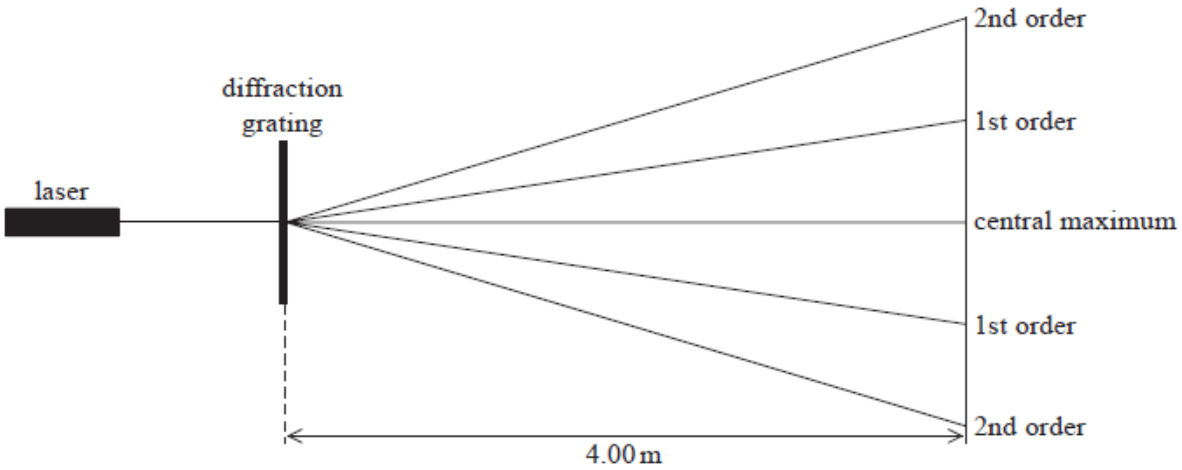
Questions

Q1.

A student used a diffraction grating to determine the wavelength of the light emitted by a laser. Light from the laser passed through the diffraction grating and the student observed a pattern on a wall 4 m away. The pattern consisted of a central maximum and 1st and 2nd order maxima as shown.



The student measured the distance between the central and a 2nd order maximum as 1350 mm. The diffraction grating had 300 slits mm^{-1}.

Measuring the distance between the two 2nd order maxima would produce a smaller percentage uncertainty in the value of wavelength.

Give a reason why.

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(Total for question = 1 mark)

Q2.

Read the extract and answer the question that follows.

In the 17th century there were two proposed theories to explain the refraction of light. Using a wave model, Huygens stated that light slows down when it passes from air to water. Using a particle model, Newton stated that light speeds up when it passes from air to water. Newton's theory was more readily accepted until the speed of light in water was measured in the 19th century.

In the early 20th century, Einstein used observations from the photoelectric effect to provide evidence for the particle model of light.

Nowadays, both the wave model of light and the particle model of light are accepted, as each can be used to explain different aspects of the behaviour of light.

Diffraction and interference can be explained using the wave model of light.

In an investigation to determine the wavelength of light from a laser, the light passed through a diffraction grating with 300 lines per millimetre.
A diffraction pattern consisting of a series of bright dots was observed on a screen.

The following data were recorded:

distance between grating and screen = 2.00 m
distance from central maximum to 2nd order maximum = 89.0 cm.

Calculate the wavelength of light from the laser.

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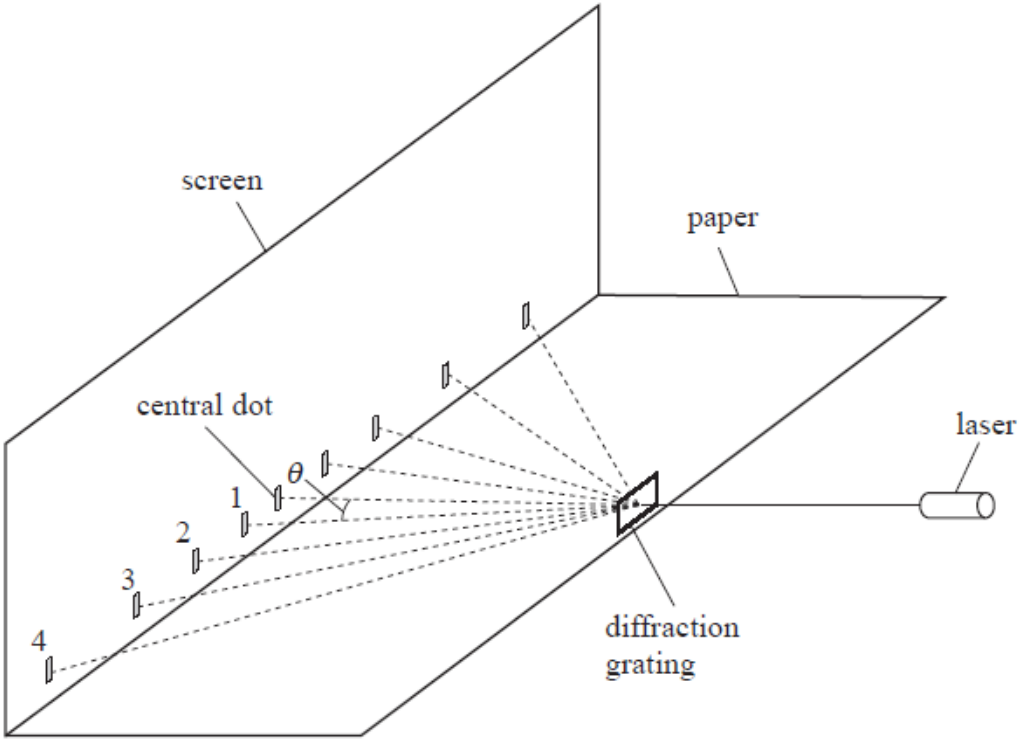
Wavelength = ...

(Total for question = 3 marks)

Q3.

The arrangement shown was used to determine the wavelength of light emitted by a laser.



A laser light beam was shone at a diffraction grating. A series of dots of light was produced on a screen. The angles θ between the light ray to the central dot and the light rays to the dots labelled 1 to 4 were measured with a protractor.

n	θ / °	$\sin\theta$
1	12	0.21
2	23	0.39
3	34	0.56
4	51	0.78

Describe how the angle θ could be determined without using a protractor.

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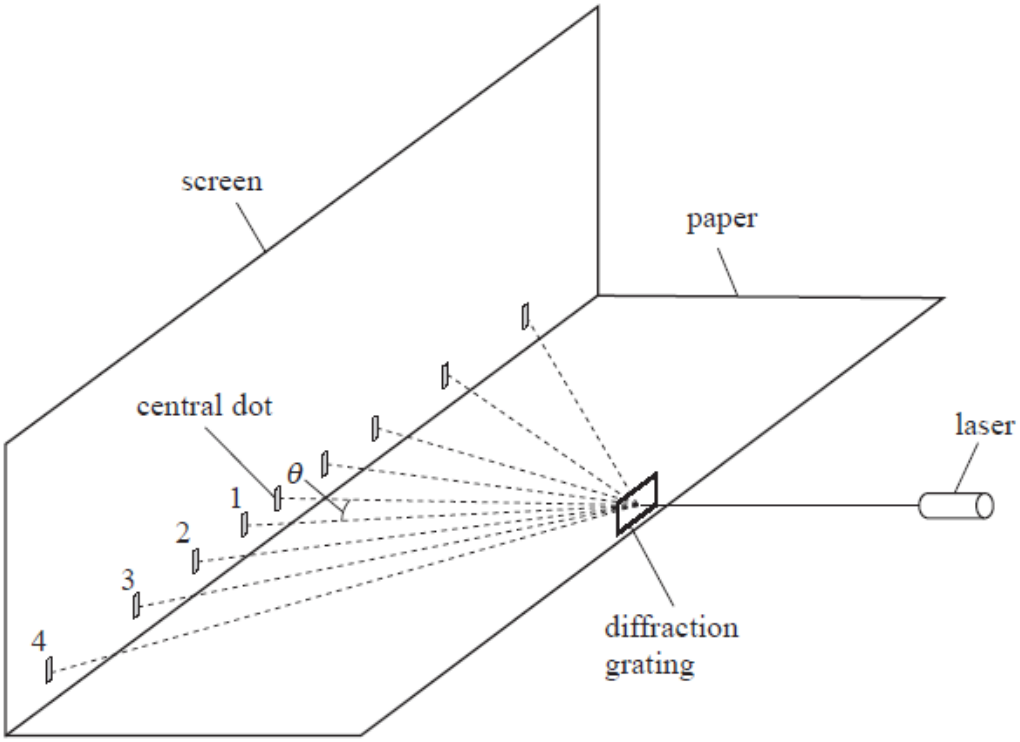
(Total for question = 2 marks)

Q4.

The arrangement shown was used to determine the wavelength of light emitted by a laser.



A laser light beam was shone at a diffraction grating. A series of dots of light was produced on a screen. The angles θ between the light ray to the central dot and the light rays to the dots labelled 1 to 4 were measured with a protractor.

n	θ / °	$\sin\theta$
1	12	0.21
2	23	0.39
3	34	0.56
4	51	0.78

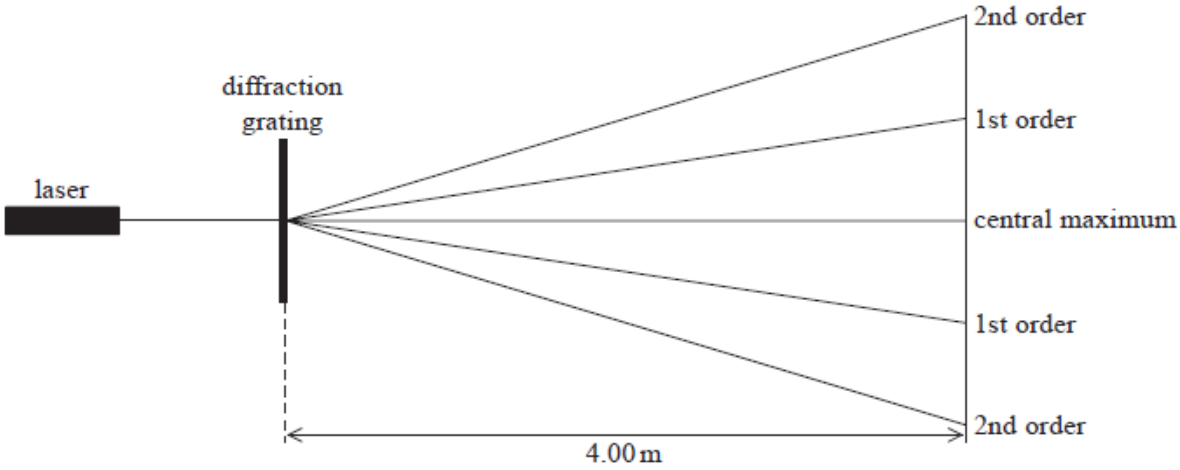
Plot a graph of n against $\sin\theta$ on the grid below.

(4)

(Total for question = 4 marks)

Q5.

A student used a diffraction grating to determine the wavelength of the light emitted by a laser. Light from the laser passed through the diffraction grating and the student observed a pattern on a wall 4 m away. The pattern consisted of a central maximum and 1st and 2nd order maxima as shown.



The student measured the distance between the central and a 2nd order maximum as 1350 mm. The diffraction grating had 300 slits mm^{-1}.

The colours and corresponding wavelengths of light emitted by commonly used lasers are given in the table.

blue	450–490 nm
green	520–560 nm
red	635–700 nm

Deduce the colour of the laser light the student used in this experiment.

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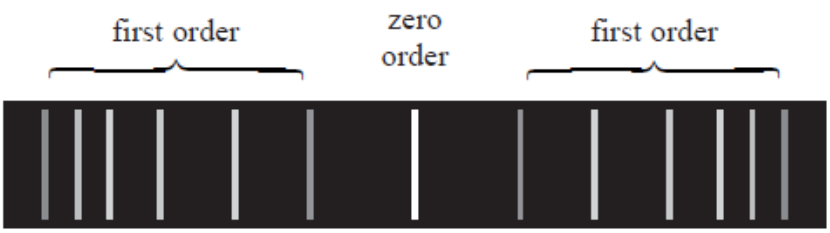
(Total for question = 4 marks)

Q6.

In a spectrometer, light from a tube of hot gas is passed through a diffraction grating.

The diagram shows the zero order and the first order maxima for the line spectrum produced.



(a) The spectrometer measures the angles between the different lines and the zero order. One of the lines has a wavelength of 650 nm and is observed, in the first order spectrum, at an angle of 19.9° from the zero order.

Calculate the number of lines per metre of the diffraction grating.

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Number of lines per metre = ...

(b) Explain one precaution that could be taken to ensure the accuracy of the measurement of the angle.

(2)

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Q7.

The diffraction of light provides evidence for the wave theory of light.

A student carried out an investigation to determine the wavelength of the light emitted from a laser pen.

He shone the light from the laser pen so that it was incident perpendicularly on a diffraction grating. The diffraction grating had 200 lines per mm. He observed the diffraction pattern on a screen 3.00 m away from the grating. The pattern consisted of a series of bright dots.

(i) Give a reason why a laser is a suitable source of light to produce a diffraction pattern.

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(ii) The student measured a distance of 102 cm between the central maximum and the centre of a third order maximum.

The table shows the range of wavelengths for each colour of the visible spectrum.

Colour	Range of wavelength / nm
violet	380 – 450
blue	450 – 495
green	495 – 570
yellow	570 – 590
orange	590 – 620
red	620 – 750

Deduce the colour of the light emitted from the laser pen.

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(Total for question = 6 marks)

Q8.

Barnard's star is a red dwarf star in the vicinity of the Sun. The wavelength of a line in the spectrum of light emitted from Barnard's star is measured to be 656.0 nm. The same light

produced by a source in a laboratory has a wavelength of 656.2 nm.

A diffraction grating can be used to analyse the radiation emitted by a variety of sources.

(i) A diffraction grating of known grating spacing is used in a school laboratory to analyse the light emitted by a laser.

Describe how the diffraction grating is used and the measurements that should be taken.

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(ii) A diffraction grating with grating spacing of 2.2×10^{-6} m is used to determine the difference in wavelength for the spectral line emitted by Barnard's star.

Comment on the suitability of using a diffraction grating with this spacing. You should include appropriate calculations.

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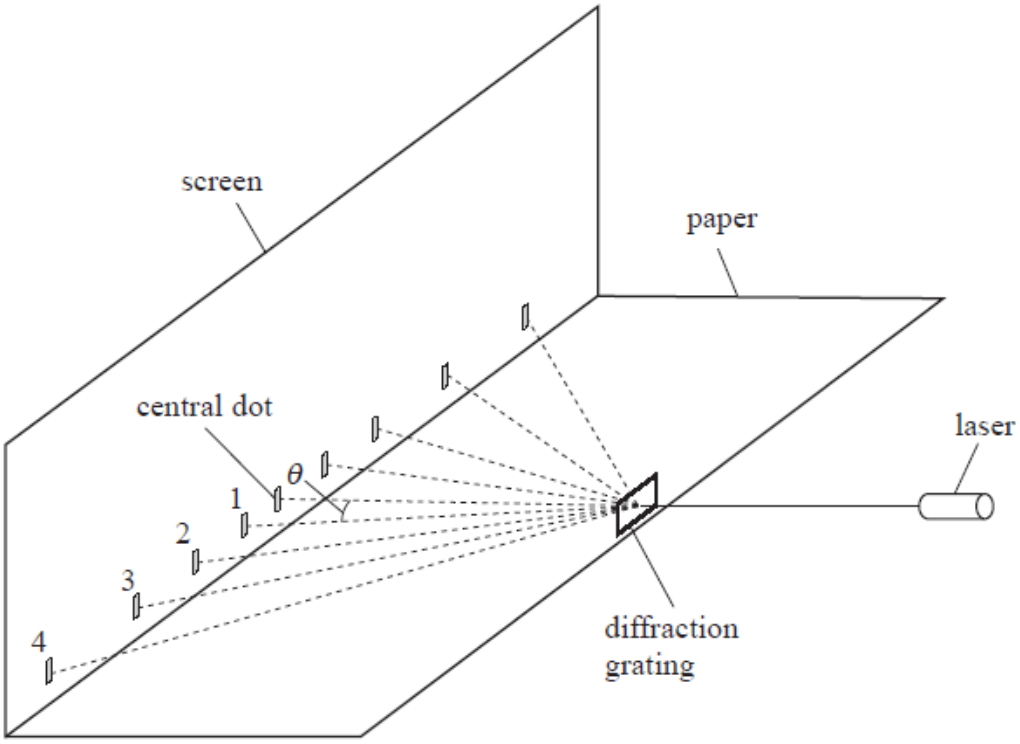
(Total for question = 7 marks)

Q9.

The arrangement shown was used to determine the wavelength of light emitted by a laser.



A laser light beam was shone at a diffraction grating. A series of dots of light was produced on a screen. The angles θ between the light ray to the central dot and the light rays to the dots labelled 1 to 4 were measured with a protractor.

n	θ / °	$\sin\theta$
1	12	0.21
2	23	0.39
3	34	0.56
4	51	0.78

(a) Describe how the angle θ could be determined without using a protractor.

(2)

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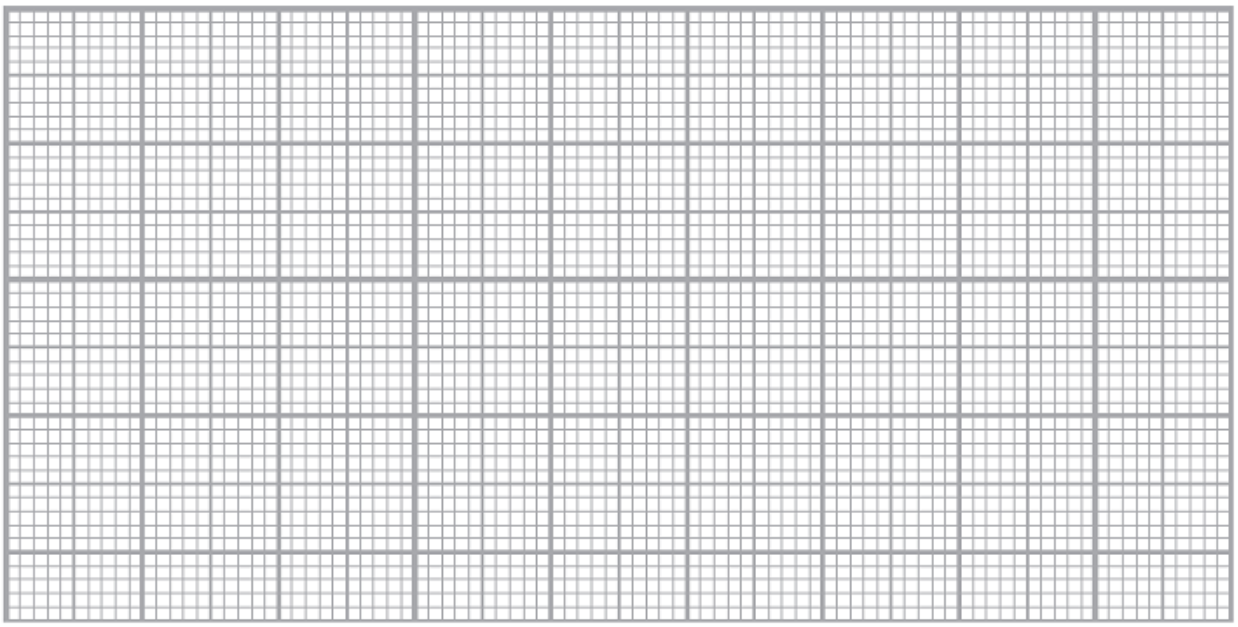
(b) Plot a graph of n against $\sin\theta$ on the grid below.

(4)



(c) The diffraction grating has 300 lines mm^{-1}.

Determine the wavelength of the laser light.

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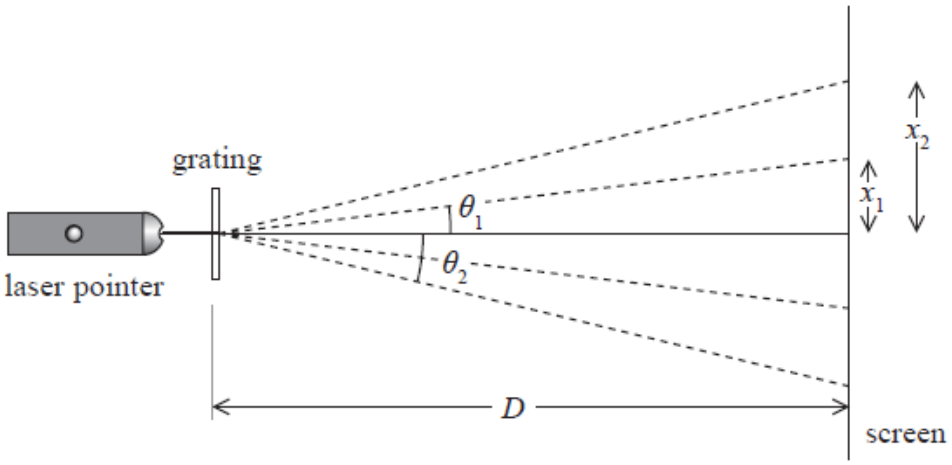
Wavelength = ...

(Total for question = 10 marks)

Q10.

A student is using a diffraction grating to determine the wavelength of the light emitted by a laser pointer. The light from the laser pointer is directed so that it is normal to the plane of the grating. The diffracted light is viewed on a screen a distance *D* from the grating.



The diagram shows the first two diffracted orders where x_1 and x_2 are the distances of the maxima for these orders from the central maximum of the diffraction pattern.

(a) Before carrying out the experiment, the student carries out a risk assessment to ensure that the experimental procedure is safe.

Explain one precaution that should be taken.

(2)

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(b) The student measures the distances from the central maximum of the diffraction pattern for various diffracted orders *n*, using a metre rule.

n	x_n / cm	θ / °	sin θ
0	0	0.00	0.000
1	35.5	11.4	0.20
2	74		
3	126.5	35.9	0.586
4	211	50.4	0.771

(i) Criticise the results that are recorded.

(1)

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(ii) Complete the data for the 2nd order maximum.

D = 1.750 m

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(iii) Add your data to the axes and draw a line of best fit.

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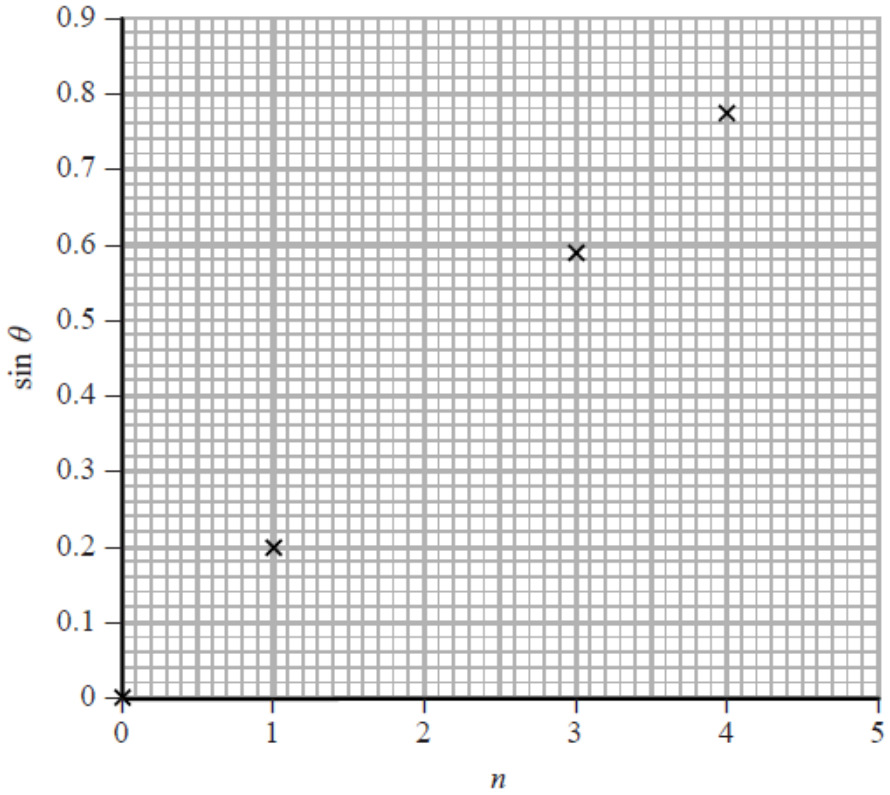

(iv) Use your graph to determine a value for the wavelength of the laser light.
The grating has 300 lines per mm

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Wavelength = ...

(c) State and justify two modifications to the experimental method which would have improved the accuracy of the value obtained for the wavelength.

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(Total for question = 15 marks)