Centre Number						Candidate Number				
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Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2014

Electronics ELEC1

Unit 1 Introductory Electronics

Monday 12 May 2014 1.30 pm to 2.30 pm

For this paper you must have:
- a pencil and ruler
- a calculator
- a Data Sheet (enclosed).

Time allowed
- 1 hour

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.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 67.

Answer **all** questions in the spaces provided.

1 A student designs an electronically controlled cat flap to enable her cat to enter and leave her house through a small hinged flap in a door.

The cat has a small magnet fitted in its collar which is detected by sensors both inside and outside the flap. When the magnet is detected by either sensor, the flap is unlocked by a solenoid for a fixed length of time and then locked again.

1 (a) Draw a system diagram as a possible plan for this system, include in your plan **two** reed switches as magnet sensors, a means of combining the inside and outside signals, and subsystems to provide the other functions.

[6 marks]

1 (b) The reed switch closes when a magnet is near.
Draw a circuit diagram using a reed switch, a battery, and **one** other component that would give a signal of 0 V only when a magnet is placed near to the reed switch.
Label the output of this circuit.

[3 marks]

1 (c) The solenoid requires a high current to operate it.
State the name of a semiconductor device that would be suitable to provide this current.

[1 mark]

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10

2 The Boolean equation for a logic circuit with inputs A and B and output Q is

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

2 (a) Complete the truth table to show the logic values of the terms in **Table 1** for all the combinations of variables A and B.

[5 marks]

Table 1

A	B	A.B	A+B	$\overline{A+B}$	Q
0	0				
0	1				
1	0				
1	1				

2 (b) Complete **Figure 1** using any gates to show how Q can be generated from inputs A and B to represent the Boolean equation above.

[5 marks]

Figure 1

2 (c) Using one or two logic gates, draw a simpler logic circuit below that would give the function described by the Boolean equation above.

[2 marks]

12

3 A student designs a circuit to obtain a USB compatible output voltage from a car power socket.

The car's power socket voltage can vary from 10.9 V to 14.4 V.

The USB port voltage must be maintained between 4.4 V and 5.25 V.

The current demand for the USB device can rise to a maximum of 90 mA.

3 (a) (i) Complete **Figure 2** by labelling the positive and negative connections from the power socket and draw a Zener diode and a resistor in their correct positions.

[4 marks]

Figure 2

3 (a) (ii) A resistor alone can be used to drop a voltage to a lower level.
Explain why the Zener diode is also required in this application.

[2 marks]

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3 (b) A Zener diode with a voltage rating of $4.7\ \mathrm{V}$ is chosen by the student. The minimum Zener current should be $10\ \mathrm{mA}$ under all conditions.

3 (b) (i) Calculate the minimum voltage across the resistor.

[1 mark]

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3 (b) (ii) Calculate the current through this resistor when the output current is at its maximum.

[1 mark]

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3 (b) (iii) Show that the required resistor value is $62\ \Omega$.

[2 marks]

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3 (c) The power socket voltage now increases to its maximum. With the resistor value given in part **(b) (iii)** above, calculate:

3 (c) (i) the voltage now present across the resistor

[1 mark]

.....

3 (c) (ii) the current through the resistor under these new conditions

[1 mark]

.....

3 (c) (iii) the power dissipated by the resistor under these new conditions.

[2 marks]

.....

.....

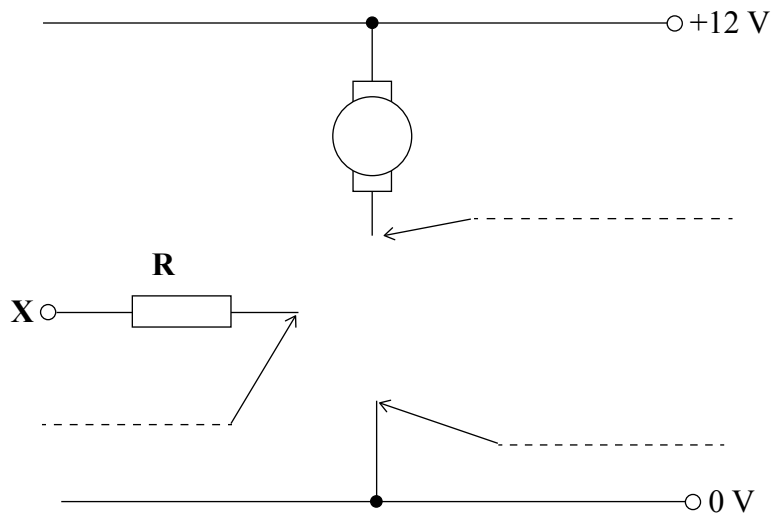
14

4 An npn junction transistor is to be used as a switch to control a small dc motor.

4 (a) (i) Draw in the correct place the transistor symbol and label the leads of the transistor in the spaces shown in **Figure 3**.

[4 marks]

Figure 3



4 (a) (ii) Add to **Figure 3** the component required to protect the transistor from the back emf of the motor.

[2 marks]

4 (b) The motor current is 100 mA when it is running.

4 (b) (i) State the collector current of the transistor when the motor is running.

[1 mark]

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4 (b) (ii) The transistor has a current gain (ratio of collector current to base current) of 40. Calculate the minimum base current when the motor is running.

[1 mark]

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4 (b) (iii) The input voltage at **X** which saturates the transistor is 5.2 V.
Calculate the value of **R**, the resistor required.

[2 marks]

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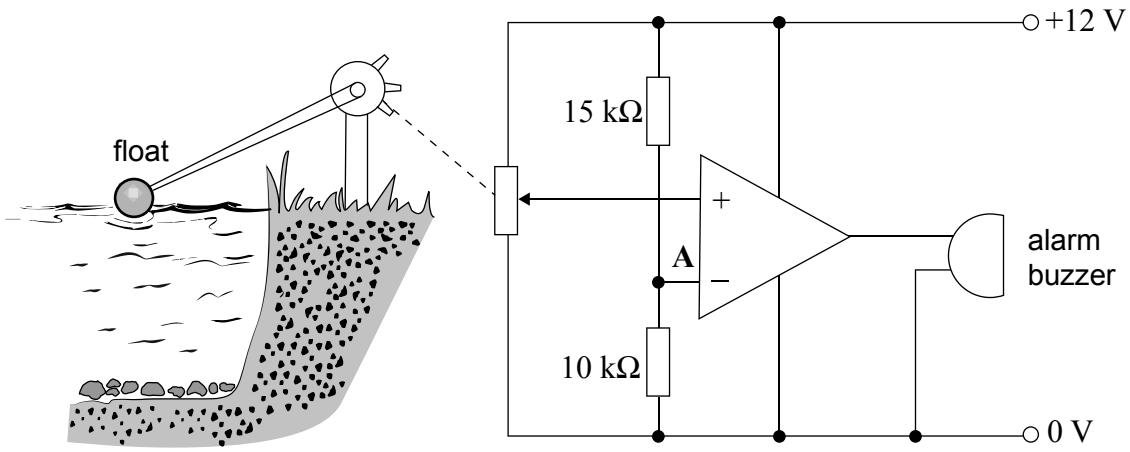
Turn over for the next question

5 A student designs a water level alarm system for the river next to where he lives. He decides to use a float, which is attached to a potentiometer connected to an electronic circuit, as shown in **Figure 4**.

Figure 4



As the float rises, the output voltage from the potentiometer increases, and at a certain voltage the op-amp output changes, turning on the alarm.

5 (a) State the type of op-amp circuit used in **Figure 4**.

[1 mark]

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5 (b) State the correct name for the op-amp input labelled **A**.

[1 mark]

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5 (c) Show that the value of the fixed voltage at **A** is 4.8 V.

[2 marks]

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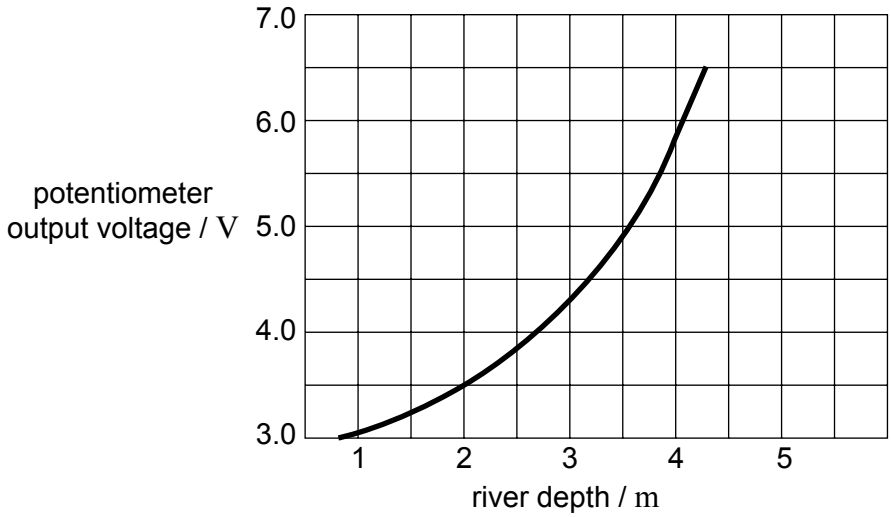
5 (d) The student measures the potentiometer output voltage at different river depths, and produces **Figure 5**.

Figure 5



5 (d) (i) Using **Figure 5**, state what the output of the op-amp should be when the river depth is 2.5 m. Give a reason for your answer.

[2 marks]

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5 (d) (ii) Estimate from **Figure 5** the river depth at which the alarm will sound.

[1 mark]

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5 (e) When the student tests the circuit, he finds that even when the river is at a safe level there is still a very faint sound from the alarm.
Explain why this might happen with a real op-amp.

[3 marks]

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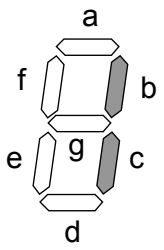
Turn over ▶

6 A bank uses a 7-segment display to tell customers which cashier is free, by displaying the numbers 1 to 5.

The logic circuit operating the display has a 3-bit binary input XYZ.
It has seven outputs for the segments a–g.
A logic 1 is required to light a segment.
Figure 6 shows the display with segments b and c illuminated to show the number 1.

Figure 6



6 (a) Put a tick in the box that corresponds to the segments for the numbers 3 and 5 being illuminated.

[1 mark]

3	5	Tick
b, c, d, g	a, c, d, f, g	
a, c, d, f, g	b, c, d, g	
a, b, c, d, g	a, c, d, f, g	
a, b, c, d, g	a, b, d, e, f, g	

6 (b) Inputs 000, 110 and 111 do not light the display, because there are only five cashiers.
Complete **Table 2** showing how the segments lit correspond with the 3-bit binary input.

[3 marks]

Table 2

cashier	binary input			segment						
	X	Y	Z	a	b	c	d	e	f	g
-	0	0	0	0	0	0	0	0	0	0
1	0	0	1					0		0
2	0	1	0					1		1
3	0	1	1	1	1	1	1	0	0	1
4	1	0	0					0		1
5	1	0	1	1	0	1	1	0	1	1
-	1	1	0	0	0	0	0	0	0	0
-	1	1	1	0	0	0	0	0	0	0

6 (c) Write the simplest Boolean expression, in terms of inputs X, Y, Z, for segments e and g.

[3 marks]

e =.....

g =.....

6 (d) Which single logic gate could be used to give the output g from the inputs?

[1 mark]

.....

6 (e) The Boolean expression for output f is

$$f = (X.\overline{Y})$$

Draw a logic circuit using **only** 2-input NAND gates to give this output.

[3 marks]

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END OF QUESTIONS

There are no questions printed on this page

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