Q1. Just over two hundred years ago Thomas Young demonstrated the interference of light by illuminating two closely spaced narrow slits with light from a single light source.

(a) What did this suggest to Young about the nature of light?

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(1)

(b) The demonstration can be carried out more conveniently with a laser. A laser produces *coherent*, *monochromatic* light.

(i) State what is meant by monochromatic.

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(ii) State what is meant by coherent.

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(2)

(iii) State **one** safety precaution that should be taken while using a laser.

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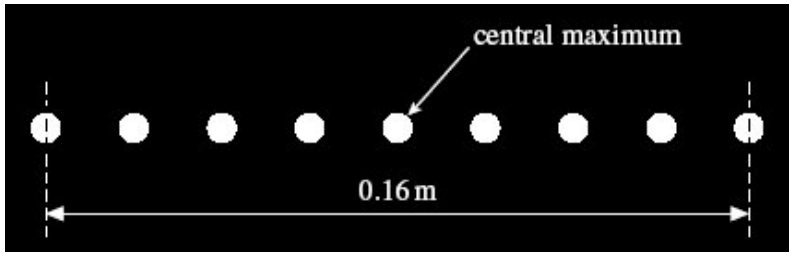
(1)

(c) The diagram below shows the maxima of a two slit interference pattern produced on a screen when a laser was used as a monochromatic light source.



The slit spacing = 0.30 mm.
The distance from the slits to the screen = 10.0 m.

Use the diagram above to calculate the wavelength of the light that produced the pattern.

answer = ... m

(3)

(d) The laser is replaced by another laser emitting visible light with a shorter wavelength.
State and explain how this will affect the spacing of the maxima on the screen.

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(2)
(Total 9 marks)

Q2. A vertical screen is placed several metres beyond a vertical double slit arrangement illuminated by a laser. The diagram below shows a full-size tracing of the pattern of spots obtained on this screen. The black patches represent red light whilst the spaces between them are dark.

(a) Using the wave theory, explain how the pattern of bright and dark patches is formed. You may be awarded marks for the quality of written communication provided in your answer.

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(3)

(b) The slit separation was 0.90 mm and the distance between the slits and the screen was 4.2 m.

(i) Calculate the spacing of the bright fringes by taking measurements on the diagram of the tracing.

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(ii) Hence determine the wavelength of the laser light used.

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(4)

(Total 7 marks)

Q3. (a) State **two** requirements for two light sources to be coherent.

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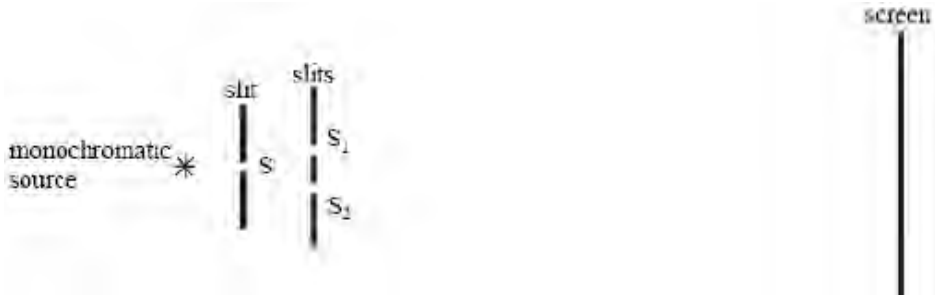
(2)

(b) **Figure 1**



Young's fringes are produced on the screen from the monochromatic source by the arrangement shown in **Figure 1**.
Explain how this arrangement produces interference fringes on the screen. In your answer, explain why slit S should be narrow and why slits S_1 and S_2 act as coherent sources.
The quality of your written answer will be assessed in this question.

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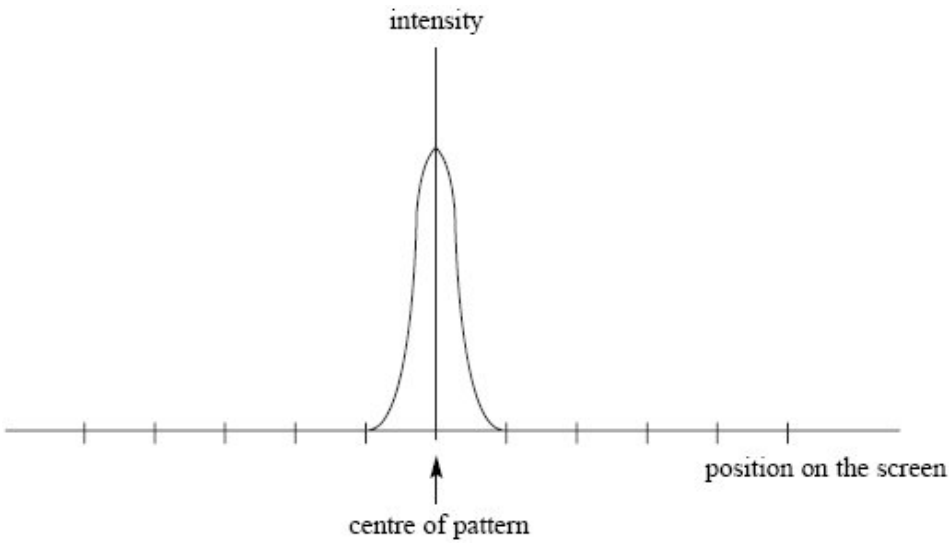
(6)

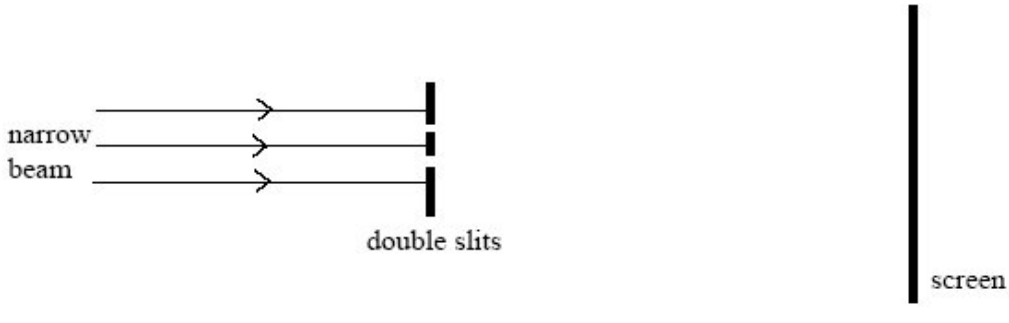
(c) The pattern on the screen may be represented as a graph of intensity against position on the screen. The central fringe is shown on the graph in **Figure 2**. Complete this graph to represent the rest of the pattern by drawing on **Figure 2**.

Figure 2



(2)
(Total 10 marks)

Q4. A narrow beam of monochromatic red light is directed at a double slit arrangement. Parallel red and dark fringes are seen on the screen shown in the diagram above.



(a) (i) Light passing through each slit spreads out. What is the name for this effect?

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(1)

(ii) Explain the formation of the fringes seen on the screen.

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(4)

(iii) The slit spacing was 0.56 mm. The distance across 4 fringe spacings was 3.6 mm when the screen was at a distance of 0.80 m from the slits. Calculate the wavelength of the red light.

Answer ..... m

(4)

(b) Describe how the appearance of the fringes would differ if white light had been used instead of red light.

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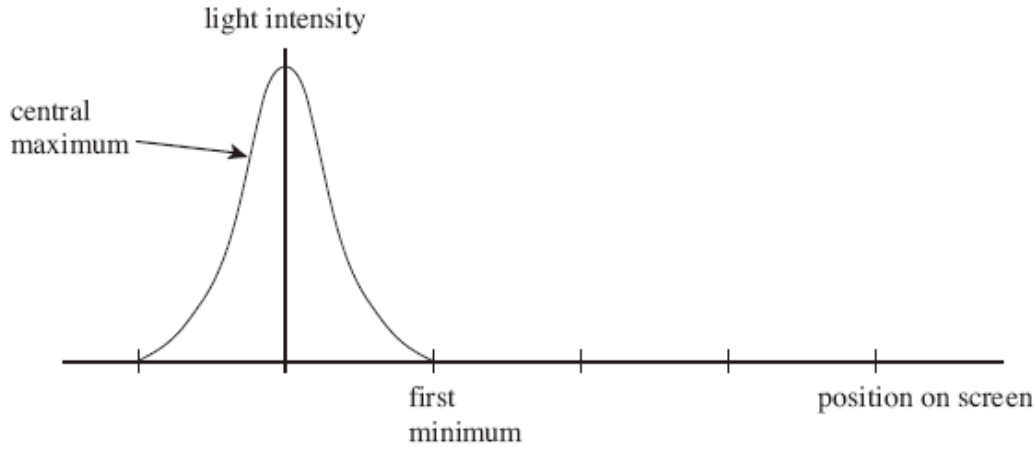
(3)

(Total 12 marks)

Q5. A single slit diffraction pattern is produced on a screen using a laser. The intensity of the central maximum is plotted on the axes in the figure below.



(a) On the figure above, sketch how the intensity varies across the screen to the right of the central maximum.

(2)

(b) A laser is a source of *monochromatic*, *coherent* light. State what is meant by

monochromatic light .....

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coherent light .....

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(2)

(c) Describe how the pattern would change if light of a longer wavelength was used.

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(1)

(d) State **two** ways in which the appearance of the fringes would change if the slit was made narrower.

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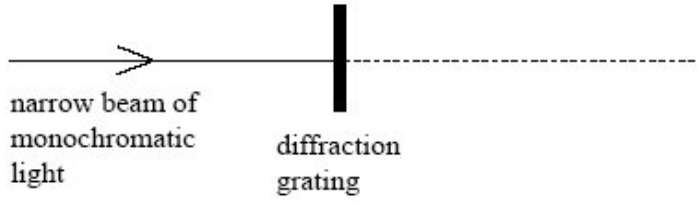
(2)

(e) The laser is replaced with a lamp that produces a narrow beam of white light. Sketch and label the appearance of the fringes as you would see them on a screen.

(3)
(Total 10 marks)

Q6. A narrow beam of monochromatic light of wavelength 590 nm is directed normally at a diffraction grating, as shown in the diagram below.



(a) The grating spacing of the diffraction grating is 1.67×10^{-6} m.

(i) Calculate the angle of diffraction of the second order diffracted beam.

answer ..... degrees

(4)

(ii) Show that no beams higher than the second order can be observed at this wavelength.

(3)

(b) The light source is replaced by a monochromatic light source of unknown wavelength. A narrow beam of light from this light source is directed normally at the grating. Measurement of the angle of diffraction of the second order beam gives a value of 42.1°.

Calculate the wavelength of this light source.

answer ..... m

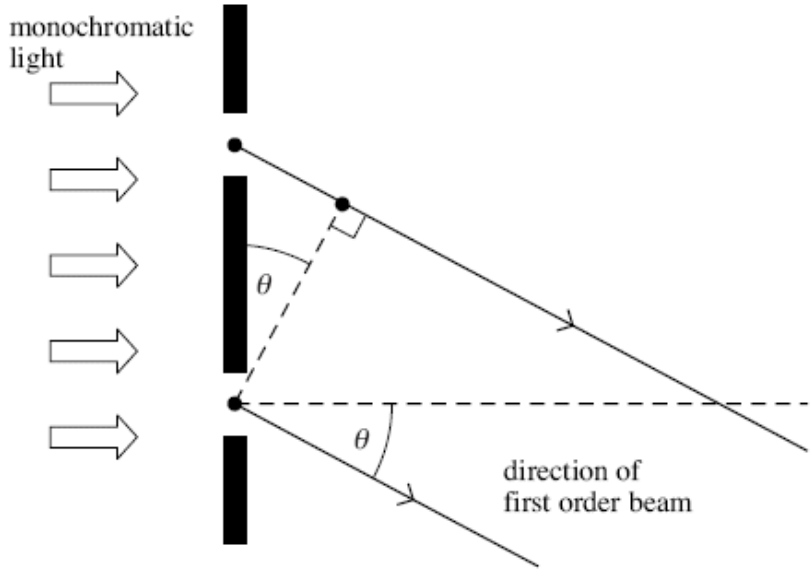
(2)

(Total 9 marks)

Q7. For a plane transmission diffraction grating, the diffraction grating equation for the first order beam is:

$\lambda = d \sin \theta$

(a) The figure below shows two of the slits in the grating. Label the figure below with the distances d and λ.



(2)

(b) State and explain what happens to the value of angle θ for the first order beam if the wavelength of the monochromatic light decreases.

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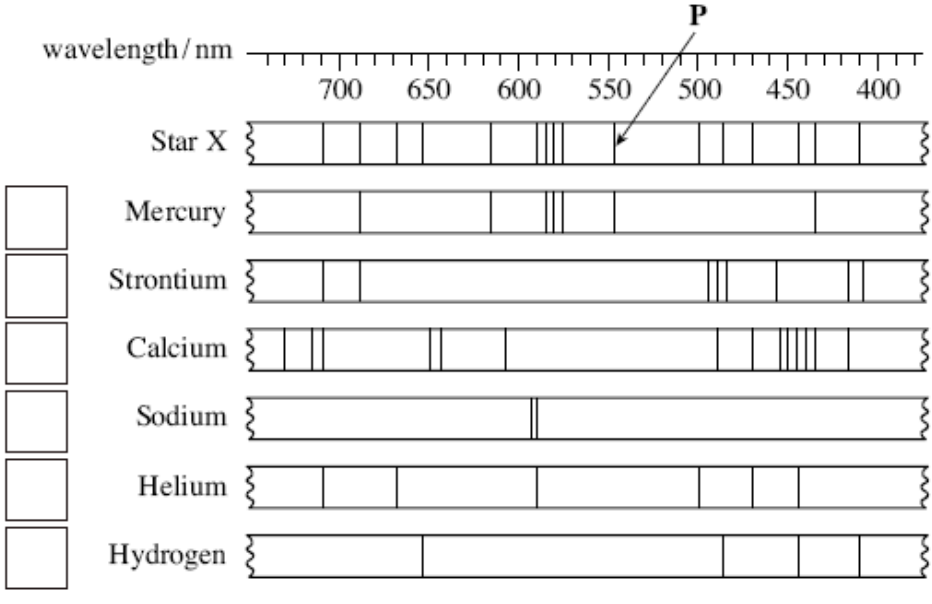
(c) A diffraction grating was used with a spectrometer to obtain the line spectrum of star **X** shown in the figure below. Shown are some line spectra for six elements that have been obtained in the laboratory.

Place ticks in the boxes next to the **three** elements that are present in the atmosphere of star X.



(2)

(d) The diffraction grating used to obtain the spectrum of star X had 300 slits per mm.

(i) Calculate the distance between the centres of two adjacent slits on this grating.

answer = ... m

(1)

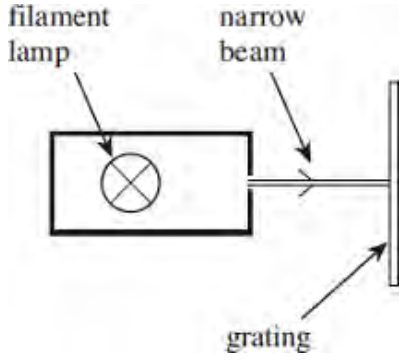
(ii) Calculate the first order angle of diffraction of line **P** in the figure above.

answer = ... degrees

(2)

(Total 9 marks)

Q8. (a) In an experiment, a narrow beam of white light from a filament lamp is directed at normal incidence at a diffraction grating. Complete the diagram in the figure below to show the light beams transmitted by the grating, showing the zero-order beam and the first-order beams.



(3)

(b) Light from a star is passed through the grating.

Explain how the appearance of the first-order beam can be used to deduce **one** piece of information about the gases that make up the outer layers of the star.

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(2)

(c) In an experiment, a laser is used with a diffraction grating of known number of lines per mm to measure the wavelength of the laser light.

(i) Draw a labelled diagram of a suitable arrangement to carry out this experiment.

(2)

(ii) Describe the necessary procedure in order to obtain an accurate and reliable value for the wavelength of the laser light.
Your answer should include details of all the measurements and necessary calculations.
The quality of your written communication will be assessed in your answer.

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(6)
(Total 13 marks)