Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________

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	
TOTAL	

There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED

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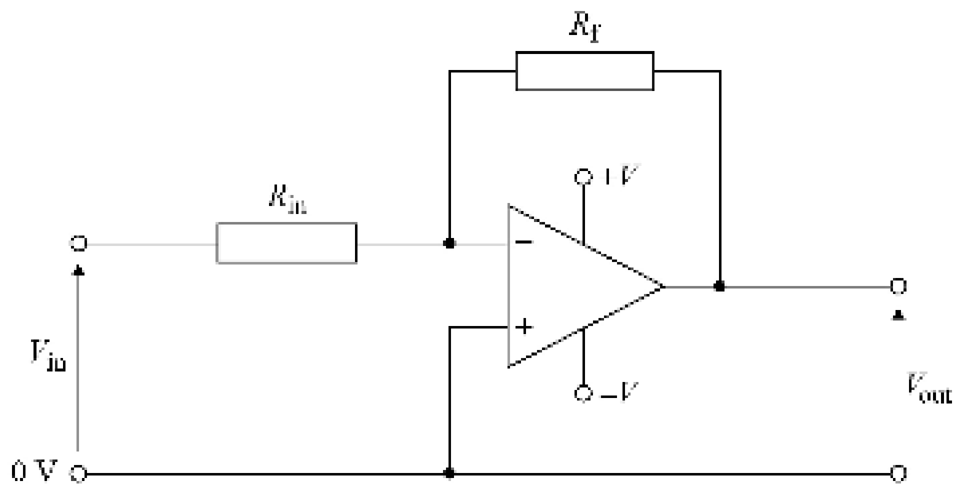
Section B

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 $\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_{in}}$

[2 marks]

Question 1 continues on the next page

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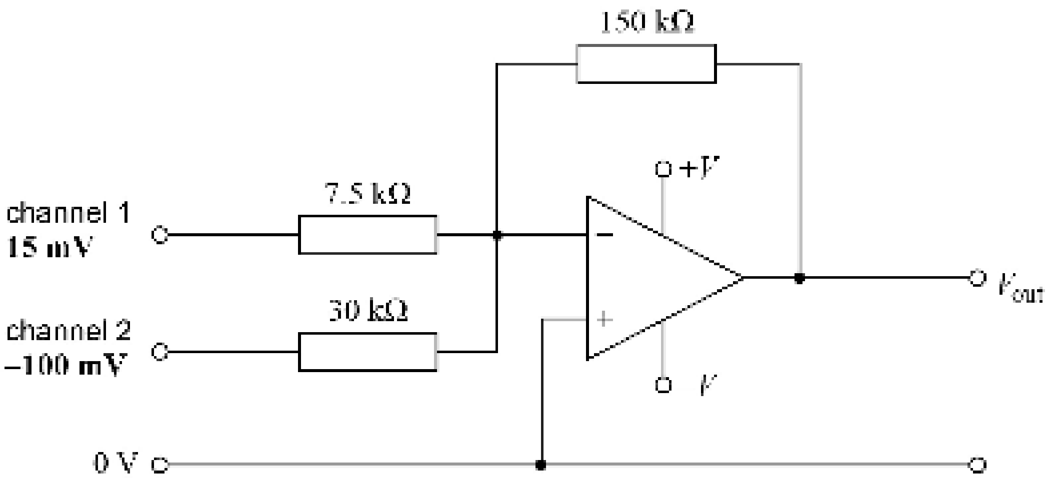
0 1 . 4 **Figure 2** shows the inverting amplifier modified to make a summing amplifier that is to form part of a two-channel audio mixer.

Figure 2



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_{out} produced in the test.

[2 marks]

V_{out} = ______________________ V

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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.

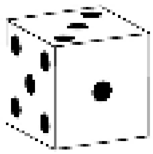
[1 mark]

8

Turn over for the next question

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

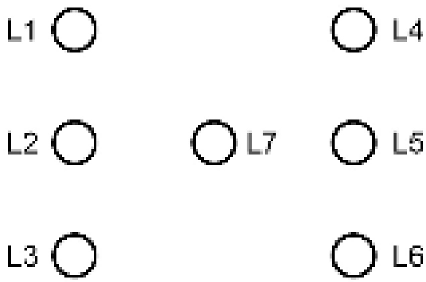
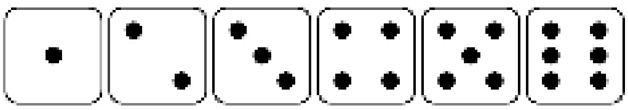


Figure 5 shows the sequence of numbers.

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

Turn over ►

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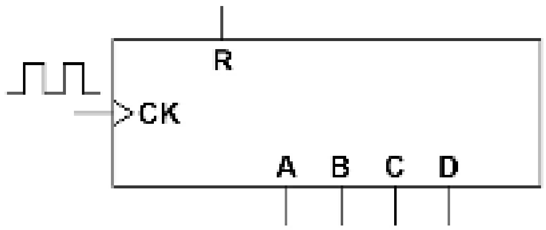
0 2 . 3 **Figure 6** shows some of the input and output pins of the 4-bit binary counter.

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]

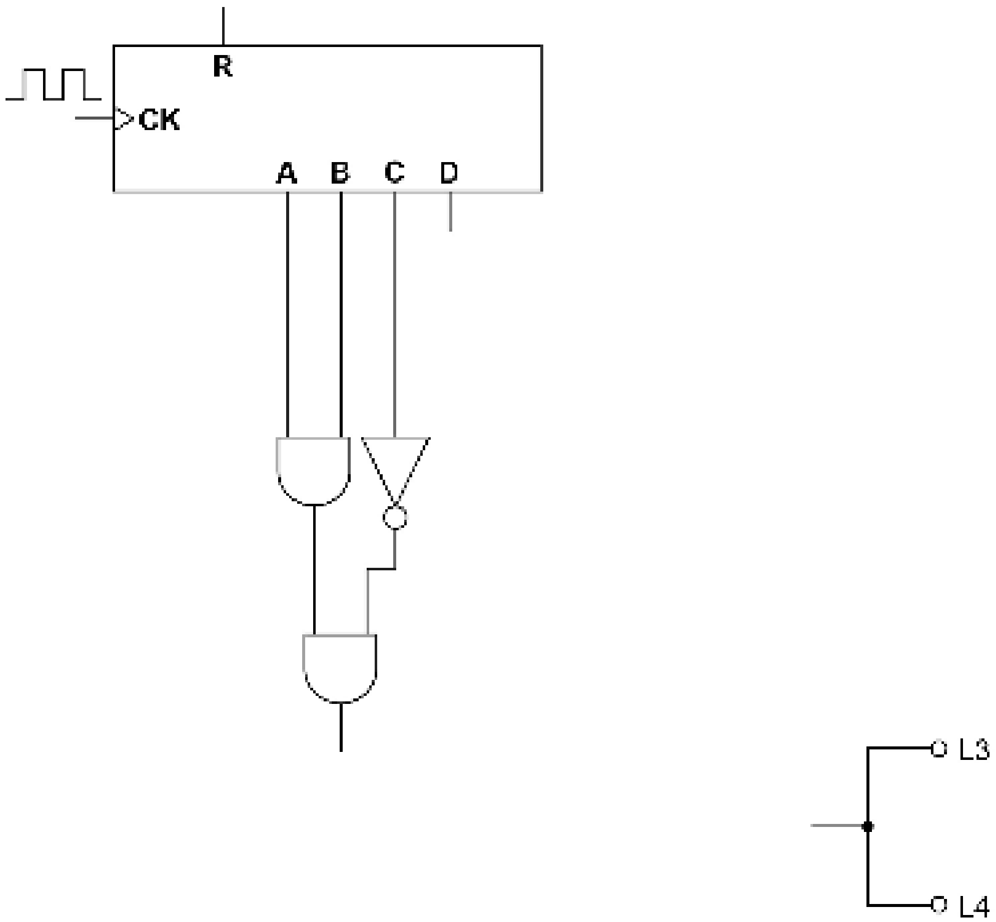
0 2 . 4 The output of both L3 and L4 can be written as **$(A . B . \overline{C}) + (\overline{B} . C)$**

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

Turn over for the next question

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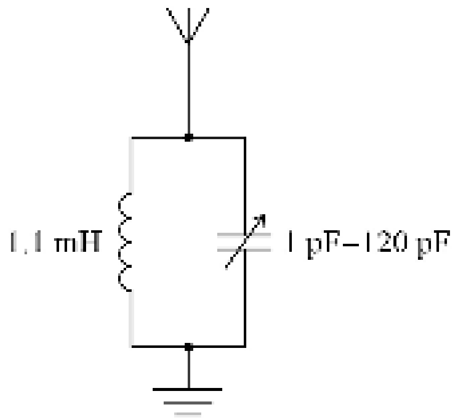
0 3 **Figure 8** shows the first-stage filter circuit for a simple AM receiver. The circuit can be adjusted to resonate at 910 kHz so that it can receive a particular radio station.

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

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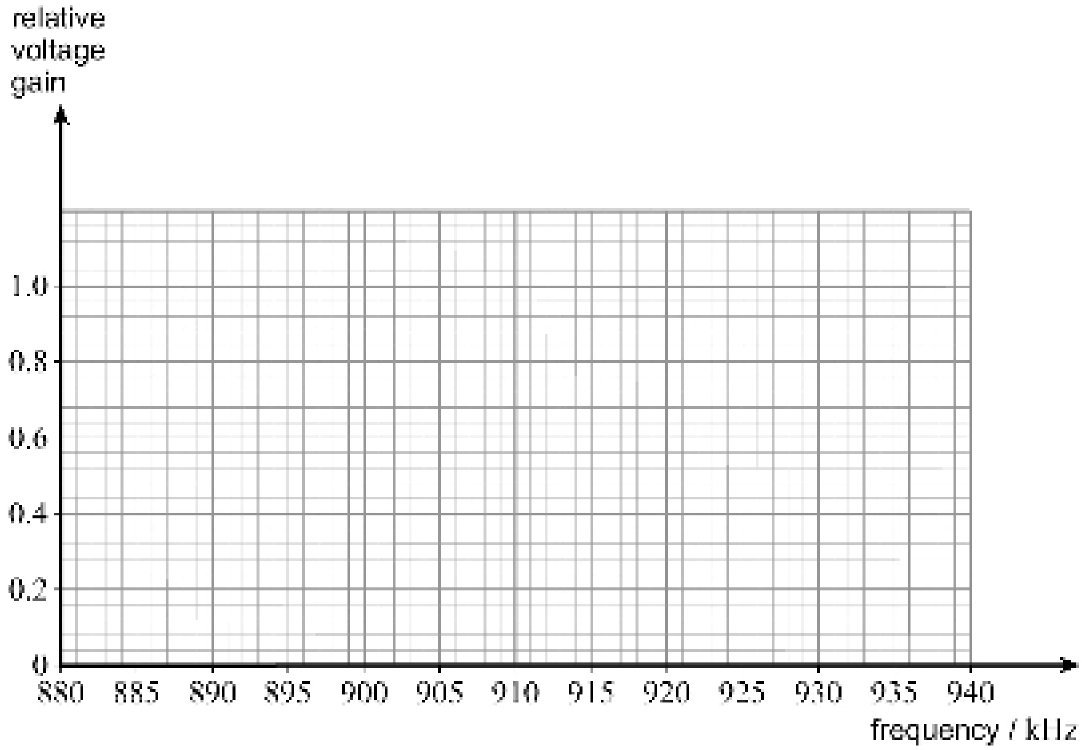
0 3 . 2 Draw on **Figure 9** an ideal response curve for the resonant circuit, labelling all relevant frequency values based upon a $10\ \mathrm{kHz}$ bandwidth.

[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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7

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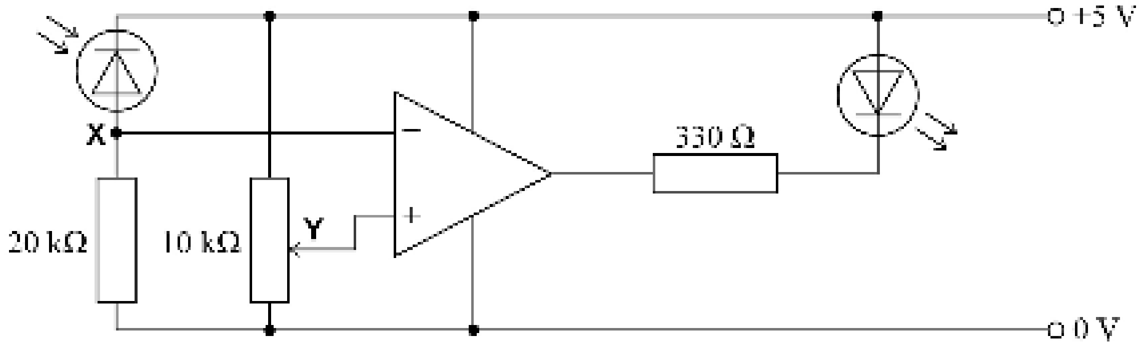
0 4 A photodiode forms part of a light meter used for checking light levels in an office. **Figure 10** shows the circuit diagram for the light meter.

Figure 10



0 4 . 1 State the mode in which the photodiode is being used in **Figure 10**.

[1 mark]

---

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 ☐

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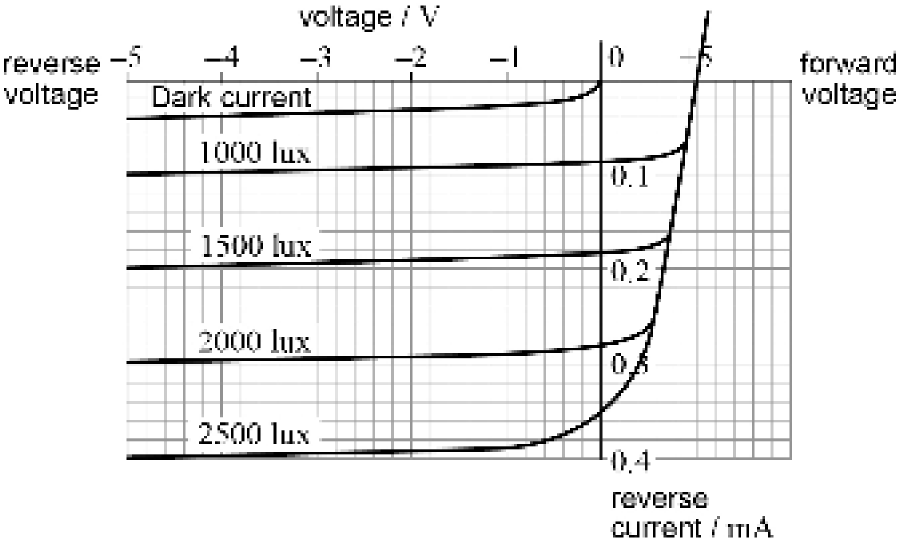
0 4 . 3 **Figure 11** shows an extract from a data sheet of the characteristics for a photodiode under different light levels measured in lux.

Figure 11



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

Turn over ►

0 4 . 5 The $10\ \mathrm{k\Omega}$ linear potential divider shown in **Figure 10** is set to give $1.75\ \mathrm{V}$ 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 $0.10\ \mathrm{mA}$.

[2 marks]

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6

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0 5 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]

Extra space is available on the next page if needed

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END OF QUESTIONS