Rewarding Learning

ADVANCED
General Certificate of Education
2025

Centre Number

Candidate Number

Life and Health Sciences

Assessment Unit A2 4

assessing

Sound and Light

[AZ041]

AZ041

TUESDAY 17 JUNE, MORNING

TIME

1 hour 45 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete questions in black ink and use a dark HB pencil for drawings and graphs.
Do not write with a gel pen.
Answer **all nine** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You may use a scientific calculator.
Quality of written communication will be assessed in question **4**.

1 Ultraviolet radiation, UV, is a region of the electromagnetic spectrum with wavelengths ranging from 10 nm to 400 nm.
When UV radiation shines on water some of the radiation penetrates a short distance below the water surface before being absorbed.

(a) (i) What **type** of waves are **all** electromagnetic waves?

_____ [1]

(ii) Name **one** wave property which is unique to electromagnetic waves.

_____ [1]

(b) (i) What is meant by the term **frequency**?

_____

_____ [1]

(ii) UV waves of wavelength 350 nm travel at a speed of $2.23 \times 10^8\,ms^{-1}$ in water.
Calculate the frequency of these waves.
Give your answer to 3 significant figures.
$1\,nm = 1 \times 10^{-9}\,m$.

Show your working out.

Frequency = _____ Hz [4]

(iii) Calculate the time period for these 350 nm UV waves travelling through water.

Show your working out.

Time period = _____ s [3]

(iv) Tick (✓) the boxes below to show all the regions of the electromagnetic spectrum with wavelengths **larger** than that of UV.

Radio waves	
Microwaves	
Infrared	
Visible light	
X-rays	
Gamma rays	

[2]

[Turn over

2 The ear is an organ made up of different parts.
Some of the parts of the ear are listed in the table below.

(a) (i) Complete the table by inserting a tick (✓) to identify the location of each part of the ear.

The first line of the table has been completed for you.

Part of the ear	Outer ear	Middle ear	Inner ear
Auditory canal	✓		
Cochlea			
Eustachian tube			
Tympanic membrane			

[3]

(ii) State the names of the **three** bones which make up the ossicles.

_____ [2]

(iii) The ossicles are connected to the tympanic membrane.

To which other part of the ear are they connected?

_____ [1]

(iv) Describe briefly how the ossicles contribute to hearing.

_____

_____ [1]

(b) Suggest how hearing loss can occur in the auditory canal.

_____

_____ [1]

(c) Behind-the-ear hearing aids can be used to improve hearing for people with mild hearing loss.

Apart from the battery, state the three main parts of behind-the-ear hearing aids and describe fully the function of each part.

Part	Function

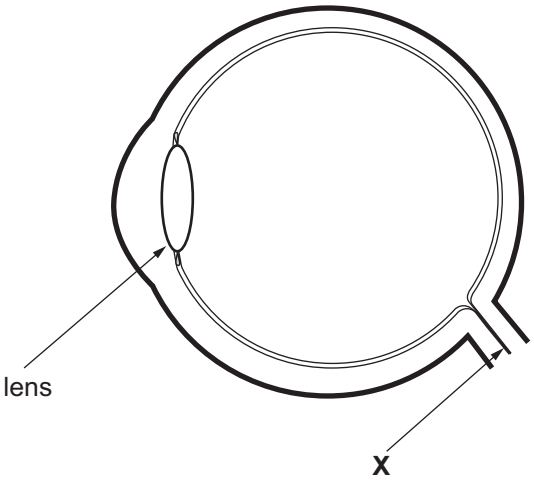
[6]

[Turn over

3 **(a)** The diagram below shows some main parts of the human eye.

(i) Label the position of the following structures on the diagram.

- Cornea
- Retina
- Vitreous humour



Source: Principal Examiner

[3]

(ii) What is the name of the structure marked **X**?

_____ [1]

The retina contains two types of photoreceptors called rods and cones.

(iii) On the diagram above, mark with the letter **Y** the place where cones are most concentrated. [1]

(iv) What is the name given to the part of the eye which contains no rods?

_____ [1]

(v) Choose which of the following correctly describe the image formed on the retina.

Tick (✓) all the boxes that correctly describe the image.

☐	real	☐	virtual
☐	upright	☐	inverted
☐	magnified	☐	diminished

[3]

(b) The near point for a normal human eye is 25 cm.

(i) What is meant by the term **near point**?

_____

_____ [1]

(ii) Describe how a person could find a reliable value for their own near point.

In your answer include any measuring instruments used.

_____

_____

_____

_____

_____

_____

_____ [3]

[Turn over

4 Write a detailed account of the similarities and differences between single mode and multi-mode fibre-optic cables.

Include in your description:

- the three main components of both types of fibre-optic cables;
- the main structural difference between a single mode and a multi-mode fibre-optic cable;
- the phenomena by which light can travel throughout a multi-mode fibre and a condition required for this to occur;
- a comparison between the paths that can be taken by light travelling through each type of fibre;
- the use of single mode and multi-mode fibres in long-range and short-range communication and an explanation as to why each fibre is suitable for the type of communication.

In this question you will be assessed on the quality of your written communication skills, including the use of specialist scientific terms.

Components

Structural difference

Phenomena

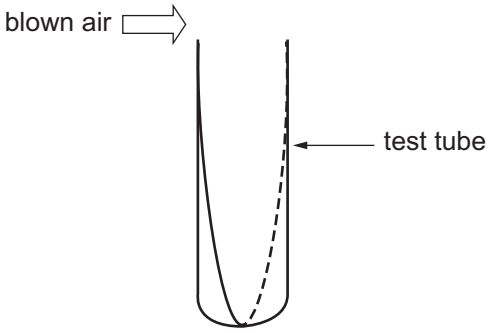
Comparison of paths

Use of single mode fibre

Use of multi-mode fibre

[8]

5 **(a)** When air is blown over the top of a test tube, a sound can be heard.
This is an example of resonance.
The diagram below shows the standing wave pattern for the fundamental frequency.



Source: Principal Examiner

(i) How is resonance observed in this example?

_____ [1]

For resonance to occur, a standing wave must have been formed.

(ii) What are the essential conditions required for a standing wave to form?

_____

_____

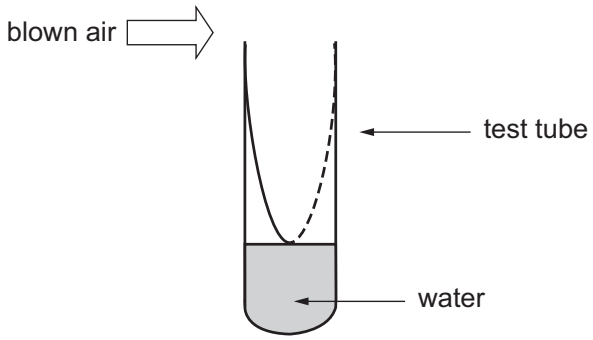
_____ [3]

(iii) Calculate the wavelength of the observed sound at the fundamental frequency.

The length of the test tube is 0.15 m.

Wavelength = _____ m [1]

When the same test tube is partially filled with water, as shown below, the fundamental frequency of the sound changes.



(iv) State and explain how the frequency of the sound changes when air is blown over the top of this test tube.

_____

_____

_____

_____

_____

_____

_____ [4]

(v) The wavelength of the sound at the new fundamental frequency changes by 8 cm.
Calculate the depth of the water in the test tube.

Show your working out.

Depth = _____ cm [2]

[Turn over

(b) Standing waves can also be observed on a stretched string when it is vibrated.

(i) Complete the diagram below to show the **third** harmonic (third mode of vibration) standing wave pattern formed on the stretched string.

[1]

(ii) Mark the position of all nodes **N** and antinodes **A** on the standing wave diagram you have drawn above. [2]

(iii) The length of the string between the fixed ends is 1.74 m.

What is the wavelength of the standing waves?

Wavelength = _____ m [1]

6 **(i)** What is the **Doppler effect**?

_____

_____ [2]

A car, sounding a horn, moves at a constant velocity towards a stationary observer. The car then passes the stationary observer.

(ii) Describe how the pitch of the observed sound changes as the car moves towards and then moves away from the observer.

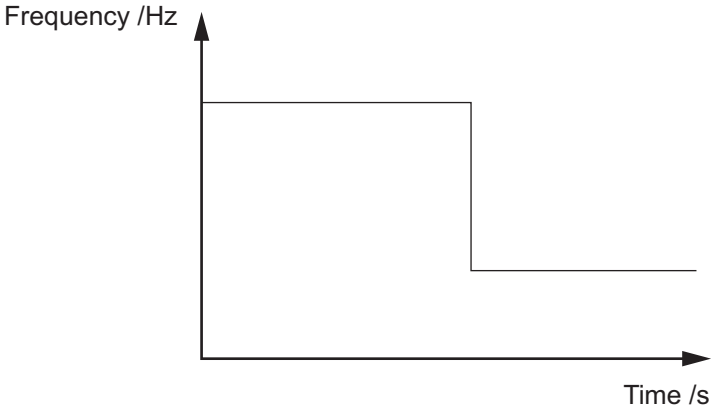
_____

_____

_____ [2]

The observer uses a microphone to record the sound.

Computer software is used to analyse the frequency of the horn observed during the time the car is moving towards and then away from the observer.
The results are shown in the graph below.



(iii) On the **y-axis**, mark the frequency, **f**, of the car horn if the car was not moving. [2]

(iv) On the **x-axis**, mark the time, **t**, when the car passes the observer. [1]

[Turn over

7 **(a)** Walkie-talkie devices provide communication without the use of a mobile phone signal.
Over long distances signal attenuation can occur.
These losses can be categorised as path-loss and space-loss.

(i) What is meant by the term attenuation?

_____

_____ [1]

(ii) Give one example of path-loss.

_____ [1]

(iii) How does space-loss occur?

_____

_____ [1]

(b) Bluetooth technology is built into wireless speakers.

Discuss the use of Bluetooth technology in wireless speakers.

Include the following information:

- a description of how Bluetooth technology works; and
- two disadvantages of using Bluetooth technology in wireless speakers.

How Bluetooth works

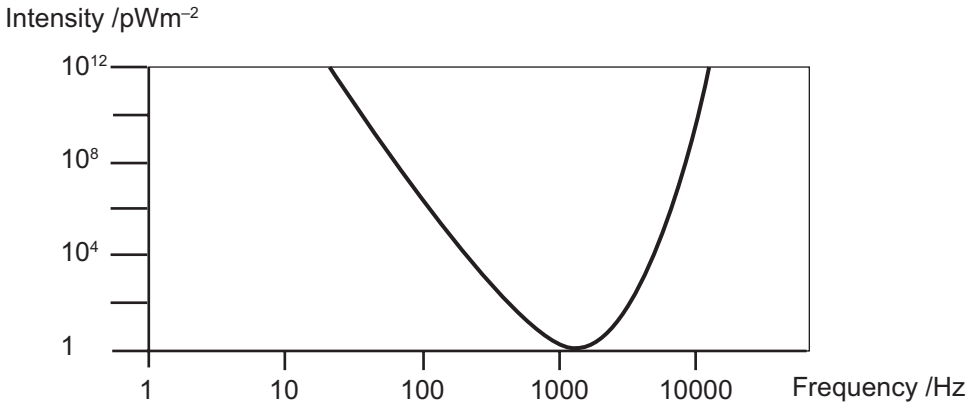
Disadvantages

1.

2.

[5]

8 The graph below shows the intensity response against frequency for an average human ear.



Source: Principal Examiner

(a) (i) Shade on the graph the range of sounds that **cannot** be detected by the average human ear. [1]

(ii) The graph shows a minimum at 1 pWm^{-2}.

What is the physical significance of this minimum?

_____

_____ [1]

(b) Long exposure to sounds louder than 80 dB can cause ear damage.

(i) Calculate the intensity of this sound.

Show your working out.

Intensity = _____ Wm^{-2} [4]

(ii) Instant perforation of the eardrum occurs at an intensity of $1 \times 10^4\,Wm^{-2}$. Calculate the decibel level (intensity level) of this sound.

Show your working out.

Decibel level = _____ dB [3]

(c) When the decibel level increases from 72 dB to 82 dB the intensity also increases.
By what factor does the intensity increase?

_____ [1]

[Turn over

9 A student completed an experiment to determine the optical power of a converging lens.
A range of experimental data was required to be collected for different object and image distances.

(i) Draw a diagram of the assembled equipment used to complete this experiment. Label each piece of equipment.

[4]

(ii) The equation used to determine the optical power, P, of the lens is known as the lens equation.
This equation is:

$$P = \frac{1}{u} + \frac{1}{v}$$

What do the letters u and v in the lens equation represent?

u = _____

v = _____ [1]

(iii) On your diagram drawn in **(i)**, mark and label the measurements u and v that are required to determine the optical power of the converging lens. [1]

(iv) One set of results collected during this experiment is shown in the table below.

u /cm	v /cm
18.6	58.9

Use these values to calculate the optical power of the lens used in the experiment.
Include a unit with your answer.

Show your working out.

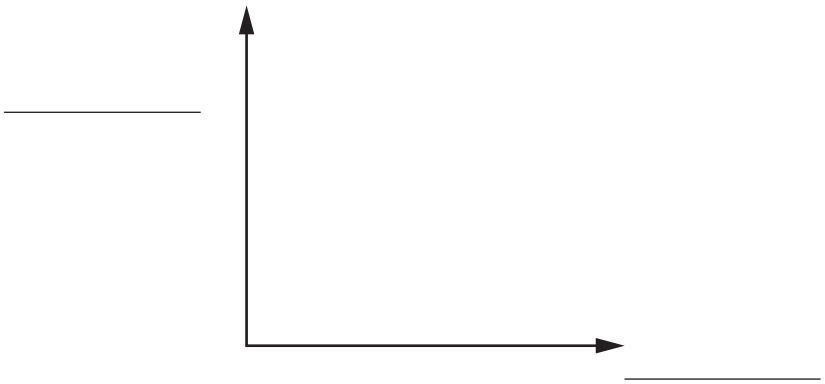
Optical power = _____ Unit = _____ [3]

[Turn over

(v) During the experiment, the student collected a range of values for u and v. These values were used to plot a **linear** graph from which the optical power could be determined.

Label the y-axis and the x-axis with quantities which would produce a linear graph.
Units for these quantities are not required.

Sketch the shape of this graph.



[2]

(vi) How can the optical power of the lens be determined from the graph you have drawn in **(v)**?

_____

_____ [1]

(vii) The student noticed that no image could be found for an object at a distance of 10.0 cm.
Explain why no image could be found.

_____ [1]

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For Examiner's use only	
Question Number	**Marks**
1	
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Total Marks	

Examiner Number