Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	

General Certificate of Secondary Education
June 2010

Design and Technology: Electronic Products 45401

Unit 1

Tuesday 22 June 2010 9.00 am to 11.00 am

You will need no other materials

Time allowed
- 2 hours

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.

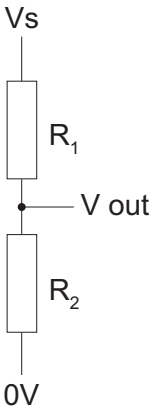
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 120.
- You are reminded of the need for good English and clear presentation in your answers. Quality of Written Communication will be assessed in your answer to Question 7 (d).

You may need to use one or more of the following formulae when answering questions which include calculations.

Potential Difference — Potential Difference = Current × Resistance (V = I × R)

Series Resistors — $R_{total} = R_1 + R_2 + R_3$ etc

Potential Divider



$$V\ out = \frac{R_2}{R_1 + R_2} \times Vs$$

where V out = signal value
Vs = supply voltage
R_1 and R_2 are resistance values

Time Constant — Time Constant ≏ Resistance × Capacitance (T ≏ R × C)

Astable Frequency for 555 $f = \frac{1.44}{(R_1 + 2R_2) \times C}$

Mark Space Ratio $= \frac{\text{Time high}}{\text{Time low}}$

Time High $= 0.693 \times (R_1 + R_2) \times C$

Time Low $= 0.693 \times R_2 \times C$

Inverting Op-Amps $Gain = \frac{-Rf}{Rin}$ Where Rf = feedback resistor value
Where Rin = input resistor value

You may need to use the following information when answering some of the questions.

The figures shown below and their decade multiples or submultiples are the series of preferred values in accordance with BS:2488.

E12 Resistor series 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82

E24 Resistor series 10, 11, 12, 13, 15, 16, 18, 20, 22, 24, 27, 30, 33, 36, 39, 43, 47, 51, 56, 62, 68, 75, 82, 91

Capacitor series 10, 22, 47

Resistor Colour Code

Colour	Band 1	Band 2	Band 3 (No. of 0s)	Band 4 (Tolerance)
Black	0	0	None	
Brown	1	1	0	
Red	2	2	00	
Orange	3	3	000	
Yellow	4	4	0000	
Green	5	5	00000	
Blue	6	6	000000	
Violet	7	7	–	
Grey	8	8	–	
White	9	9	–	
				Gold = 5%
				Silver = 10%

Turn over for the first question

SECTION A

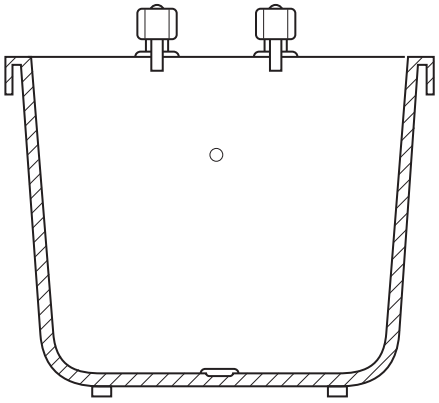
Answer **all** questions.

1 This question is about designing a water level warning device.

Many homeowners have experienced flooded bathrooms.

A small manufacturing company have asked you to consider and design a proposal for a bath water level monitoring product.

Figure 1



1 (a) Using notes **and** sketches design a product, in the box provided on page 5, that meets each of the criteria below.

- The device is suitable for use in a bathroom *(3 marks)*
- A method of switching on and off *(2 marks)*
- The product is visually appealing *(3 marks)*
- It can be adjusted or set for alternative water levels *(3 marks)*
- It will warn the user when a water level is reached *(2 marks)*
- It will attach easily to the bath *(2 marks)*

1 (b) Complete the block diagram below to explain each stage of the water level warning system.

(3 marks)

Question 1 continues on the next page

1 (c) State **two** suitable input devices that could be used for the water level warning device.

Give a suitable design advantage for each.

Input device 1 .....

Advantage of input 1 .....

.....

.....

.....

Input device 2 .....

Advantage of input 2 .....

.....

.....

.....

(6 marks)

1 (d) (i) The product is to be manufactured as a one-off.

State a suitable material, process and the reason for your choice.

Material .....

Process .....

Reason .....

.....

.....

(4 marks)

1 (d) (ii) The product is to be manufactured in a batch of 5000.

State a suitable material, process and the reason for your choice.

Material .....

Process .....

Reason .....

.....

.....

(4 marks)

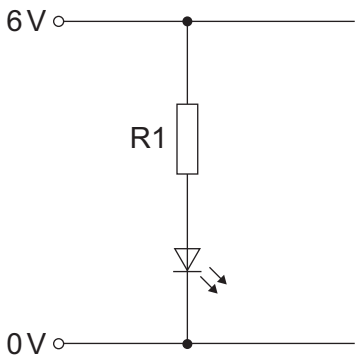
32

SECTION B

Answer **all** questions.

2 This question is about resistors and Light Emitting Diodes (LEDs).

Figure 2



2 (a) Calculate the value of R1 in **Figure 2**.

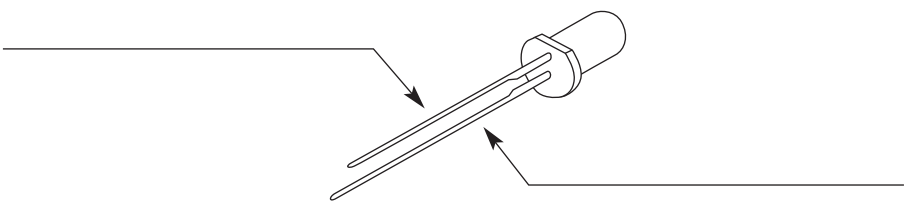
The LED has a forward voltage drop of 2 volt and draws 20 mA.

Calculation

Value of R1 .....

(4 marks)

2 (b) (i) Identify the LED's leads on the diagram below.



(2 marks)

Question 2 continues on the next page

2 (b) (ii) Describe **two** advantages and **one** disadvantage of using LEDs rather than filament lamps.

Advantage 1 .....

Advantage 2 .....

Disadvantage .....

.....

.....

.....

.....

.....

(5 marks)

11

3 This question is about batteries and charging.

Many products are powered by batteries.

3 (a) In the box provided below draw a circuit diagram showing how several cells can be connected correctly to provide a 6-volt supply.

(3 marks)

Question 3 continues on the next page

3 (b) Explain in detail why you might choose an alternative to disposable batteries.

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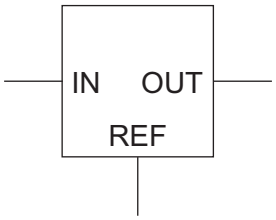
(3 marks)

3 (c) A digital device requires a 5-volt supply

The device circuit symbol shown below is a 7805 voltage regulator.



Explain why voltage regulation is required for some circuits.

.....

.....

.....

.....

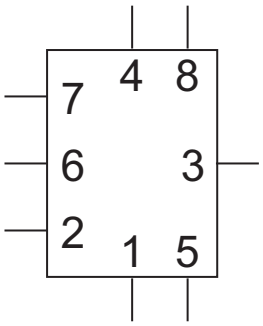
(2 marks)

8

4 This question is about the 555 timer and time constants.

A student is asked to design and develop a toothbrush timer for children, using a 555 timer.

4 (a) State the **two** additional components required to control the time period for a 555 connected as a monostable.



Component 1 .....

Component 2 .....

(2 marks)

4 (b) Using two fixed values of component will provide a fixed time delay.

Name a component that will allow the user to alter the time delay easily.

.....

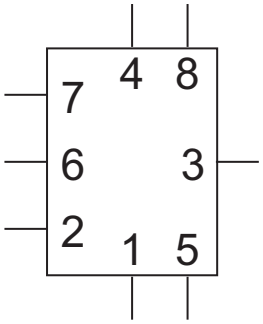
(1 mark)

Question 4 continues on the next page

4 (c) Draw **and** label a resistor and a push to make switch correctly connected to pin 2 of the timer in **Figure 3**.

Describe their function in this circuit.

Figure 3



Function of resistor .....

Function of push to make switch .....

.....

(6 marks)

4 (d) Three minutes (180 seconds) is the recommended brushing time for teeth.

The electrolytic capacitor value used is 1000 µF.

Calculate the value of the resistor required in the space provided below.

State the formula used .....

Resistor value .....

(4 marks)

4 (e) When the circuit was constructed it was found to have a slightly different time delay to that calculated.

Explain why this happened.

.....

.....

.....

.....

(2 marks)

4 (f) If a manufacturer were to develop a multifunction timer the most likely choice would be to use a PIC microcontroller solution.

Give **three** advantages of using a PIC microcontroller that would justify that choice.

1 .....

.....

2 .....

.....

3 .....

.....

(6 marks)

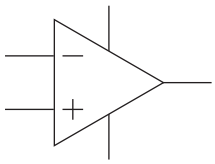
21

Turn over for the next question

5 This question is about operational amplifiers.

An operational amplifier has been selected as a comparator to control temperature in a project.

Figure 4



5 (a) Explain what is meant by the term *comparator*.

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(2 marks)

5 (b) Name and explain the purpose of the two inputs on the operational amplifier symbol shown in **Figure 4** (+ and –).

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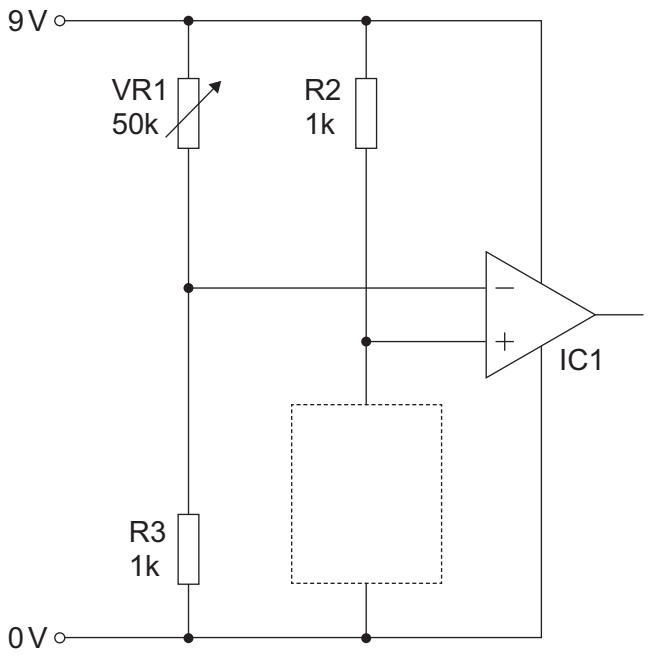
.....

.....

(2 marks)

5 (c) (i) Describe the purpose of the two resistors VR1 and R3 connected to pin 2 in **Figure 5** below.

Figure 5



R3 .....

VR1 .....

(2 marks)

5 (c) (ii) Draw the circuit symbol for a suitable temperature sensor in the space provided in **Figure 5**.

(1 mark)

5 (c) (iii) Name the temperature sensor drawn.

.....

(1 mark)

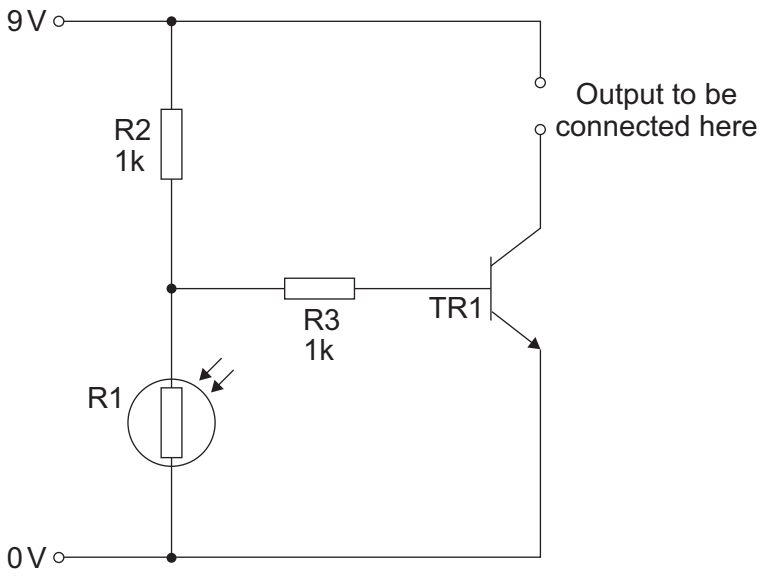
8

Turn over for the next question

6 This question is about designing and using transistors.

6 (a) Identify a suitable product application for the circuit in **Figure 6** and the purpose of R3 and TR1 in operating the circuit below.

Figure 6



Product application .....

Describe the purpose of R3 .....

.....

.....

Describe the purpose of TR1 .....

.....

.....

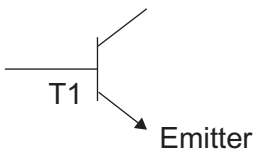
(5 marks)

6 (b) Complete the labelling on **Figure 7**.

Figure 7

.....

.....

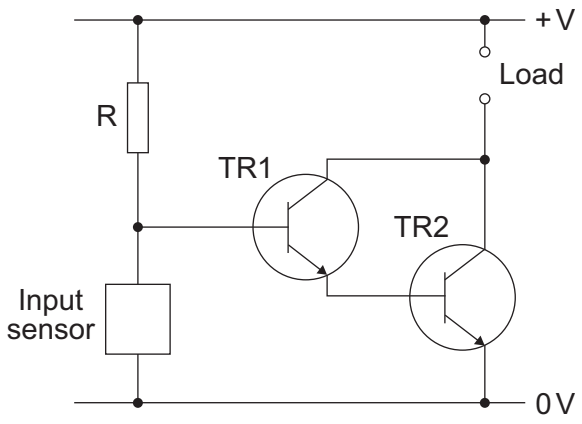


(2 marks)

6 (c) Name the arrangement of TR1 and TR2 used in the circuit **Figure 8** below.

Explain the function of TR1 **and** TR2.

Figure 8



Arrangement .....

Function of TR1 and TR2 .....

.....

.....

.....

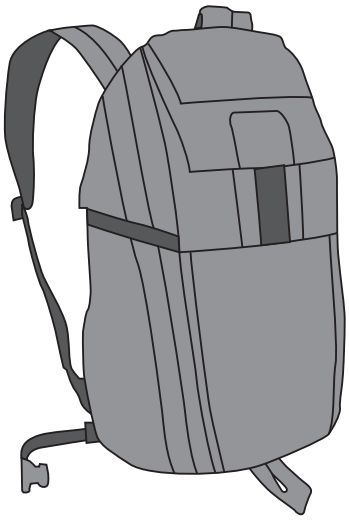
(3 marks)

10

Turn over for the next question

7 This question is about manufacturing a product.

Many pupils walk or cycle to and from school in low light or darkness. You have been asked to create a suitable small product to attach to a bag or rucksack. It will need to have a flashing LED output.



7 (a) State **four** things to consider in the design of this 'flashing' product.

1 .....

2 .....

3 .....

4 .....

(4 marks)

7 (b) An 8 pin PIC has four outputs A, B, C and D that can be used to drive LEDs.

Suggest a possible flash (on/off) sequence for all four of the LEDs.

Sequence .....

.....

.....

.....

(2 marks)

7 (c) Explain using a labelled diagram a sequence of PIC program commands.

The program switches each alternate pair (A + B) then (C + D) of LED outputs on for 2 seconds then off for 2 seconds continuously.

(5 marks)

Question 7 continues on the next page

7 (d) Describe how you would evaluate the design, reliability **and** effectiveness of the safety device once you had made a prototype.

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(6 marks)

17

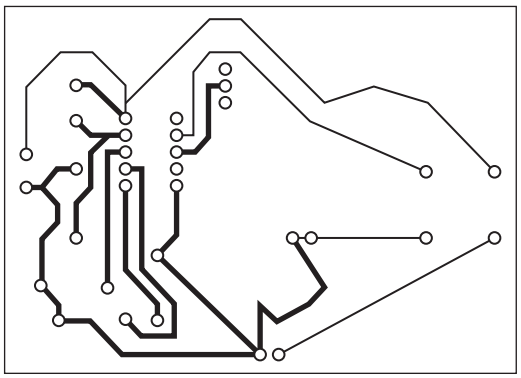
8 This question is about designing and making electronic parts.

The PCB design in **Figure 9** has various problems.

These included:

- A difficulty in soldering: some tracks were prone to breaking.
- Once assembled with a battery it was difficult to fit in the manufactured case.
- The battery leads broke off too easily when in use.

Figure 9



8 (a) Suggest **three** changes you could make to the PCB design in **Figure 9** to improve it.

1 .....

2 .....

3 .....

(3 marks)

Question 8 continues on the next page

8 (b) Describe the stages in the manufacturing process of a PCB ready to be populated with components.

(6 marks)

8 (c) State a test instrument *or* method you could use to check the copper track and to fault-find.

.....

.....

.....

.....

(2 marks)

8 (d) Suggest **two** safety hazards that might need to be considered when making and populating a PCB.

1 .....

2 .....

(2 marks)

13

END OF QUESTIONS

There are no questions printed on this page

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