PHYSICS
EXPERIMENTS
(LIGHT)

'In the matter of physics, the first lessons should contain nothing but what is experimental and interesting to see. A pretty experiment is in itself often more valuable than twenty formulae extracted from our minds.' - *Albert Einstein*

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LEAVING CERTIFICATE PHYSICS

LISTED EXPERIMENTS

CONTENTS

LIGHT

Experiment at Higher Level only*

NOTE

For examination purposes any valid method will be acceptable for describing a particular experiment unless the syllabus specifies a particular method in a given case.
Students will be expected to give details of equipment used, assembly of equipment, data collection, data manipulation including graphs where relevant. Students will also be expected to know the conclusion or result of an experiment and appropriate precautions.

SAFETY

1. The Leaving Certificate Physics syllabus states on page three:

    'Standard laboratory safety precautions must be observed, and due care must be taken when carrying out all experiments.
    The hazards associated with electricity, EHT, lasers etc. should be identified where possible, and appropriate precautions taken. The careful use of sources of ionising radiation is essential. It is important that teachers follow guidelines issued by the Department of Education and Science.'

2. The guidelines referred to here consist of two books, which were published by the Department of Education in 1997. The books are

    'Safety in School Science'

    and

   'Safety in the School Laboratory (Disposal of chemicals)'

    When these books were published they were distributed to all schools. They have been revised and are available on the 'physical sciences initiative' web site at www.psi-net.org in the 'safety docs' link of the physics section.

3. Teachers should note that the provisions of the Safety, Health and Welfare at Work Act, 1989 apply to schools. Inspectors appointed under that act may visit schools to investigate compliance.

MEASUREMENT OF THE FOCAL LENGTH OF A CONCAVE MIRROR

Apparatus

Concave mirror, screen, lamp-box with crosswire.
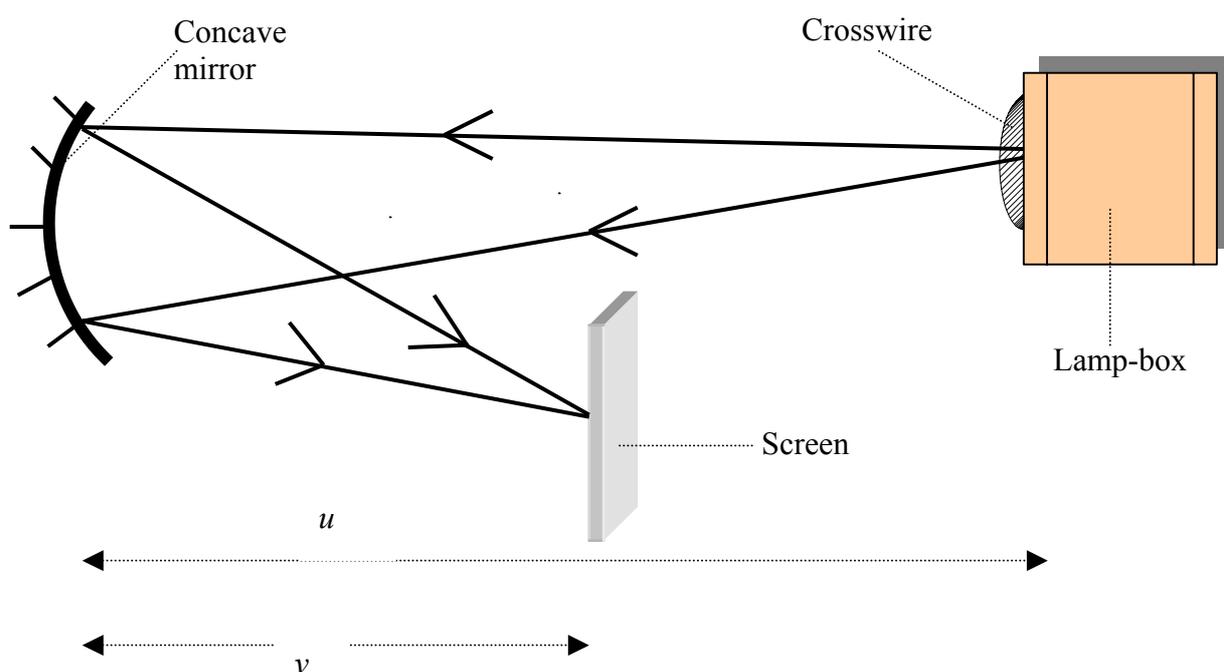
Procedure

1. Place the lamp-box well outside the approximate focal length - see notes.
2. Move the screen until a clear inverted image of the crosswire is obtained.
3. Measure the distance u from the crosswire to the mirror, using the metre stick.
4. Measure the distance v from the screen to the mirror.
5. Calculate the focal length of the mirror using $\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$.
6. Repeat this procedure for different values of u.
7. Calculate f each time and then find an average value.

Results

| u/cm	$\dfrac{1}{u}$ /cm^{-1}	v/cm	$\dfrac{1}{v}$ /cm^{-1}	$\dfrac{1}{f}$ /cm^{-1}	f/cm

Average $f =$

Notes

The approximate method for finding the focal length is recommended as a starting point for this experiment. The approximate method is described in the Appendix.

A microscope lamp makes a very suitable strong light source. Cover the glass of the lamp with a piece of tracing paper. Use 'peel-and-stick' letters to create an 'object' on the tracing paper.

VERIFICATION OF SNELL'S LAW OF REFRACTION

Apparatus

Glass block, lamp-box, 0-360^0 protractor, (photocopied from page 56 of Physics A Teacher's Handbook)   .

Lamp-box

0 - 360° Protractor

Glass Block

i

A

B

r

C
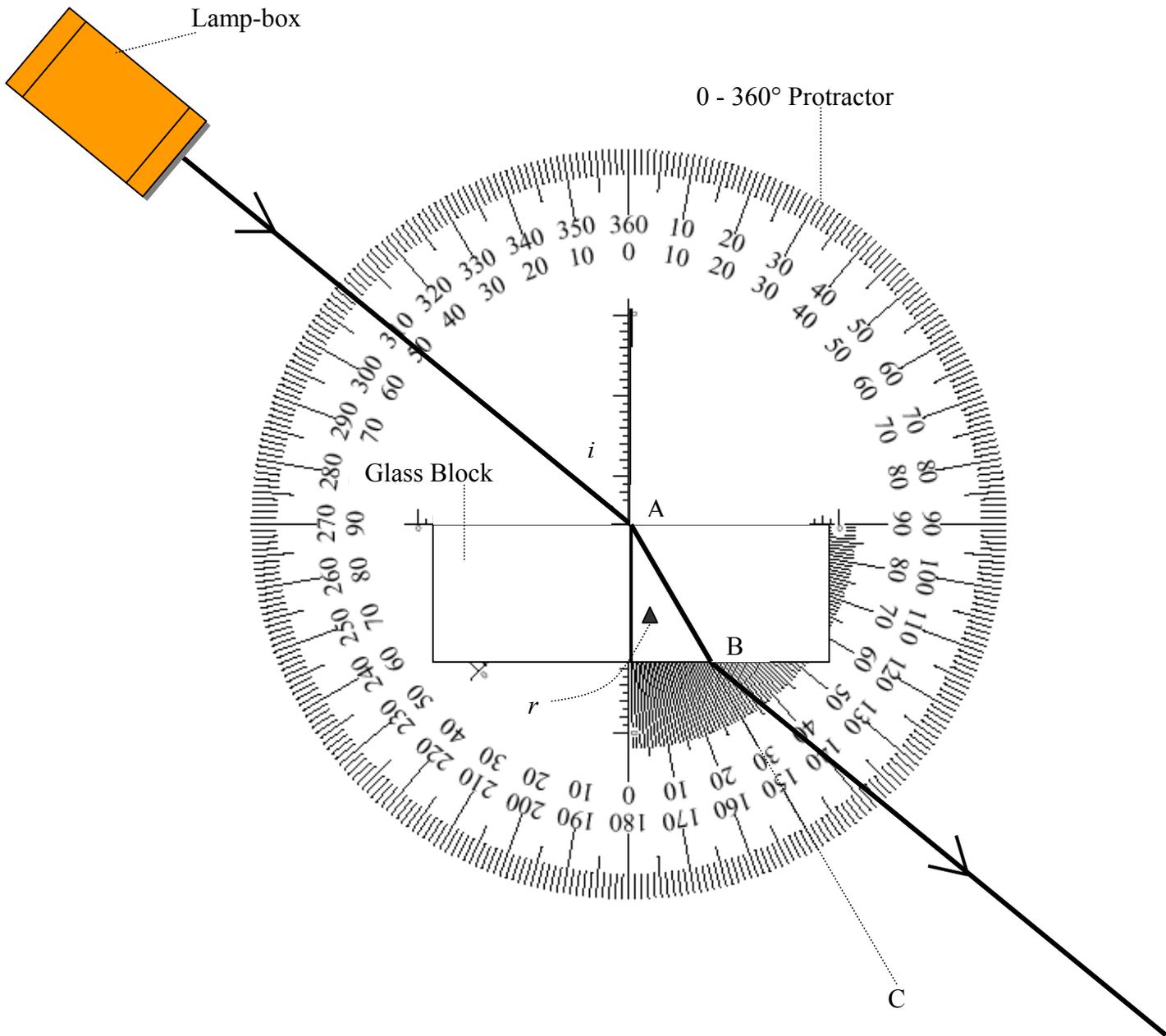
Procedure

1. Place a glass block on the 0-360^0 protractor in the position shown on the diagram and mark its outline.
2. Shine a ray of light from a lamp-box at a specified angle to the near side of the block and note the angle of incidence.
3. Observe the ray of light leaving the glass block and similarly mark the exact point B where it leaves the glass block.
4. Remove the glass block. Join BA and extend to C.
5. Note the angle of refraction r.
6. Repeat for different values of i.
7. Draw up a table as shown.
8. Plot a graph of sin i against sin r.

Results

$i/°$	$r/°$	sin i	sin r	$\dfrac{\sin i}{\sin r}$

Average value of $\dfrac{\sin i}{\sin r} =$

A straight line through the origin verifies Snell's law of refraction i.e. $\sin i \propto \sin r$.

The slope of the line gives a value for the refractive index of glass.

The refractive index of glass is equal to the average value of $\dfrac{\sin i}{\sin r}$.

Notes

Look directly down through the glass or plastic block to measure the angle of refraction.

Print the 360° protractor directly from page 56 of 'Physics A Teachers Handbook' to obtain the clearest delineation of the marked angles.
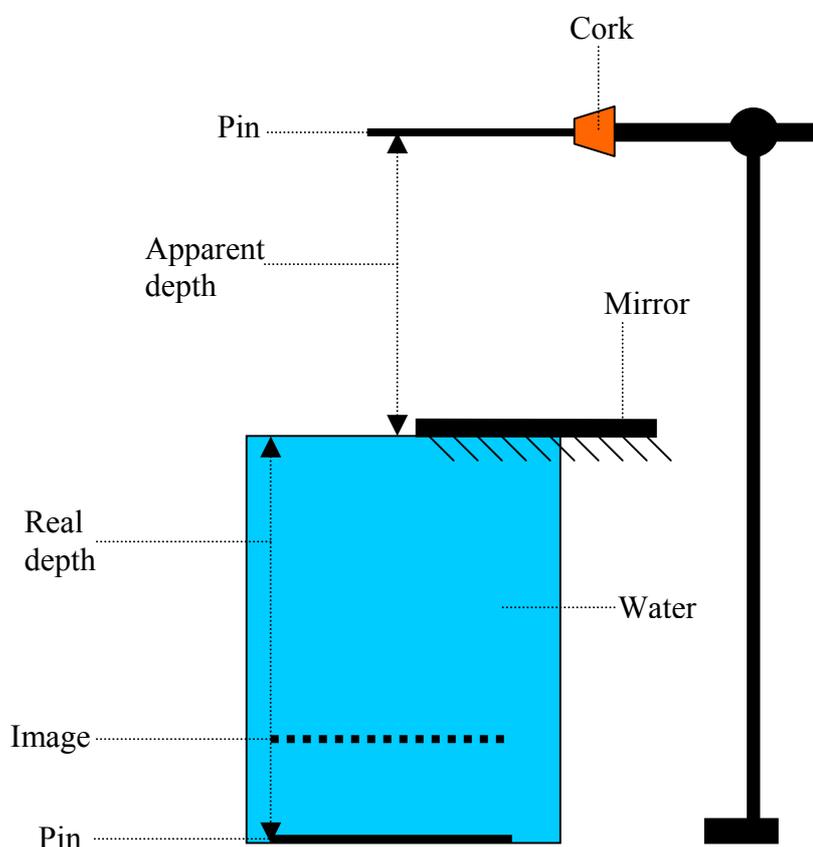
A semi-circular glass block can be used instead of the rectangular block.

A commercial model of the 360° protractor is also available. The model has a 'rotating' protractor housed in a horizontal rectangular base.

MEASUREMENT OF THE REFRACTIVE INDEX OF A LIQUID

Apparatus

Plane mirror, two pins, cork, retort stand, large containers.

Procedure

1. Fill a container to the top with water.
2. Place the plane mirror to one side on top of the container.
3. Put a pin on the bottom of the container.
4. Adjust the height of the pin in the cork above the mirror until there is no parallax between its image in the mirror and the image of the pin in the water.
5. Measure the distance from the pin in the cork to the back of the mirror – this is the apparent depth.
6. Measure the depth of the container – this is the real depth.
7. Calculate the refractive index, $n = \dfrac{\text{real depth}}{\text{apparent depth}}$.
8. Repeat using different size containers and get an average value for n.
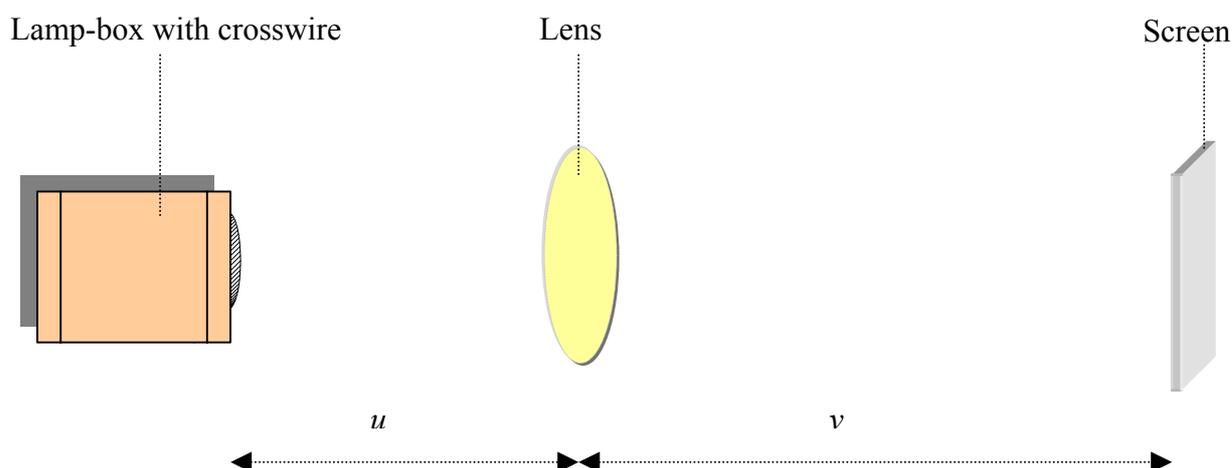
Results

real depth/cm	apparent depth/cm	$n = \dfrac{\text{real depth}}{\text{apparent depth}}$

Average $n =$

MEASUREMENT OF THE FOCAL LENGTH OF A CONVERGING LENS

Apparatus

Converging lens, screen, lamp-box with crosswire, metre stick, retort stand.

Lamp-box with crosswire   Lens   Screen

u v

Procedure

1. Place the lamp-box well outside the approximate focal length – see notes.
2. Move the screen until a clear inverted image of the crosswire is obtained.
3. Measure the distance u from the crosswire to the lens, using the metre stick.
4. Measure the distance v from the screen to the lens.
5. Calculate the focal length of the lens using $\dfrac{1}{f} = \dfrac{1}{u} + \dfrac{1}{v}$.
6. Repeat this procedure for different values of u.
7. Calculate f each time and then find the average value.

Results

| u/cm	$\dfrac{1}{u}$ /cm^{-1}	v/cm	$\dfrac{1}{v}$ /cm^{-1}	$\dfrac{1}{f}$ /cm^{-1}	f/cm

Average $f =$

Notes

The approximate method for finding the focal length is recommended as a starting point for this experiment. The approximate method is described in the Appendix.

A microscope lamp makes a very suitable strong light source that can be used in daylight. Cover the glass of the lamp with a piece of tracing paper. The tracing paper can be attached with some bluetack. Use 'peel-and-stick' letters to create an 'object' on the tracing paper. If the 'object' is a simple three-letter word then the inversion of the image will be obvious.

MEASUREMENT OF THE WAVELENGTH OF MONOCHROMATIC LIGHT

Apparatus

Sodium lamp, spectrometer and diffraction grating (300 lines per mm).
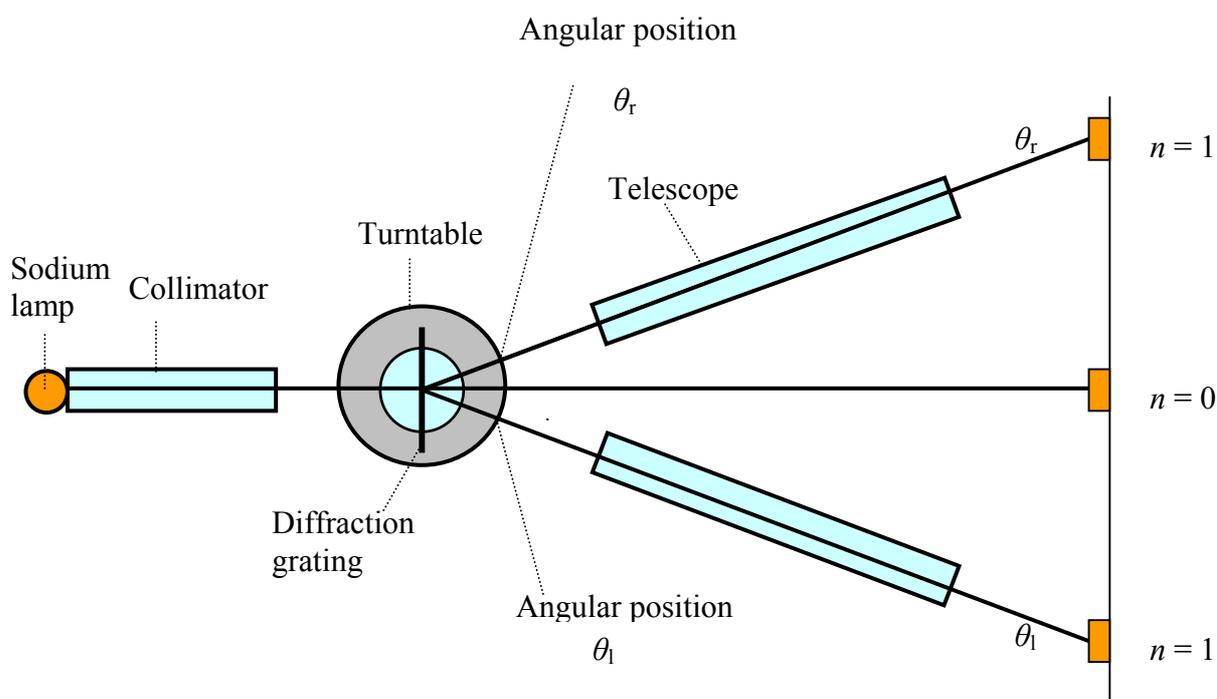
Procedure

1. Adjust the eyepiece of the telescope so that the crosswires are sharply focused.
2. Focus the telescope for parallel light using a distant object. There should be no parallax between the image seen in the telescope and the crosswires seen through the eyepiece.
3. Place the sodium lamp in front of the collimator.
4. Level the turntable of the spectrometer if necessary.
5. Looking through the telescope, focus the collimator lens and adjust the width of the slit until a clear narrow image is seen.
6. Place the diffraction grating on the turntable at right angles to the beam.
7. Move the telescope to the right until the cross wires are centred on the first bright image. Take the reading θ_r from the scale on the turntable. (To see the scale more easily shine a lamp on it and use a magnifying lens).
8. Move the telescope back through the centre and then to the first bright image on the left.
9. Take the reading θ_l from the scale.
10. Calculate θ using $\theta = \dfrac{\theta_r - \theta_l}{2}$.

11. Calculate the distance d between the slits using $d = \dfrac{1}{N}$ where N is the number of lines per metre on the grating.
12. Calculate the wavelength λ using $n\lambda = d \sin \theta$.
13. Repeat this for different orders (n) and get an average value for the wavelength.

Results

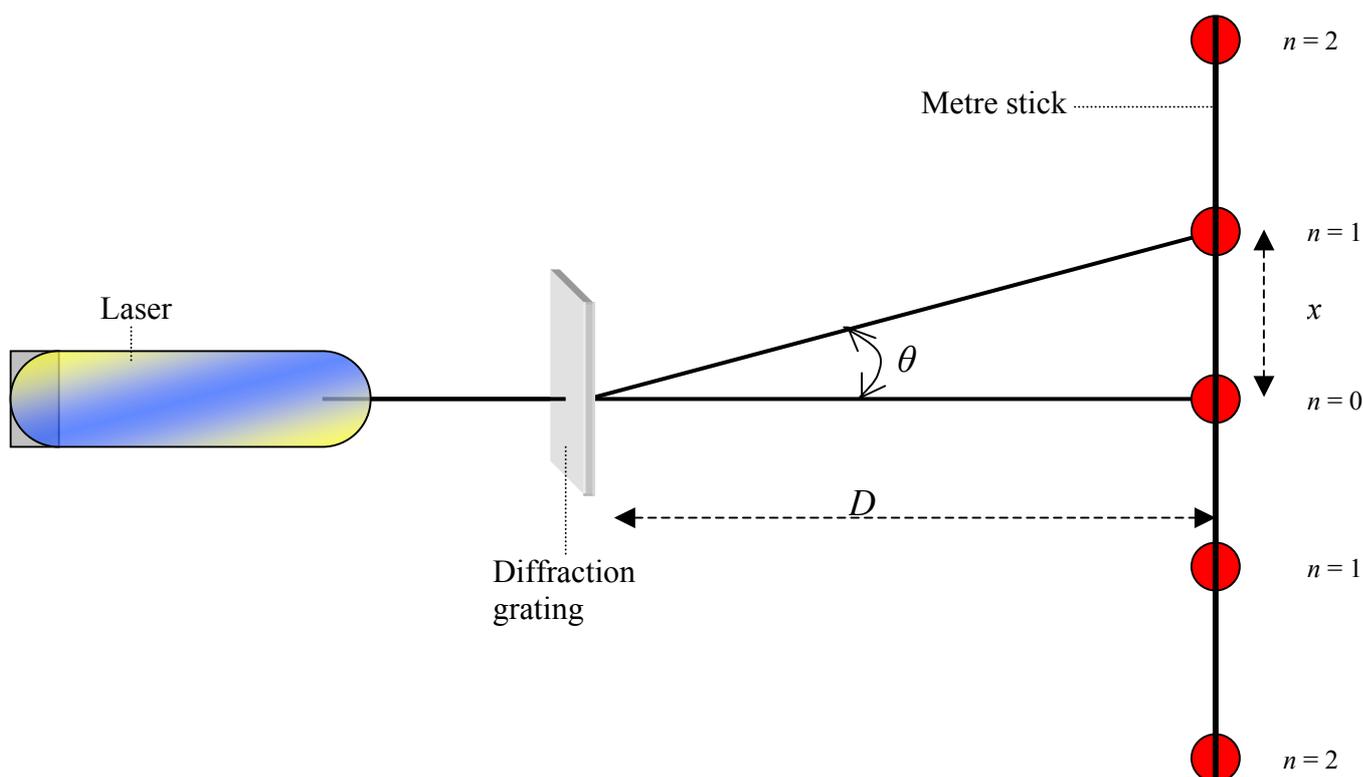| n	θ_r/ °	θ_l/ °	$\theta = \dfrac{\theta_r - \theta_l}{2}$ / °	λ/m

Average λ =

MEASUREMENT OF THE WAVELENGTH OF MONOCHROMATIC LIGHT (using the laser)

Apparatus

Laser, diffraction grating (600 lines per mm), 2 metre sticks.

Procedure

1. Clamp a metre stick horizontally in a stand.
2. Allow the laser beam to hit the metre stick normally (at 90 °).
3. Move the metre stick sideways until the spot is on the 50 cm mark.
4. Place the grating between the laser and the metre stick, at right angles to the beam.
5. Observe the interference pattern on the metre stick – a series of bright spots.
6. Calculate the mean distance x between the centre (n=1) bright spot and the first (n =1) bright spot on both sides of centre.
7. Measure the distance D from the grating to the metre stick.
8. Calculate θ using $\tan\theta = \dfrac{x}{D}$.
9. Calculate the distance d between the slits, using $d = \dfrac{1}{N}$, where N is the number of lines per metre on the grating.
10. Calculate the wavelength λ using $n\lambda = d\sin\theta$.
11. Repeat this procedure for different values of n and get the average value for λ.

Results

n	x/m	D/m	$\theta/\degree$	λ/m

Average λ =