuit for the monostable is shown below. Complete the circuit by adding a resistor, a 100 μF capacitor and all connections necessary. Calculate the ideal resistor value to give a time period of 1 s. [4]

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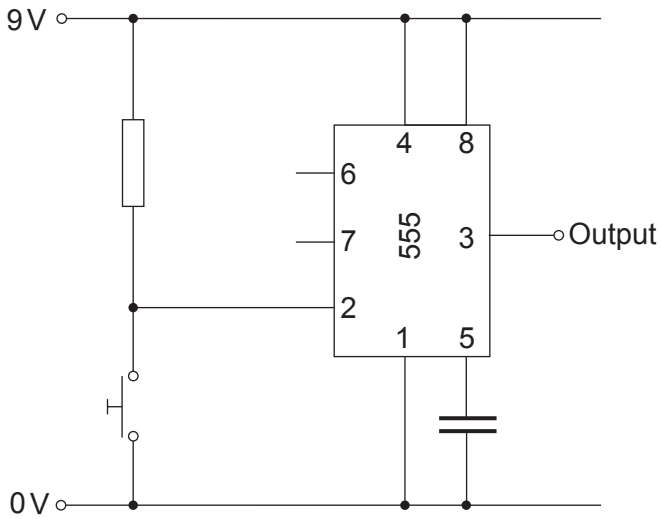

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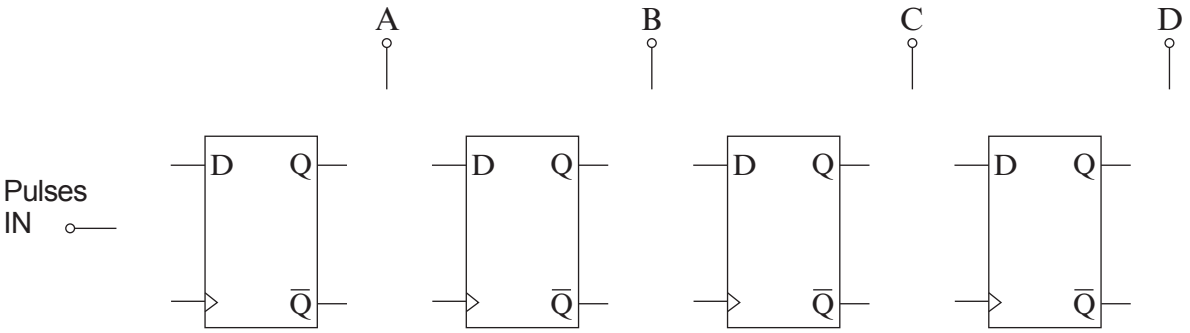
(b) Complete the circuit diagram below for a 4-bit binary up-counter. [3]



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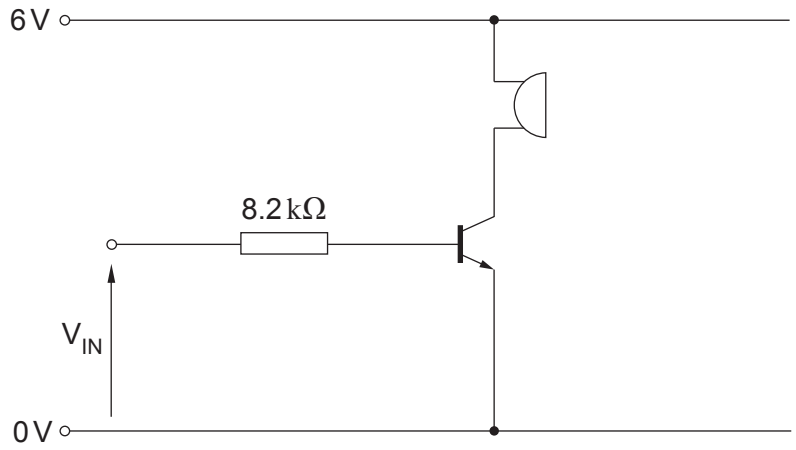
5. This is the transistor circuit used to control a buzzer in a photographer's darkroom. The buzzer comes on to warn if the light level is too high.



(a) The current gain of the transistor, h_{FE} = 60. The buzzer is rated at 6 V, 180 mW. Calculate the minimum value of V_{IN} to make the buzzer operate at its rated value. [5]

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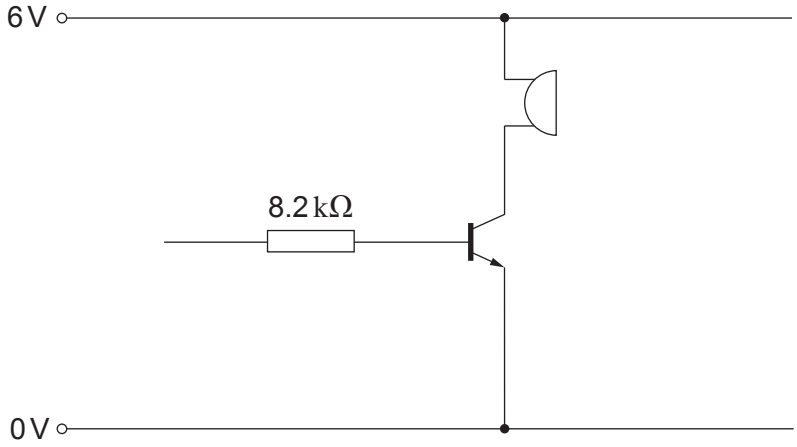
(b) The circuit is used to monitor the light level in the darkroom. When the light gets too bright, the buzzer sounds. Add the light sensing sub-system to the circuit diagram below. [2]



Examiner only

(c) It was found that at certain light levels the buzzer comes on too quietly. Explain why this happens and how you would adapt the circuit to avoid this problem. [4]

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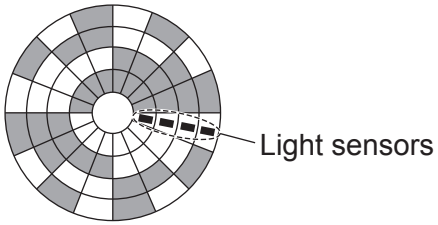
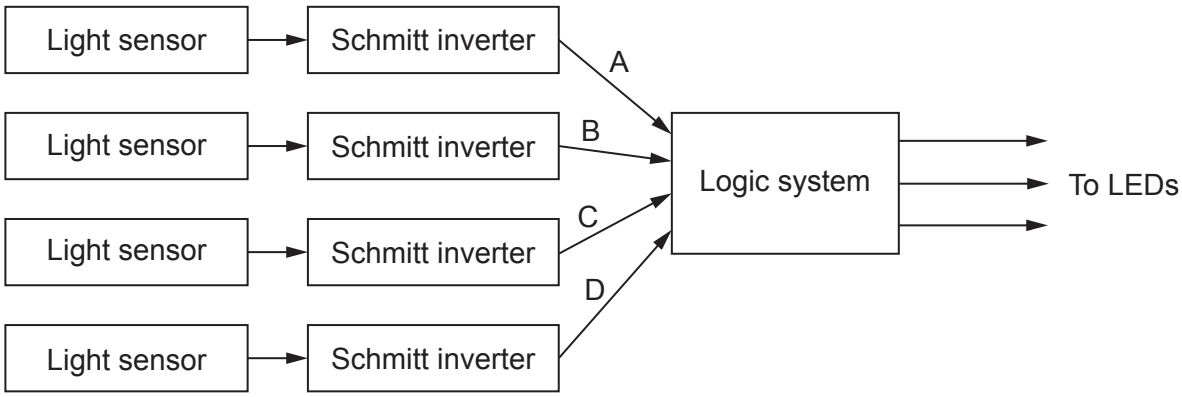
6. In a game at a fairground, the customer spins a wheel and the position it stops at determines the prize. A segmented disc is used with the coding read by four light sensors.



An electronic system is needed to indicate whether the prize is the top prize (indicated by a blue LED), a mid-value prize (indicated by a yellow LED) or no prize (indicated by a red LED).

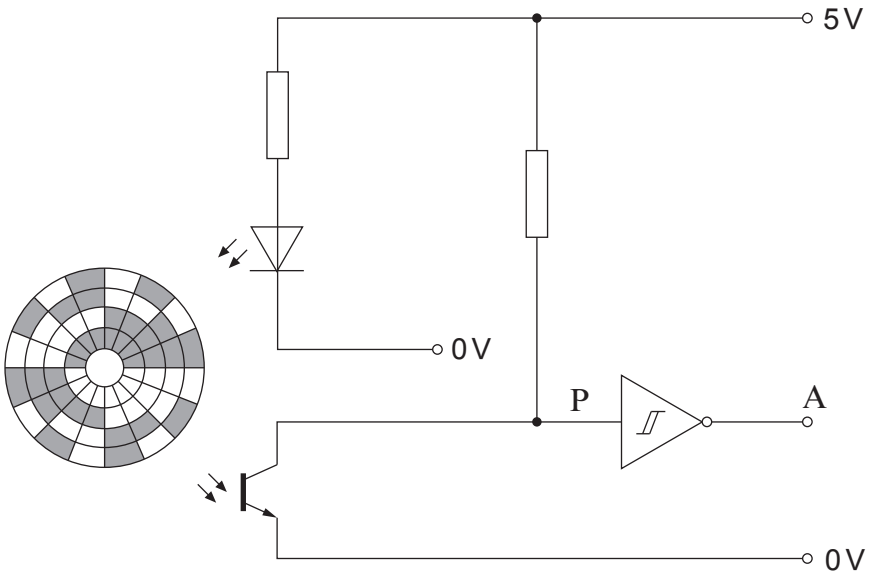
A block diagram for part of the system is shown below.



Examiner only

(a) The circuit for one of the light sensors used to read a segment of the disc along with the Schmitt inverter is shown below. Light is reflected from the white segments onto the phototransistor but not from the black segments.

The Schmitt inverter characteristics are:
Logic 0 = 0 V Logic 1 = 5 V
Output changes from a logic 0 to logic 1 when a falling input voltage reaches 1.5 V.
Output changes from a logic 1 to logic 0 when a rising input voltage reaches 3.5 V.

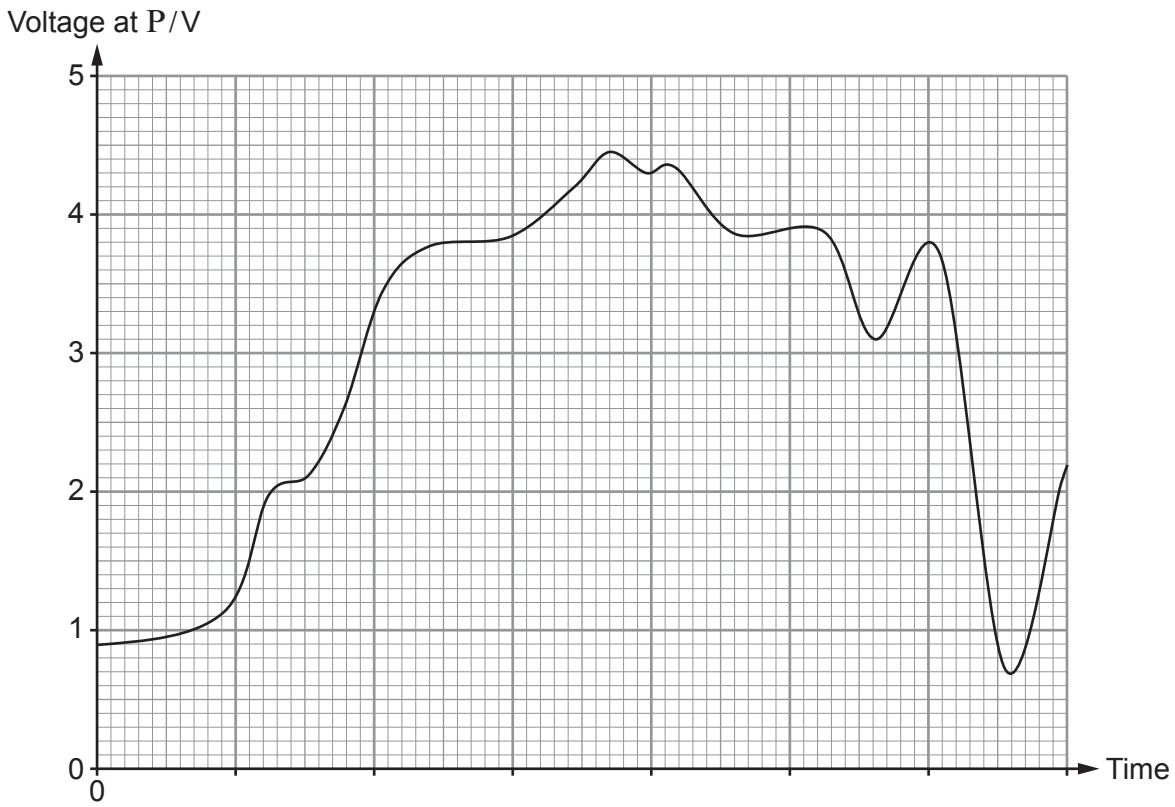


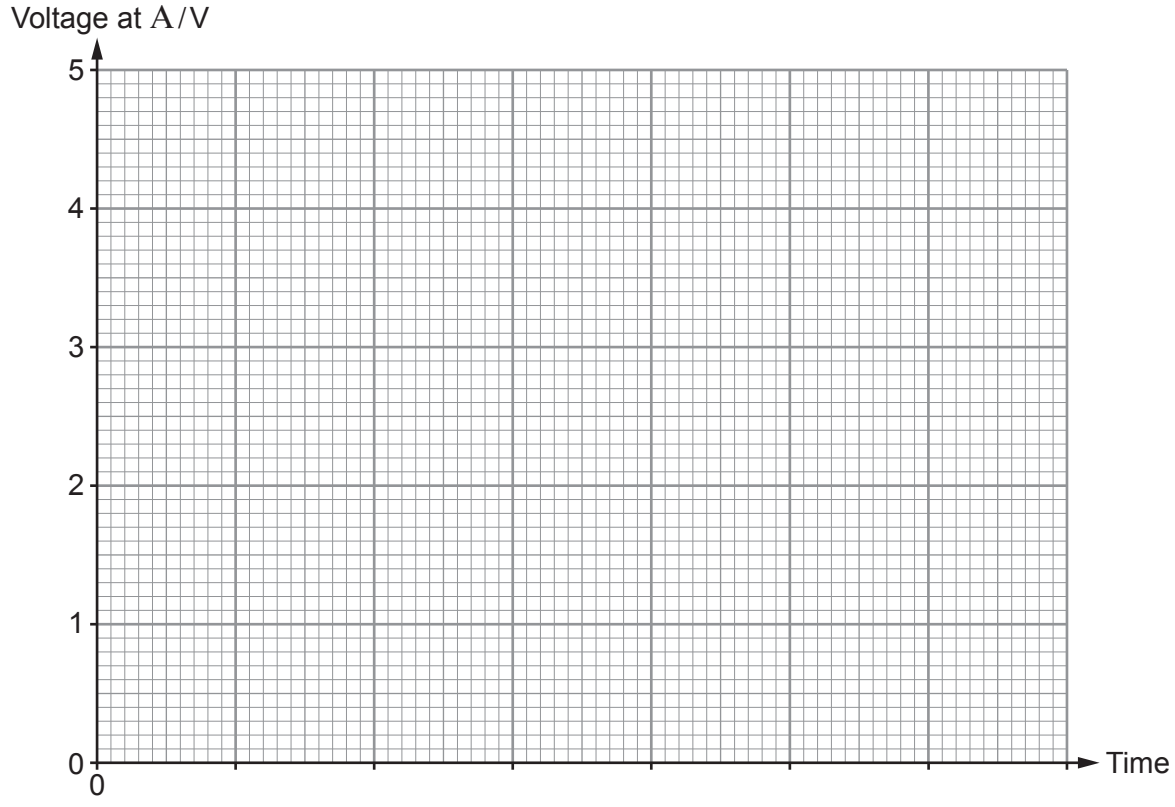
(i) Give the logic level at A when the disc segment is black. [1]

A = ...

Examiner only

(ii) For the following voltage at P draw the corresponding voltage at A. [3]



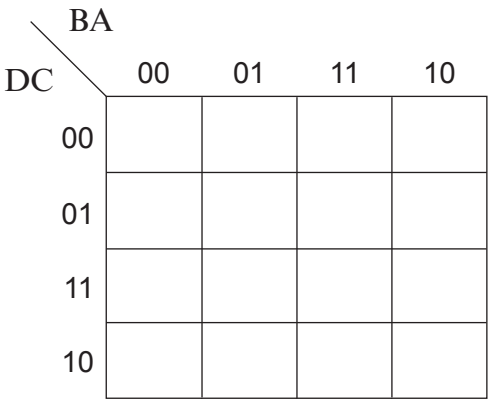


Examiner only

(b) The truth table for the logic system is given below. The signals A, B, C, and D are obtained from the Schmitt inverters.

D	C	B	A	Red	Yellow	Blue
0	0	0	0	1	0	0
0	0	0	1	1	0	0
0	0	1	0	1	0	0
0	0	1	1	0	1	0
0	1	0	0	1	0	0
0	1	0	1	1	0	0
0	1	1	0	1	0	0
0	1	1	1	0	1	0
1	0	0	0	0	1	0
1	0	0	1	0	1	0
1	0	1	0	1	0	0
1	0	1	1	1	0	0
1	1	0	0	0	1	0
1	1	0	1	0	1	0
1	1	1	0	0	1	0
1	1	1	1	0	0	1

(i) Complete the Karnaugh map for the red LED. [1]



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(ii) The Karnaugh map for the yellow LED has been completed for you. Use it to identify the groups and produce the simplest Boolean equation for the output.

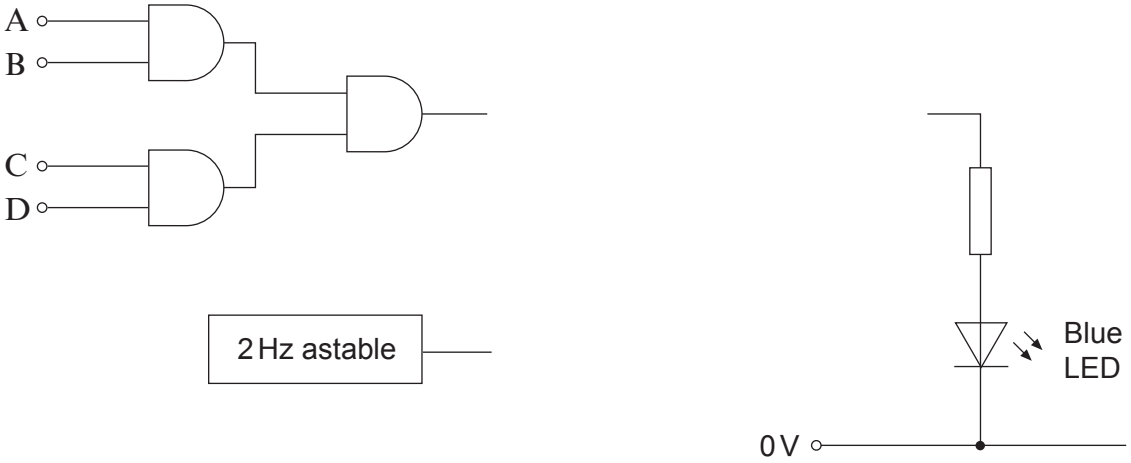
[4]

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

Output = ...

Examiner only

(iii) In an improvement to the system, it was thought that the blue LED should flash at 2 Hz when the output = D.C.B.A. Complete the diagram for the improved system. [2]



(iv) Draw a Schmitt astable circuit that produces the 2 Hz pulses using a 10 μF capacitor, and calculate the values of any other components used. [3]

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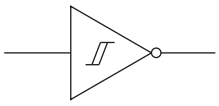

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14

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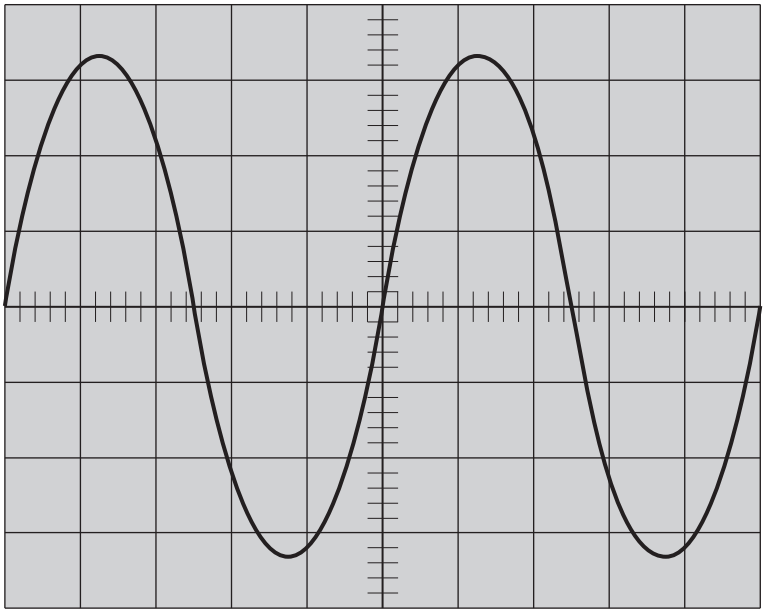
7. A student needs to analyse a simple filter made from a resistor and a capacitor. A signal generator is connected to the input of the filter and an oscilloscope to the filter output.

(a) The signal generator is set at 4 kHz. The output of the filter is shown on the screen of the oscilloscope pictured below. The voltage gain is set at 2 V/cm.



(i) Determine the time base setting. [3]

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Examiner only

(ii) Use the oscilloscope trace to determine the amplitude of the output at 4 kHz and add this value to the table of results. [2]

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Frequency / Hz	Input / V	Output / V
10	10	10.0
40	10	10.0
100	10	10.0
400	10	9.6
1000	10	8.6
4000	10	.....
10 000	10	5.0
40 000	10	2.9
100 000	10	2.0

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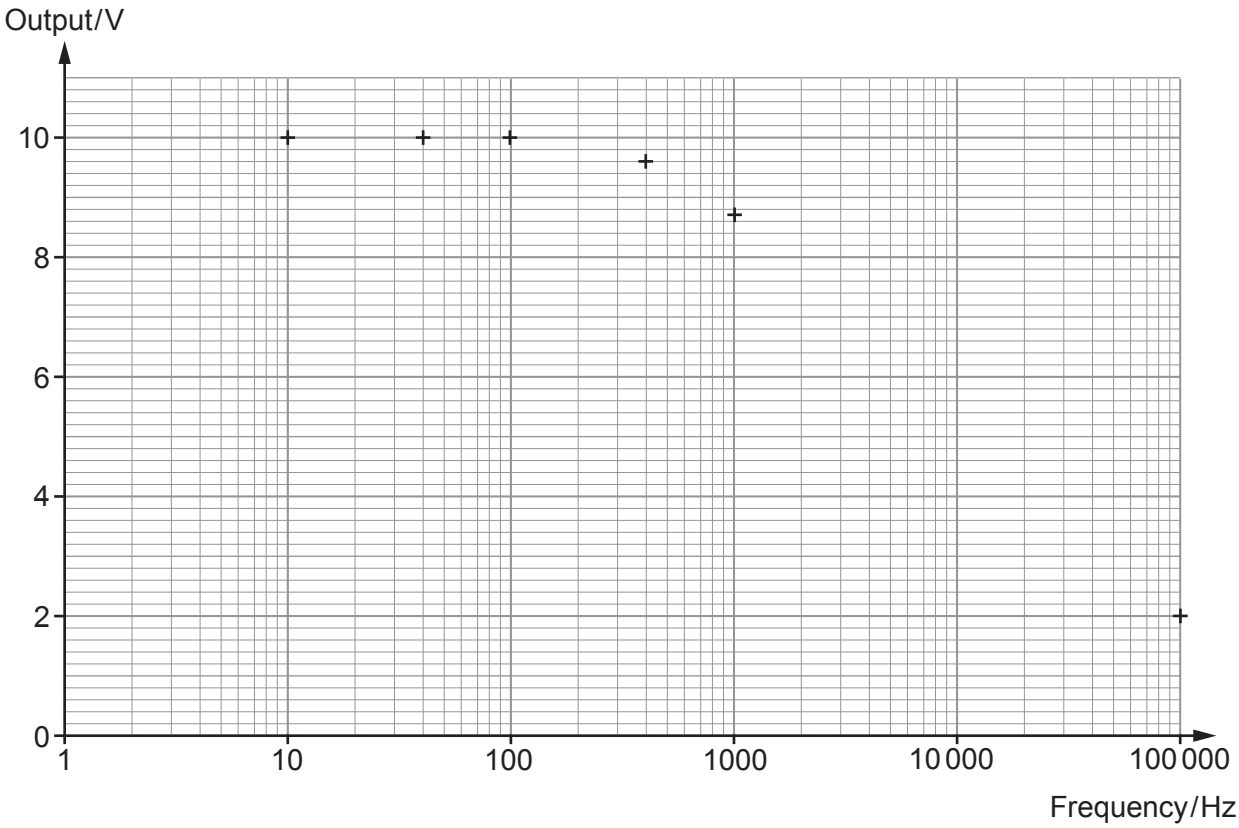
(b) Some of the points have been plotted for you on the graph.

(i) Complete the graph by plotting the points for frequencies 4000, 10 000 and 40 000 Hz and drawing the frequency response. [3]



(ii) State the name of this type of passive filter. [1]

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(iii) Use the graph to determine the break frequency. Show clearly how you used the graph. [3]

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Examiner only

(iv) Draw the circuit diagram for this type of filter, clearly showing the input and output. No component values are needed. [2]

14

Examiner only

8. (a) Complete the sentences below. [4]

(i) In FM the information is contained in the ..... of the modulated wave.

(ii) AM is ..... susceptible to noise than FM.

(iii) The bandwidth for AM is ..... than for FM.

(iv) For a given audio signal, the minimum carrier frequency needs to be ..... for FM than for AM.

(b) (i) A 9 kHz sinusoidal wave is amplitude modulated onto a 250 kHz carrier wave. On the axis below draw the frequency spectrum of the transmitted signal. Label all significant frequencies. [2]

Examiner only

(ii) An audio signal with frequencies from 100 Hz to 9 kHz replaces the 9 kHz sinusoidal wave. The carrier wave remains 250 kHz. On the axis below draw the frequency spectrum of the transmitted signal. Label all significant frequencies and give the broadcast bandwidth of the signal. [3]

Broadcast bandwidth = ...

Examiner only

(c) An FM broadcast has a frequency deviation of 80 kHz on a 98 MHz carrier wave. The audio signal range is 100 Hz to 18 kHz.

(i) Calculate the modulation index for the transmission. [2]

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(ii) Calculate the broadcast bandwidth of the signal. [2]

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(iii) The broadcast band is from 97.6 MHz to 99.8 MHz. How many channels with this specification can be broadcast? [2]

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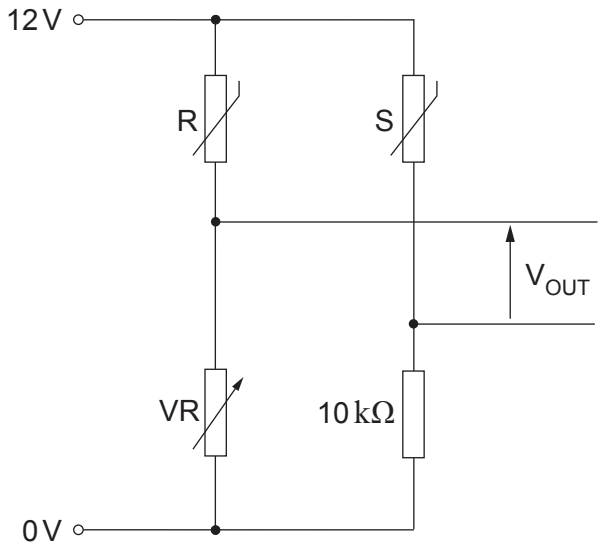
Examiner only

9. This is a thermistor bridge circuit.



(a) Calculate V_{OUT} under the following conditions:

The resistance of R = 10.3 kΩ
The resistance of S = 10.0 kΩ
The resistance of VR = 9.7 kΩ [3]

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(b) Add a difference amplifier based on an op−amp to the circuit above. Choose suitable values of resistors to give a voltage gain of 50. Label the resistors with these values. [4]

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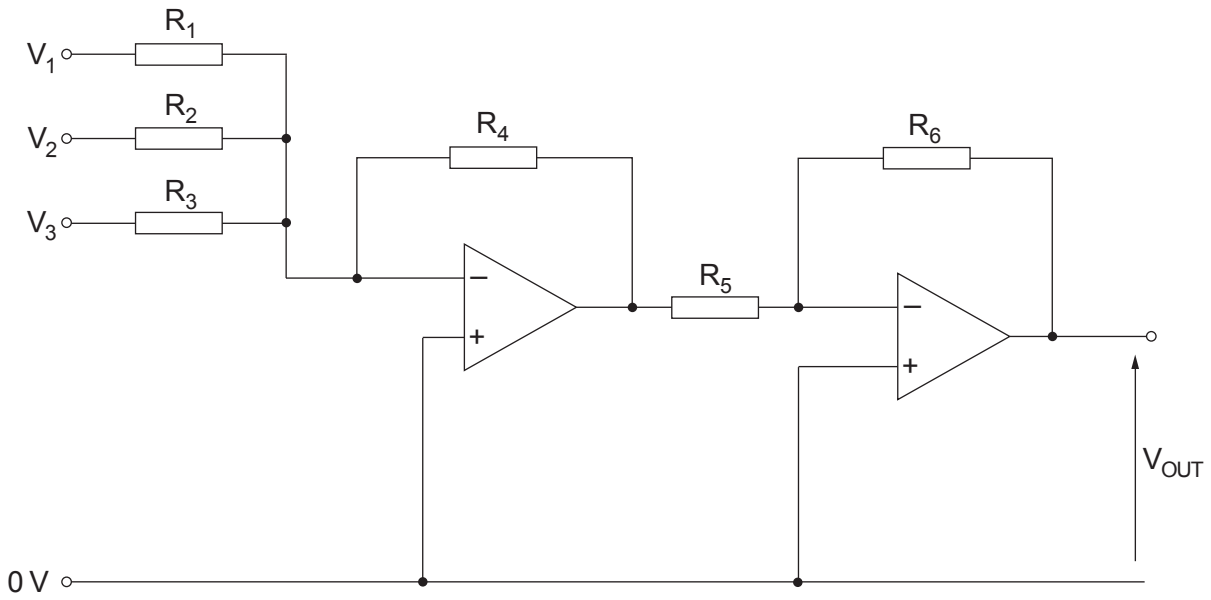
10. The design of a summing amplifier is shown below.



(a) Calculate all resistor values to satisfy the equation

$$V_{OUT} = 3V_1 + V_2 + 0.5V_3$$

[4]

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R_1 = ... R_2 = ... R_3 = ...

R_4 = ... R_5 = ... R_6 = ...

Examiner only

(b) The operational amplifiers saturate at ±14 V. Referring to part (a), calculate the output voltage when:

(i) $V_1 = 1\,V$, $V_2 = 3\,V$ and $V_3 = 8\,V$ [2]

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(ii) $V_1 = 3\,V$, $V_2 = 5\,V$ and $V_3 = 9\,V$ [2]

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Examiner only

(c) (i) Explain with the aid of calculations how you would alter the design to make a 3-bit DAC with the specification:

- Input voltage of 5 V for logic 1 and 0 V for logic 0.
- Output voltage range of 0 to 14 V.
- V_1 is the LSB. [4]

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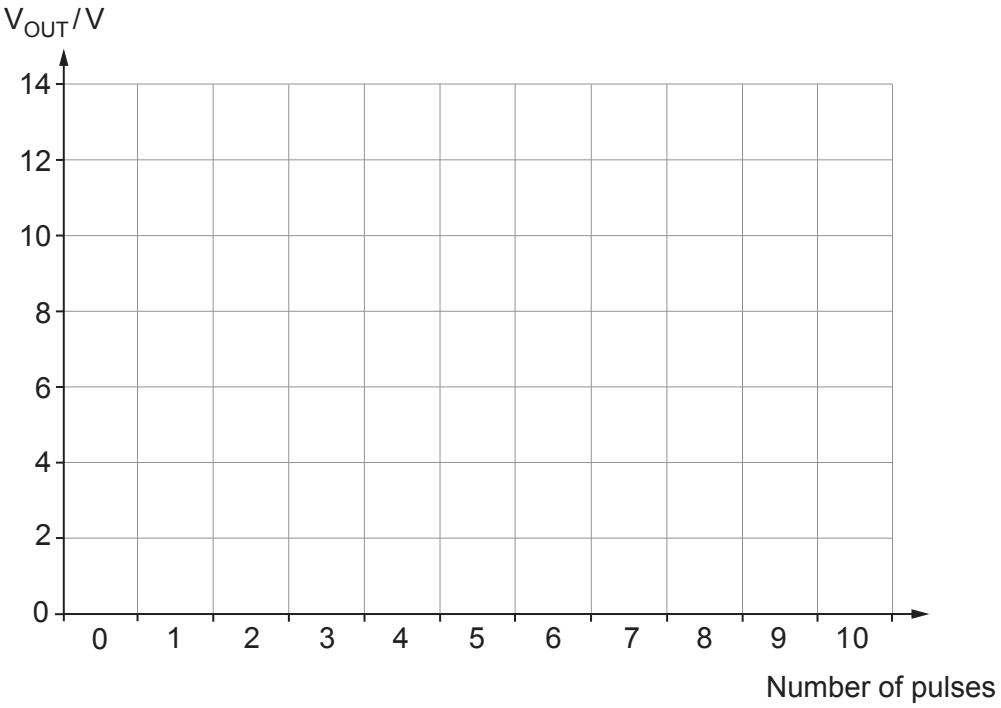
(ii) The inputs of the DAC are connected to a 3-bit binary up-counter driven by a pulse generator. Sketch the output voltage, V_{OUT}, on the graph provided. [3]



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11. A communications link consists of a transmitter, coaxial cable and a receiver.

(a) Communications links suffer from noise.

(i) State what is meant by noise in this context and give an example of a source of noise. [2]

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(ii) The receiver requires an input signal power of 200 mW. What is the maximum acceptable value of the noise power to limit the signal to noise ratio (SNR) to 20 dB? [3]

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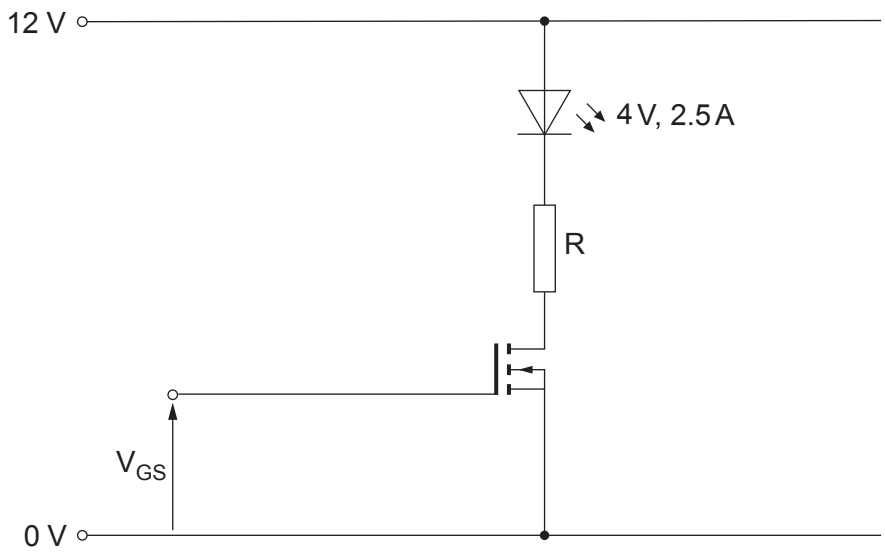
Examiner only

(b) An alternative system uses a fibre optic link.

The LED for the transmitter is driven by a MOSFET. Parameters for the MOSFET are given in the table.

Property	Value
V_{GS} / V (max)	15
P_{TOT} / W (max)	90
g_m / S	0.8
r_{DSon} / Ω	0.04

This is the circuit used.



(i) Calculate the value of V_{GS} needed to run the LED at its rated value. [2]

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(ii) Calculate the ideal value of R to protect the LED and select a suitable preferred value for R. [3]

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Examiner only

(iii) Calculate the power dissipated in the MOSFET when the LED is operating at its rated value. [2]

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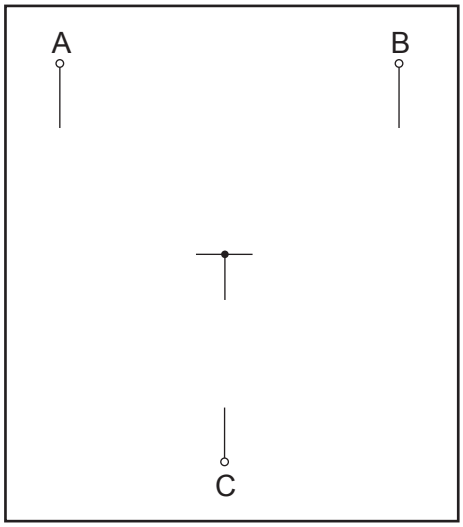
12

Examiner only

12. A box contains a circuit with two resistors and a silicon diode. There are three external connections A, B and C and an internal connection point. The current is measured using an ammeter with a 9 V power supply connected across each combination of connections in each direction.



The results of the testing are shown in the table below.

+9 V connected to connection	A	B	A	C	B	C
0 V connected to connection	B	A	C	A	C	B
Current / A	0.03	0.03	0.083	0	0.0415	0

Use the table of results to identify the circuit layout and the values of the resistors. Explain how you deduced this showing all calculations. Draw the circuit in the diagram above. [6 QER]

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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