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Centre number

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# A-level PHYSICS

Paper 3

Section B    Electronics

Thursday 29 June 2017

Morning

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

## Materials

For this paper you must have:

- a pencil and a ruler
- a scientific calculator
- a Data and Formulae booklet.

## Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

## Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 35.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
<b>TOTAL</b>	



J U N 1 7 7 4 0 8 3 B E 0 1

**There are no questions printed on this page**

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ANSWER IN THE SPACES PROVIDED**



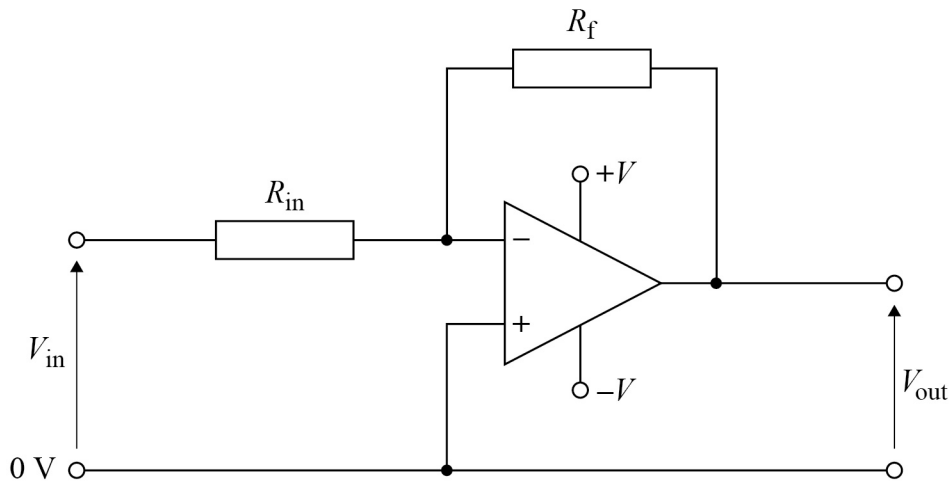
## Section B

Answer **all** questions in this section.

0 1

Figure 1 shows an operational amplifier used as an inverting amplifier.

Figure 1



0 1 . 1

Label Figure 1 with an X to show the point which is a virtual earth.

[1 mark]

0 1 . 2

Name the input pin shown by a (+) on the operational amplifier.

[1 mark]

0 1 . 3

Derive the expression for the inverting amplifier gain  $\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_f}{R_{\text{in}}}$ 

[2 marks]

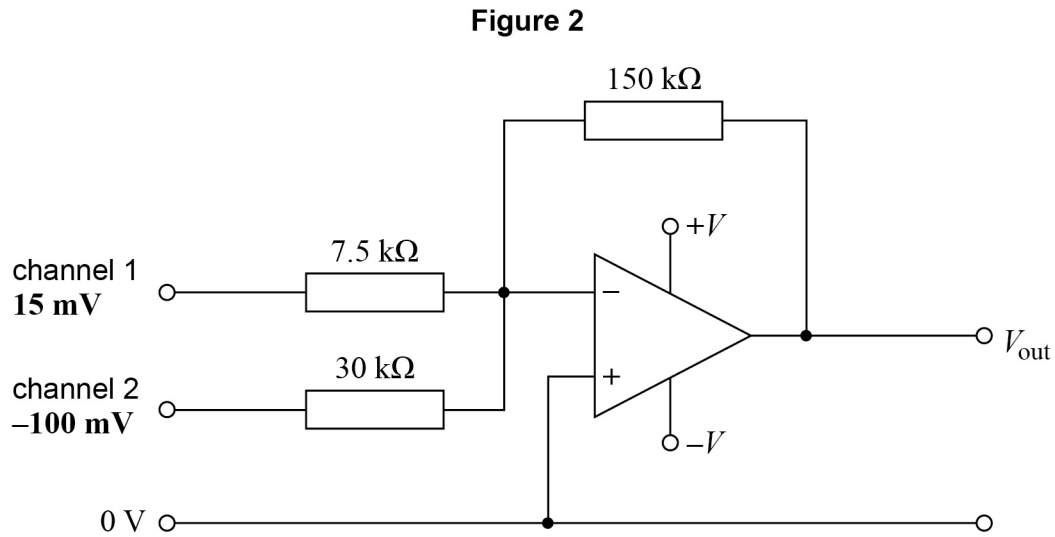
Question 1 continues on the next page

Turn over ►



0 1 . 4

**Figure 2** shows the inverting amplifier modified to make a summing amplifier that is to form part of a two-channel audio mixer.



Calculate the voltage gain produced by channel 1.

[1 mark]

voltage gain (channel 1) = \_\_\_\_\_

0 1 . 5

The mixer is tested using the input signals to channels 1 and 2 with the amplitudes shown in **Figure 2**.

Calculate the amplitude of the output voltage  $V_{\text{out}}$  produced in the test.

[2 marks]

$V_{\text{out}} =$  \_\_\_\_\_ V



0 1 . 6

Describe how the function of the audio mixer could be improved by changing the two input resistors from fixed values to variable values.

**[1 mark]**

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**8**

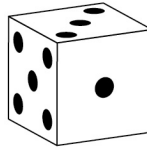
**Turn over for the next question**

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0 2

A die, where dots on the faces of a cube indicate the numbers 1 to 6, is shown in **Figure 3** and is used in many games.

**Figure 3**

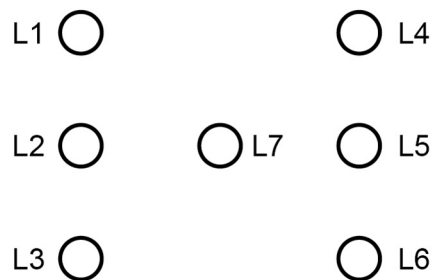


A student makes an electronic version of this by feeding pulses from a pulse generator into a 4-bit binary counter.

The circuit uses the first three outputs of the counter A (least significant bit), B and C.

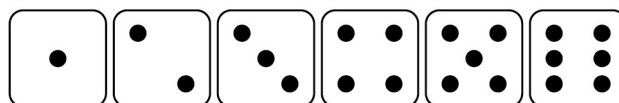
By feeding the outputs from the counter through logic gates, the seven LEDs shown in **Figure 4** can be made to display the numbers 1 to 6 in sequence.

**Figure 4**



**Figure 5** shows the sequence of numbers.

**Figure 5**



The black dots show which LEDs are lit for each of the numbers 1 to 6.



The partially completed truth table in **Table 1** shows which of the LEDs (L1 to L6) are ON (logic 1) and which are OFF (logic 0) during the counting sequence.

**Table 1**

Number shown on die	Logic inputs			Logic outputs						
	C	B	A	L1	L2	L3	L4	L5	L6	L7
1	0	0	0		0	0	0	0		1
2	0	0	1		0	0	0	0		0
3	0	1	0		0	0	0	0		1
4	0	1	1		0	1	1	0		0
5	1	0	0		0	1	1	0		1
6	1	0	1		1	1	1	1		0
Reset 6 → 1										

0 2 . 1

Complete **Table 1** to show the logic outputs for the lamps L1 and L6.

[2 marks]

0 2 . 2

Deduce the **simplest** Boolean expression that can be used to show how output L7 can be controlled by the logic inputs.

[1 mark]

Question 2 continues on the next page

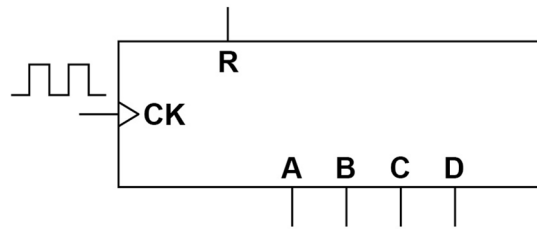
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0 2 . 3

**Figure 6** shows some of the input and output pins of the 4-bit binary counter.

**Figure 6**



The data sheet for the counter indicates that the counter resets when the reset pin **R** is taken from logic 0 to logic 1.

Draw on **Figure 6** the logic gate needed and the connections required from the outputs to the reset pin **R** on the counter so that the counter cycles as required.

**[2 marks]**





0 2 . 4

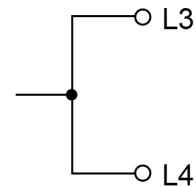
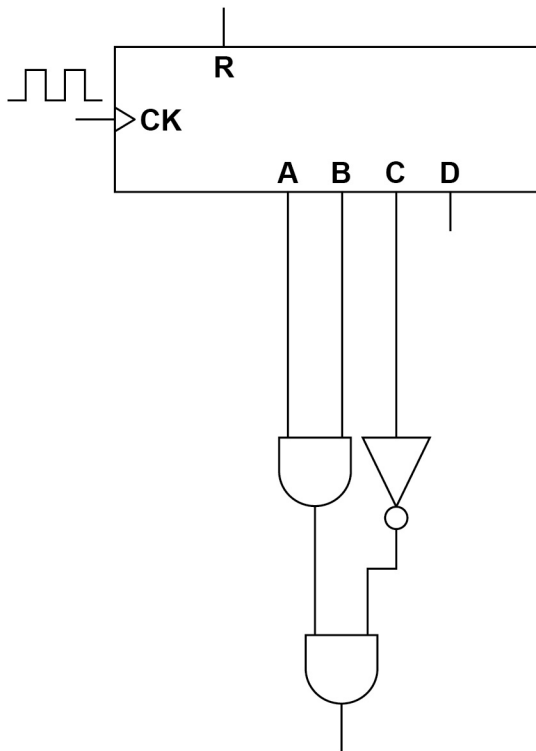
The output of both L3 and L4 can be written as  $(A \cdot B \cdot \bar{C}) + (\bar{B} \cdot C)$

**Figure 7** shows part of a logic circuit needed to represent this Boolean expression.

Complete the logic circuit in **Figure 7** by adding AND, OR and NOT gates.

[3 marks]

**Figure 7**



8

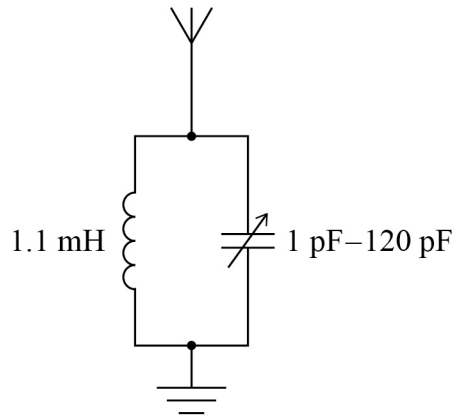
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0 3

**Figure 8** shows the first-stage filter circuit for a simple AM receiver. The circuit can be adjusted to resonate at 910 kHz so that it can receive a particular radio station.

**Figure 8**

0 3 . 1

Calculate the value of the capacitance when the circuit resonates at a frequency of 910 kHz.

**[2 marks]**

capacitance = \_\_\_\_\_ pF

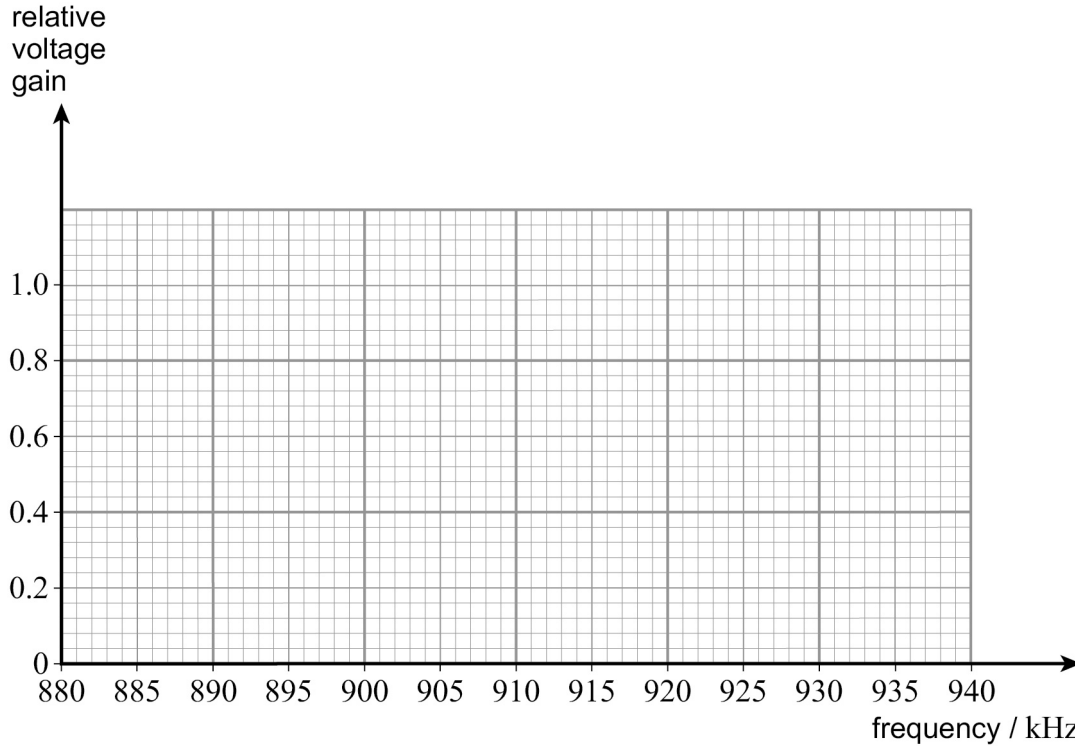


0 3 . 2

Draw on **Figure 9** an ideal response curve for the resonant circuit, labelling all relevant frequency values based upon a 10 kHz bandwidth.

[3 marks]

**Figure 9**



0 3 . 3

The Q-factor for the practical tuning circuit has a smaller value than the ideal one assumed in question **03.2**.

Discuss the changes the listener might notice when tuning to this station due to the practical Q-factor being smaller.

[2 marks]

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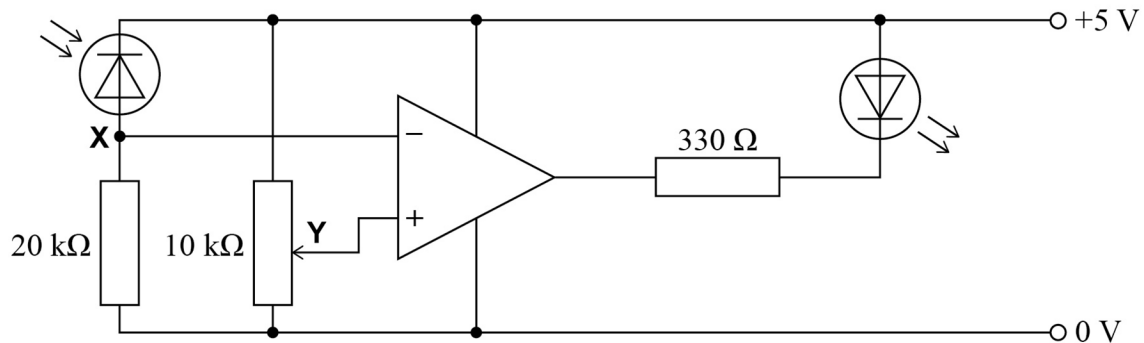
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0 4

A photodiode forms part of a light meter used for checking light levels in an office. **Figure 10** shows the circuit diagram for the light meter.

Figure 10



0 4 . 1

State the mode in which the photodiode is being used in **Figure 10**.

[1 mark]

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0 4 . 2

In which mode is the operational amplifier being used in **Figure 10**?

Tick (✓) the correct box.

[1 mark]

Non-inverting amplifier

Comparator

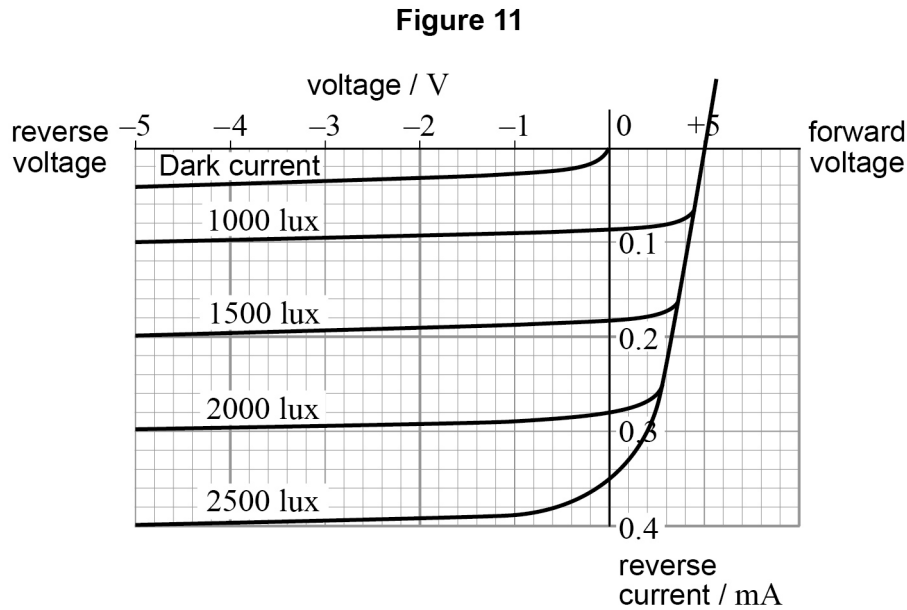
Summing amplifier

Difference amplifier



0 4 . 3

**Figure 11** shows an extract from a data sheet of the characteristics for a photodiode under different light levels measured in lux.



For a particular lighting condition, the current through the photodiode in **Figure 10** was 0.10 mA.

Estimate, using the information in **Figure 11**, the light level needed to cause this reverse current through the photodiode.

[1 mark]

light level = \_\_\_\_\_ lux

0 4 . 4

Calculate the voltage at point **X** in the circuit shown in **Figure 10** for the light level in question **04.3**.

[1 mark]

voltage = \_\_\_\_\_ V

**Question 4 continues on the next page**

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0	4	.	5
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The  $10\text{ k}\Omega$  linear potential divider shown in **Figure 10** is set to give  $1.75\text{ V}$  at point **Y**.

Assume that the operational amplifier has ideal characteristics.

Deduce whether the output LED would be switched ON or OFF when the current through the photodiode is  $0.10\text{ mA}$ .

**[2 marks]**

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6
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0	5
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Discuss how longwave (LW), shortwave (SW) and microwave links can be used to communicate beyond the visible horizon.

For each link, you should give:

- a typical carrier frequency that is used
- an explanation of how the signals travel from the transmitter to the receiver
- a typical use.

You may use a diagram to help make clear aspects of your answer.

**[6 marks]**

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### END OF QUESTIONS

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