Oxford Cambridge and RSA

AS Level Physics A

H156/02 Depth in physics

Thursday 9 June 2016 – Afternoon

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet (sent with general stationery)

You may use:
- a scientific calculator
- a ruler (cm/mm)

First name	
Last name	

Centre number						Candidate number				

INSTRUCTIONS
- Use black ink. HB pencil may be used for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

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

Answer **all** the questions.

1 **(a)** Describe the difference between longitudinal and transverse waves.

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.... **[2]**

(b) A loudspeaker emits a sound wave. A microphone is connected to an oscilloscope. The trace produced on the screen of the oscilloscope due to the sound wave is shown in Fig. 1.

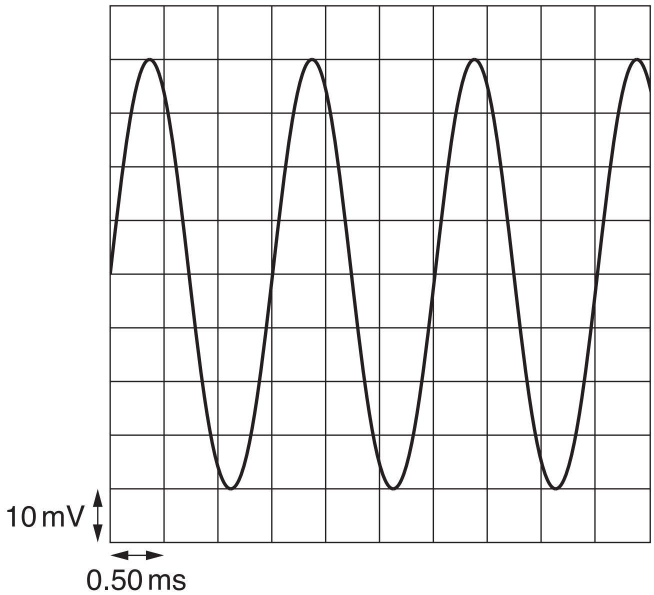

Fig. 1

The vertical *y*-sensitivity of the oscilloscope is set to $10\,\text{mV}\,\text{div}^{-1}$ and the horizontal time-base is set to $0.50\,\text{ms}\,\text{div}^{-1}$.

(i) Determine the amplitude of the signal displayed on the oscilloscope.

amplitude = ... mV **[1]**

(ii) The frequency *f* of the sound wave is the same as the frequency of the signal shown in Fig. 1. Determine *f*.

f = ... Hz **[2]**

(iii) The speed of sound in air is $330\,\mathrm{m\,s^{-1}}$. Calculate the wavelength λ of the sound wave.

λ = ... m **[1]**

(c) The output from the loudspeaker is adjusted so that the **intensity** of the sound wave at the microphone is a quarter of its original value. The controls on the oscilloscope are not altered.

Describe and explain how the signal displayed on the oscilloscope will be different from Fig. 1.

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.... **[2]**

2 A student is investigating the interference of microwaves after passing through two narrow slits.

(a) **(i)** State the principle of superposition of waves.

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.... **[1]**

(ii) For interference effects to be observed, the waves from the two slits must be *coherent*. State what is meant by the term *coherent*.

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.... **[1]**

(b) A student sets up an experiment to demonstrate the interference of microwaves as shown in Fig. 2.

A microwave transmitter is placed in front of the two slits. A microwave detector is moved along the line **PQ**. Maxima are detected at points **A**, **C**, and **E**. Minima are detected at points **B** and **D**.

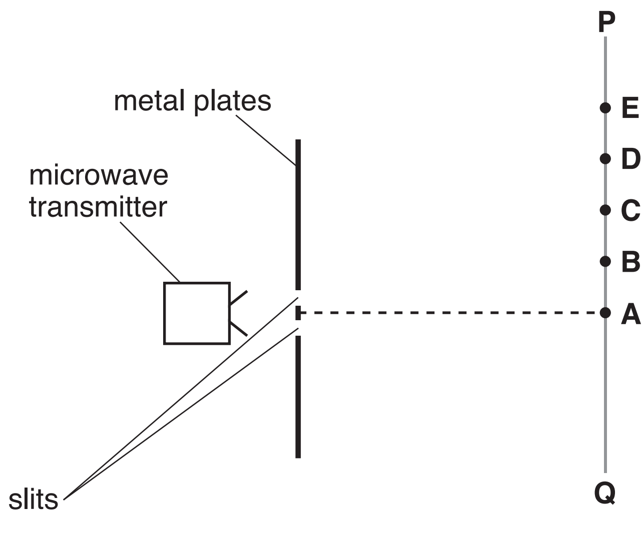

Fig. 2 (not to scale)

The distance travelled by the microwaves from each slit to point **A** is the same.
State the path difference in terms of the wavelength λ of the microwaves from the two slits at

1 point **C**

path difference = ...

2 point **D**

path difference = ...
[2]

(c) The separation between the slits is increased.

State and explain the effect this has on the separation between adjacent maxima.

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.... **[2]**

3 In a hockey match a hockey ball is hit 18.0 m from the front of the goal. The ball leaves the hockey stick with initial velocity v at an angle θ to the horizontal ground. The ball passes over the goal at a maximum height of 2.0 m as shown in Fig. 3.

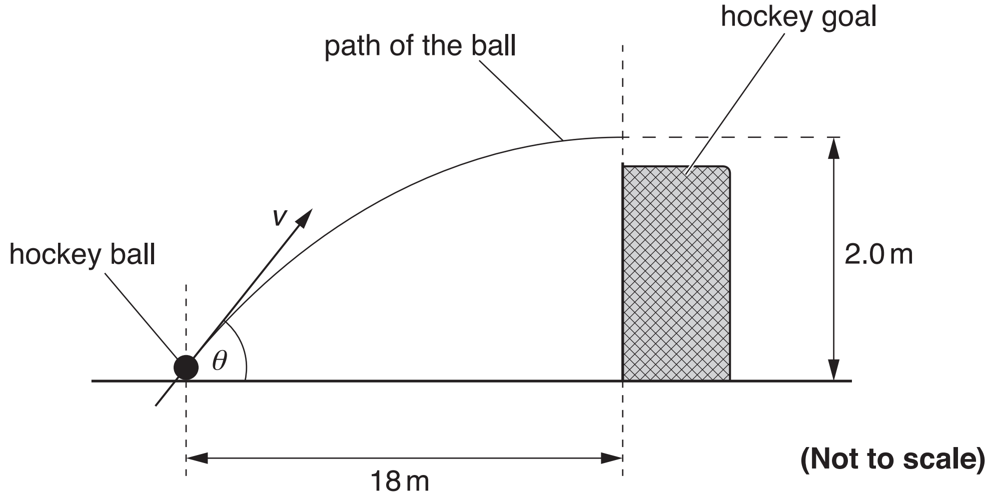

Fig. 3

(a) The initial vertical component of the velocity of the ball is $6.3\,\mathrm{m\,s^{-1}}$. Air resistance has negligible effect on the motion of the ball.

(i) Show that the time t taken for the ball to reach the maximum height is about 0.6 s.

[1]

(ii) Use the answer to **(a)(i)** and **Fig. 3** to show that the horizontal component of the velocity of the ball as it leaves the hockey stick is about $30\,\mathrm{m\,s^{-1}}$.

[1]

(iii) Calculate the magnitude of the initial velocity v of the ball.

v = ... m s^{-1} **[2]**

(b) The hockey ball has a mass of 0.160 kg.

(i) Calculate the initial kinetic energy E_k of the ball as it leaves the hockey stick.

E_k = ... J **[1]**

(ii) Calculate the change in gravitational potential energy E_p of the ball as it moves from the ground to the maximum height.

E_p = ... J **[1]**

(iii) Calculate the kinetic energy of the ball at the maximum height.

kinetic energy = ... J **[1]**

(c) The hockey ball is replaced with a ball that is affected by air resistance. This ball is hit with the hockey stick so that it leaves the stick with the same initial velocity v.

On **Fig. 3** sketch the path the ball is likely to take. **[2]**

4 **(a)** The unit of potential difference is the volt.

Use the equation $W = VQ$ to show that the volt may be written in base units as $\mathrm{kg\,m^2\,A^{-1}\,s^{-3}}$.

[3]

(b) A student is investigating a potential divider circuit containing a light-dependent resistor (LDR). The student sets up the circuit shown in Fig. 4.

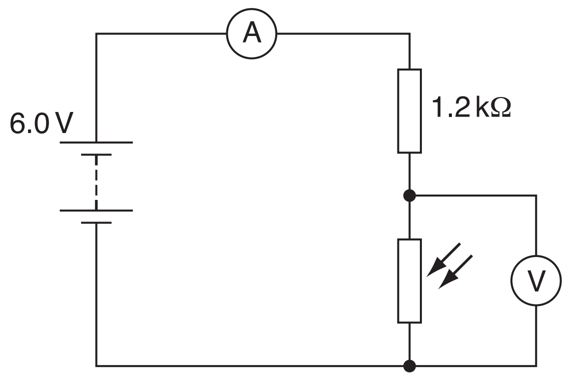

Fig. 4

The battery has an e.m.f. of 6.0 V and negligible internal resistance. The resistor has a resistance of 1.2 kΩ. In a dark room the voltmeter reading is 5.1 V.

(i) Show that the resistance R_{LDR} of the LDR is $6800\,\Omega$.

[2]

(ii) Calculate the current I delivered by the battery.

I = ... A **[1]**

(c) The circuit is moved so that the LDR is now in sunlight.

Without reference to the potential divider equation, describe and explain how the readings on the ammeter and voltmeter will change.

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.... **[4]**

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5 A student is investigating the resistance of a conducting putty.

(a) The density of conducting putty is 5300 kg m^{-3}. The student has a 100 g sample of this putty. Show that the volume V of the sample is about 1.9×10^{-5} m^3.

[1]

(b) The student rolls the putty into a cylinder shape and connects the ends of the cylinder to metal plates as shown in Fig. 5.1. The ohm-meter is used to measure the resistance R of the conducting putty.

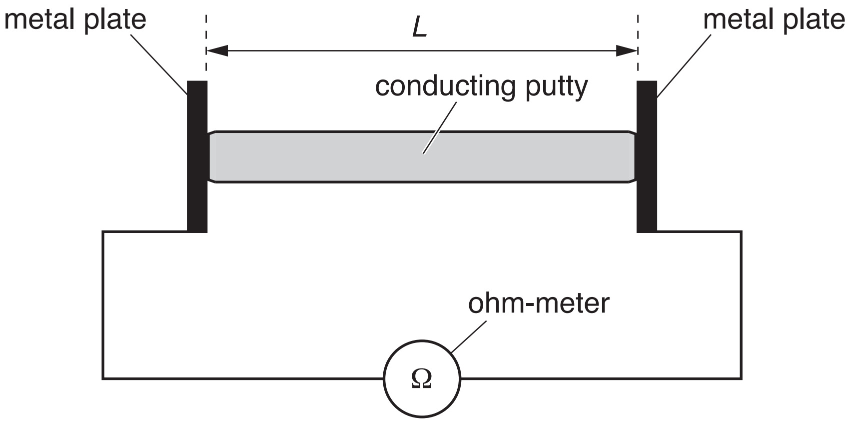

Fig. 5.1

(i) Suggest why the student uses large metal plates at the ends of the conducting putty.

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.... **[1]**

(ii) Describe how the student can check that the diameter of the conducting putty is constant.

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.... **[2]**

(c) The student measures the resistance R of the conducting putty for different length L. The volume of the conducting putty is kept constant.

The student's results are shown in Table 5.2.

L/m	R/Ω	$L^2/10^{-3}\,m^2$
0.049	14	2.4
0.060	21	3.6
0.069	28	4.8
0.081	37	
0.090	46	8.1
0.099	57	9.8

Table 5.2

(i) Complete the table for the missing value of L^2. **[1]**

(ii) Each length is measured to the nearest millimetre using a ruler.
Determine the percentage uncertainty in L^2 for $L = 0.049$ m.

percentage uncertainty = ... % **[1]**

(d) Fig. 5.3 shows the graph of R (y-axis) against L^2 (x-axis).

(i) Plot the missing data point and draw the straight line of best fit. **[2]**

(ii) Determine the gradient of the line of best fit.

gradient = ... **[2]**

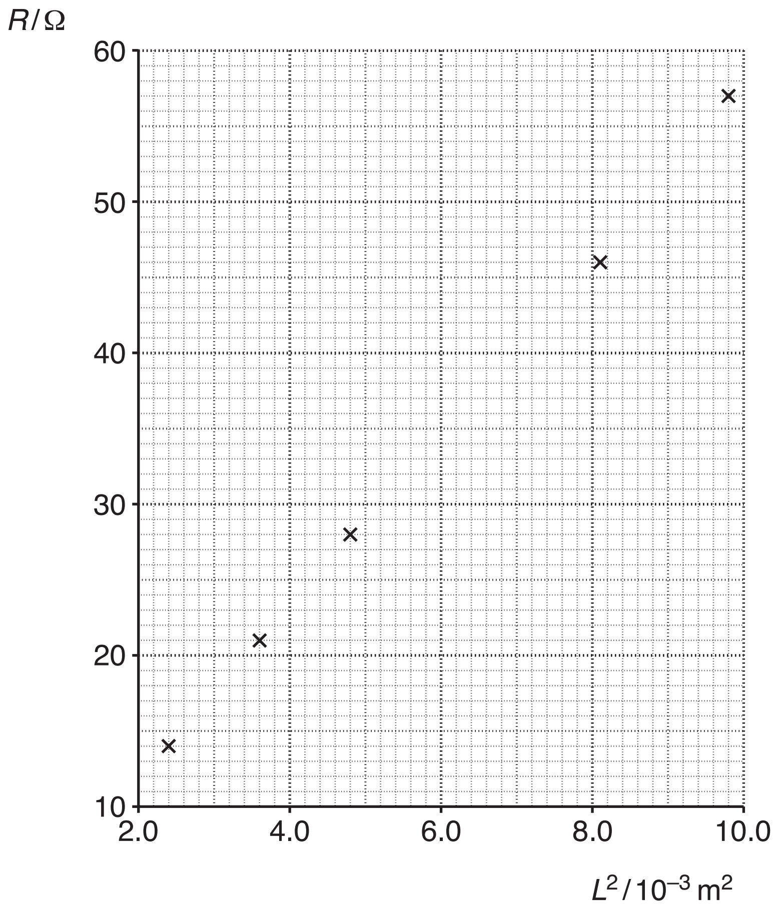

Fig. 5.3

(e) The relationship between R and L is

$$R = \frac{\rho}{V} L^2$$

where ρ is the resistivity of the conducting putty and V is the volume.

Use your answer to **(d)(ii)** and $V = 1.9 \times 10^{-5}\,\text{m}^3$ to determine a value for ρ. Include an appropriate unit.

ρ = ... unit: .... **[3]**

6 (a)* A student wishes to determine experimentally the breaking stress of a metal in the form of a thin wire.

Describe with the aid of a diagram how this experiment can be safely conducted, and how the data can be analysed to determine the breaking stress of the metal.

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.... [6]

(b) A group of students are investigating the loading and unloading of glass and rubber. Glass is a brittle material and rubber is a polymeric material.

Sketch the stress against strain graphs for the loading and unloading of glass and rubber on **Fig. 6**.

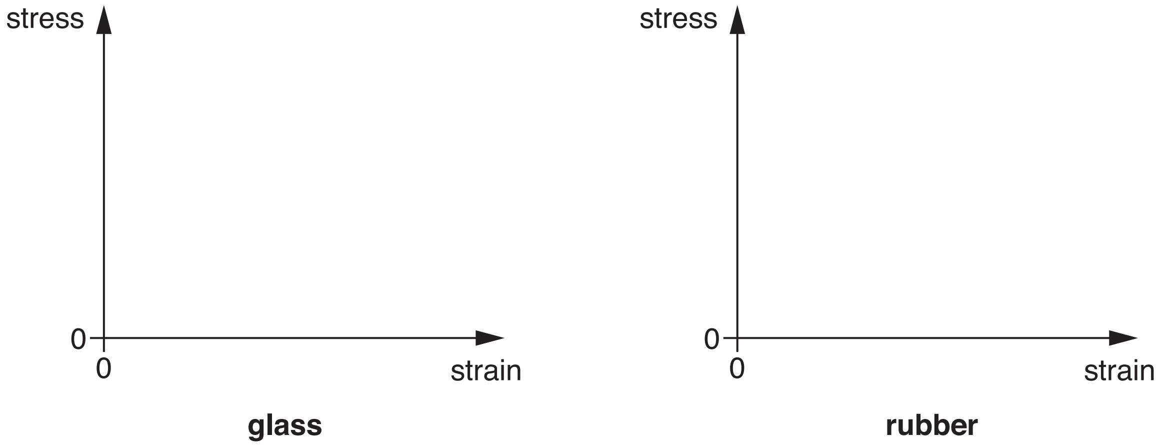

Fig. 6

[2]

7 (a)* A gold leaf electroscope is used to demonstrate the photoelectric effect. A zinc plate is placed on top of the electroscope. The zinc plate is negatively charged as shown in Fig. 7.

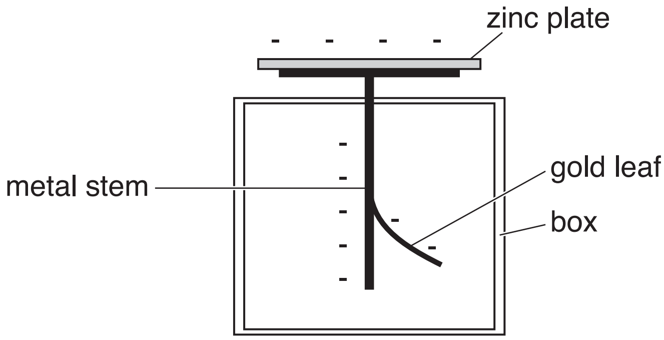

Fig. 7

White light from a table lamp is allowed to fall on to the electroscope from a distance of 10.0 cm. The experiment is then repeated with light from a distance of 4.0 cm. Both experiments are then repeated with ultraviolet radiation. The electroscope is fully charged before each experiment.

The observations are recorded in Table 7.

Incident radiation	**Observations**
Light at a distance of 10.0 cm	Gold leaf takes a very long time to fall
Light at a distance of 4.0 cm	Gold leaf takes a very long time to fall
Ultraviolet radiation at a distance of 10.0 cm	Gold leaf falls quickly
Ultraviolet radiation at a distance of 4.0 cm	Gold leaf falls very quickly

Table 7

Explain how these observations demonstrate the photoelectric effect and provide evidence for the particulate nature of electromagnetic radiation. **[6]**

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(b) In another experiment, electromagnetic radiation of frequency 9.60×10^{14} Hz falls on a negatively-charged metal surface with a work function of 3.2 eV.

Calculate the maximum kinetic energy $E_{k\,(max)}$ in joules of the particles emitted from the surface of the metal.

$E_{k\,(max)}$ = ... J **[3]**

8 Electron diffraction provides evidence for the wave-like behaviour of particles. Electrons are diffracted by a thin slice of graphite.

In one experiment, electrons are accelerated from rest through a potential difference of 300 V.

(a) Show that the final speed v of the electrons is $1.0 \times 10^{7}\,\mathrm{m\,s^{-1}}$.

[3]

(b) Determine the de Broglie wavelength λ of the electrons.

λ = ... m **[2]**

(c) After the electrons are diffracted by the graphite they hit a fluorescent screen.
The electrons are diffracted because of the spacing between the carbon atoms is comparable with the de Broglie wavelength of the electrons. Fig. 8 shows the diffraction pattern (bright rings) seen on the fluorescent screen when the electrons are accelerated through a potential difference of 300 V.

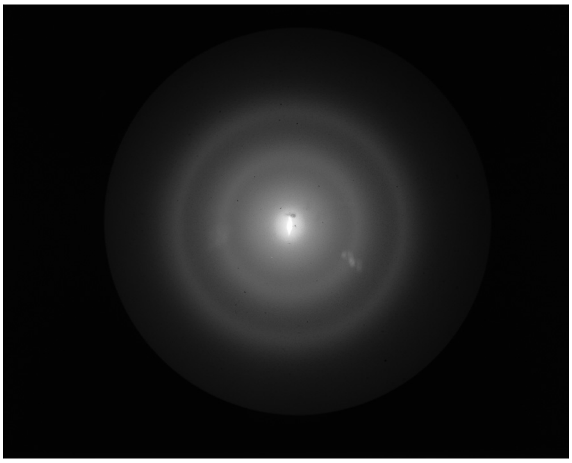

Fig. 8

The potential difference is now increased. Explain how the diffraction pattern will change.

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.... **[2]**

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.