OCR
RECOGNISING ACHIEVEMENT

**ADVANCED SUBSIDIARY GCE UNIT** **2860**

# PHYSICS B (ADVANCING PHYSICS)

Physics in Action

**FRIDAY 8 JUNE 2007** Morning

Time: 1 hour 30 minutes

Additional materials:
- Data, Formulae and Relationships Booklet
- Electronic calculator
- Ruler (cm/mm)

*CUP/T23228*

Candidate Name

Centre Number

Candidate Number

**INSTRUCTIONS TO CANDIDATES**

- Write your name, Centre Number and Candidate Number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.
- Show clearly the working in all calculations and give answers to only a justifiable number of significant figures.

**INFORMATION FOR CANDIDATES**

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 90.
- You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.
- There are four marks for the quality of written communication in Section C.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.

| FOR EXAMINER'S USE | | |
|---|---|---|
| **Section** | **Max.** | **Mark.** |
| **A** | **20** | |
| **B** | **41** | |
| **C** | **29** | |
| **Total** | **90** | |

This document consists of **21** printed pages and **3** blank pages.

  

Answer **all** the questions.

## Section A

**1** Here is a list of mechanical properties of materials.

**brittleness** **plasticity** **stiffness** **strength**

**(a)** For each of the descriptions below write down the word from the list that is being described:

a measure of the stress a material can take before yielding ......................................

a measure of a material's resistance to stretching or bending ......................................

the tendency of a material to break by crack propagation ......................................

[3]

**(b)** State the meaning of the remaining property that you have not chosen above.

[1]

**2** A student is measuring the conductance of a component.

He measures the current in the component as $I = 0.24 \pm 0.01$ A
and the p.d. across the component as $V = 5.4 \pm 0.1$ V.

**(a)** Calculate the best estimate for the conductance $G$.

Give your answer to a sensible number of significant figures.

$G$ = ...................................... S [1]

**(b)** Use the largest current and smallest p.d. within his uncertainty range.

Calculate the maximum value of $G$ consistent with the data.

maximum value of $G$ = ...................................... S [1]

**(c)** State an estimated value for the $\pm$ uncertainty in the measurement of $G$.

uncertainty in $G = \pm$ ...................................... S [1]

**3** Here is a list of units.

**A s** **C s$^{-1}$** **J C$^{-1}$** **V A$^{-1}$** **J s$^{-1}$**

Write down the units from the list that are equivalent to the units below:

W .............. A ..............

Ω .............. V .............. [4]

**4** Fig. 4.1 shows a tiny section of a digital image where there is a vertical dark-to-light edge. The section contains some noise.

**Fig. 4.1**

Fig. 4.2 shows the pixel values for this tiny section of the image.

| | | | | |
|---|---|---|---|---|
| 200 | 200 | 200 | 100 | 100 |
| 200 | 200 | 200 | 100 | 100 |
| 200 | 200 | 0 | 100 | 100 |
| 200 | 200 | 200 | 100 | 100 |
| 200 | 200 | 200 | 100 | 100 |

**Fig. 4.2**

**(a)** One method of reducing noise is by averaging each pixel value with its surrounding 8 neighbours, by taking the mean.

Show that the averaged value of the central 9 pixels in Fig. 4.2 is 144.

[1]

**(b)** Another method of reducing noise is by averaging each pixel value with its surrounding 8 neighbours, by taking the median.

The two 3 x 3 arrays in Fig. 4.3 show the averaged values of the central 9 pixels from Fig. 4.2, the first by taking **means** and the second by taking **medians**.

| | | |
|---|---|---|
| 178 | 144 | 111 |
| 178 | 144 | 111 |
| 178 | 144 | 111 |

by **means**

| | | |
|---|---|---|
| 200 | 200 | 100 |
| 200 | 200 | 100 |
| 200 | 200 | 100 |

by **medians**

**Fig. 4.3**

Describe the appearance of this section of the image after the averaging process

**(i)** by **means**

**(ii)** by **medians**.

[2]

**5** A lady is long-sighted. This means she can see distant objects, but the optical power of her eyes is not enough to focus on nearby objects for reading.

**(a)** The nearest object that she can focus clearly on her retina is 2.0 m away from her eyes.

Calculate the curvature of waves arriving at her eyes from 2.0 m away.

curvature = ............... D [1]

**(b)** She wants to be able to form a clear image of the print in a book placed 0.25 m from her eyes.

Calculate the curvature of waves arriving at her eyes from 0.25 m away.

curvature = ............... D [1]

**(c)** Calculate the extra curvature that corrective lenses must add, so that she can read a book placed at a distance of 0.25 m from her eyes.

curvature = ............... D [1]

**6** A swimming pool is illuminated by a lamp at the bottom as shown in Fig. 6.1.

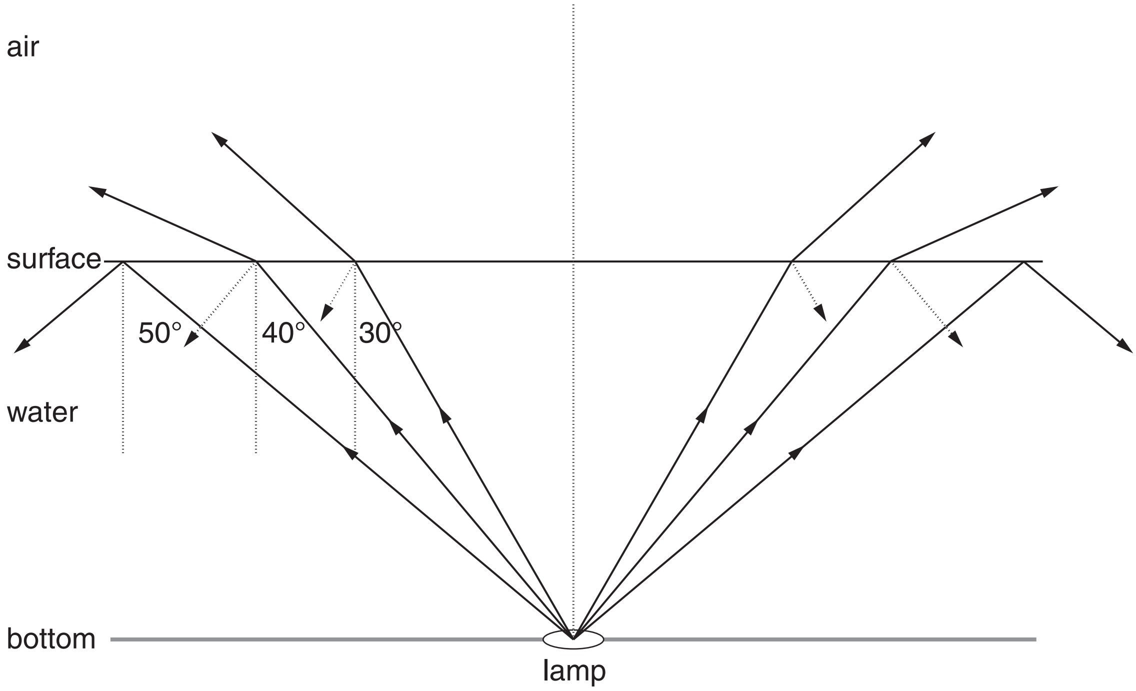


**Fig. 6.1**

Rays of light from the lamp at 30°, 40° and 50° to the vertical are shown incident on the water-air surface from below.

**(a)** State why there is no refracted ray into the air at an angle of incidence of 50°.

[1]

**(b)** Do a suitable calculation to support your explanation in **(a).**

refractive index *n* of water = 1.33

[2]

[Section A Total: 20]

## Section B

7 This question is about information storage on a CD.

Fig. 7.1 shows part of the surface of a CD where bits of information are stored on a spiral track.

**An image has been removed due to third party copyright restrictions**

Details: An image of a CD and the surface of a part of the CD showing a focused laser spot which scans the spiral track

Fig. 7.1

(a) (i) Estimate the distance between rows of the spiral using the scale on Fig. 7.1.

distance = …………… μm [1]

(ii) Laser light focused to a finite spot, as shown on Fig. 7.1, scans the spiral track reading 0's and 1's as the CD rotates.

Suggest why the bits **cannot** be separated by less than about 1.0 μm along or between the tracks.

[1]

(iii) The CD can store 650 Mbytes of information.

Show that the total length of the spiral track is more than 5 km.

[3]

**(b)** Recently advances in technology have resulted in DVD players using blue lasers, whereas CD players used infra-red lasers.
The focused laser spot is still about one wavelength in diameter.
The blue light has half the wavelength of the infra-red ($\lambda_{\text{blue}} = \frac{1}{2}\lambda_{\text{infra-red}}$).

Estimate the ratio $= \dfrac{\text{information stored on DVD}}{\text{information stored on CD}}$.

Explain your reasoning.

ratio = ............... [3]

**(c)** Disks are one example of **digital information storage**.

State what you believe is one **advantage** and one **disadvantage** of digital information storage technology **to society**, and justify each statement.

advantage

disadvantage

[4]

[Total: 12]

**8** This question is about the properties of an LDR.

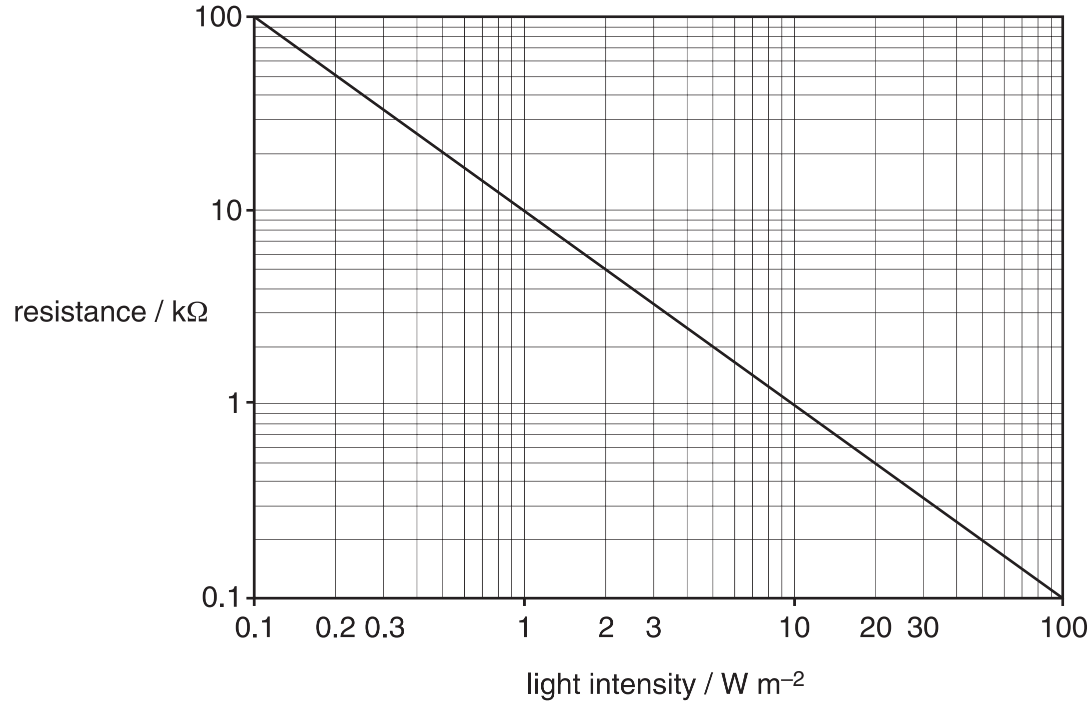


**Fig. 8.1**

The graph in Fig. 8.1 shows how the resistance of the LDR varies with incident light intensity.

**(a)** The unit of light intensity is $W\,m^{-2}$.

Complete an equation for the incident light intensity $I$, in terms of the power $P$ of the light and the area $A$ through which the light passes normally.

$I$ =

[1]

**(b)** **(i)** State how you recognise that the scales of the graph in Fig. 8.1 are **logarithmic**.

[1]

**(ii)** Use Fig. 8.1 to find the resistance of the LDR at a light intensity of $2.0\,W\,m^{-2}$.

resistance of LDR = …………… Ω [2]

**(c) (i)** The line in Fig. 8.1 obeys the relationship

resistance × intensity = constant.

Calculate the value and state the units of this constant.

constant = …………… units …………… [2]

**(ii)** Graphs **A**, **B**, **C**, **D** in Fig. 8.2 show possible variations for the resistance $R$ of the LDR plotted against light intensity $I$, but now using **linear** scales.

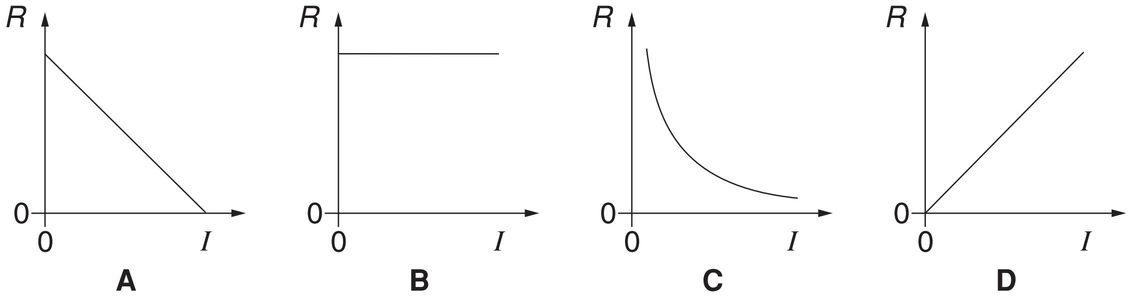


**Fig. 8.2**

State which of the graphs **A**, **B**, **C**, **D** represents the data plotted in Fig. 8.1.

…………… [1]

**(d)** Electrons are released from bonds in the material of the LDR by absorbing incident photons. They remain free to conduct for about 50 ms before returning to be localised in bonds again.

Imagine an LDR which is brightly illuminated, which is suddenly plunged into darkness.

Suggest why the resistance of the LDR also takes about 50 ms to respond.

[1]

**(e) (i)** Suggest a reason why the charge carrier density in the LDR material **doubles** when the incident light intensity **doubles**.

[1]

**(ii)** Explain why it is expected that the resistance of the LDR is **inversely proportional** to the light intensity incident on it.

[2]

[Total: 11]

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**9** This question is about the material silver sulphide and its use in a nanoswitch.

**(a)** Fig. 9.1 shows a conducting platinum electrode very near to a silver sulphide surface. When a negative voltage is applied to the platinum electrode, silver ions flow through the silver sulphide. A deposit of silver atoms forms on the surface, touches the electrode and completes a circuit.

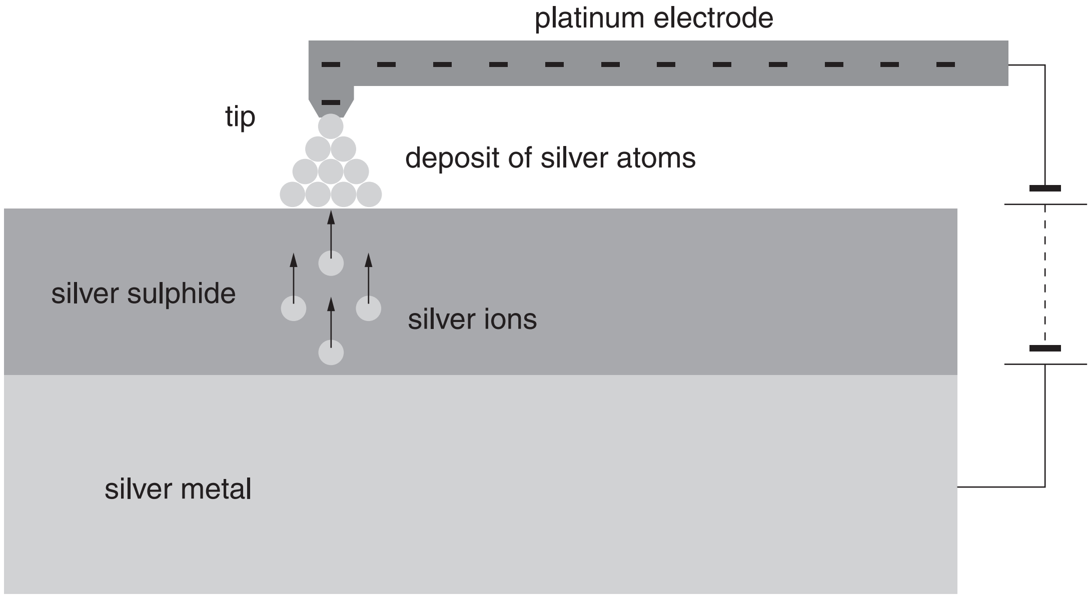


**Fig. 9.1**

**(i)** A silver deposit is made from 30 silver atoms.

Calculate the quantity of electrical charge needed to change 30 silver ions into atoms.

charge on silver ion = $+ 1.6 \times 10^{-19}$ C

charge = …………… C [1]

**(ii)** The motion of the silver ions which form the deposit can be reversed by making the platinum electrode positive.

Suggest why the device has been called a **nanoswitch**.

[2]

**(b)** The height of the deposit of silver atoms depends on the length of time the voltage is applied. Fig. 9.2 shows how the height of the deposit varies with the length of time the voltage pulse has been applied.

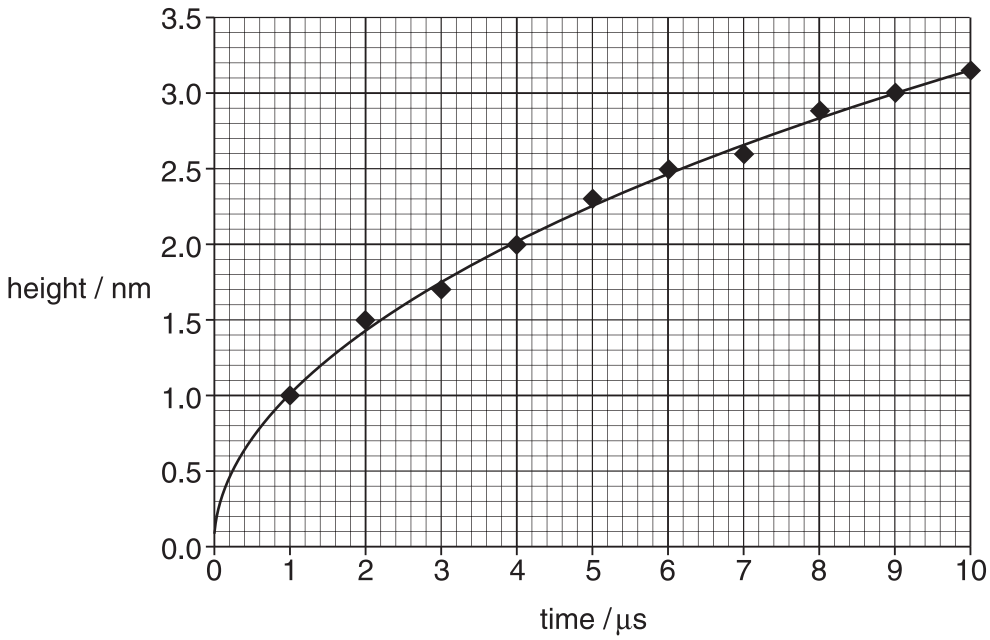


**Fig. 9.2**

**(i)** Estimate the number of layers of silver atoms that are deposited when the voltage is applied for 4.0 μs.

The silver atoms in the deposit have a diameter of 0.29 nm.

number of layers = ............... [2]

**(ii)** Look at the arrangement of atoms in the silver deposit in Fig. 9.1.

Suggest a reason why the graph in Fig. 9.2 is non-linear.

[1]

**(iii)** Suggest **one** reason why the gap between the platinum electrode and the silver sulphide surface is made as small as possible.

[1]

[Total: 7]

**10** This question is about a strain gauge.

**(a)** **(i)** Fig. 10.1 shows a metallic wire conductor used to form the strain gauge.

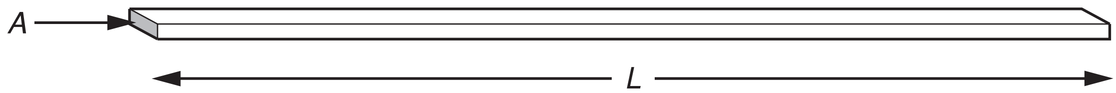


**Fig. 10.1**

*A* is the cross-sectional area and *L* the length of the wire.

$\rho$ is the resistivity of the wire material.

Complete the equation for the resistance *R* of a wire, in terms of *A, L* and $\rho$.

$R$ =

[1]

**(ii)** The cross-sectional area of the wire is $8.0 \times 10^{-10}$ m$^2$.

The resistivity of the wire material is $4.8 \times 10^{-7}$ Ω m.

Calculate the length *L* of wire needed to achieve a resistance of 120 Ω.

$L$ = ...................................... m [2]

**(iii)** Fig. 10.2 shows a wire strain gauge of resistance 120 Ω.

The gauge is made from ten short lengths of the wire connected in series, having the same total length *L* as in **(a)(ii)**.

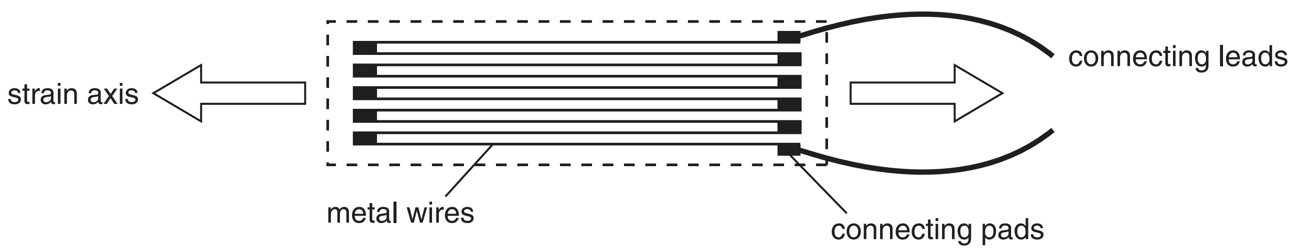


**Fig. 10.2**

Suggest a reason for the zigzag construction of this strain gauge.

[1]

**(b) (i)** The strain gauge works by stretching the metallic wire, changing its dimensions and hence its electrical resistance.

You may assume that the volume $V$ of metal in the total length of wire, that is $V = A \times L$, remains **constant** as the wire is stretched.

Substitute this equation into your resistance equation in **(a)(i)** to show that, in this case, the resistance of the wire is proportional to the length squared ($R \propto L^2$).

[2]

**(ii)** State an assumption that you have made about the resistivity, in showing the proportionality in **(b)(i)**.

[1]

**(iii)** In an experiment using the strain gauge, the sensing wire in the gauge is stretched elastically to a strain of 0.003.

Show that the resistance of the gauge increases by about 0.6 %, using the information from **(b)(i)**.

[2]

**(c)** The Young modulus for the metal of the wire is $4.6 \times 10^{10}$ Pa.

Calculate the stress in the wire under a strain of 0.003.

stress = ...................................... Pa [2]

[Total: 11]

[Section B Total: 41]

## Section C

In this section, you will choose the context in which you give your answers.

Use diagrams to help your explanations and take particular care with your written English. In this section, four marks are available for the quality of written communication.

**11** In this question you are asked to choose and discuss an imaging system that can deliver useful information.

**(a) (i)** Identify your chosen imaging system.

............................................................................................................................ [1]

**(ii)** Describe the system that forms your image, and how it operates.

Use a labelled diagram in your answer.

[5]

**(b)** **(i)** State a typical resolution for your imaging system.

resolution = …………… unit …………… [2]

**(ii)** Suggest and explain **one** change that could be made to your imaging system that would improve its resolution.

[2]

**(c)** Explain **two** uses of the information obtainable from your imaging system that are of benefit to society.

[2]

[Total: 12]

**12** In this question, you are asked to describe the operation of an electrical sensor system of your choice.

**(a)** **(i)** State what physical variable your system is designed to monitor or measure.

...................................................................................................................................... [1]

**(ii)** Draw and label a circuit diagram for your electrical sensor system.

[3]

**(iii)** Explain how the circuit operates.

[2]

**(b) (i)** Explain the terms **response time** and **linearity** as applied to an electrical sensor system.

response time

linearity

[2]

**(ii)** For **your** electrical sensor system, describe how you would investigate the **linearity** of the system.

Make clear what apparatus you would use (other than your electrical sensor system), and what measurements you would make.

You may find it useful to include a labelled diagram.

[5]

[Total: 13]

[Quality of Written Communication: 4]

[Section C Total: 29]

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