



General Certificate of Education
Advanced Subsidiary Examination
June 2010

Physics

PHA3/B3/XTN

(Specifications A and B)

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

Instructions to Supervisors Confidential

To be given immediately to the teacher(s) responsible for GCE Physics

Open on receipt

- These instructions are provided to enable centres to make appropriate arrangements for the Unit 3 Externally Marked Practical Assignment (EMPA)
- It is the responsibility of the Examinations Officer to ensure that these *Instructions to Supervisors* are given immediately to the Supervisor of the practical examination.

INSTRUCTIONS TO THE SUPERVISOR OF THE EXTERNALLY MARKED PRACTICAL EXAMINATION

General

Security/confidentiality

The instructions and details of the EMPA materials are strictly confidential. In no circumstances should information concerning apparatus or materials be given before the examination to a candidate or other unauthorised person.

The EMPA supplied by AQA at AS and at A2 for a given academic year must only be used in that academic year. It may be used for practice in later academic years.

Using information for any purpose beyond that permitted in this document is potentially malpractice. Guidance on malpractice is contained in the JCQ document Suspected Malpractice in Examinations and Assessments: Policies and Procedures.

The Examinations Officer should give copies of the Teacher Notes (PHA3/B3/XTN and/or PHA6/B6/XTN) to the teacher entrusted with the preparation of the examination upon receipt.

Material from AQA

For each EMPA, AQA will provide:

- *Instructions to Supervisors*
- Section A Task 1 and Task 2 question paper/answer booklets
- Section B EMPA written test papers.

Preparation/Centre responsibility

This practical assessment should be carried out after candidates have acquired the necessary skills and after the appropriate sections of the specification have been taught so that candidates are familiar with any specialist apparatus involved.

The assessment must be carried out between the dates specified by AQA.

It is the responsibility of the centre to ensure that each of the specified practical activities works with the materials provided to the candidates.

The assessment and management of risks are the responsibility of the centre.

Practical Skills Verification (PSV)

Candidates must undertake the five practical activities specified, in order for them to demonstrate in the EMPA that they can use apparatus appropriate to the teaching of Physics at this level. In doing so, candidates will be familiar with the equipment and skills they will use in the EMPA. The teacher must confirm on the *Candidate Record Form* that this requirement has been met.

Section A: Task 1 and Task 2

- Candidates should work individually and be supervised throughout. They should not discuss their work with other candidates at any stage.
- The work can be carried out in normal timetabled lessons and at a time convenient to the centre. Teachers will be in the best position to judge how many sessions are appropriate for candidates in their own centre.
- The candidates' work must be handed to the teacher at the end of each practical session and kept securely until the next stage of assessment.
- There is no specified time limit for these tasks, however candidates should be informed by the Supervisor of the expected timescale and timetable arrangements involved in carrying out the EMPA. Candidates must also be instructed that all readings must be entered in the question paper/answer booklet provided and all working must be shown. **Scrap paper must not be used.**

Sharing equipment / working in groups

Candidates are to work individually. Where resources mean that equipment has to be shared, the teacher should ensure that the candidates complete the tasks individually. Where appropriate, spare sets of apparatus should be prepared to ensure that time is not lost due to any failure of equipment.

Centres may choose to provide sufficient sets of apparatus for the candidates to work on Section A in a circus format with some candidates completing the questions in reverse order. In such cases the changeover should be carefully supervised and the apparatus returned to its original state before being used again.

Practical sessions

Before the start of the test the apparatus and materials for each candidate should be arranged, ready for use, on the bench. The apparatus should not be assembled unless a specific instruction to do so is made in these Instructions.

If a candidate is unable to perform any experiment, or is performing an experiment incorrectly, or is carrying out some unsafe procedure, the supervisor is expected to give the minimum help required to enable the candidate to proceed. In such instances the *Supervisor's Report* should be completed with the candidate's name and number, reporting to the Examiner the nature and extent of the assistance given. No help may be given to proceed with the analysis of their experimental data.

Any failure of equipment which, in the opinion of the Supervisor, may have disadvantaged any candidate should be detailed on the *Supervisor's Report*.

Turn over ►

Section B: EMPA written test

- The Section B EMPA written test should be taken as soon as convenient after completion of Section A.
- The test must be carried out under controlled conditions and must be completed in a single uninterrupted session.
- When carrying out the Section B EMPA written test, candidates should be provided with their completed copy of Section A Task 2 question paper/answer booklet.
- Supervisors should ensure that candidates understand that Section A Task 2 is for reference only and they must not make any written alterations to this previous work while undertaking Section B.
- The duration of the Section B EMPA written test is 1 hour 15 minutes except where candidates have been granted additional time.

Administration

Candidates must not bring any paper-based materials into any session or take any assessment materials away at the end of a session. Mobile phones or other communication devices are not allowed.

Modifications

The equipment requirements for the experimental tasks are indicated on these Instructions. Centres are at liberty to make any reasonable minor modifications to the apparatus which may be required for the successful working of the experiment but it is advisable to discuss these with the Assessment Adviser or with AQA. A written explanation of any such modification must be given in the *Supervisor's Report*.

Absent candidates

Candidates absent for any of the Section A Tasks should be given an opportunity to carry out the tasks before attempting the Section B EMPA written test. In extreme circumstances, when such arrangements are not possible, the teacher can supply a candidate with class data. In this case, there will be no evidence for Task 1 or Task 2, so no marks can be awarded for Section A.

Redrafting

Candidates may make only one attempt at a particular EMPA and redrafting is **not** permitted at any stage during the EMPA.

The Supervisor's Report

Details to be given on the *Supervisor's Report* (page 24) should explain

- any part of the equipment provided that differs significantly from that specified in these Instructions
- any help given to candidates in those circumstances given on page 3.

Supervisors must also include any numerical data that is specified in the Instructions. This may involve the Supervisor performing an experiment before the test and collecting certain data. Such data should be given to the uncertainty indicated.

Note that the Examiners may rely heavily on such data in order to make a fair assessment of a candidate's work.

Security of assignments

Candidates' scripts and any other relevant materials, printed or otherwise, should be collected and removed to a secure location at the end of each session. Under no circumstances should candidates be allowed to remove question papers from the examination room.

Once completed, each candidate's EMPA should be collated in the following order.:

- Section A Task 1
- Section A Task 2
- Section B EMPA written test.

The assembled material should then be secured using a treasury tag.

Completed EMPAs are to be treated in the same manner as other completed scripts and should be kept under secure conditions before their despatch to the Examiner.

Submission of materials to the AQA Examiner

By the specified deadline centres should assemble and then despatch the following materials:

- collated candidates' scripts, in candidate number order
- the *Supervisor's Report* (page 24 of these Instructions)
- a completed *Candidate Record Form* for each candidate, arranged in candidate number order
- a completed *Centre Declaration Sheet*.

Section A Task 1

Candidates are to use a diffraction grating to observe the diffracted images of a slit, illuminated by light from an LED.

Question 1

Apparatus

For the circuit to be used in Question 1

- dc voltage supply, capable of providing a continuously variable terminal pd up to 6.0 V, current to be set by the candidate at 20 mA for either position of the switch (note that for a given terminal pd the current in the LED will differ by about 2 mA according to which colour of light is being emitted)
- SPDT switch, toggle or slide type, labelled S with positions labelled 'G' and 'R' according to which colour of light is being emitted
- 3 mm Red/Green/Yellow tri-colour LED, RAPID 56-0620:
for technical details see <http://www.rapidonline.com/netalogue/specs/56-0620.pdf>
- milliammeter, capable of reading currents to 1 mA; maximum current should not exceed 25 mA
- 220 Ω resistor, 0.5 W or 0.6 W, RAPID 62-0542
- connecting leads (and strip-board if circuit is to be soldered)

Other equipment

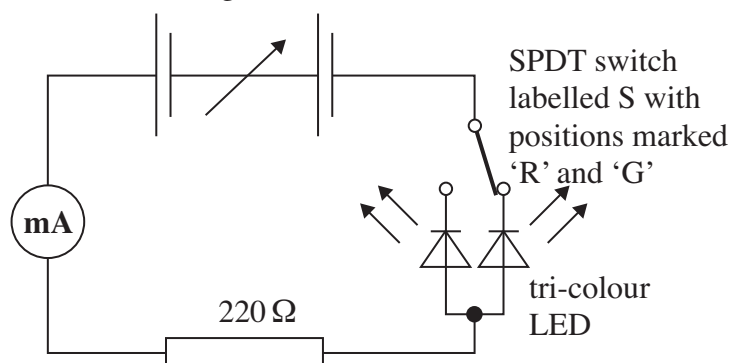
- rectangular piece of stiff card or mounting board, 25 \times 15 cm
- **Insert 1** to these instructions, see page 8, to be removed and then glued to the card; this provides a mm scale against which candidates may view the diffracted images of the slit; this will need to be copied for each candidate
- two new razor blades of traditional type, to form a narrow parallel slit
- diffraction grating with 300 lines per mm, e.g. RAPID 52-9006, but also available from a wide range of educational suppliers
- half-metre ruler and set-square
- three retort stands, each fitted with boss and clamp
- Sellotape

The Supervisor should assemble the circuit shown in the diagram.

The diodes are connected in a common cathode configuration and will display red or green light.

Avoid connecting both diodes together since this will cause the diode to emit yellow light.

Note that the green anode is the short leg and the common cathode is the centre leg.



Cut out the rectangular aperture shown at the centre of the insert (which has been glued to the card) to form a rectangular hole of about 20 mm \times 5 mm.

Produce a narrow parallel slit less than 0.5 mm wide, by taping the razor blades over this hole on the side of the card not covered by the insert.

Position the half-metre ruler on the bench, perpendicular to the edge with the 500 mm graduation towards the edge of the bench; tape down the ruler to the bench. Use two retort stands to position the card with the slit in a vertical plane and at right angles to the ruler; the slit should be vertical and the side with the insert glued to it should face the edge of the bench. The slit should be directly above the 50 mm graduation on the ruler.

The LED should be positioned behind the slit so that the slit is evenly illuminated. Using the remaining retort stand and clamp, the grating should be clamped with the rulings vertical and the centre of the grating at the same height above the bench as the centre of the slit. The face of the grating should be at right angles to the ruler at the 450 mm graduation and the rulings on the grating should face the slit.

Any information on the grating giving the spacing of the rulings should be concealed from the candidate.

Orientate the stands so that it is possible for the candidates to use the set-square to determine the positions of the slit and the grating above the ruler.

Candidates will be instructed not to move the LED, slit or half-metre ruler, or the stand holding the grating.

The experiment can be set up with the room in a semi-darkened state. This will not affect the candidates' ability to carry out Question 2. It is suggested that spare circuits are available in case of emergency.

The Examiners require no information for this question.

Question 2

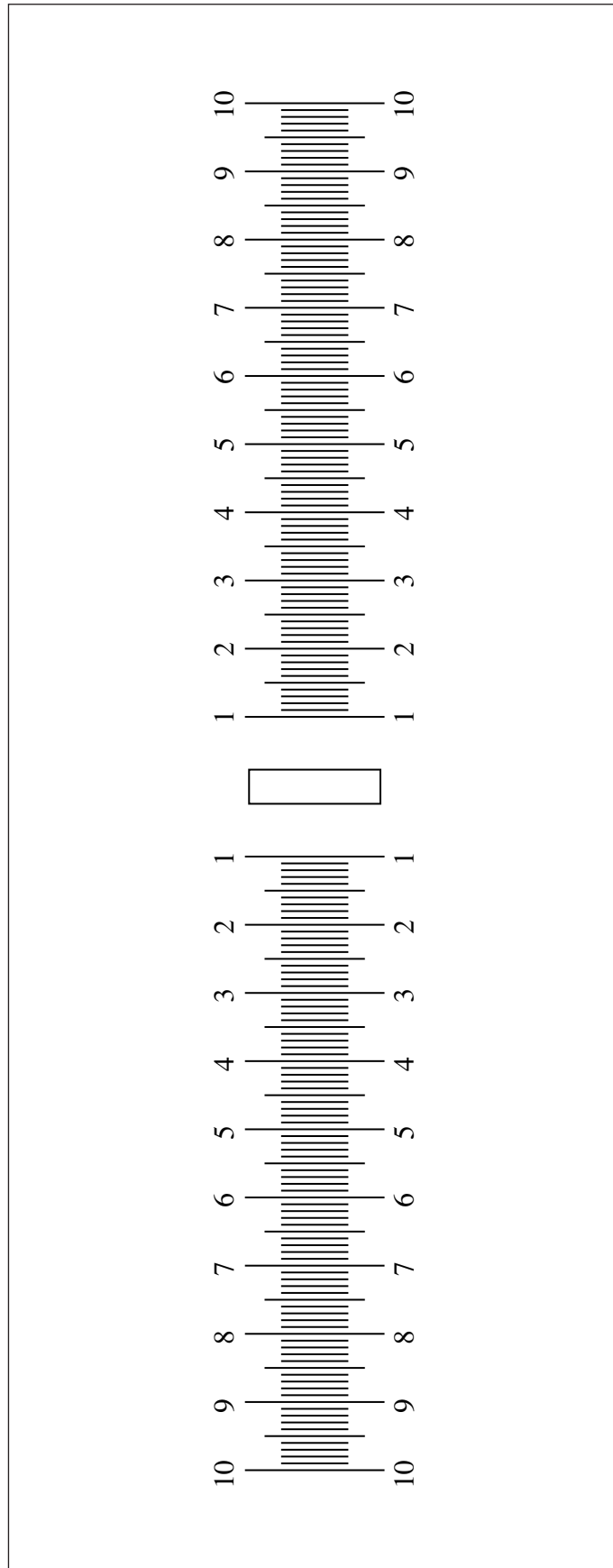
Candidates are to investigate a Moiré fringe interference pattern.

Apparatus

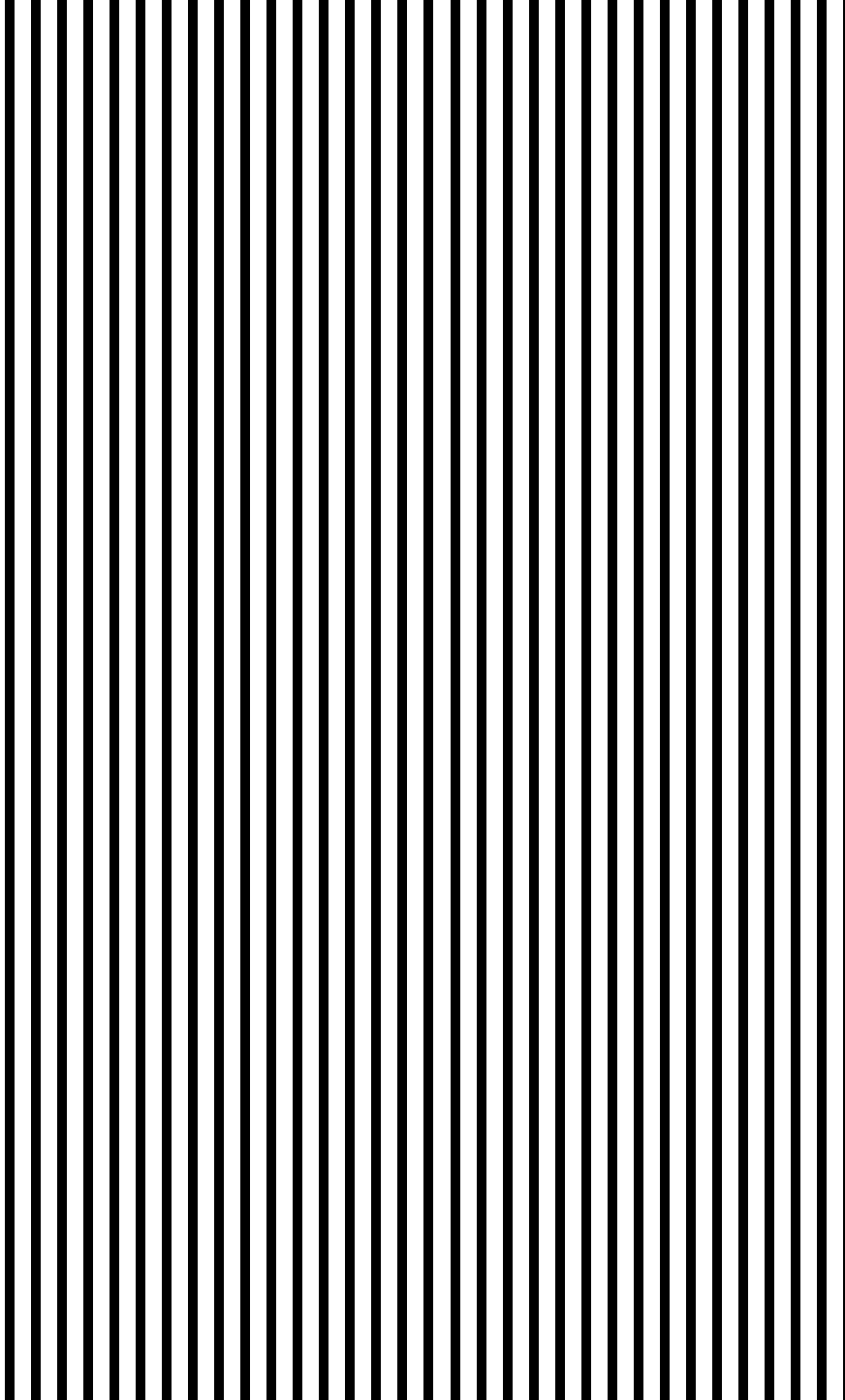
- **Insert 2** to these instructions, see page 9, to be photocopied, full scale, onto a transparency for each candidate; they will use this in conjunction with **Figure 4** in their question paper/answer booklet
- 300 mm Perspex ruler

Place the transparency and the ruler on the bench for the candidates' use. A fresh transparency should be provided for any candidate following on.

The Examiners require no information for this question.



Insert 1, to be removed and then glued to the card; this provides a mm scale against which candidates may view the diffracted images of the slit.



Insert 2, to be photocopied, full scale, onto an OHP transparency; candidates will use this in conjunction with **Figure 4** in their question paper/answer booklet.

Turn over ►

Section A Task 2

Candidates are to investigate the bending of a plastic metre ruler under its own weight.

Question 1

Apparatus

Candidates should assemble the apparatus for themselves

- vertical reading injection-moulded plastic metre ruler, cm and mm scales (Philip Harris B8A73889); horizontal reading ruler (B8A73878) may also be used but this will require one scale to be covered, e.g. with masking tape
- conventional wooden metre ruler
- retort stand fitted with two bosses, clamp attached in each; these are to be used to clamp the wooden metre ruler vertically
- optical pin or similar to act as pointer to be fixed at free end of plastic ruler; a small quantity of Blu-Tac or Sellotape should be provided for candidates to fix the pin in place
- small plane mirror
- wooden blocks and G-clamp to secure the fixed end of plastic ruler to the bench as shown in **Figure 5** of the question
- set-square

Place all this apparatus on the bench beforehand. No prior assembly required.

Examiners require no information for this question

Section B

Apparatus

- small plane mirror, as used in Section A Task 2

The mirror may be used to assist the candidates in making their gradient determinations.

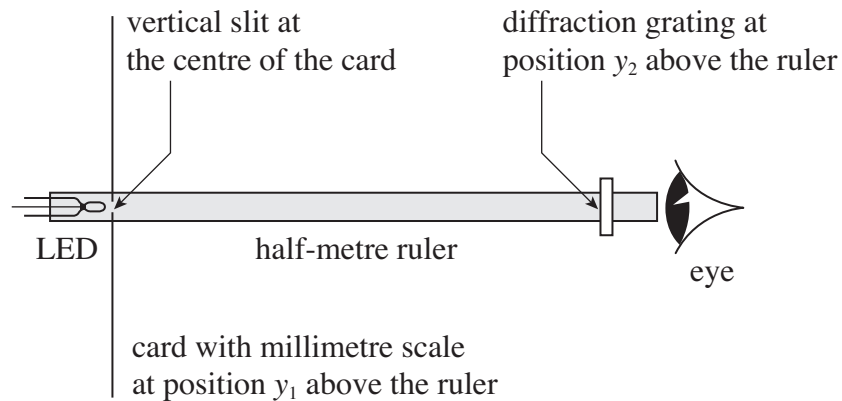
Note that when completing Section B of the test candidates should be provided with their completed copy of Section A Task 2, whereas candidates' copies of Section A Task 1 should **not** be made available to them.

Section A Task 1

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**.

$$y_1 = \dots\dots\dots$$

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**.

$$y_2 = \dots\dots\dots$$

(1 mark)

Turn over ►

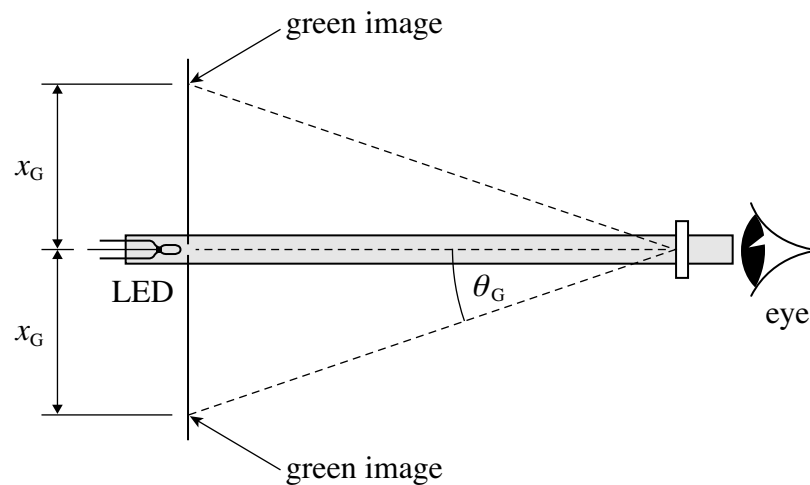
- 1 (b) The LED will emit green or red light depending on the setting of switch S. Set the switch to the position marked G and adjust the output voltage of the power supply until the current in the LED is 20 mA. View the slit through the grating with your eye close to the grating and observe the diffracted 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.
- 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. (2 marks)

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

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.

1 (c) (ii) Evaluate $\frac{\sin \theta_R}{\sin \theta_G}$. (3 marks)

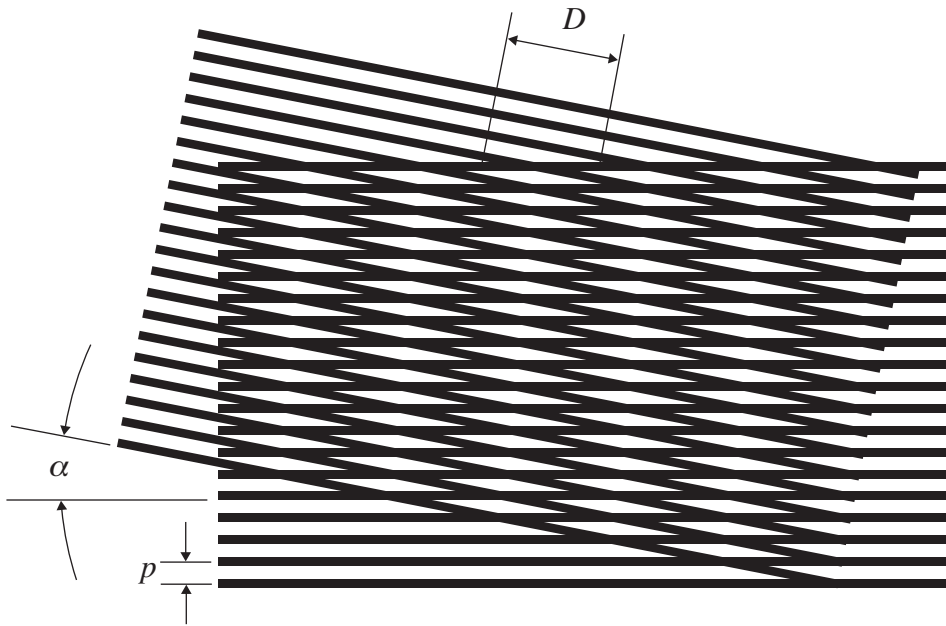
1 (d) Explain how you could determine the spacing of the lines on the diffraction grating you used. In your answer

- 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.

(4 marks)

- 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 16 of these notes.
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**.
- 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.

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

(3 marks)

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

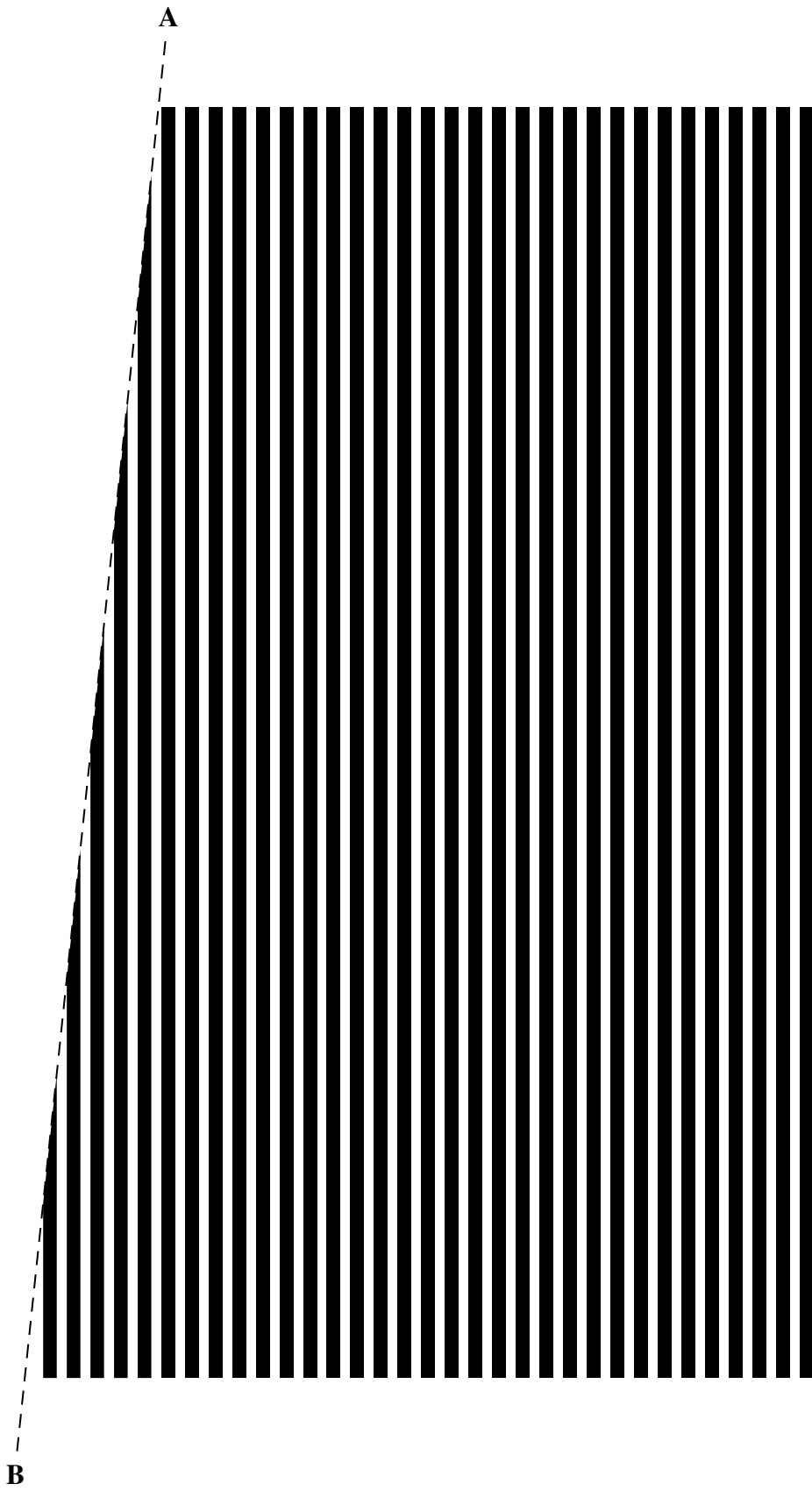
(1 mark)

4

END OF QUESTIONS

Turn over ►

Figure 4



END OF QUESTIONS

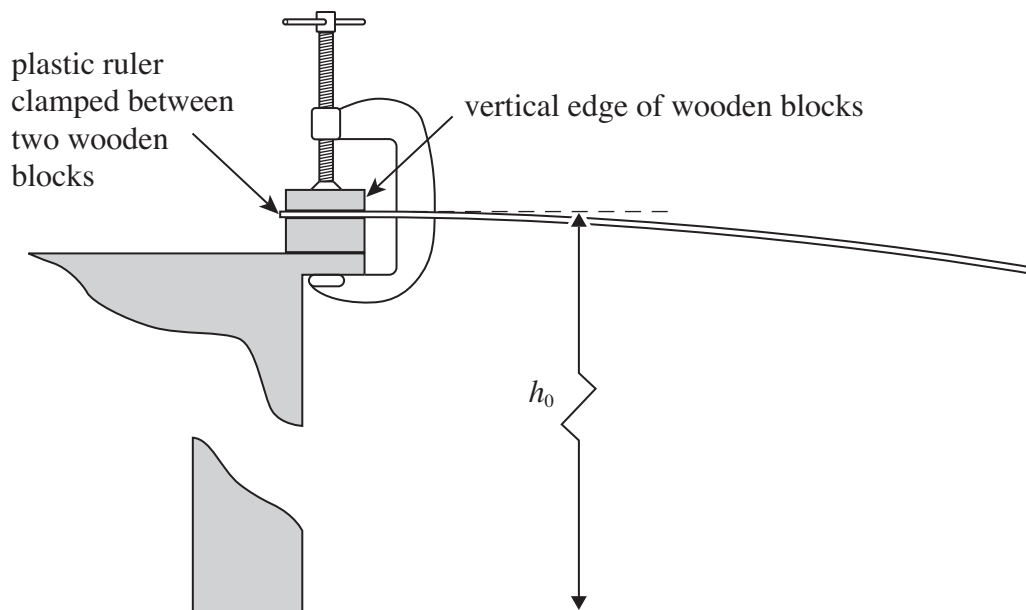
Section A Task 2

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



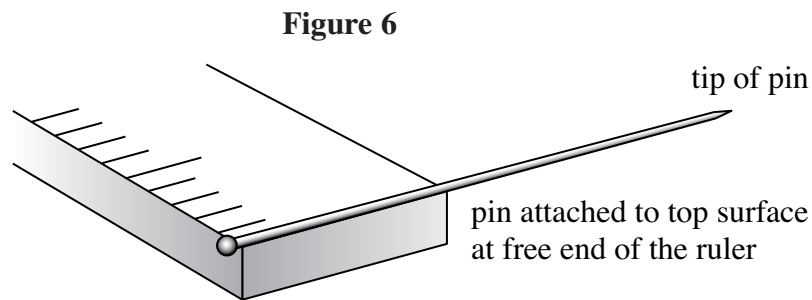
Measure and record h_0 , the vertical height between the top of the plastic ruler and the floor, at the end where the ruler is clamped between the wooden blocks.

$h_0 = \dots\dots\dots$

(1 mark)

Turn over ►

- 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**.



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

Section B

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

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 $x = 750$ mm.

1 (a) (ii) Determine the gradient, G_2 , of your graph, at $x = 650$ mm. *(3 marks)*

1 (b) Evaluate $\frac{G_1}{G_2}$. *(2 marks)*

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

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.

(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.

(3 marks)

6

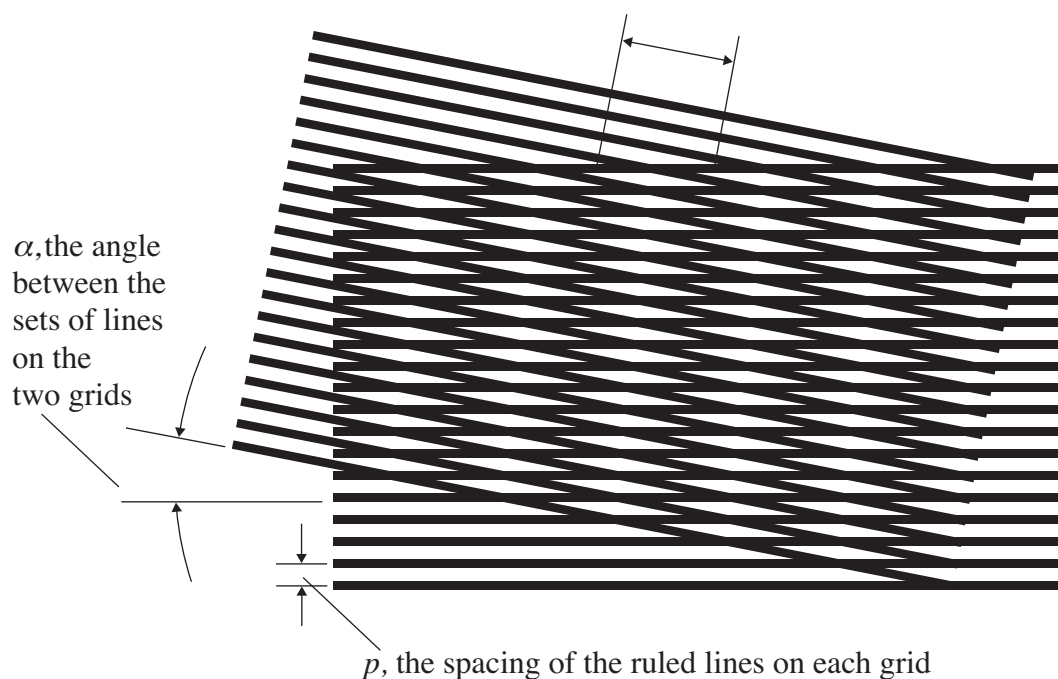
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Turn over ►

- 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

D , the perpendicular distance
between adjacent Moiré fringes



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, $D \approx \frac{57p}{\alpha}$, 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.

$\alpha / ^\circ$	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.

(4 marks)

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

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.

(2 marks)

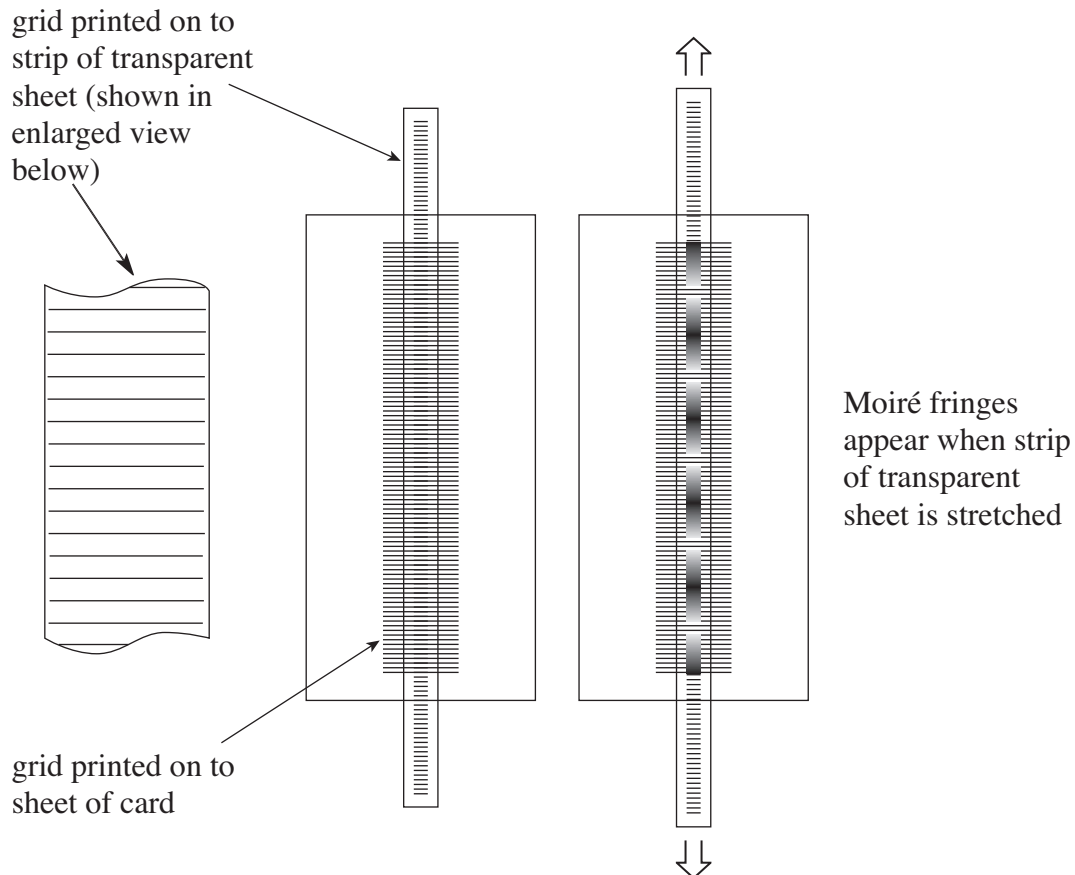
- 3 (c) The theoretical separation of the Moiré fringes when $\alpha = 2^\circ$, shows $D = 0.0859$ mm. Calculate the percentage difference between this value and the student's spreadsheet result for D when $\alpha = 2^\circ$.

(2 marks)

- 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.
- (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).
- (1 mark)*

7

END OF QUESTIONS

General Certificate of Education
June 2010
Advanced Subsidiary Examination



**PHYSICS (SPECIFICATIONS A AND B) PHA3/B3/XTN
Unit 3**

SUPERVISOR'S REPORT

When completed by the Supervisor, this Report must be attached firmly to the attendance list, before despatch to the Examiner.

Information to be provided by the centre.

Section A Task 1

Question 1 No information is required.

Question 2(a) No information is required.

Section A Task 2

Question 1 No information is required.

Supervisor's Signature

Centre Number

Date

Centres may make copies of this Supervisor's Report for attachment to individual scripts where necessary.