OCR
Oxford Cambridge and RSA

Wednesday 24 May 2023 – Afternoon

AS Level Physics B (Advancing Physics)

H157/02 Physics in depth

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

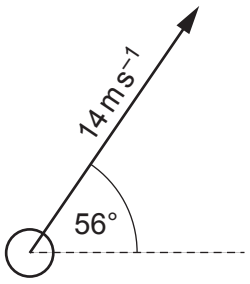
INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **20** pages.

ADVICE
- Read each question carefully before you start your answer.

Section A

1 A ball is thrown with an initial speed of $14\,m\,s^{-1}$ at an angle of 56° to the horizontal, as shown in the diagram. The ball leaves the thrower's hand at a vertical distance of 1.7 m above the ground.



(a) Write down the horizontal and vertical components of velocity of the ball at the instant it is thrown.

horizontal component, u_H = ... $m\,s^{-1}$

vertical component, u_V = ... $m\,s^{-1}$

[2]

(b) Calculate the maximum height above the ground reached by the ball. You can assume that air resistance is negligible.

height = ... m **[2]**

(c) Calculate the horizontal distance between the point where the ball is thrown and the point where it reaches its maximum height.

distance = ... m **[2]**

2 A light-emitting diode (LED) emits monochromatic blue light of wavelength 470 nm. Each photon emitted is produced by a single electron crossing the LED.

(a) Calculate the work done by an electron in the LED as one photon of blue light is emitted.

work done = ... J **[2]**

(b) Explain why a p.d. of 2.60 V across the LED would **not** result in the emission of light.

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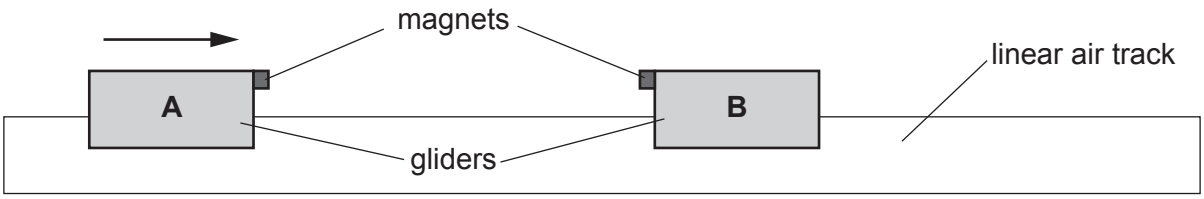
..... **[2]**

(c) In use, the LED draws an electric current of 30 mA.

Calculate the number of photons emitted each second, assuming that the energy efficiency of a blue LED is 93%.

number per second = ... s^{-1} **[2]**

3 The diagram shows a linear air track with two gliders **A** and **B**, with different masses, which move on the track with negligible friction. The gliders each carry a magnet arranged to repel the other glider when they approach. Initially, glider **A** moves towards glider **B**, which is stationary, as shown.



The velocity V_A of glider **A** varies with time t as shown in the graph.

(a) Calculate the velocity v_B of glider **B** after the impact.
Mass of glider **A** = 160 g
Mass of glider **B** = 120 g

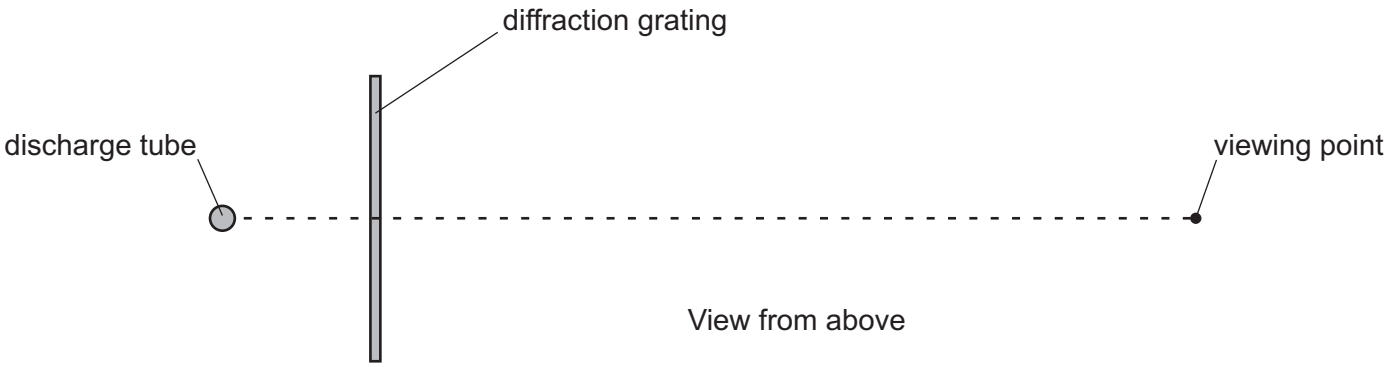
v_B = ... $m\,s^{-1}$ **[3]**

(b) Calculate the mean force exerted on glider **B** by glider **A** during the impact.

mean force = ... N **[1]**

4 A diffraction grating has 300 lines per mm. It is to be used to measure the wavelengths of light emitted by a discharge tube, where a high voltage causes a low-pressure gas to emit light.

The diagram shows a plan view of the diffraction grating (the grating lines run down into the plane of the diagram) mounted near the discharge tube perpendicular to the light emitted by the tube.



A student looking towards the discharge tube from the viewing point sees several vertical bright lines. In the direction of the tube there is the zero-order spectral line. To left and right of the zero-order there are also several red- and blue-coloured lines.

(a) (i) State why the zero-order spectral line is a different colour from the other lines.

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..... **[2]**

(ii) State why the first-order blue spectral lines are closer to the zero-order line than the first-order red lines.

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

(b) Describe how the student could determine the wavelength of the blue light emitted by the discharge tube.

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..... **[3]**

5 Wirewound resistors are used where a high level of power has to be dissipated. A typical wirewound resistor consists of a coil of nichrome wire of uniform cross-section wound on a ceramic core.

(a) Calculate the length L of nichrome wire of diameter 0.508 mm required to give a resistance of 15 Ω.
electrical resistivity of nichrome = $1.10 \times 10^{-6}\,\Omega\,\text{m}$

L = ... m **[2]**

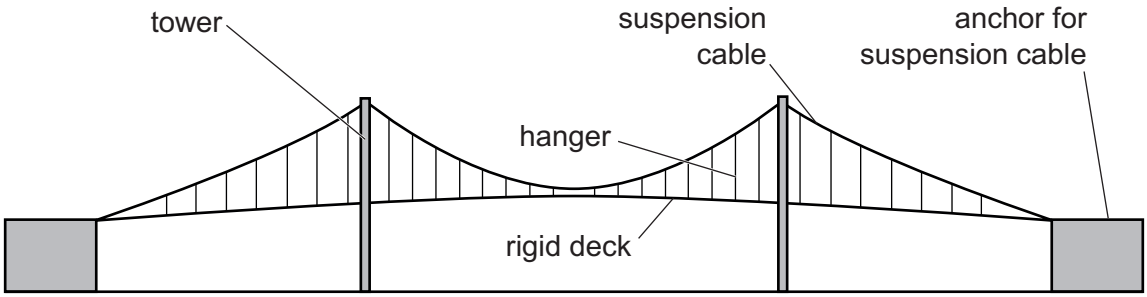
(b) The resistance of the resistor must be accurate to within ± 0.1 Ω.

Calculate the maximum uncertainty ΔL which can be allowed in the length measurement.

ΔL = ... m **[2]**

Section B

6 This question is about the stresses in vertical cables ('hangers') used to support the rigid deck of a suspension bridge and the vehicles it carries. The hangers are attached to suspension cables which are firmly anchored at each end of the bridge and pass over two supporting towers as shown below.



(a)* The suspension cables and the hangers are made from steel, but the towers of suspension bridges are made from concrete. The rigid deck is made from steel covered with concrete and is stiffened by steel girders.

Give reasons for these choices in terms of the behaviour of steel and of concrete under tensile and compressive stress and other factors which may affect the material choices.

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..... **[6]**

(b) A suspension bridge has a rigid deck supported by 500 steel hangers of circular cross-section.

Length of bridge between the two anchors = 2.7 km

Diameter of each hanger = 0.32 m

Mass of rigid deck = 1.4×10^8 kg

Yield stress of steel in hangers = 2.7×10^9 Pa

Young modulus of steel, $E = 2.1 \times 10^{11}$ Pa

(i) Use the data above to show that the tensile stress in the hangers is less than 2 % of their yield stress. You can assume the load is evenly shared between the hangers.

[3]

(ii) The maximum number of vehicles allowed on this bridge at any one time would give an additional load of 6000 kg per metre length of the suspended deck.

Calculate the ratio $\frac{\text{mean hanger stress with the maximum load on the bridge}}{\text{mean hanger stress with no vehicles on the bridge}}$ to an appropriate number of significant figures.

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

(iii) Suggest **two** reasons why the maximum number of vehicles allowed on the bridge is less than the theoretical number based on calculations of stress.

1. .....

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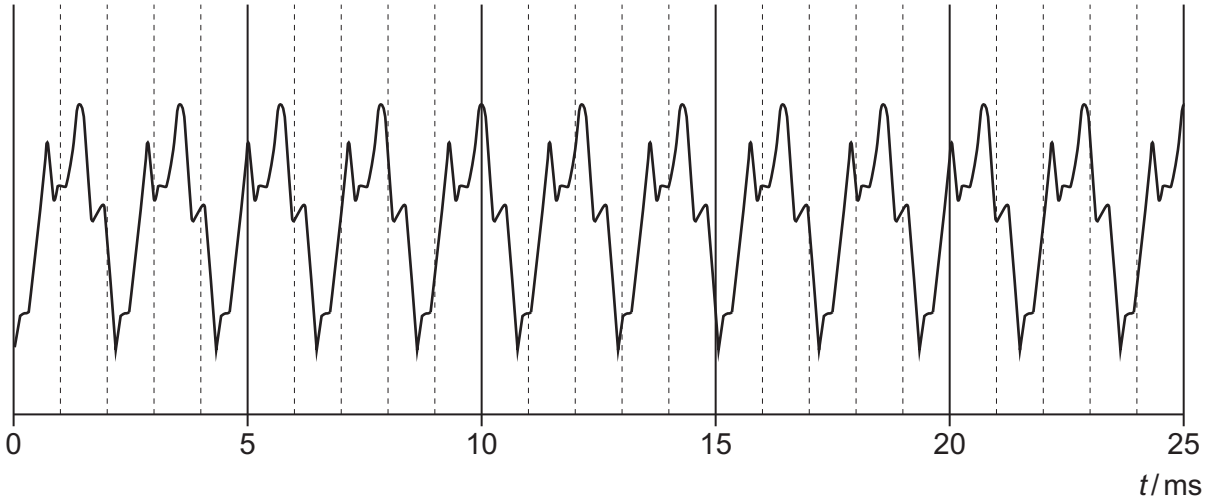
2. .....

..... **[2]**

7 This question is about recording music.

(a) **Fig. 7.1** shows an oscilloscope trace of a musical note played by a clarinet.

Fig. 7.1



(i) Use data from **Fig. 7.1** to make as accurate an estimate as possible of the frequency f of the musical note together with the uncertainty Δf of the value. Show your working clearly.

frequency, $f \pm \Delta f$ = ... ± ..... Hz **[4]**

(ii) Describe and explain the feature of **Fig. 7.1** which shows that this musical note contains more than one frequency.

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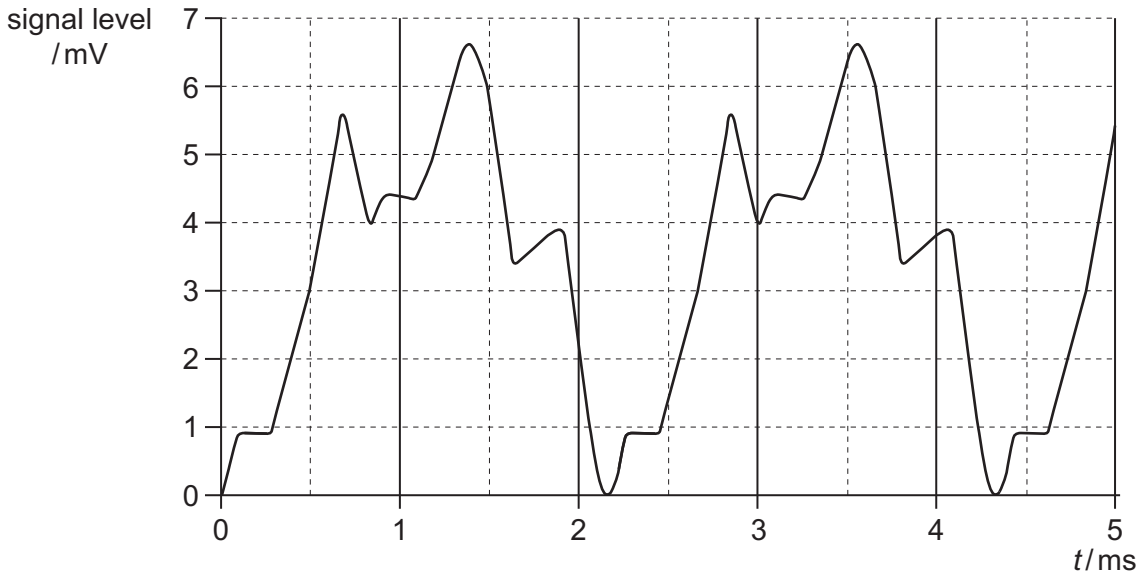
..... **[2]**

(b) The analogue signal of **Fig. 7.1** is to be recorded and stored digitally. **Fig. 7.2** shows the beginning of the signal in greater detail.

Fig. 7.2



It is suggested that this signal should be digitised using eight voltage-levels (0 – 7 mV) with the signal being sampled every 0.25 ms.

(i) Explain how the eight voltage levels illustrated can be encoded with a three-bit binary number and give the binary code which would represent a value of 3 mV.

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binary code: ..... **[3]**

(ii) Explain why the audio signal produced from this code will sound different from the original clarinet note.

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..... **[2]**

(c) A piece of music for solo clarinet lasts for 1 minute and 39 seconds. Assuming that it is digitised with eight voltage levels (3-bit coding) sampled every 0.25 ms, calculate the number of bytes of memory required to store the piece.

number of bytes = ... **[2]**

(d) A commercial download of the music described in **(c)** is a stereophonic (two-channel) recording sampled at 44.1 kHz with 8-bit coding. Calculate the time taken to download the piece of music at a download rate of 65 Mbit s^{-1}.

time = ... s **[2]**

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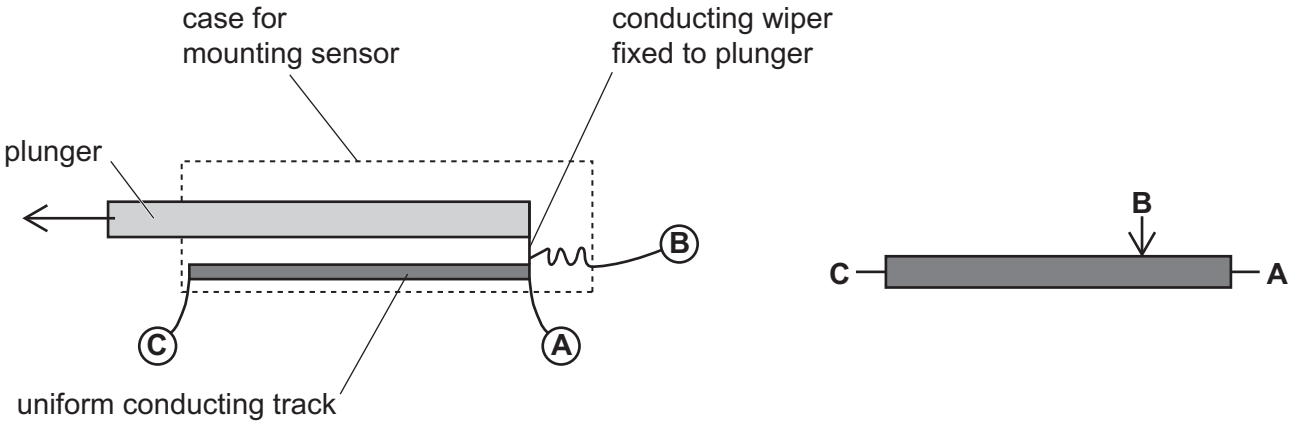
Section C

8 Alex is planning an investigation which requires measurement of position which changes slowly with time.

Alex decides to use a position sensor to monitor the changes. This sensor is a linear potential divider as shown in **Fig. 8.1**. As the plunger moves through its complete range, the conducting wiper moves from **A** to **C**.

Fig. 8.1



structure of position sensor **position sensor as potential divider**

(a) The position sensor is connected in series with a fixed resistor R_{fixed} and a battery of emf 4.5 V and negligible internal resistance. The p.d. V_{AB} across the portion of the position sensor between the end **A** of position sensor and the conducting wiper **B** is measured with a voltmeter of very high resistance. The total resistance of the track **AC** is 10 kΩ.

(i) Draw and label fully the circuit diagram described above.

[2]

(ii) The p.d. V_{AB} is to be used to calculate the resistance of the active length **AB** of the sensor. Explain why the voltmeter should have a resistance much higher than R_{fixed}.

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..... **[2]**

(b) Alex calibrates the sensor using a 30 cm metal rule with divisions every 1 mm and a voltmeter of resolution 1 mV.

He records the reading V_{AB} at various displacements d of the plunger from its position of minimum resistance and obtains the following readings.

d/mm	0	2	5	8	11	15	20	25	32	40	48
V_{AB}/V	0.00	0.82	1.61	2.12	2.47	2.81	3.10	3.31	3.51	3.68	3.80

(i) Alex did not take readings of V_{AB} at uniform intervals of d.
By referring to the data in the table, explain why this was an appropriate decision.

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..... **[2]**

(ii) Alex rounded the p.d. values to the nearest 10 mV. By comparing the precision available in the two measuring instruments, state why this was appropriate.

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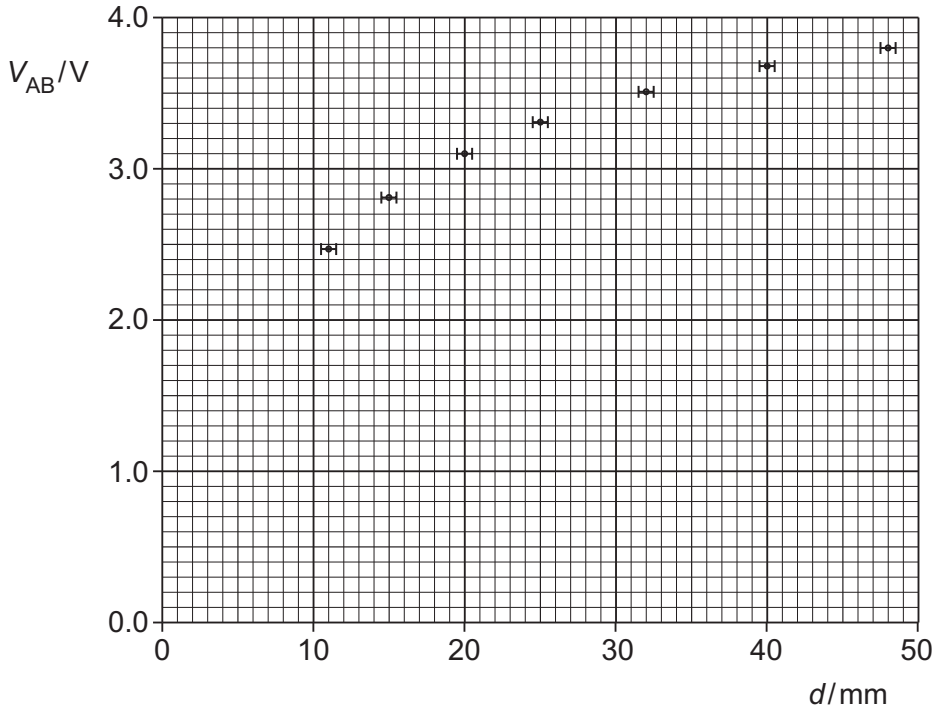
(c) Use data from the table in **(b)** to complete the graph of **Fig. 8.2** below.

Fig. 8.2



[2]

(d)* Alex repeats the calibration, using the same position sensor and the same battery, and obtains the data in the following table.

d/mm	0	2	5	8	11	15	20	30	50
V_{AB}/V	0.00	0.30	0.68	1.00	1.27	1.57	1.88	2.33	2.88

Explain the difference from the circuit which gave the data used in **Fig. 8.2**, and evaluate the change in the performance of the sensor circuit produced.

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END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).