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General Certificate of Education
Advanced Subsidiary Examination
June 2010

Physics
(Specifications A and B)

PHA3/B3/X

Unit 3 Investigative and Practical Skills in AS Physics
Route X Externally Marked Practical Assignment (EMPA)

Section A Task 1

For this paper you must have:
- a calculator
- a pencil
- a ruler.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- **Figure 4** is printed on a perforated sheet. You may wish to detach this sheet before starting Question 2(a).

Information
- The marks for questions are shown in brackets.
- The maximum mark for Section A Task 1 is 14.

Section A Task 1

Follow the instructions given below.

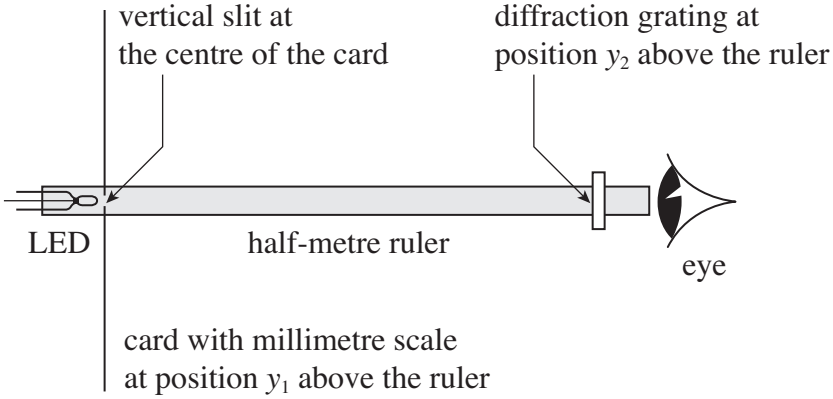
Answer **all** the questions in the spaces provided.

No description of the experiment is required.

You are to use a diffraction grating to observe the diffracted images of a vertical single slit illuminated by light from an LED.

1 The slit is in the centre of a card. A horizontal scale on the card shows the distances from the centre of the slit.
The slit is vertically above a half-metre ruler, with the card at right angles to the ruler.

Figure 1



1 (a) (i) Read and record the reading, y_1, on the half-metre ruler, directly below the slit, as shown in **Figure 1**.

y_1 = ...

A diffraction grating has been positioned so that it is vertically above the ruler and at right-angles to it. The grating lines are vertical, with the centre of the grating at the same height as the centre of the slit.
Do not move the stand to which the grating has been clamped or change the position of the grating in it.

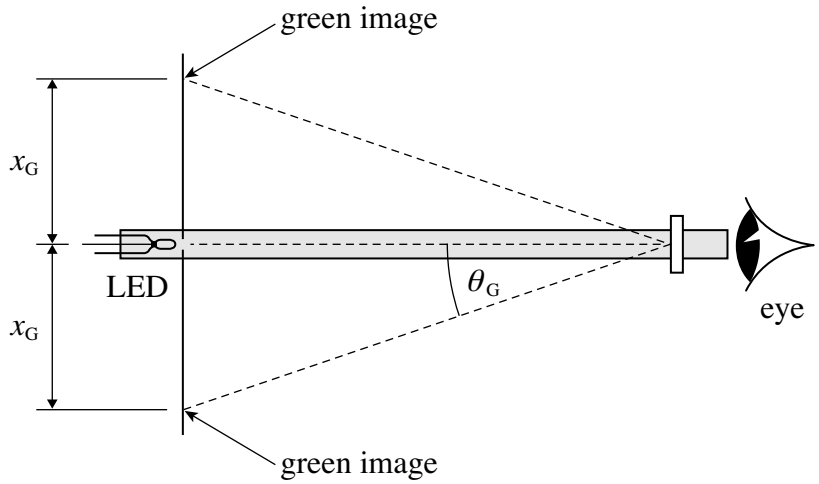
1 (a) (ii) Read and record the reading, y_2, on the half-metre ruler, vertically below the face of the grating that is closest to the slit, as shown in **Figure 1**.

y_2 = ...

(1 mark)

1 (b) The LED will emit green or red light depending on the setting of switch S.
Set the switch to the position marked G and adjust the output voltage of the power supply until the current in the LED is 20 mA.
View the slit through the grating with your eye close to the grating and observe the diffracted images of the slit. You will see three images of green light, which are the central (undeviated) image of the slit and the first-order diffracted images to the left and right.
Ignore any yellow or orange light produced by the LED.
If you are colour-blind you should assume that the green images are those closest to the slit.
A plan view of the apparatus when green light is emitted from the LED is shown in **Figure 2**.

Figure 2



1 (b) (i) Make readings to determine the mean distance, x_G, between the centre of the first-order green diffracted images and the centre of the slit. You should do this by looking at the scale on the card with one eye, whilst looking through the grating at the slit with the other eye.

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.....

.....

x_G = ...

1 (b) (ii) Without changing the position of the grating or slit, set the switch S to the position marked R and adjust the output voltage of the power supply until the current in the LED is 20 mA. Make readings to determine the mean distance, x_R, between the centre of the first-order red diffracted images and the centre of the slit.

.....

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x_R = ...

(2 marks)

1 (c) The angle of diffraction, θ, is given by $\tan \theta = \dfrac{x}{y_2 - y_1}$

1 (c) (i) Use your measurements to determine θ_G and θ_R, the angles of diffraction for the first-order images for green light and red light, respectively.

.....

.....

θ_G = ...

.....

.....

θ_R = ...

1 (c) (ii) Evaluate $\dfrac{\sin \theta_R}{\sin \theta_G}$.

.....

$\dfrac{\sin \theta_R}{\sin \theta_G}$ = ...

(3 marks)

1 (d) Explain how you could determine the spacing of the lines on the diffraction grating you used. In your answer

- state what additional information you would need to determine the spacing of the lines on the diffraction grating
- explain how you would use your measurements to calculate the spacing of the lines on the diffraction grating
- describe **one** procedure or modification that would reduce the uncertainty in your result.

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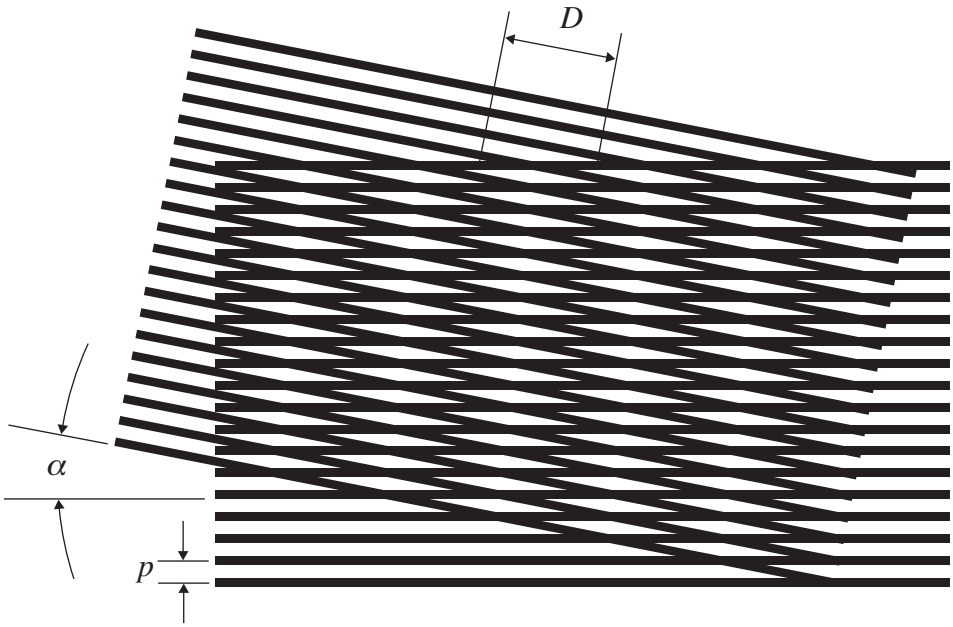
(4 marks)

10

Turn over for the next question

2 You are to make measurements of an optical pattern produced when two grids of parallel, ruled lines are overlaid, as shown in **Figure 3**.
The alternate lighter and darker regions in the pattern are called Moiré fringes.
The perpendicular distance, D, between adjacent Moiré fringes depends on the angle, α, between the sets of lines on the two grids and on p, the spacing between the centres of the adjacent lines on the grid.

Figure 3



Note that Figure 4, for use with this question, is printed on page 9.
You may wish to detach this perforated sheet before starting Question 2(a).

2 (a) (i) Make suitable measurements to determine p, the spacing of the ruled lines on the grid shown in **Figure 4**.

.....

.....

p = ...

2 (a) (ii) Place the transparent copy over **Figure 4** so that the two sets of grid lines are parallel, then rotate the transparent copy until the grid lines on it are parallel to the line AB on **Figure 4**. Make suitable measurements to determine D, the perpendicular distance between adjacent Moiré fringes.

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.....

D = ...

2 (a) (iii) Evaluate $\frac{D}{p}$.

.....

.....

$\frac{D}{p}$ = ...

(3 marks)

2 (b) Justify the number of significant figures you gave with your result for $\frac{D}{p}$.

.....

.....

(1 mark)

4

END OF QUESTIONS

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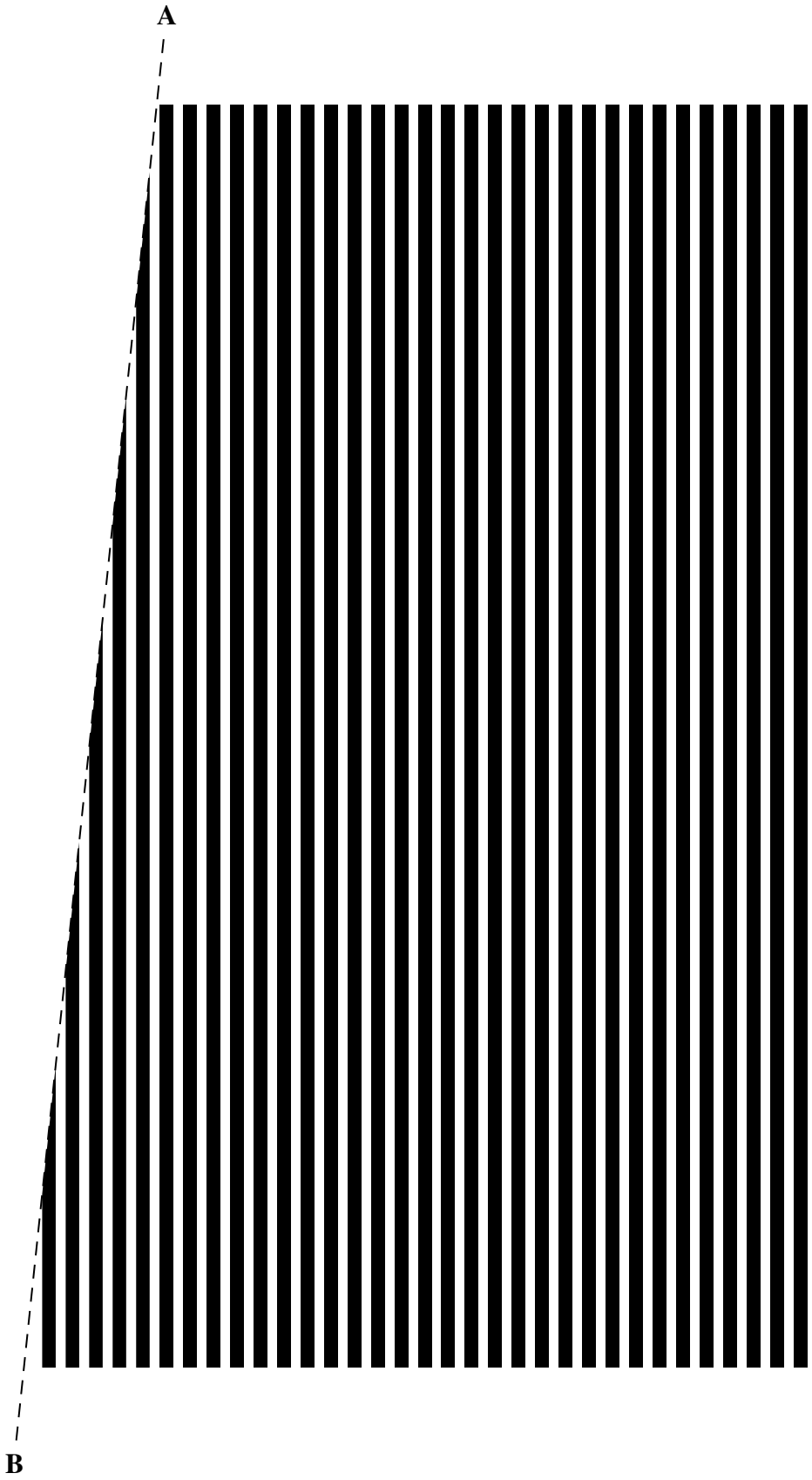
Figure 4



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Physics PHA3/B3/X

(Specifications A and B)

Unit 3 Investigative and Practical Skills in AS Physics
Route X Externally Marked Practical Assignment (EMPA)

Section A Task 2

For this paper you must have:
- a calculator
- a pencil
- a ruler.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for Section A Task 2 is 15.

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Section A Task 2

Follow the instructions given below.

Answer **all** the questions in the spaces provided.

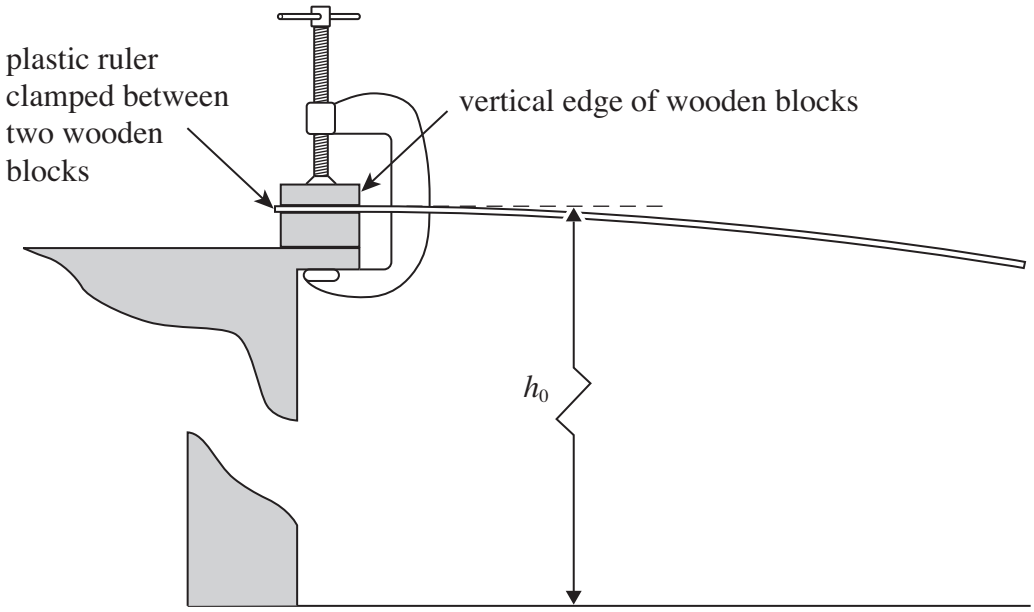
No description of the experiment is required.

In this experiment you will investigate the bending of a plastic metre ruler under its own weight.

1 (a) You are provided with a wooden metre ruler to be used as a vertical scale.
Make the ruler vertical with the zero graduation of the ruler in contact with the floor.
Use the stand and clamp provided to secure the ruler in this position.

Use the G-clamp and blocks of wood to clamp the plastic metre ruler to the top of the bench so that x, the length of the ruler between the vertical edge of the blocks and the free end of the ruler is 90.0 cm, as shown in **Figure 5**.

Figure 5



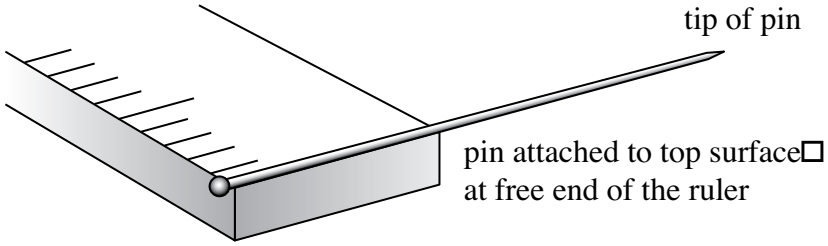
Measure and record h_0, the vertical height between the top of the plastic ruler and the floor, at the end where the ruler is clamped between the wooden blocks.

h_0 = ...

(1 mark)

1 (b) Attach the pin to the free end of the plastic ruler, so that the tip of the pin projects horizontally at right angles to the top surface of the ruler at the free end, as shown in **Figure 6**.

Figure 6



Measure and record h, the vertical height between the tip of the pin and the floor.
You should use the mirror that is provided to assist you in measuring h.

Investigate how h varies with x for **five** smaller values of x.

Record all your measurements and observations below.
Note that the independent variable should be recorded in the **left-hand** column of your table.
Leave space in your table for an extra column for the data you will be required to plot on your graph (see part (c) below).

(6 marks)

1 (c) Plot, on the grid opposite, a graph of $(h_0 - h)$ on the vertical axis and x on the horizontal axis.

(8 marks)

END OF QUESTIONS

15

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Physics
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PHA3/B3/X

Unit 3 Investigative and Practical Skills in AS Physics
Route X Externally Marked Practical Assignment (EMPA)

Section B

For this paper you must have:
- a calculator
- a pencil
- a ruler
- your completed Section A Task 2 question paper/ answer booklet.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for Section B is 26.

Section B

Answer **all** the questions in the spaces provided.

The time allowed is 1 hour 15 minutes.

You will need to refer to the work you did in Section A Task 2 when answering these questions.

1 You are provided with a small plane mirror which you may use to assist you in answering part (a) of this question.

1 (a) (i) Determine the gradient, G_1, of your graph, at $x = 750\,\text{mm}$.

.....

.....

$G_1 =$ .....

1 (a) (ii) Determine the gradient, G_2, of your graph, at $x = 650\,\text{mm}$.

$G_2 =$ .....

(3 marks)

1 (b) Evaluate $\frac{G_1}{G_2}$.

.....

$\frac{G_1}{G_2} =$ .....

(2 marks)

1 (c) Explain the procedure you used to determine the gradients, G_1 and G_2.

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.....

(1 mark)

6

2 (a) Describe how you ensured that the wooden metre ruler was vertical whilst you made your measurements of h and h_0.
You may wish to use a sketch to illustrate your answer.

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(2 marks)

2 (b) Explain how you used the pin and the mirror when measuring the vertical height of the free end of the plastic ruler above the floor.
Identify the error that the procedure you have explained is intended to overcome.
You may wish to use a sketch to illustrate your answer.

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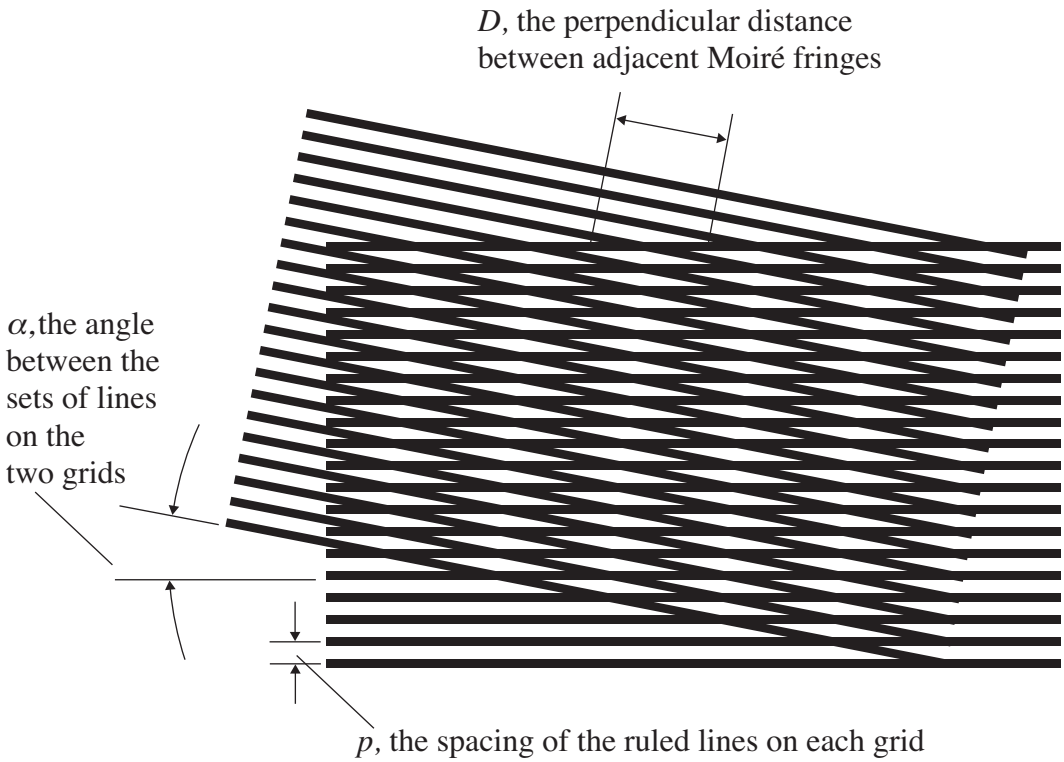
(3 marks)

5

3 In an experiment in Section A, you saw how two grids of parallel ruled lines can be used to produce Moiré fringe patterns, as shown in **Figure 7**.

Figure 7



A student obtains two diffraction gratings thought to be identical with a line spacing of about 3×10^{-6} m. The student finds that when these are placed together and viewed against a white background a Moiré fringe pattern is observed when one grating is rotated slightly.
For small angles, the distance between the Moiré interference fringes, D, is given by the approximate equation, $D \simeq \frac{57p}{\alpha}$, where α is in degrees.
By assuming that $p = 3.0 \times 10^{-6}$ m, the student uses this equation in a spreadsheet to find D for values of α up to 16°.
The student's results are shown below.

α/°	D/mm
2	0.0855
4	0.0428
6	0.0285
8	0.0214
10	0.0171
12	0.0143
14	0.0122
16	0.0107

The student intends to view the Moiré fringes through a microscope to check the spreadsheet results for D by measuring D using the microscope directly.
The vernier scale on the microscope can measure to the nearest 0.01 mm.

3 (a) Explain using suitable calculations why this microscope is not suitable to check the results of the spreadsheet calculation.

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(4 marks)

3 (b) The equation for D can be rearranged to give $p \simeq \frac{\alpha D}{57}$.

The student suggests that if a better microscope can be provided and α can be set to produce values of D greater than 0.10 mm, the value of p can be found experimentally. Discuss whether the student's suggestion is sensible.

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(2 marks)

3 (c) The theoretical separation of the Moiré fringes when $\alpha = 2°$, shows $D = 0.0859$ mm. Calculate the percentage difference between this value and the student's spreadsheet result for D when $\alpha = 2°$.

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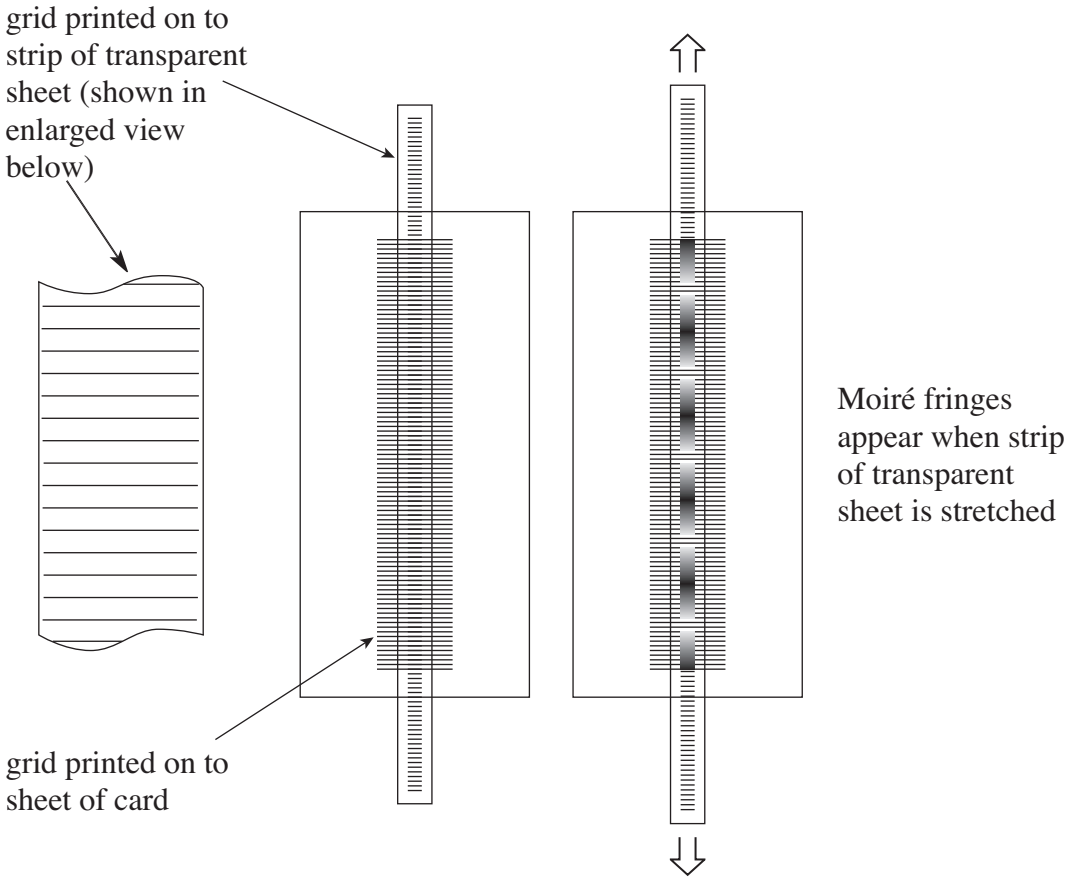
(2 marks)

8

4 In the experiment in Section A Task 1 you observed Moiré fringes using a transparent sheet on which gridlines were printed. This question is about an experiment to measure the stiffness of a narrow strip of the transparent sheet.

In **Figure 8**, which is not to scale, the strip of the transparent sheet is suspended vertically in front of a sheet of card; the lines printed in the strip are parallel to those on the card.
A grid, of identical spacing to that on the transparent sheet, is printed on the card.
The strip is stretched and when viewed against the grid on the card, Moiré fringes are seen.

Figure 8



It can be shown that Δl, the extension of the strip of transparent sheet, is given by

$$\Delta l = \frac{p \times l}{2d},$$

where p = distance between centres of adjacent lines on the grid printed on the card,
d = the distance between the centres of adjacent dark Moiré fringes,
l = length of the strip before being stretched.

The stiffness, k, of the strip is given by

$$k = \frac{F}{\Delta l},$$

where F = the force applied at each end to stretch the strip of transparent sheet.

4 (a) Explain how the stiffness of the strip of transparent sheet can be determined experimentally.
You may assume that the value of p is known.
In your answer

- state what measurements should be taken, explaining how each will be made
- describe procedures to reduce uncertainty in each of these measurements
- explain how the measurements can be used to calculate the stiffness of the strip of transparent sheet.

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(6 marks)

4 (b) In Section A Task 2 you used a plastic metre ruler.
Explain why it is not sensible to measure the stiffness of the plastic ruler using the method suggested in part (a).

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(1 mark)

7

END OF QUESTIONS

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