OCR
RECOGNISING ACHIEVEMENT

Thursday 12 January 2012 – Afternoon

AS GCE PHYSICS B (ADVANCING PHYSICS)

G491 Physics in Action

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator
- Ruler (cm/mm)

Duration: 1 hour

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Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **60**.
- You are advised to spend about 20 minutes on Section A and 40 minutes on Section B.
- 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.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means, for example, you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** the questions.

Section A

1 Here is a list of units:

A Pa V W S

(a) From the list write down the unit for:

pressure ..... conductance ..... **[2]**

(b) From the list write down the unit that is equivalent to:

$J\,s^{-1}$ ..... $J\,C^{-1}$ ..... **[2]**

2 An analogue signal contains frequencies in the range 200 to 4000 Hz.

(a) State the bandwidth of the analogue signal. ..... Hz **[1]**

(b) The signal is to be digitised. State the lowest suitable sampling frequency.

.....Hz **[1]**

(c) The signal has noise associated with it at a voltage variation given by

$$V_{noise} = V_{total} / 128.$$

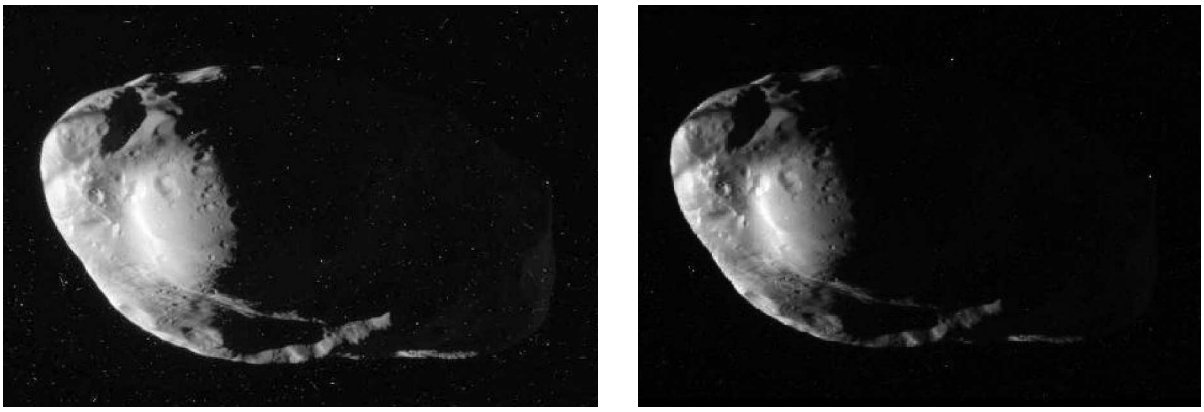
Show that 7 bits per sample is sufficient to code all of the information when digitising this signal.

[1]

(d) Use your answers to **(b)** and **(c)** to calculate the rate of transfer of digital information needed for this signal.

rate of transfer = ... $bit\,s^{-1}$ **[1]**

3 Fig. 3.1 shows two images of one of Saturn's moons. The left hand image is the original photograph taken and the right hand one is a processed image.



original image processed image

Fig. 3.1

(a) State one improvement in the processed image compared with the original image.

[1]

(b) The two columns below list some **processes** that can be used to improve images and **explanations** of how they are done.

processes	**explanations**
noise removal	alter pixel value range
sharpening	median filter
contrast adjust	edge detection

Draw a straight line from each **process** box to the box containing the **explanation** of how it is done. **[2]**

4 A battery has an emf ε of 3.0 V and an internal resistance r of 0.38 Ω.

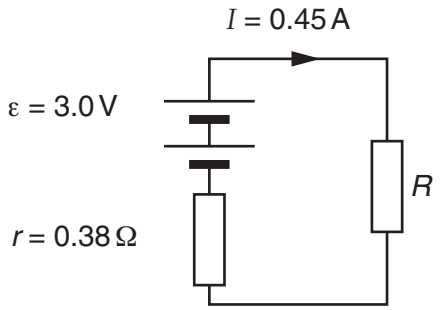


Fig. 4.1

(a) Here are five suggested statements about electro-motive force (emf).

Draw rings around **A**, **B**, **C**, **D** or **E** to indicate which **two** statements are correct.

A It is the maximum current the battery can produce.

B It is the maximum p.d. the battery can produce when the current delivered is negligible.

C It is the maximum power the battery can deliver.

D It is the force per unit charge acting on electrons that pass through the battery.

E It is the energy transferred per unit charge by the battery to the electrons in the circuit. **[2]**

(b) The battery delivers a current I of 0.45 A into a resistor R as shown in Fig. 4.1.

(i) Show that the p.d. across the resistor R is about 2.8 V.

[2]

(ii) Calculate the resistance of the resistor R.

resistance = ... Ω **[1]**

5 Fig. 5.1 shows plane wavefronts of light from a distant star passing through a thin converging lens to form an image of the star.

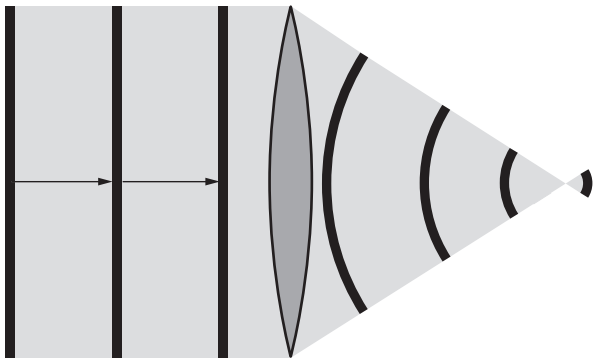


Fig. 5.1

(a) Label Fig. 5.1 with the letter **X** at the point where the image of the star is formed. **[1]**

(b) State what the lens does to the curvature of the wavefronts.

[1]

6 The refractive index of diamond is 2.4.

Calculate the speed of light in diamond.

$c = 3.0 \times 10^8 \,\text{m s}^{-1}$

speed of light in diamond = ... m s^{-1} **[2]**

7 The following measurements of a uniform metal wire are taken so that its resistivity ρ can be calculated.

resistance $R = 118.3 \pm 0.1\,\Omega$

length $L = 2.500 \pm 0.002\,\text{m}$

diameter $D = 0.25 \pm 0.01\,\text{mm}$

The equation used to calculate the resistivity is: $\rho = \dfrac{\pi D^2 R}{4L}$

(a) State which measurement has the greatest effect on the uncertainty in the calculated value of ρ.

measurement ..... **[1]**

(b) Give a reason for your choice in **(a)**.

[1]

[Total Section A: 22]

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Section B

8 A crane uses steel cables to lift heavy objects as shown in Fig. 8.1.

Fig. 8.1

(a) The cables need to be strong. Name **one** other mechanical property of steel that is important in this application and explain why.

property .....

explanation

[2]

(b) When the tension in a cable is 5.4×10^4 N the stress is 1.1×10^8 Pa.

Calculate the cross-sectional area of the cable.

cross-sectional area = ... m^2 **[2]**

(c) (i) Show that the strain in the cable at a stress of 1.1×10^8 Pa is about 0.05%.

Young modulus of steel = 2.1×10^{11} Pa

[2]

(ii) The total length of a cable on the crane is 650 m.

Calculate the extension of the cable when the stress is 1.1×10^8 Pa.

extension = ... m **[2]**

(d) Suggest why the maximum stress in a cable is limited to about 1/3 of its yield stress.

[1]

[Total: 9]

9 A thermistor is to be used as a temperature sensor. It is connected in series with a fixed resistor in a potential divider circuit as shown in Fig. 9.1.

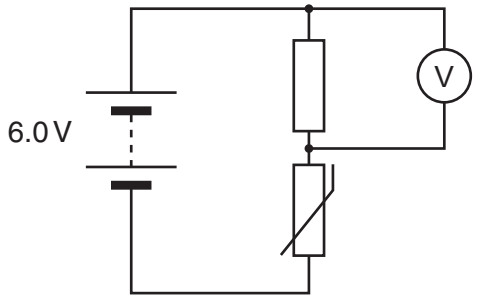


Fig. 9.1

(a) (i) Explain why the circuit can be described as a potential divider.

[1]

(ii) The resistance of the thermistor decreases as the temperature rises.

Explain why the p.d. measured by the voltmeter across the fixed resistor increases as the temperature of the thermistor rises.

You should ensure that your spelling, punctuation and grammar are accurate.

[3]

(b) Fig. 9.2 shows how the p.d. across the fixed resistor changes with temperature in the temperature sensor circuit of Fig. 9.1.

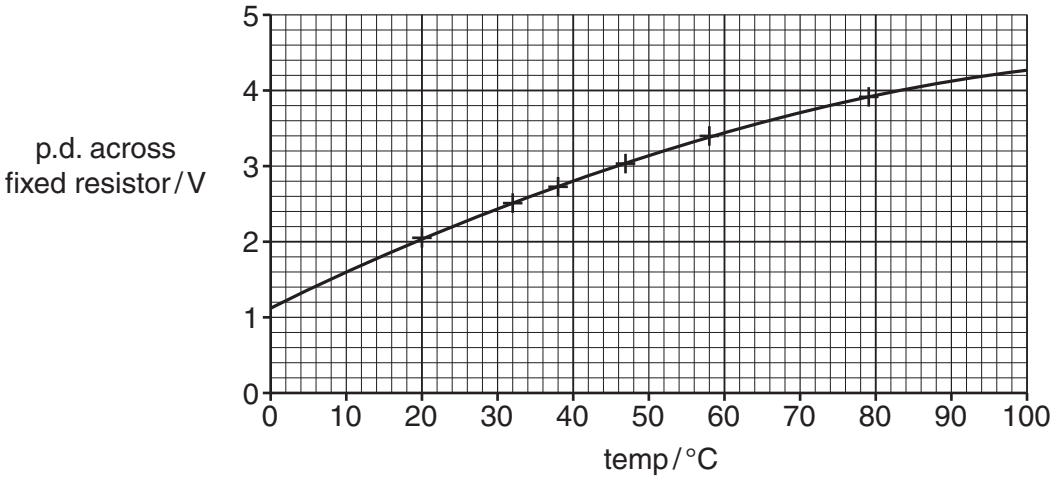


Fig. 9.2

(i) Describe how the sensitivity of the sensor changes as the temperature changes.

[1]

(ii) Estimate the sensitivity of the sensor at 70 °C. Make your method clear.

sensitivity = ... V °C^{-1} **[3]**

(iii) The resistance of the thermistor at 70 °C is 800 Ω.

The p.d. across the potential divider is 6.0 V.

Use data from Fig. 9.2 to calculate the resistance of the fixed resistor.

resistance = ... Ω **[3]**

[Total: 11]

10 The movement of tennis balls can be tracked using a set of linked high-speed fixed-focus cameras placed around the court. The ball's position is measured and its trajectory reconstructed, as shown in Fig. 10.1.

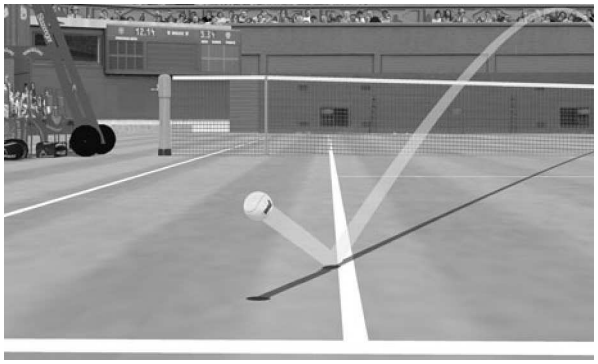


Fig. 10.1

(a) A tennis ball has a diameter of 67 mm. When the ball is 10 metres from a camera, a sharp image of it is formed on a CCD 55 mm behind the lens as shown in Fig. 10.2.

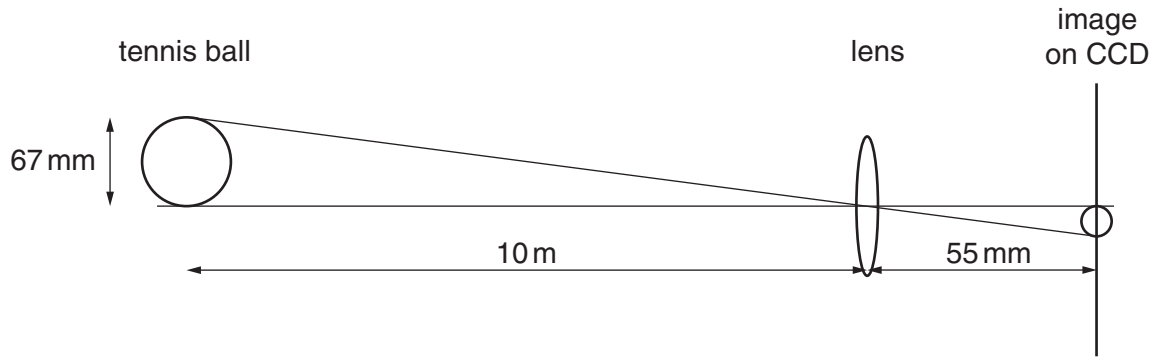


Fig. 10.2 (not to scale)

(i) Calculate the magnification of this image.

magnification = ... **[1]**

(ii) Show that the power of the lens in the fixed focus camera is about 18 D.

[2]

(iii) Show that the diameter of the image of the ball on the CCD is about 0.4 mm. Make your method clear.

[2]

(b) There are 70 pixels per mm on the CCD.

(i) Calculate the number of pixels across the image of the 67 mm diameter ball.

number of pixels = ... **[1]**

(ii) As the ball moves, its image moves across the CCD.

Calculate the least distance the ball must move sideways for its image to move one pixel.

distance = ... m **[1]**

(c) The position of the ball on 2 consecutive images can be used to determine the distance it has moved between images. Two such images give a value for the distance moved of 0.080 m.

State and explain the maximum possible value for this measurement based on your answer to **(b)(ii)**.

maximum possible value = ...

Explanation

[2]

[Total: 9]

11 This question is about electrical light fittings and plugs and the materials used in their construction.

(a) (i) A 12V halogen lamp is rated at 25W.

Calculate the operating current for the lamp.

current = ... A **[1]**

(ii) Calculate the conductance of the lamp.

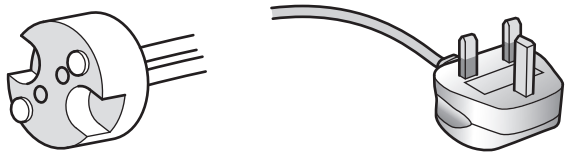
conductance = ... S **[1]**

(b) Explain in terms of their microscopic structure why metals are good electrical conductors.

Your answer should be clear and well structured.

[3]

(c) Fig. 11.1 shows a ceramic lamp fitting and a plastic plug.



ceramic lamp fitting

plastic plug

Fig. 11.1

The pins of a 12V halogen lamp slot into metal sockets held by ceramic fittings, but plastic plugs with metal contacts are used to connect appliances to the mains.

(i) Ceramics and plastics are suitable materials for lamp fittings and plugs because of their good electrical insulation properties.

Suggest a reason why, unlike metals, ceramics and plastics are good insulators.

[1]

(ii) Suggest and explain in terms of their material properties why ceramics are preferred to plastics for halogen lamp fittings.

[2]

(iii) Suggest a reason, in terms of their material properties, why plastics are preferred to ceramics for electric plugs.

[1]

[Total: 9]

[Total Section B: 38]

END OF QUESTION PAPER

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