



Interference

Question Paper

Name: _____

Class: _____

Date: _____

Time: **73 minutes**

Marks: **58 marks**

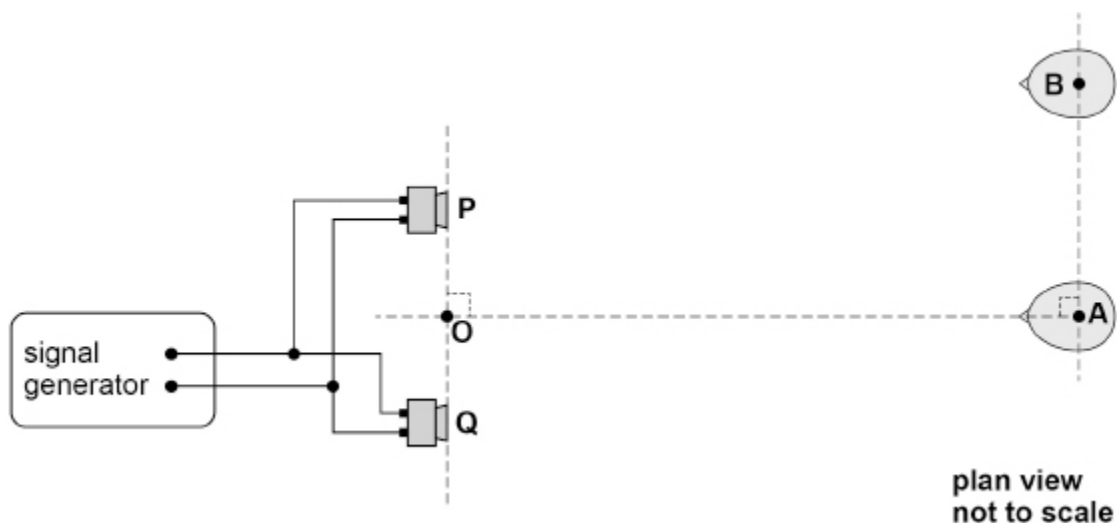
Comments:

1.

A student investigates the interference of sound waves using two loudspeakers, **P** and **Q**, connected to a signal generator (oscillator). Each loudspeaker acts as a point source of sound.

Figure 1 shows the arrangement.

Figure 1



Point **O** is the midpoint between **P** and **Q**.

(a) Explain why the two loudspeakers are coherent sources of sound waves.

(2)

(b) The student faces the two loudspeakers at point **A**. Point **A** is at equal distances from **P** and **Q**.
 He then moves to point **B**, at right angles to the line **OA**, still facing the two loudspeakers. As his head moves from **A** to **B** the amplitude of the sound wave he hears decreases and then increases. The amplitude starts to decrease again as he moves beyond **B**.

Explain why the variation in amplitude occurs as he moves from **A** to **B**.

(3)

(c) The student records the following data:

separation of the two loudspeakers	= 0.30 m
distance OA	= 2.25 m
distance from A to B	= 0.95 m

Show that the path difference for the sound waves from the two loudspeakers to point **B** is about 0.1 m.

(3)

(d) The frequency of the sound wave is 2960 Hz.

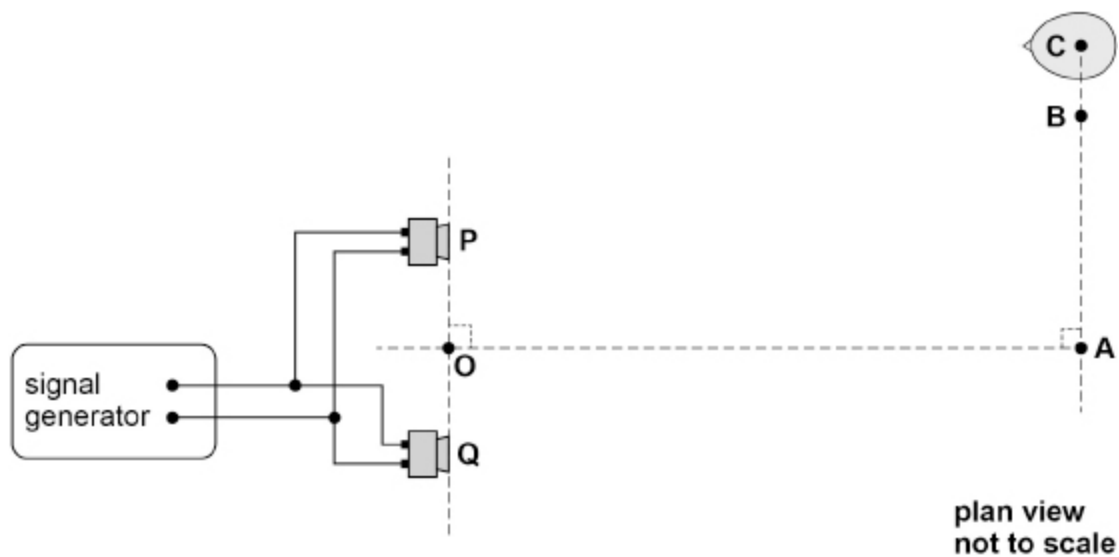
Calculate the speed of sound from the student's data.

speed of sound = _____ m s⁻¹

(1)

- (e) The student moves his head to point **C** as shown in **Figure 2**. The emitted frequency of the sound from the loudspeakers is then gradually decreased.

Figure 2

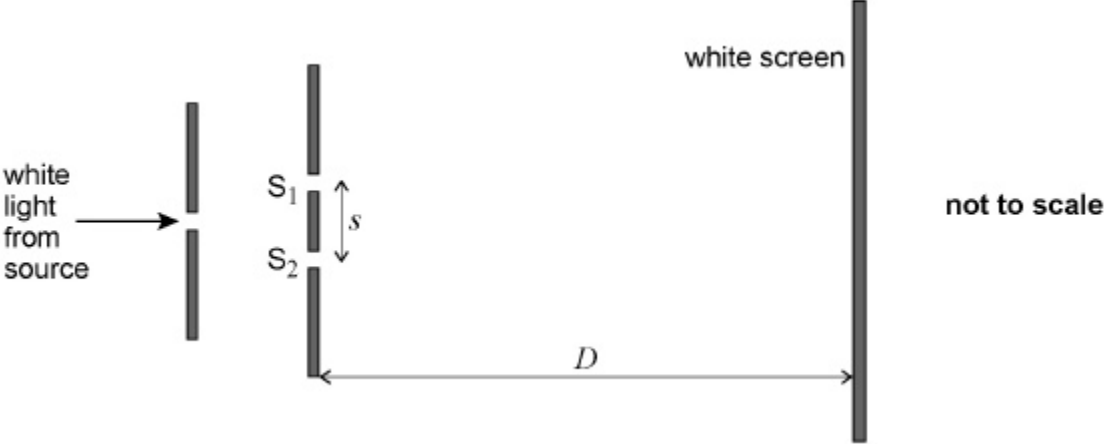


Discuss the effect that this decrease in frequency has on the amplitude of the sound wave heard by the student.

(3)
(Total 12 marks)

2.

The figure below shows a diagram of apparatus used to demonstrate the formation of interference fringes using a white light source in a darkened room. Light from the source passes through a single slit and then through two narrow slits S_1 and S_2 .



(a) Describe the interference pattern that is seen on the white screen.

(2)

- (b) A filter transmits only green light of wavelength λ and red light of wavelength 1.2λ . This filter is placed between the light source and the single slit.

Describe the interference pattern now seen on the white screen.

Use a calculation to support your answer.

(4)

- (c) A student decides to use the apparatus shown in the figure to determine the wavelength of red light using a filter that transmits only red light.

The student suggests the following changes:

- decrease slit separation s
- decrease D , the distance between the slits and the screen.

The student decides to make each change independently.

Discuss the effects each independent change has on the interference pattern, and whether this change is likely to reduce uncertainty in the determination of the wavelength.

(6)

(Total 12 marks)

3.

The table shows results of an experiment to investigate how the de Broglie wavelength λ of an electron varies with its velocity v .

$v / 10^7 \text{ m s}^{-1}$	$\lambda / 10^{-11} \text{ m}$
1.5	4.9
2.5	2.9
3.5	2.1

- (a) Show that the data in the table are consistent with the relationship $\lambda \propto \frac{1}{\nu}$

(2)

- (b) Calculate a value for the Planck constant suggested by the data in the table.

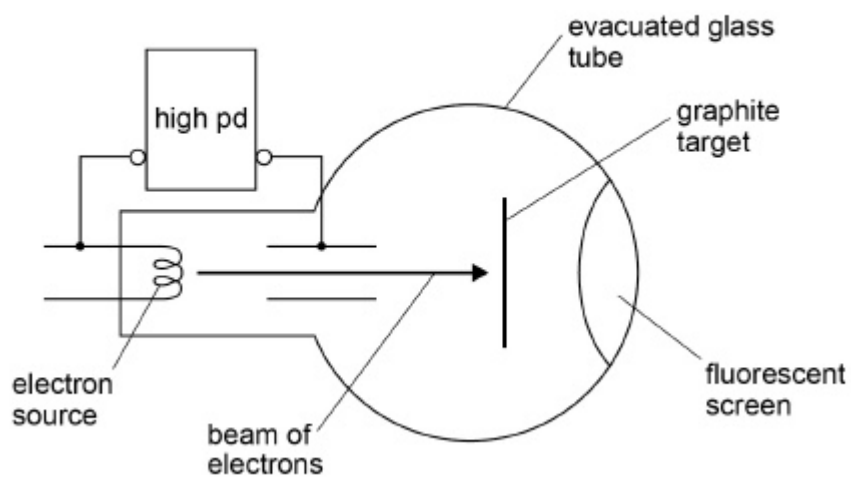
Planck constant = _____ J s

(2)

- (c) **Figure 1** shows the side view of an electron diffraction tube used to demonstrate the wave properties of an electron.

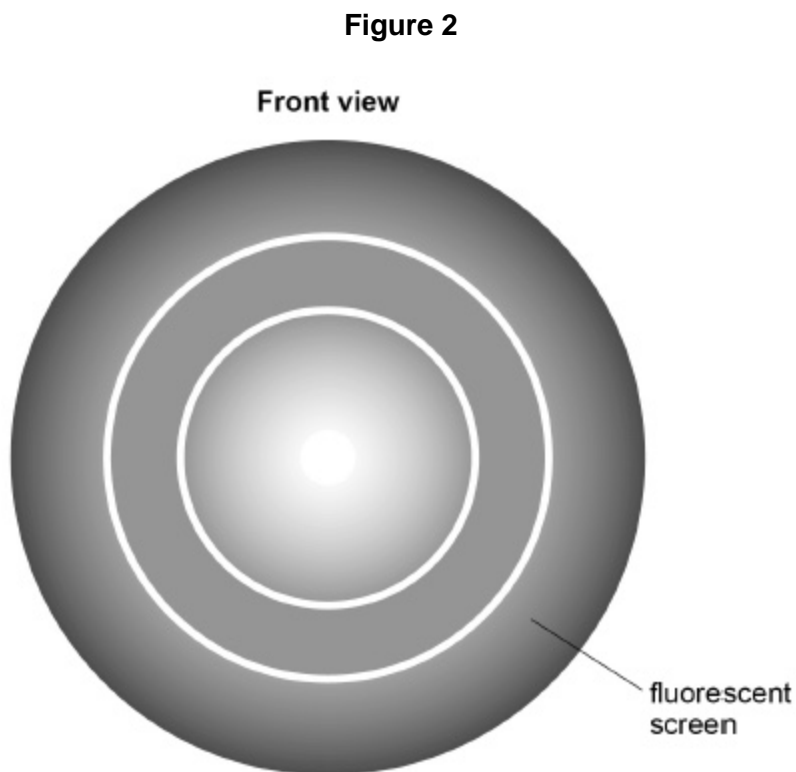
Figure 1

Side view



An electron beam is incident on a thin graphite target that behaves like the slits in a diffraction grating experiment. After passing through the graphite target the electrons strike a fluorescent screen.

Figure 2 shows the appearance of the fluorescent screen when the electrons are incident on it.



Explain how the pattern produced on the screen supports the idea that the electron beam is behaving as a wave rather than as a stream of particles.

(3)

- (d) Explain how the emission of light from the fluorescent screen shows that the electrons incident on it are behaving as particles.

(3)

(Total 10 marks)

4.

Figure 1 shows an arrangement used to investigate double slit interference using microwaves. **Figure 2** shows the view from above.

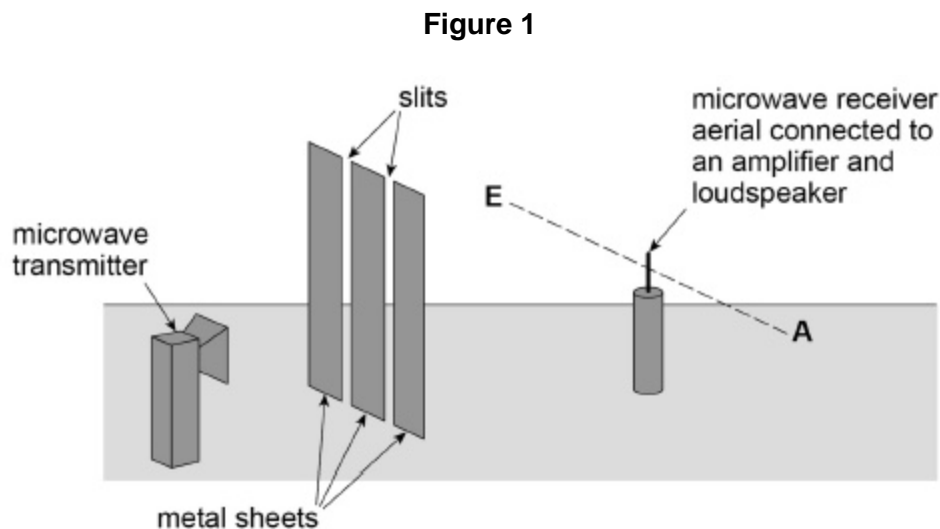
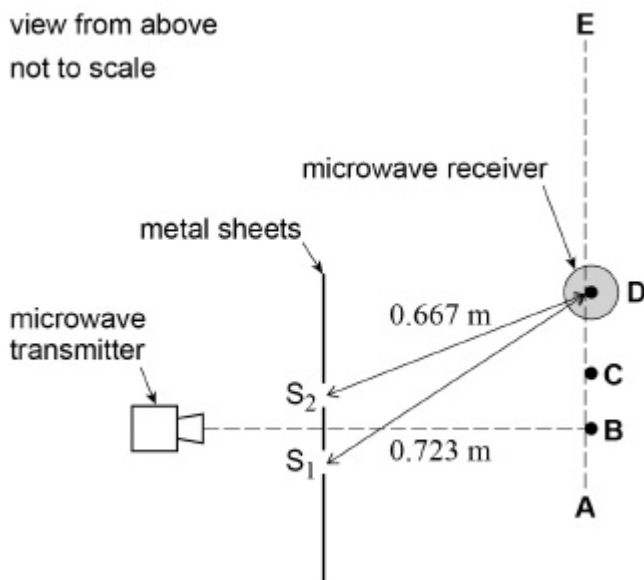


Figure 2



The microwaves from the transmitter are polarised. These waves are detected by the aerial in the microwave receiver (probe). The aerial is a vertical metal rod.

The receiver is moved along the dotted line **AE**. As it is moved, maximum and minimum signals are detected. Maximum signals are first detected at points **B** and **C**. The next maximum signal is detected at the position **D** shown in **Figure 2**.

Figure 2 shows the distances between each of the two slits, S_1 and S_2 , and the microwave receiver when the aerial is in position **D**.

S_1D is 0.723 m and S_2D is 0.667 m.

- (a) Explain why the signal strength falls to a minimum between **B** and **C**, and between **C** and **D**.

(3)

(b) Determine the frequency of the microwaves that are transmitted.

frequency = _____ Hz

(3)

(c) The intensity of the waves passing through each slit is the same.

Explain why the minimum intensity between **C** and **D** is not zero.

(2)

- (d) The vertical aerial is placed at position **B** and is rotated slowly through 90° until it lies along the direction **AE**.

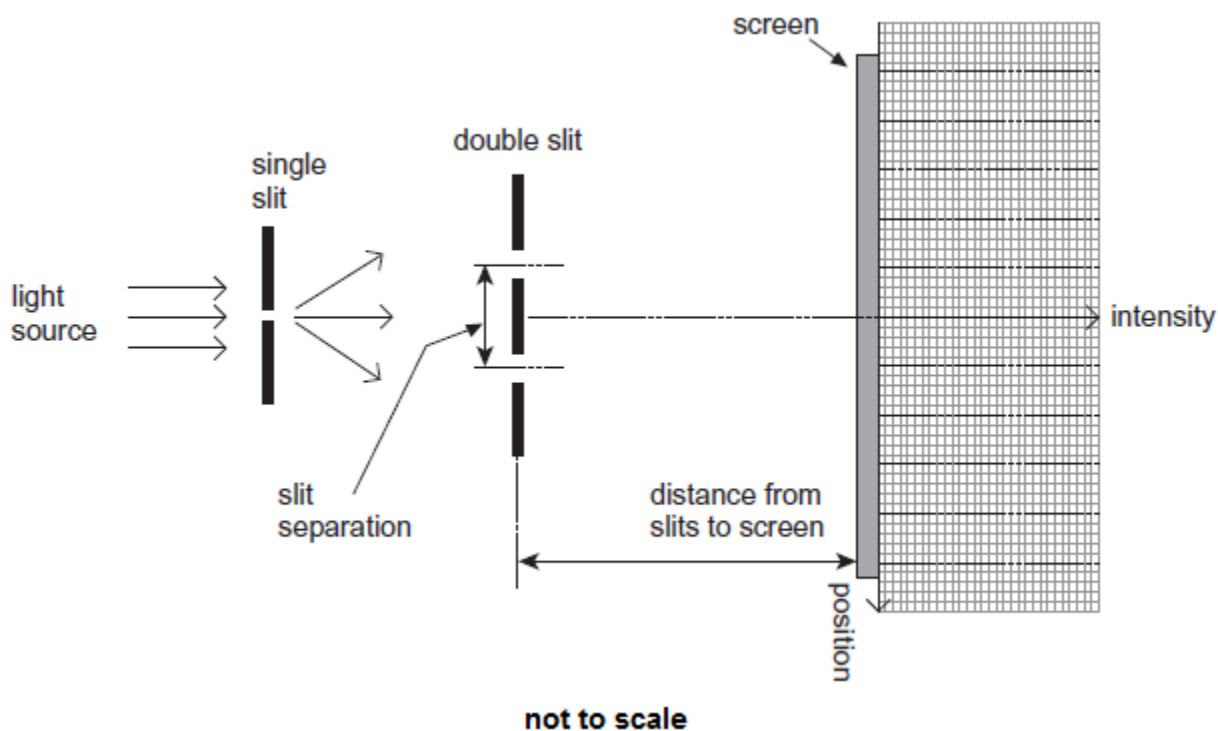
State and explain the effect on the signal strength as it is rotated.

(3)

(Total 11 marks)

5.

The diagram shows Young's double-slit experiment performed with a tungsten filament lamp as the light source.



- (a) On the axes in the diagram above, sketch a graph to show how the intensity varies with position for a **monochromatic** light source.

(2)

- (b) (i) For an interference pattern to be observed the light has to be emitted by two **coherent sources**.

Explain what is meant by coherent sources.

(1)

- (ii) Explain how the use of the single slit in the arrangement above makes the light from the two slits sufficiently coherent for fringes to be observed.

(1)

- (iii) In this experiment light behaves as a wave.
Explain how the bright fringes are formed.

(3)

- (c) (i) A scientist carries out the Young double-slit experiment using a laser that emits violet light of wavelength 405 nm. The separation of the slits is 5.00×10^{-5} m.

Using a metre ruler the scientist measures the separation of two adjacent bright fringes in the central region of the pattern to be 4 mm.

Calculate the distance between the double slits and the screen.

distance = _____ m

(2)

- (ii) Describe the change to the pattern seen on the screen when the violet laser is replaced by a green laser. Assume the brightness of the central maximum is the same for both lasers.

(1)

- (iii) The scientist uses the same apparatus to measure the wavelength of visible electromagnetic radiation emitted by another laser. Describe how he should change the way the apparatus is arranged and used in order to obtain an **accurate** value for the wavelength.

(3)

(Total 13 marks)