

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



General Certificate of Education  
Advanced Subsidiary Examination  
June 2015

# Electronics

# ELEC1

## Unit 1 Introductory Electronics

Tuesday 12 May 2015 9.00 am to 10.00 am

**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.



J U N 1 5 E L E C 1 0 1

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

- 1** A student has been asked to design a low-temperature warning system for an incubator at a wildlife centre.  
The design brief for the system has the following features.
- A sensor monitors the incubator temperature and the system detects when the temperature drops below a certain level, which can be adjusted.
  - A light sensor unit detects when it is dark.
  - An audio signal is sent to a loudspeaker only when the warning system is activated when it is dark.

**1 (a)** Draw a system diagram to represent the solution by using one of each of the subsystems below.

**adjustable voltage reference    audio amplifier    audio signal generator    comparator**

**light sensor unit    loudspeaker    temperature sensor    two input logic gate**

**[7 marks]**

**1 (b)** State the subsystem in which each of the following components could be used.

**[3 marks]**

op-amp .....

potentiometer .....

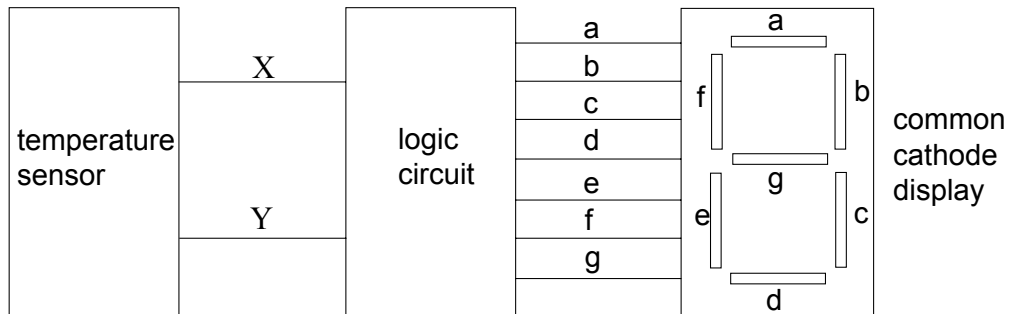
power MOSFET .....

**10**



- 2 A fridge is fitted with a temperature-sensing unit to indicate whether the temperature inside the fridge is too high, too low, or at a safe temperature. The system consists of a temperature sensor that produces a 2-bit binary output, a logic circuit and a low current, common cathode 7-segment display. **Figure 1** shows a block diagram of the system.

Figure 1



**Table 1** shows the operation of the system.

Table 1

Fridge temperature	Temperature sensor output		7-segment display output
	X	Y	
< 3 °C	0	0	L
3 °C to 4 °C	0	1	S
4 °C to 5 °C	1	0	S
> 5 °C	1	1	H

**Key**

L = low

S = safe

H = high

- 2 (a) Complete **Table 2** to show the logic signals required on lines a to g to display the specified characters.

[3 marks]

Table 2

X	Y	a	b	c	d	e	f	g	Display
0	0								L
0	1								S
1	0								S
1	1								H

Question 2 continues on the next page

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**2 (b)** Circle the single logic gate which would generate the required signal for segment **a**. **[1 mark]**

- AND                      EXOR                      OR                      NAND                      NOR                      NOT

**2 (c)** The system in **Figure 1** uses a common cathode display.  
An equivalent system could have been designed using a common anode display.

Explain the difference in the logic signals needed to operate the two types of display. **[2 marks]**

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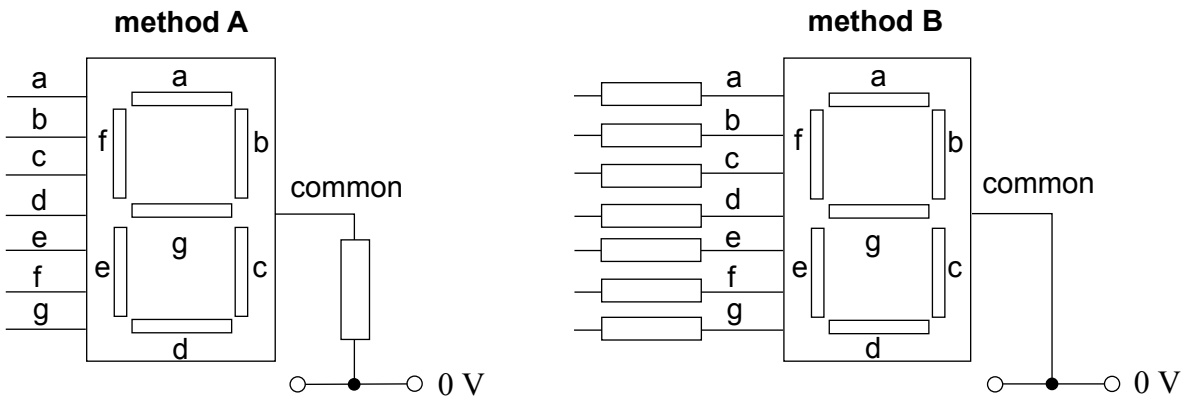
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**2 (d)** The LEDs in the 7-segment display must be protected by current limiting resistors. **Figure 2** shows two methods, **A** and **B**, of connecting current limiting resistors.

**Figure 2**



**2 (d) (i)** State **one** disadvantage of **method A**. **[1 mark]**

.....

.....



**2 (d) (ii)** Calculate the value of the current limiting resistors required in **method B** to limit the current in each segment to 20 mA.  
Assume the voltage from the logic circuit is 5 V and the forward voltage drop across each LED in the 7-segment display is 2.2 V.

**[2 marks]**

.....  
.....  
.....

**2 (d) (iii)** Circle the appropriate value for these resistors from the following list of E24 resistors.

**[1 mark]**

- 110 Ω      150 Ω      270 Ω      1.1 kΩ      1.5 kΩ

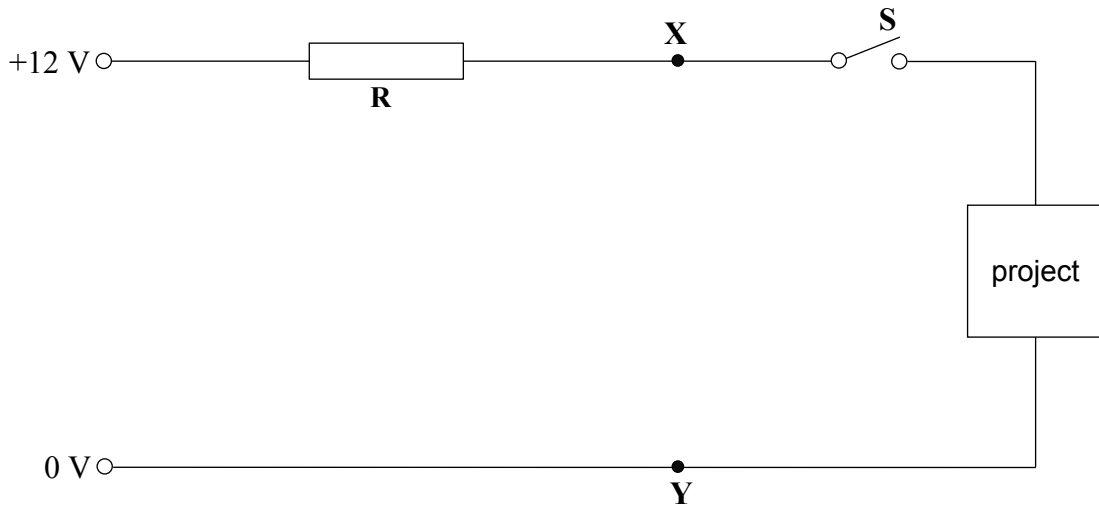
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- 3** A Zener diode is used to produce a stabilized 5.1 V from an unregulated 12 V supply to power a project that requires 80 mA.  
Part of the circuit is shown in **Figure 3**.

**Figure 3**

- 3 (a)** Draw on **Figure 3** the Zener diode connected correctly between points **X** and **Y**. **[2 marks]**
- 3 (b)** The Zener diode requires at least 5 mA to maintain its Zener voltage of 5.1 V.
- 3 (b) (i)** Calculate the minimum current flowing through **R** when switch **S** is closed. **[1 mark]**
- .....
- 3 (b) (ii)** Calculate the voltage across resistor **R** under these conditions. **[1 mark]**
- .....
- .....
- 3 (b) (iii)** Calculate the value of resistor **R**. **[2 marks]**
- .....
- .....
- .....



**3 (c)** The circuit in **Figure 3** is now constructed using a value of  $75\ \Omega$  for resistor **R**.

**3 (c) (i)** Show that the power dissipated in the resistor is approximately  $0.6\ \text{W}$ .

**[2 marks]**

.....  
.....  
.....

**3 (c) (ii)** The project is disconnected by turning switch **S** off, but the  $12\ \text{V}$  supply remains connected.

Calculate the current that now flows through the Zener diode.

**[2 marks]**

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<b>10</b>

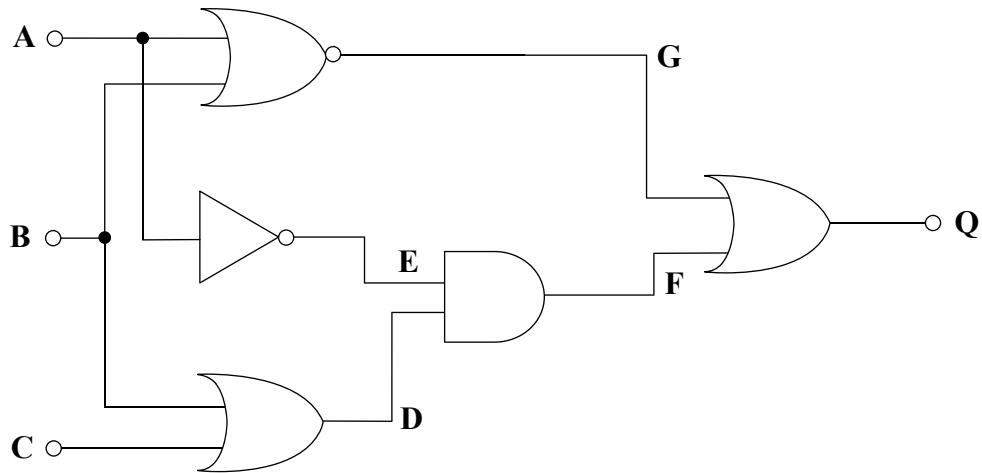
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4 Figure 4 shows a logic circuit with three inputs A, B and C.

Figure 4



4 (a) Write the Boolean expressions for the signals at the intermediate points D, E, and G in terms of the inputs A, B and C only.

[3 marks]

D .....

E .....

G .....

4 (b) Complete the truth table (Table 3) for the logic signals at the intermediate points D, E and G.

[5 marks]

Table 3

Inputs			Intermediate points		
C	B	A	D	E	G
0	0	0			
0	0	1			
0	1	0			
0	1	1			
1	0	0			
1	0	1			
1	1	0			
1	1	1			





**4 (c)** The final output **Q** in **Figure 4** could be expressed in the following way.

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

Show how the circuit in **Figure 4** could be reduced to a single gate.

Start by simplifying the equation for **Q**.

You may use Boolean algebra **and / or** a Karnaugh map to generate your solution.  
You must show your working.

**[3 marks]**

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The single equivalent gate is.....

<b>11</b>

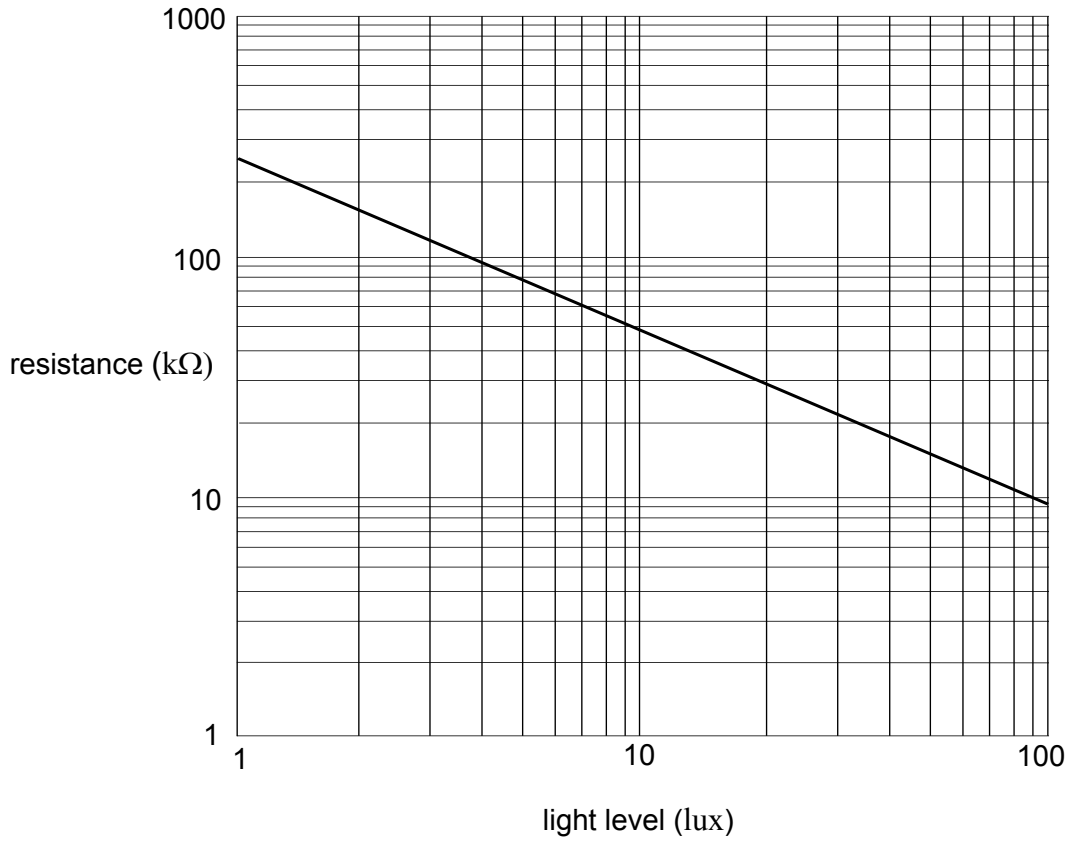
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- 5** An LDR is being used as a light sensor in a system that will switch on a porch light when it gets dark.  
The characteristic for the LDR is shown in **Figure 5**.

**Figure 5**



- 5 (a) (i)** Explain how the use of the logarithmic scale in **Figure 5** is helpful when displaying this characteristic.

[1 mark]

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- 5 (a) (ii)** The LDR has a resistance of 60 kΩ when the light level causes the system to switch on the porch light.

State the value of this light level by reading from the graph in **Figure 5**.

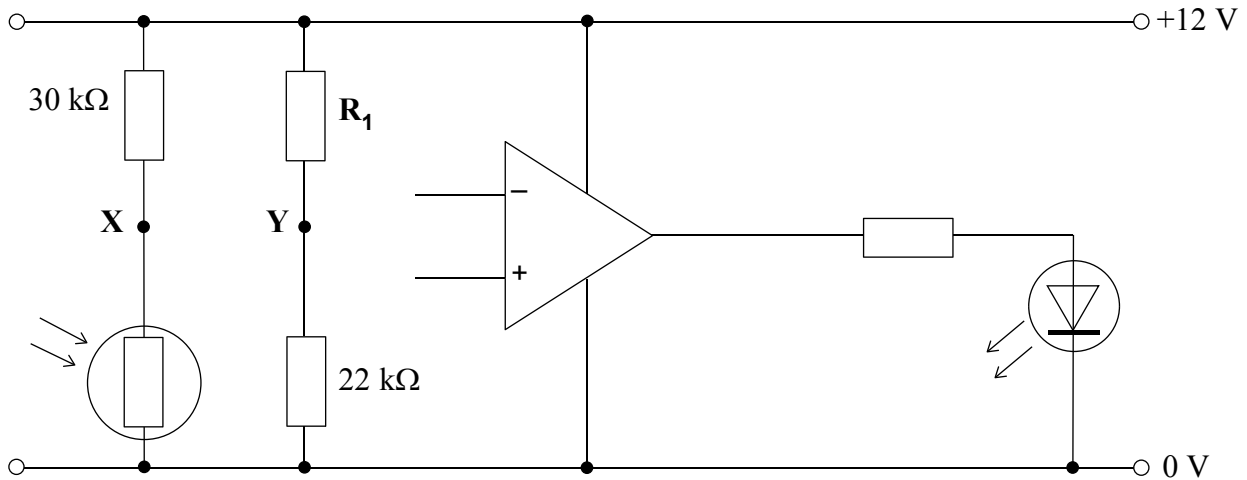
[1 mark]

light level..... lux



- 5 (b)** **Figure 6** shows the circuit for detecting the light level. The design makes use of an op-amp acting as a comparator. A red LED acts as an output indicator to aid testing of the detector circuit.

**Figure 6**



Draw on **Figure 6** the connections from points **X** and **Y** to the op-amp inputs so that the red LED switches on when the light level falls below the required value.

[1 mark]

- 5 (c) (i)** Calculate the voltage at point **X** when the red LED switches on.

[2 marks]

.....

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.....

- 5 (c) (ii)** The reference voltage at **Y** is produced by two fixed-value resistors.

Calculate the value for resistor **R<sub>1</sub>** in order to achieve the required circuit operation.

[2 marks]

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**Question 5 continues on the next page**

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**5 (d)** The red LED was found to stay on dimly even when the light level was well above the value expected to switch it off.

Explain why this might happen and how the problem could be solved.

**[3 marks]**

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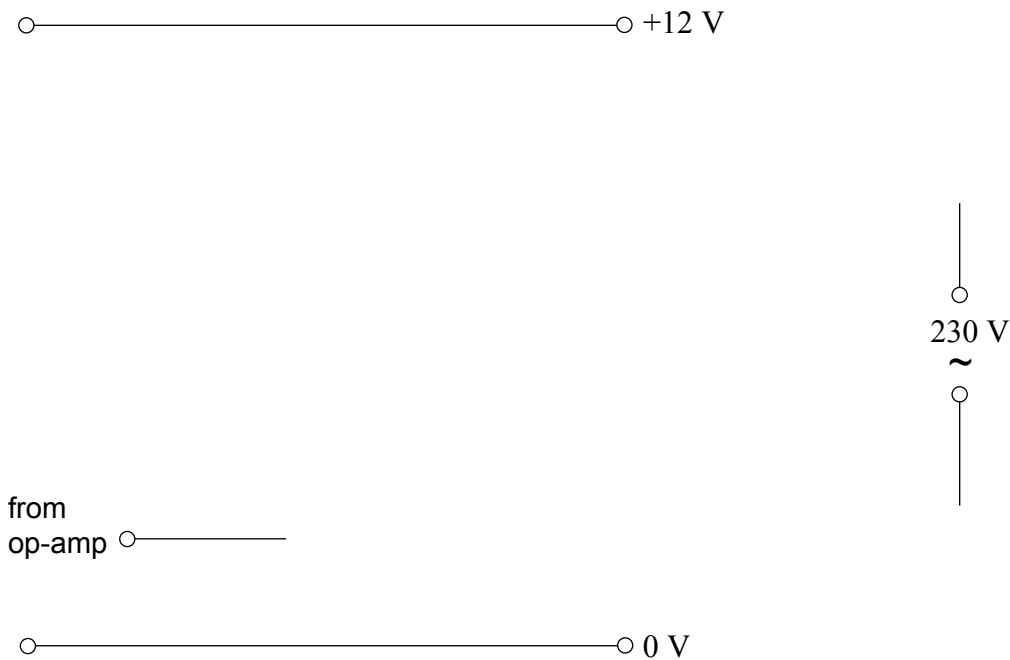
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**5 (e)** Following successful testing of the circuit, the LED is replaced with the final output stage. This includes a high power 230 V mains lamp which is controlled by the op-amp. The output circuit is based on an n-channel MOSFET with an electromagnetic relay to switch on the 230 V lamp.

Complete the circuit in **Figure 7** using the MOSFET, the relay, and any other components needed.

**[4 marks]**

**Figure 7**



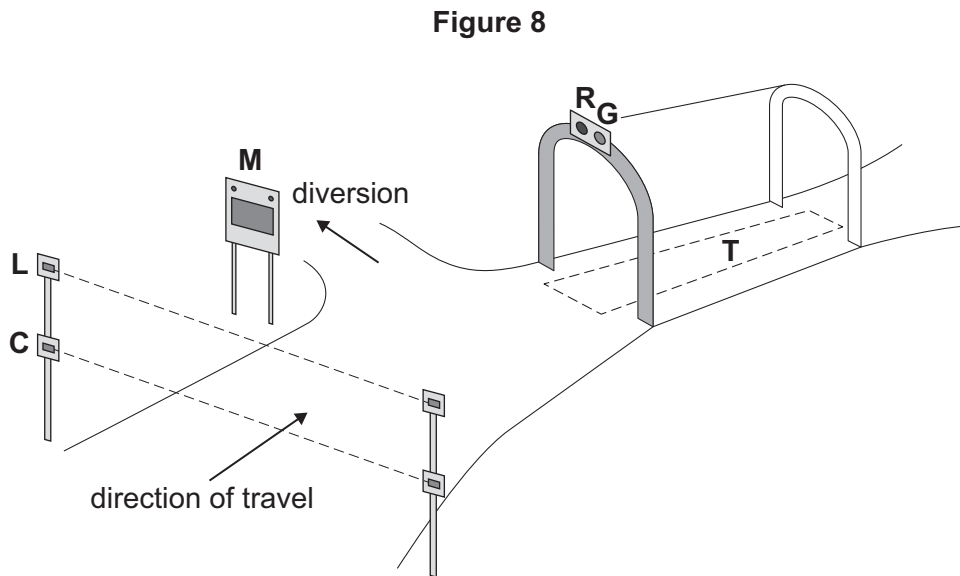
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- 6 **Figure 8** is a simplified diagram of a road safety system for traffic travelling towards a road tunnel. The tunnel is too narrow for two-way traffic and too low for lorries.



**C** and **L** are laser beam sensors placed at different heights on the road just before the tunnel. When a beam is broken, the sensor produces a logic 1.

Cars will break the beam at sensor **C only**. Lorries will break the beams at both sensor **L** and sensor **C**.

**M** is an electronic message display that tells lorries to take a diversion. The message display lights up when it receives a logic 1.

**T** is a sensor buried in the road inside the tunnel. It produces a logic 1 when an oncoming car is in the tunnel.

The red stop light **R** comes on when a lorry is detected or when there is an oncoming car in the tunnel. **R** will light up when it receives a logic 1.

The green go light **G** comes on when a car is detected and there are no oncoming cars in the tunnel. **G** will light up when it receives a logic 1.



- 6 (a)** Complete the truth table (**Table 4**).  
Some of the data has already been entered for you.

[4 marks]

**Table 4**

Inputs			Outputs		
Sensor T	Sensor C	Sensor L	Message display M	Red stop light R	Green go light G
0	0	0	0	0	1
0	0	1	0	0	1
0	1	0		0	
0	1	1		1	
1	0	0		1	
1	0	1	0	1	0
1	1	0		1	
1	1	1		1	

- 6 (b)** Write the simplest Boolean expression for the red stop light **R** in terms of **T**, **C** and **L**.

[2 marks]

.....

**Question 6 continues on the next page**



**6 (c) (i)** The expression for the green go light **G** could be written as  $G = \bar{T} \cdot (\bar{C} + \bar{L})$

Draw on **Figure 9** the logic diagram for this expression using only NOT, AND and OR gates.

**[3 marks]**

**Figure 9**

**T** ○ —

**C** ○ —

**L** ○ —



**6 (c) (ii)** Draw on **Figure 10** an alternative logic diagram for the green go light **G** using only NAND gates.

**[3 marks]**

**Figure 10**

**T** ○ —

**C** ○ —

**L** ○ —



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**END OF QUESTIONS**

