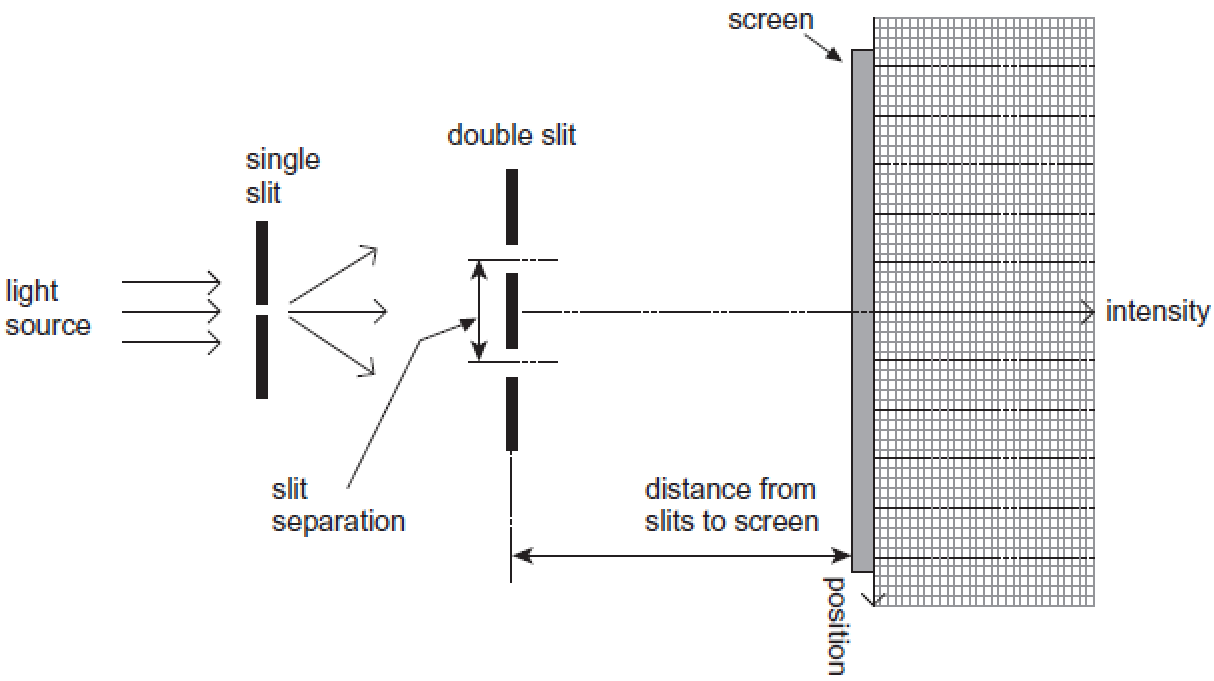
Q1. The diagram shows Young's double-slit experiment performed with a tungsten filament lamp as the light source.



not to scale

(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.

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(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.

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.... **(1)**

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

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.... **(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.

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(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.

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(3)
(Total 13 marks)

Q2. A student has a diffraction grating that is marked 3.5×10^3 lines per m.

(a) Calculate the percentage uncertainty in the number of lines per metre suggested by this marking.

percentage uncertainty = ... %
(1)

(b) Determine the grating spacing.

grating spacing = ... mm

(2)

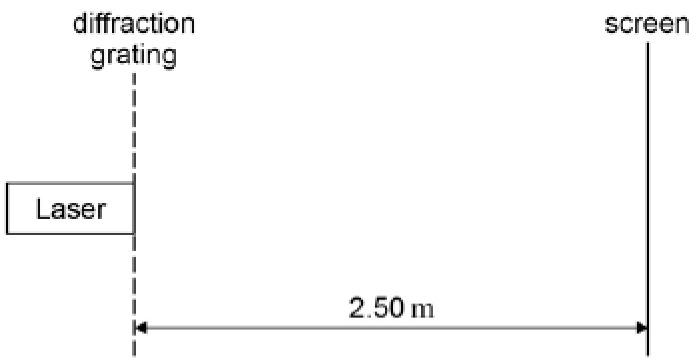
(c) State the absolute uncertainty in the value of the spacing.

absolute uncertainty = ... mm

(1)

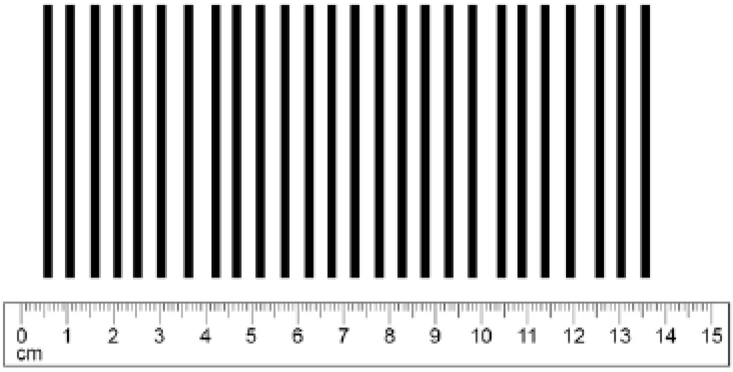
(d) The student sets up the apparatus shown in **Figure 1** in an experiment to confirm the value marked on the diffraction grating.

Figure 1



The laser has a wavelength of 628 nm. **Figure 2** shows part of the interference pattern that appears on the screen. A ruler gives the scale.

Figure 2



Use **Figure 2** to determine the spacing between two adjacent maxima in the interference pattern. Show all your working clearly.

spacing = ... mm

(1)

(e) Calculate the number of lines per metre on the grating.

number of lines = ...

(2)

(f) State and explain whether the value for the number of lines per m obtained in part (e) is in agreement with the value stated on the grating.

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(2)

(g) State **one** safety precaution that you would take if you were to carry out the experiment that was performed by the student.

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(1)
(Total 10 marks)

Q3. A light source emits light which is a mixture of two wavelength, λ_1 and λ_2. When the light is incident on a diffraction grating it is found that the fifth order of light of wavelength λ_1 occurs at the same angle as the fourth order for light of wavelength λ_2. If λ_1 is 480 nm what is λ_2?

A 400 nm

B 480 nm

C 600 nm

D 750 nm

(Total 1 mark)

Q4. Read through the following passage and answer the questions that follow it.

Measuring the speed of sound in air

After the wave nature of sound had been identified, many attempts were made to measure its speed in air. The earliest known attempt was made by the French scientist Gassendi in the 17th century. The procedure involved timing the interval between seeing the flash of a gun and hearing the bang from some distance away. Gassendi assumed that, compared with the speed of sound, the speed of light is infinite. The value he obtained for the speed of sound was 480 m s^{-1}. He also realised that the speed of sound does not depend on frequency.

A much better value of 350 m s^{-1} was obtained by the Italian physicists Borelli and Viviani using the same procedure. In 1740 another Italian, Bianconi, showed that sound travels faster when the temperature of the air is greater.

In 1738 a value of 332 m s^{-1} was obtained by scientists in Paris. This is remarkably close to the currently accepted value considering the measuring equipment available to the scientists at that time. Since 1986 the accepted value has been 331.29 m s^{-1} at 0 °C.

(a) Suggest an experiment that will demonstrate the wave nature of sound (line 1).

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.... **(1)**

(b) Using Gassendi's value for the speed of sound (line 6), calculate the time between seeing the flash of a gun and hearing its bang over a distance of 2.5 km.

time = ... s

(1)

(c) Explain why it was necessary to assume that 'compared with the speed of sound, the speed of light is infinite' (line 5).

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.... **(1)**

(d) Explain **one** observation that could have led Gassendi to conclude that 'the speed of sound does not depend on frequency' (line 7).

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.... **(2)**

(e) Explain how the value obtained by Borelli and Viviani was 'much better' than that obtained by Gassendi (line 8).

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(1)

(f) The speed of sound c in dry air is given by

$$c = k\sqrt{\theta + 273.15}$$

where θ is the temperature in °C, and k is a constant.

Calculate a value for k using data from the passage.

k = ... m s^{-1} $K^{-½}$

(2)

(g) State the steps taken by the scientific community for the value of a quantity to be 'accepted' (line 13).

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(2)
(Total 10 marks)

Q5. When comparing X-rays with UV radiation, which statement is correct?

A X-rays have a lower frequency. ☐

B X-rays travel faster in a vacuum. ☐

C X-rays do not show diffraction and interference effects. ☐

D Using the same element, photoelectrons emitted using X-rays have the greater maximum kinetic energy. ☐

(Total 1 mark)

Q6. Monochromatic light of wavelength 490 nm falls normally on a diffraction grating that has 6×10^5 lines per metre. Which one of the following is correct?

A The first order is observed at angle of diffraction of 17°. ☐

B The second order is observed at angle of diffraction of 34°. ☐

C The third and higher orders are not produced. ☐

D A grating with more lines per metre could produce more orders. ☐

(Total 1 mark)

Q7. The figure below shows a spectrometer that uses a diffraction grating to split a beam of light into its constituent wavelengths and enables the angles of the diffracted beams to be measured.

(a) Give **one** possible application of the spectrometer and diffraction grating used in this way.

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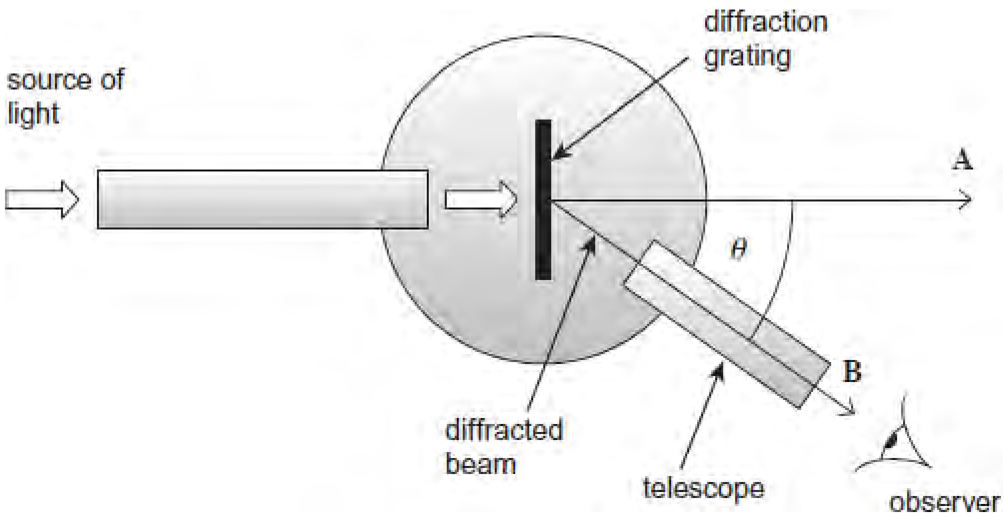

(1)

(b) (i) When the spectrometer telescope is rotated from an initial angle of zero degrees, a spectrum is not observed until the angle of diffraction θ is about 50°. State the order of this spectrum.

....

(1)

(ii) White light is directed into the spectrometer. Light emerges at **A** and **B**. State **one** difference between the light emerging at **B** compared to that emerging at **A**.

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(1)

(c) The angle of diffraction θ at the centre of the observed beam **B** in the image above is 51.0° and the grating has 1480 lines per mm.

Calculate the wavelength of the light observed at the centre of beam **B**.

wavelength .... m

(3)

(d) Determine by calculation whether any more orders could be observed at the wavelength calculated in part (c).

(2)
(Total 8 marks)