Rewarding Learning

ADVANCED
General Certificate of Education
2009

Centre Number

71	

Candidate Number

Physics

Assessment Unit A2 1

assessing

Module 4: Energy, Oscillations and Fields

[A2Y11]

A2Y11

THURSDAY 21 MAY, AFTERNOON

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all six** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in question **4**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formula Sheet which is inside this question paper.
You may use an electronic calculator.
Question **6** contributes to the synoptic assessment requirement of the Specification.
You are advised to spend about 55 minutes in answering questions **1–5**, and about 35 minutes in answering question **6**.

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
Total Marks	

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If you need the values of physical constants to answer any questions in this paper, they may be found on the Data and Formulae Sheet.

Examiner Only	
Marks	Remark

Answer **all six** questions

1 **(a)** State the principle of conservation of momentum.

____

____

____ [2]

(b) A man is holding a rifle of mass 4.2 kg against his shoulder. The rifle is loaded with a bullet of mass 15 g. When the rifle is fired, the bullet leaves the barrel of the rifle with a velocity of 250 m s^{-1}. The man's shoulder is pushed backward by the recoil of the gun.

(i) Calculate the magnitude of the momentum of the bullet as it leaves the gun.

Momentum of bullet = ____________________ kg m s^{-1} [1]

(ii) Explain why the gun recoils backwards.

____

____

____ [1]

(iii) Calculate the magnitude of the velocity of the backward recoil of the rifle.

Velocity = ____________________ m s^{-1} [1]

Examiner Only	
Marks	Remark

(c) The bullet travels a horizontal distance and then hits and becomes embedded in a block of wood of mass 3.0 kg which is freely suspended by a long string as shown in **Fig. 1.1**.

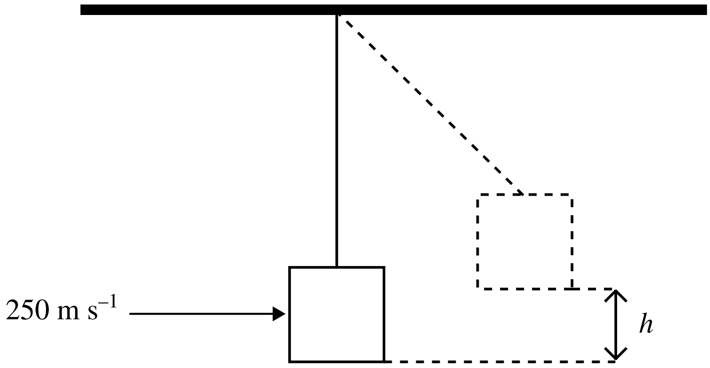

Fig. 1.1

(i) Neglecting air resistance, calculate the magnitude of the initial velocity of the wooden block and the bullet after impact.

Velocity = ____________________ m s^{-1} [2]

(ii) Use your answer to **(c)(i)** to calculate the kinetic energy of the block and bullet immediately after the impact.

Kinetic energy = ____________________ J [2]

(iii) Calculate the maximum height *h* above the equilibrium position to which the block and bullet rise after impact.

h = ____________________ m [2]

(iv) Explain why, in a real situation, the value of *h* as shown in **Fig. 1.1** would be less than that calculated in **(c)(iii)**.

____

____ [1]

(v) In the list below, mark with a tick (✓) the quantity or quantities which are conserved in this impact.

Momentum ☐

Kinetic energy ☐

Total energy ☐ [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

2 A student states Boyle's law for an ideal gas as follows:

"The volume V of air is proportional to the pressure p applied."

(a) There are three important omissions in the student's statement. State the omissions and explain why additions are needed to make the statement of Boyle's law correct.

(i) Omission 1:

____

____

Explanation of addition: ______________________________

____

____

(ii) Omission 2:

____

____

Explanation of addition: ______________________________

____

____

(iii) Omission 3:

____

____

Explanation of addition: ______________________________

____

____ [6]

Examiner Only	
Marks	Remark

(b) On a day when the atmospheric pressure is 102 kPa and the outside temperature is 12.0 °C, the pressure in a car tyre is 175 kPa above atmospheric pressure. After a long journey, the temperature of the air in the tyre rises to 28.0 °C.

(i) Calculate the pressure above atmospheric of the air in the tyre at 28.0 °C. Assume that the volume of the tyre remains constant.

Pressure above atmospheric = ____________________ kPa [3]

(ii) In racing car tyres, nitrogen commonly replaces air. This is because, as the temperature of the tyre changes, it can be more accurately predicted by how much the nitrogen will expand. Suggest how this information can be used by a racing team.

____

____

____ [1]

3 **Fig. 3.1** shows a funfair ride called a *Chair-O-Plane*. Seats are suspended by chains hanging from rigid arms attached to a vertical shaft, which can rotate. As the angular velocity of the shaft is increased, passengers experience a thrilling ride.

hhttp://www.dizzyland.com.au/images/chair_o_plane_lrg2.jpg

Fig. 3.1

Fig. 3.2 is a simplified diagram of one empty seat when the ride is at rest.

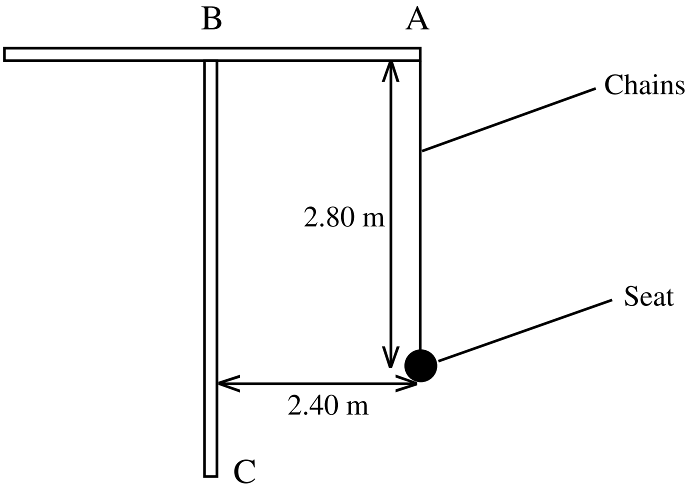

Fig. 3.2

The suspension chain hangs from point A on a rigid radial arm AB that is attached to the vertical shaft BC and rotates with it. The distance of A from the axis is 2.40 m and the length of the chain is 2.80 m. Thus, when the vertical shaft BC starts to rotate, the initial motion of the seat is in a horizontal circle of radius 2.40 m.

(a) (i) Describe qualitatively how the motion of the seat changes as the angular velocity of the vertical shaft increases.

____

____ [1]

(ii) At one stage, the period of rotation of the seat is 4.00 s. Calculate the angular velocity of the seat.

Angular velocity = ____________________ rad s^{-1} [1]

Examiner Only	
Marks	Remark

(iii) Fig. 3.3 shows the position of the empty seat at the instant when it is rotating with the angular velocity you calculated in **(a)(ii)**.

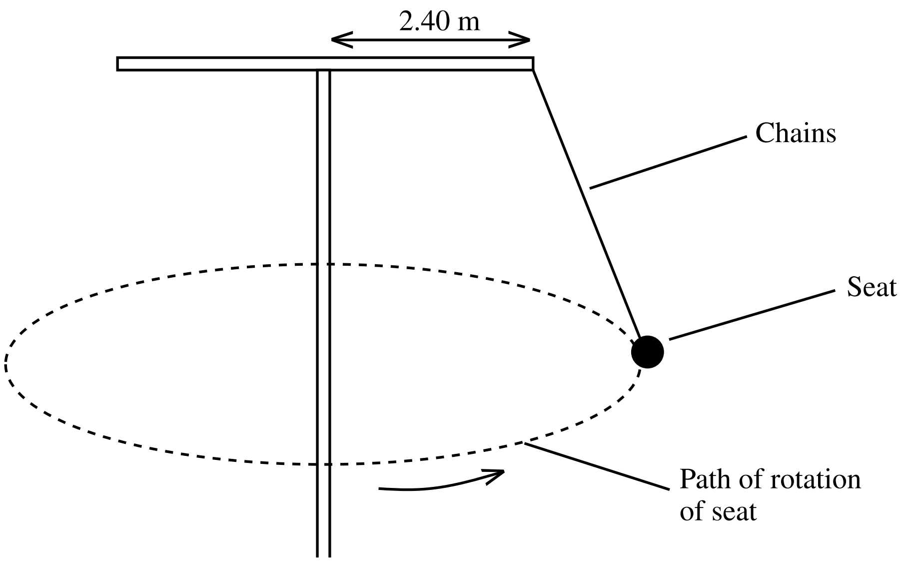

Fig. 3.3

1. Explain why the seat is subject to a centripetal force.

____

____ [1]

2. What provides this centripetal force?

____

____ [2]

Examiner Only	
Marks	Remark

(b) **(i)** The angular velocity of the shaft is increased so that the centripetal acceleration of the seat becomes $21.0\,\mathrm{m\,s^{-2}}$. The mass of the seat is $12.0\,\mathrm{kg}$. Calculate the tension in the chain supporting the seat at this new angular velocity.

Tension = ___________________ N [4]

(ii) At this new angular velocity, the seat moves in a horizontal circle of radius *R*. Calculate the value of *R*.

R = ___________________ m [3]

Where appropriate in this question you should answer in continuous prose. You will be assessed on the quality of your written communication.

Examiner Only

Marks	Remark

4 A motorcycle is fitted with a rear view mirror attached to an arm which is bolted to the handlebars. The mirror and arm assembly has a natural frequency of vibration of 13.0 Hz. The motorcyclist is stopped by traffic lights and the engine of the motorcycle is running at 800 revolutions per minute. The handlebars of the motorcycle vibrate at the frequency of the engine.

(a) Explain why the image of a car which is behind the motorcycle is shaking and hard to see when viewed by the motorcyclist.

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____ [2]

(b) The traffic lights change to green and the motorcycle accelerates so that the engine is running at 3000 revolutions per minute. Explain how the quality of the image of the car would change, if at all.

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____ [3]

(c) In an attempt to rectify the shaking of the image in **(a)**, the motorcyclist puts some thick foam between the handlebars and the arm of the mirror assembly. Would adding the foam get rid of the shaking of the image? Explain your answer.

____

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____

____ [2]

Quality of written communication [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

5 **(a)** Define **electric field strength**.

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____ [2]

(b) **Fig. 5.1** shows two point charges Q_1 and Q_2 of magnitude +2 μC and +4.5 μC respectively placed a distance 20 cm apart.

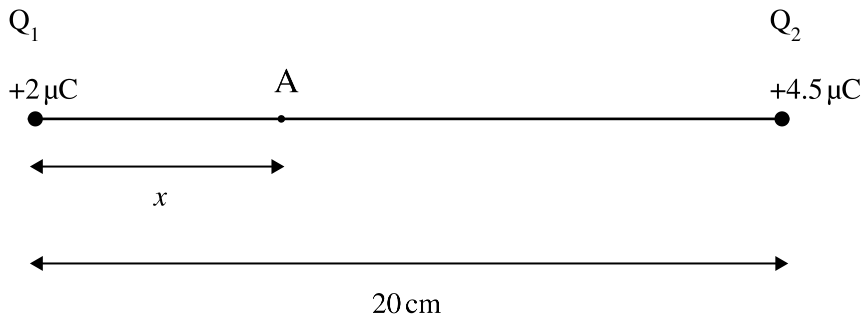

Fig. 5.1

(i) The resultant electric field strength at A, a distance x from Q_1, due to the charges Q_1 and Q_2 is zero. Calculate the magnitude of x.

x = ______________ cm [4]

(ii) A charge of +3 μC is now placed at the point A. State the value of the electric force exerted on the +3 μC charge at A. Explain your answer.

Force on +3 μC charge = ______________ N

Explanation

____

____

____ [2]

(iii) The $+3\,\mu C$ charge is now moved to a point B, midway between Q_1 and Q_2 as shown in **Fig. 5.2**.

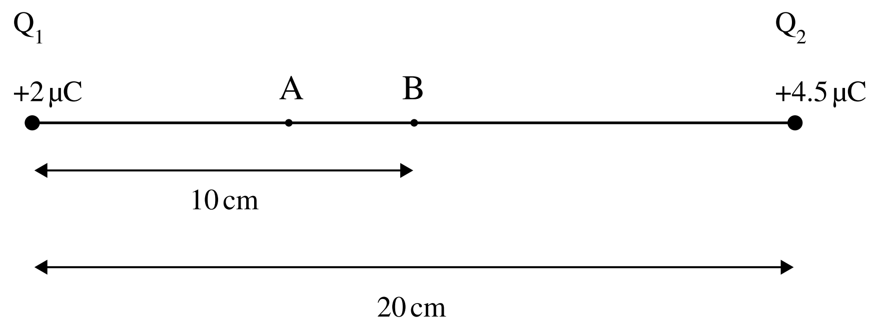

Fig. 5.2

Explain qualitatively why energy would be needed to move the $+3\,\mu C$ charge from A to B.

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____ [3]

Examiner Only	
Marks	Remark

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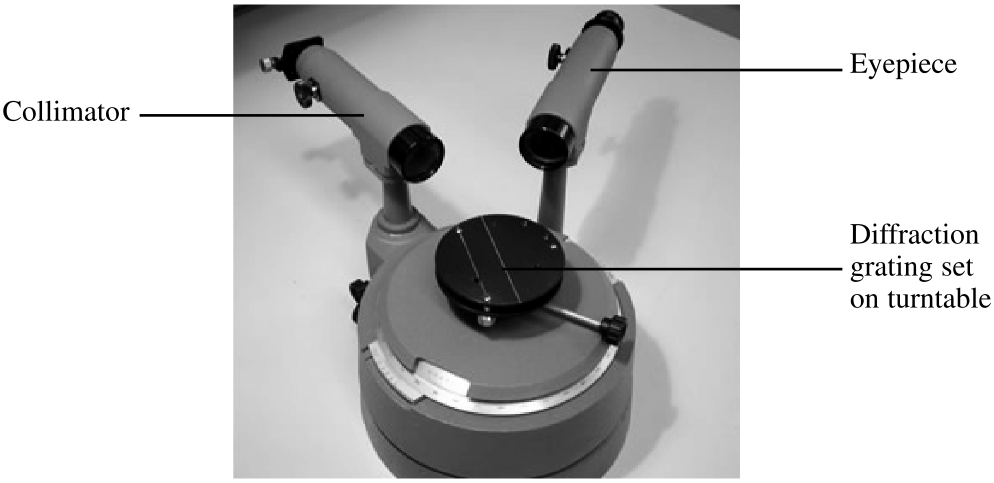
6 Data analysis question
This question contributes to the synoptic assessment requirement of the specification. In your answer you will be expected to bring together and apply principles and contents from different areas of physics, and to use the skills of physics, in the particular situation described.

You are advised to spend about 35 minutes in answering this question.

The grating spectrometer

Introduction

Fig. 6.1 shows a picture of a spectrometer and **Fig. 6.2** is a plan view of the instrument. A light source is placed at the far end of the collimator. The light passes through the diffraction grating and the spectral lines produced can be viewed through the eyepiece. The spectrometer allows accurate evaluation of the angle of diffraction of the light.



Source: http://www.kingsviewoptical.com/images/2302Spectrometer_300.pjg

Fig. 6.1

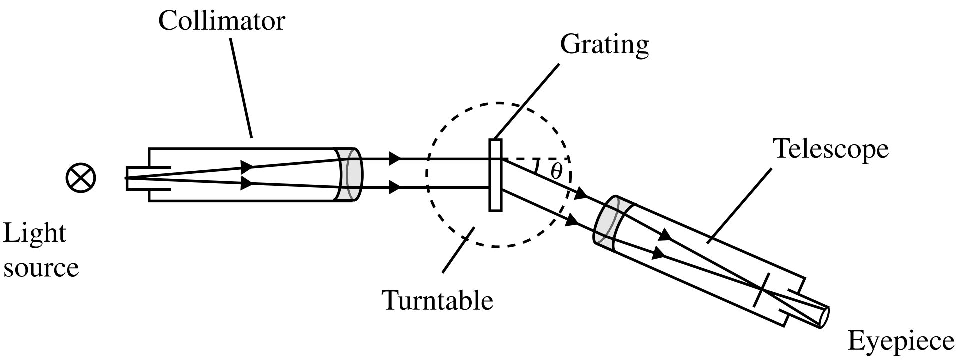


Fig. 6.2

A diffraction grating is to be calibrated by such a spectrometer with the source emitting a spectrum consisting of five lines of known wavelengths λ. The spectrometer is set up with light incident normally on the grating from the collimator, and the angles of diffraction θ for the first-order diffraction pattern for the five lines (in descending order) are recorded and tabulated (**Table 6.1**).

Examiner Only	
Marks	Remark

Table 6.1

λ/nm	θ/°	
656	79.7	
486	46.8	
434	40.6	
410	38.0	
400	36.8	

An expression connecting wavelengths and angles of diffraction in this first-order spectrum is

$$\sin\theta = A\lambda$$ **Equation 6.1**

where A is a constant called the grating constant.

(a) **(i)** State the straight-line graph which should be plotted to enable a value for A to be obtained.

y-axis ____________

x-axis ____________ [1]

(ii) How will the value of A be obtained from this graph?

____[1]

(iii) Head the blank column in **Table 6.1** appropriately. Insert any additional values needed. Record these values to an appropriate number of significant figures. [4]

(iv) Use the graph grid in **Fig. 6.3** to plot the graph stated in **(a)(i)**. Label the axes, choose suitable scales, plot the points, and draw the best-fit straight line. [5]

(v) From your graph, determine the value of the grating constant A.

A = ____________ m^{-1} [3]

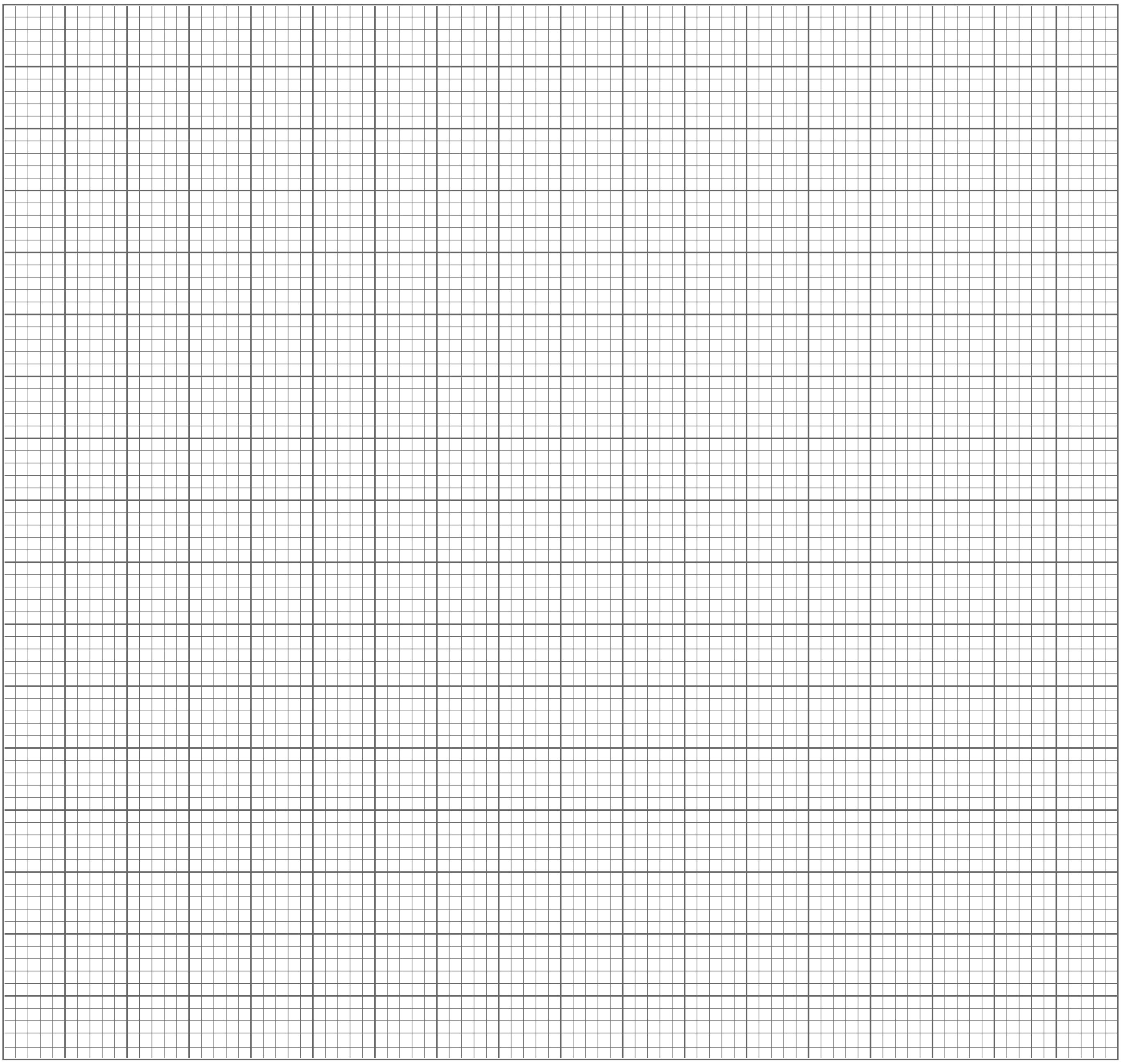


Fig. 6.3

Examiner Only	
Marks	Remark

(vi) Explain why, even for the wavelength of 400 nm, a second order of the diffraction pattern could not be found.

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____ [3]

(b) (i) It is possible to obtain a value for A by a non-graphical method. Using **Table 6.2**, insert appropriate headings in the blank columns and calculate the values required. Hence obtain an accurate value for A using this non-graphical method.

Table 6.2

λ/nm	θ/°		
656	79.7		
486	46.8		
434	40.6		
410	38.0		
400	36.8		

A = _________ m^{-1} [4]

(ii) Discuss in detail which of the two methods you consider to be the more accurate **in this case**. Explain your answer fully.

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____

____ [4]

Examiner Only

Marks	Remark

(c) **(i)** The diffraction grating is now replaced by one which has a known grating constant of $7.5 \times 10^5\,m^{-1}$. Use **Equation 6.1** to calculate theoretical values for θ and record them in **Table 6.3** to an appropriate number of significant figures.

Table 6.3

λ/nm	θ/°
656	
486	
434	
410	
400	

[3]

(ii) A student misreads the spectrometer and claims to locate a first-order line at a diffraction angle of 42.5 °.
Explain why this claim can be dismissed.

____

____ [3]

(iii) Explain whether using the first-order spectral lines with this grating is more or less suitable than using the same order pattern with the first grating.

____

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____ [3]

Examiner Only
Marks	Remark

(iv) How could the second grating be calibrated more accurately using the wavelengths in **Table 6.3**?

____

____ [1]

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER