This document contains resources to support the teaching of AQA AS and A-level sciences. Some of the resources on these pages are third party content produced for sharing.

Resource provided as an example of good practice by Zenos Christodoulides, at King David High School, Manchester.

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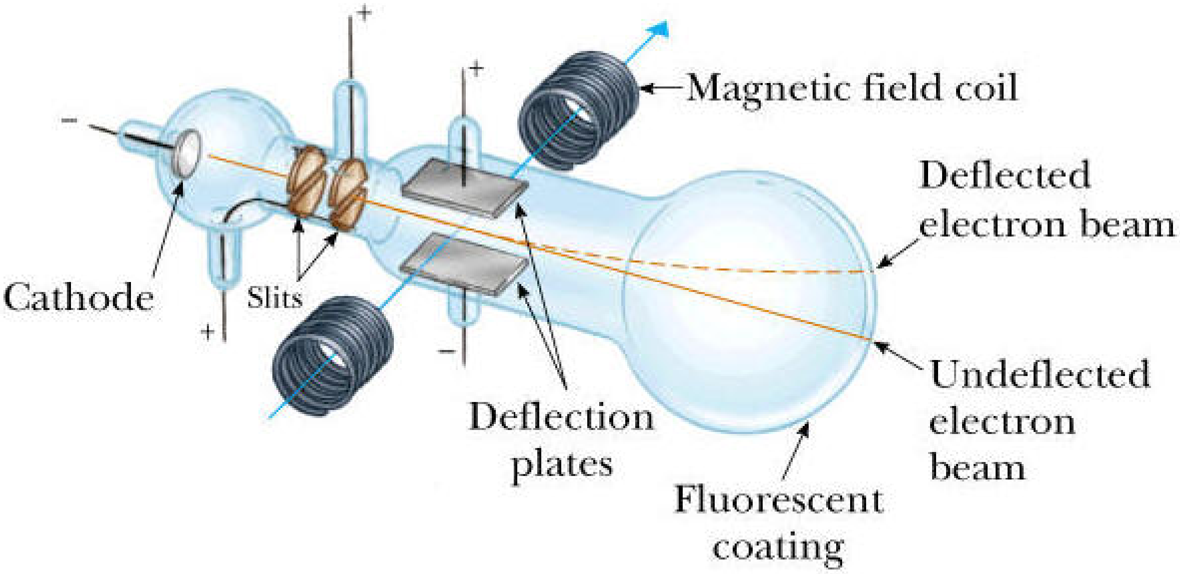
KDHS Physics AS Practicals



Student handbook

Introduction

This handbook details the necessary standard practicals that you will need to complete this academic year. The practicals should be completed in pairs and will be allocated on a rota basis. Your “practical buddy” will work with you for the whole course.

Please make sure that you prepare yourselves adequately beforehand for each practical. This means reading the notes *thoroughly* and doing the necessary background reading and research.

After each practical has been completed, you will need to write up the evaluation and analysis as well as carry out some other activities which have been designed to enhance your understanding of the physics involved.

Your practicals should be handed in by the requested deadline and you will then be given feedback.

Be aware that thorough familiarisation and understanding of the physics practicals is an essential part of your physics AS course. **You will be examined on these practicals in your written papers in the summer examinations**.

The cover image shows the apparatus used by J.J Thompson to discover the electron.

Physics AS Practical 0 - Estimation of errors

You are expected to research the following before attempting this practical: the Vernier scale; how a micrometer works; minimising absolute errors; and combining errors. Tabulate values where appropriate and don't forget to use the correct SI units in each case.

1. **Diameter and cross sectional area of a wire**

Use an appropriate instrument to measure the diameter of a wire. You should take ***several*** readings along the length of the wire and then use the precision of your instrument to record the error in each reading. Remember to then take the mean and estimate the overall uncertainty in the diameter as ±0.5 x spread (spread is maximum minus minimum value). Use your measured value of the diameter to calculate the cross sectional area of the wire along with the estimated error in the cross sectional area. Show your working clearly.

2. **Volume of a rectangular block**

Taking each dimension of the block along with its estimated uncertainty (this will be the precision of your instrument) and hence calculate the volume of the block and its associated uncertainty. How many significant figures should you quote overall? Show your working.

3. **Thickness of a sheet of paper**

Use an appropriate technique to measure the thickness of a single sheet of paper. Remember to use the rule that the uncertainty in the thickness will be ±0.5 x spread.

4. **Time period for simple pendulum**

Use an appropriate method to calculate the period of a simple pendulum of length 60cm. You should quote your period to an appropriate number of significant figures.

5. **Length of a kinked metal wire**

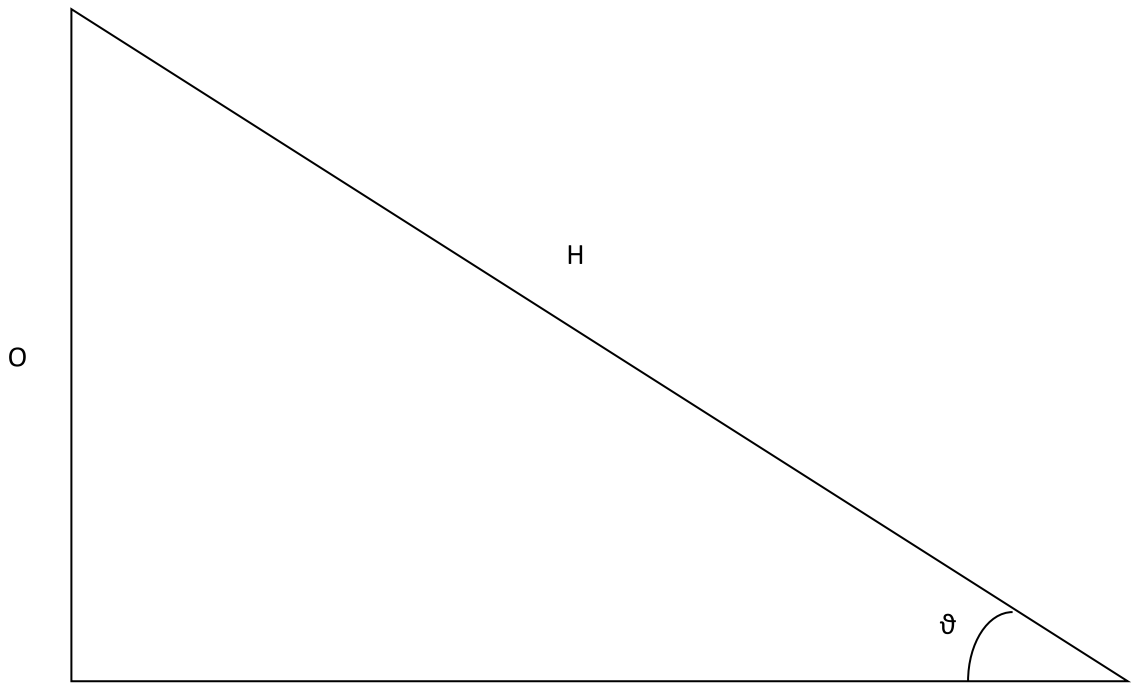
You are required to measure the length of a kinked metal wire. Your instrument precision (metre ruler) is ±1mm but the kinks in the wire will not allow this level of precision. You will need to make a reasonable estimate of the error in your answer.

6. **Angle measurement**

Use a protractor to measure the angle below and record the uncertainty. Compare the relative uncertainty of this method with measuring the length O and length H and then using the sine function to calculate the angle.

In all the above examples you should:

1. State the apparatus/equipment you used along with the precision of your instrument
2. Note the techniques and procedures you used, along with annotated diagrams
3. Note any potential risks/hazards and explain how to mitigate them
4. Record your observations accurately and methodically, using tables if necessary
5. Record any additional notes in your write up with sources of reference
6. Explain any decisions you had to make clearly



Estimation of Errors – example methods and analysis

These numbers do NOT necessarily correspond to the dimensions of your measurements. You must use your OWN readings!

1. Diameter of Wire

Precision of instrument = ± 0.01 mm

Diameter = 0.22 ± 0.01 mm

If several readings taken, take mean ± 0.5 x spread (if all identical, error is ± 0.01mm)

Area

Cross sectional area = 0.0380 mm^2 (Use $A = \pi r^2$ or $A = \frac{1}{4}\pi d^2$)

% error in diameter = (0.01 X 100)/0.22 = ± 4.5%

% error in area = 2 x 4.5% = ± 9 % (Using $\Delta A/A = 2\Delta d/d$)

2 Volume of Rectangular Block

Precision of instrument = ± 1mm

Length = 100 ± 1mm % uncertainty = ± 1%

Width = 60 ± 1 mm % uncertainty = ± 1.7%

Height = 40 ± 1 mm % uncertainty = ± 2.5 %

Uncertainty in volume = ± 5.2% (or just 5%) (Using $\Delta V/V = \Delta l/l + \Delta h/h + \Delta w/w$)

Volume = 240 ± 12 cm^3

BUT 5% error only justifies 2 s.f. therefore volume = 240 ± 10 cm^3

3. Thickness of single sheet of Paper

Thickness of 100 sheets = 9 mm ± 1mm (precision of ruler)

% error = (1 x 100)/9 = 11%

% error in a single sheet will also be 11%

Hence thickness of single sheet = 0.09 ± 0.01 mm

4. Time Period of a Simple pendulum

Length of pendulum = 60cm. Precision of stop clock = ± 0.01 s

Times for 10 oscillations: 15.75, 15.61, 15.43 s

Uncertainty = 0.5 x spread = 0.5 x 0.32 = 0.16 s

Mean time for 10 oscillations = 15.60 ± 0.16 i.e. error = ±1%

Same uncertainty in 1 oscillation

Time period = 1.56 ± 0.02 s (Error is too large to quote 1.560 s which would be 3.s.f.)

5. Length of Metal wire

Measured Length = 51.2 cm

Instrument precision = ± 1 mm **BUT** kinks in wire do not allow measurement to this precision. Estimate error to be ± 2 – 5 mm depending on amount of kinking

e.g. Length = 51.2 ± 0.3 cm

6. Angle Measurement

By protractor: Angle = $35^0 \pm 1^0$ (precision of protractor = 1^0)

By length measurements: length ‘o’ = 10.7 $\pm$ 0.1 cm % error = $\pm$ 0.9%

Length ‘h’ = 18.7 $\pm$ 0.1 cm % error = $\pm$ 0.5%

Total % error is approximately 1.4%, rounded to 1%

Using sine of angle = 10.7/18.7 Gives angle = 34.9^0

Assume uncertainty is approximately $\pm$ 1% (NB error in sine value is not exactly same as error in angle, but will be approximately the same in this instance)

Gives Angle = 34.9 ± 0.4^0

Physics AS Practical 1: Investigating standing waves on a string

Objective: to study the relationship between the tension in a stretched length of vibrating string and its various frequencies.

Preparation:

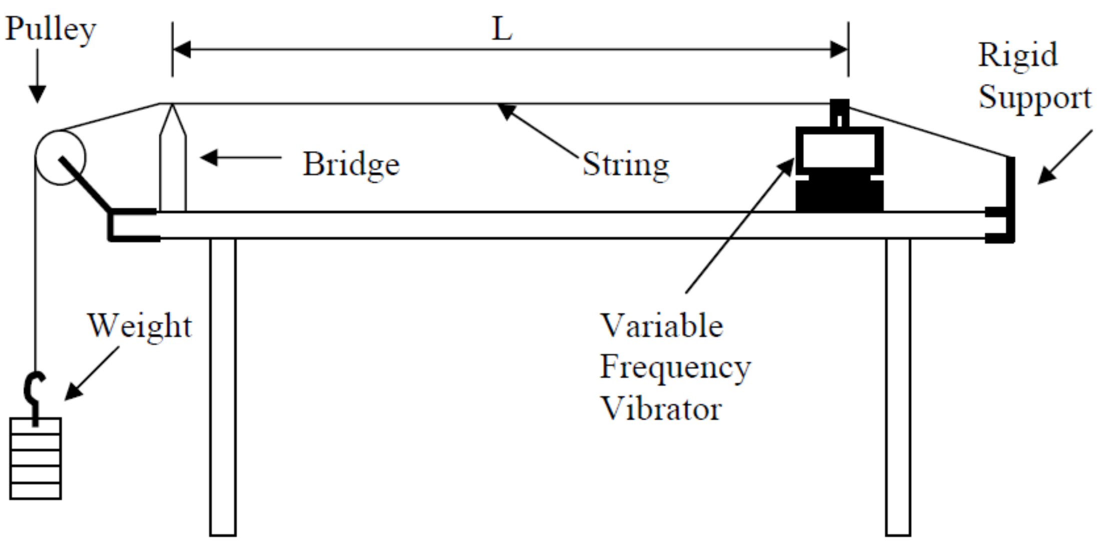
Watch these videos beforehand:

https://www.youtube.com/watch?v=-gr7KmTOrx0

https://www.youtube.com/watch?v=QcoQvzNQp6Q

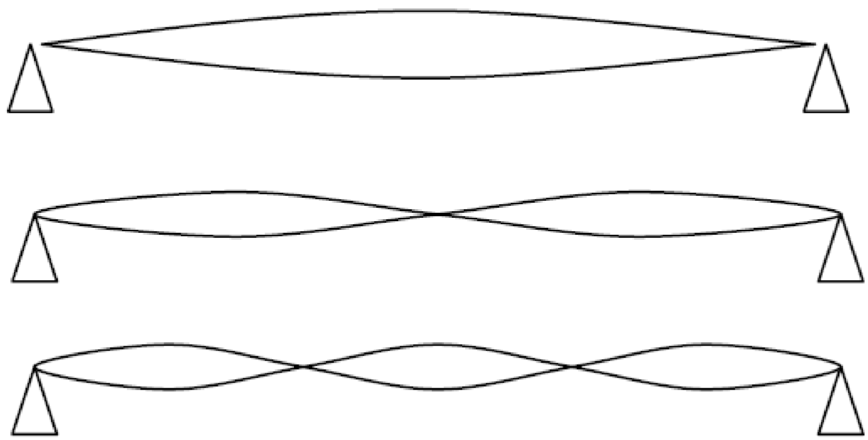
Introduction: A string under tension is one example of the many physical systems that show various modes of vibration with discrete, characteristic frequencies. The phenomenon of characteristic frequencies in a string can be understood as a superposition of two waves which travel in opposite directions. When these waves have the same frequency, the same amplitude, and when ***integral*** multiples of ***half*** the wavelength fit into the length between the string supports, then the result is a stationary mode of vibration, called a standing or stationary wave. Nodes are the locations along the string where there is no motion of the string. Antinodes are those points where the motion of the string is the greatest. The fixed ends of the string are nodes.

Procedure:



1. Set up the apparatus as shown in the Figure 2 above. Set L to 1m. Set the tension by making the suspended mass m=50g (this is just the mass holder on its own).

2. Adjust the frequency of the vibrator to get a standing wave pattern. Observe what happens as the frequency of the vibrator is slowly increased. Make sure you can get the patterns shown below – you will need to carefully adjust the frequency dial to get the best possible standing wave, with maximum amplitude (do this by adjusting the frequency dial and obtaining the maximum frequency by eye and then adjusting the frequency by +/- 0.1Hz at a time). These are called the modes of vibration, or characteristic frequencies. The lowest frequency, with one loop is called the fundamental. The next highest with two loops, is called the second harmonic and the one with three loops is call the third harmonic etc.



n = 1 (fundamental)

n = 2 (2^{nd} harmonic)

n = 3 (3^{rd} harmonic)

3. Now adjust the vibrator to obtain the fundamental again (at maximum amplitude) and record the value of the frequency. Increase the frequency until a maximum amplitude standing wave with 2 loops is obtained. Repeat to a maximum frequency of about 60 – 100 Hz. The wavelength **λ** for each standing wave pattern can be found from the equation **$\lambda = 2L/n$** where n = 1,2,3,4,5 and 6 and L is the distance shown in the apparatus set up. You should record frequency f (Hz) and wavelength λ (m) in a table. Create a column for 1/λ (m^{-1}) and calculate this quantity too (note the units).

4. Now fix the frequency of the vibrator to the fundamental again. Increase the mass on the end in 50g steps, each time readjusting the frequency to obtain the fundamental. Do this up to a maximum of 400g. You should record frequency f (Hz) against tension T (N) in the string. The tension can be found from the formula **T = mg**, where m is the mass and g = 9.8N/kg. Create a column for $\sqrt{T}$ (***with units $N^{1/2}$***) and calculate this quantity too.

5. Take a free length of the same string used in the experiment and measure both its length and its mass using a top pan balance. Obtain an estimate for the mass per unit length **μ** (kgm^{-1}) of the string by dividing the mass of the string by its length. Record the precision of your instruments.

Analysis and write up

6. Plot a graph of frequency **f** (Hz) against **1/λ** (m^{-1}) using your table in step 3 above. Obtain the gradient as well as the uncertainty in the gradient (using |best gradient – worst gradient|). State the units of the gradient. You may use appropriate graphing/tabulating software.

7. Plot a graph of frequency **f** (Hz) against √**T** ($N^{1/2}$) using your table in step 4 above. . Obtain the gradient as well as the uncertainty in the gradient, making use of error bars if necessary. State the units of the gradient.

Theory shows that the frequency of a stretched string varies according to the formula

$$f = \frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$

Where λ can be calculated from

$$\lambda = \frac{2L}{n}$$

for each of the values of n = 1, 2, 3 etc.

8. Using your first graph, you are keeping T constant at 0.49N. Your gradient m_1 in this case is equal to √ (0.49/μ). Use the gradient m_1 to obtain a value for μ.

9. Explain why $\Delta\mu/\mu = 2\Delta m_1/m_1$. Hence calculate the uncertainty in μ from your experiment. Use the uncertainties in length and mass of the string to calculate an uncertainty in μ from your directly measured value. How does your directly measured value of μ compare with the experiment?

10. In your second graph, you are keeping λ constant. Your gradient m_2 in this case is equal to $1/\lambda\sqrt{\mu}$. Show that $\Delta m_2/m_2 = \Delta\mu/\mu$ and use this gradient to obtain another value for μ. How does your calculated value of μ now compare with the directly measured value?

11. What are the sources of error for this experiment? How would you minimise these?

12. Write a brief risk assessment for this experiment, highlighting precautions and any additional safety equipment that would minimise the risks further.

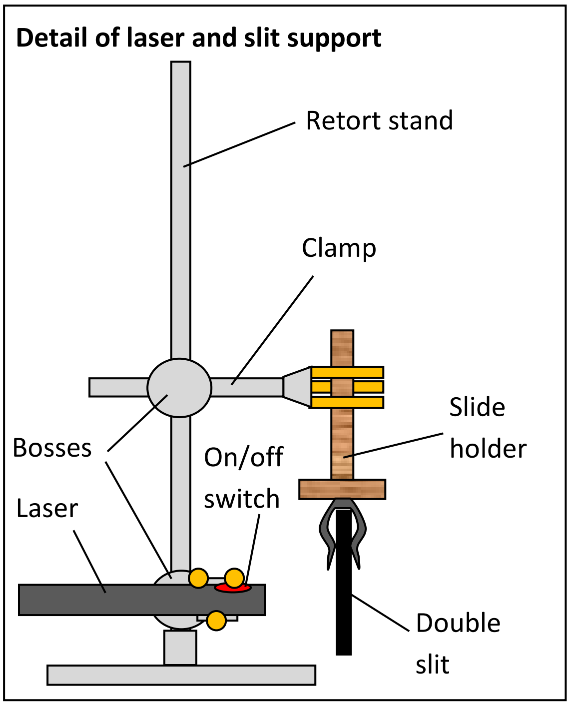
To include as part of your write up:

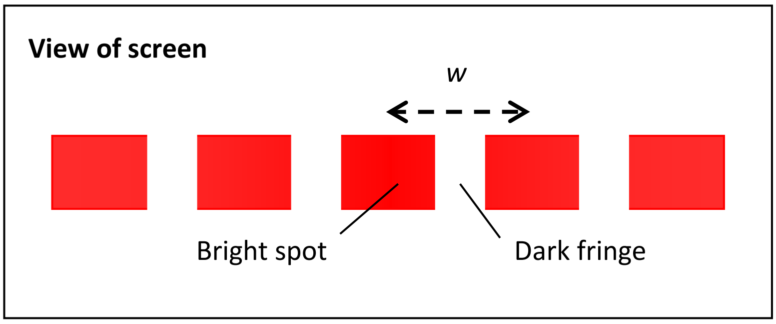
How would you run a similar experiment to investigate how frequency f varies with mass per unit length μ of a wire?

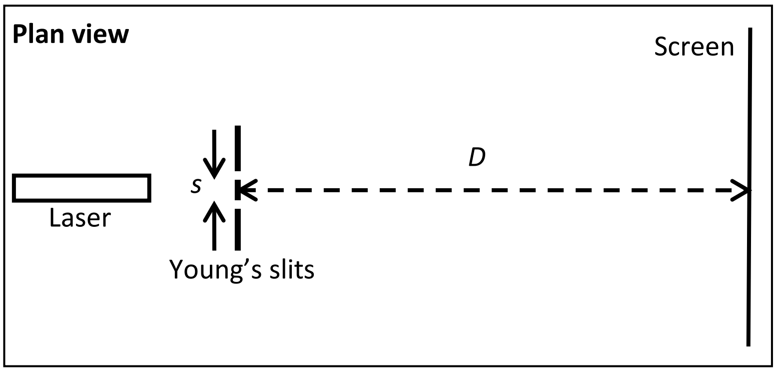
You should discuss the apparatus you would use, the readings you would take and how you would carry out the experiment. Don't forget to include a clear, labelled diagram.

Write a brief risk assessment for this new experiment. Make sure you also quote any references you used in your research. If you use websites, make sure to also note the access date.

Physics AS Practical 2a: Young's two slit experiment







Preparation

1. Watch this video:

https://www.youtube.com/watch?v=Iuv6hY6zsd0

2. Find out what is meant by coherent light. Why does the light have to be coherent in this experiment? Laser light is coherent – can coherent light be obtained without a laser?

3. How would the experiment change if you used light of a different wavelength?

Introduction

When **coherent monochromatic** light is shone through a pair of slits of separation similar to the wavelength of the light will produce a series of bright and dark interference fringes on a screen.

The separation of the fringes is given by

$$w = \frac{\lambda D}{s}$$

Where *w* = fringe spacing; λ = wavelength of light; *s* = slit separation; *D* = distance from slits to screen.

Provided the distance to the screen is much greater than the slit separation.

Therefore, for large enough distance between the slits and the screen a graph of *w* against *D* should be a straight line, with a gradient given by λ/*s*.

Risk Assessment

4. What are the risks associated with this experiment? Write a brief risk assessment and highlight precautions and equipment that will minimise the risks.

Procedure

Record all your readings in an appropriate manner.

5. Look at the available slits. Which slit separation, s should you choose and why?
6. Set up the apparatus as shown, choosing a suitable value for the distance, *D*, between the slits and the screen.
7. Measure the fringe spacing, *w*, think about ways to reduce the uncertainty on this measurement.
8. Change the distance between the slits and the screen.
9. Take repeat readings.

Analysis

10. Plot a graph of *w* against *D.* Use error bars for w. You may use appropriate graphing software.
11. Find the gradient m of the best fit line and the uncertainty in your gradient from (worst gradient – best gradient).
12. What was the precision of the travelling microscope you used to measure the slit separation?
13. Calculate the percentage uncertainty on the slit separation.
14. Using your measurement of the slit separation, s, determine the wavelength, λ, of the laser light you used from your measured gradient. Show that $\Delta\lambda/\lambda = \Delta m/m + \Delta s/s$ and use this to determine the uncertainty in λ.

Evaluation

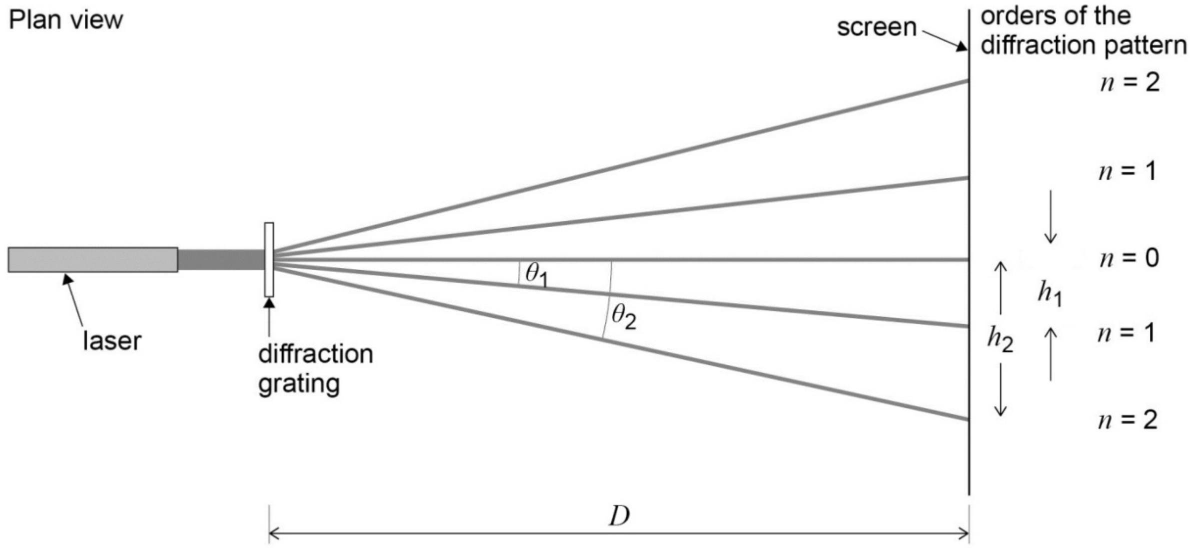
15. Explain why you chose the range of values of the distance from the slits to the screen, *D*, that you used in your experiment.
16. Describe the steps you took to minimise errors in your experiment.
17. This question concerns the error on your measurement of the fringe spacing, *w*.
    a. State and explain which value of the distance from the slits to the screen, *D*, you would expect to lead to the largest percentage error on the fringe spacing.
    b. Calculate the precision of your measurement of the fringe spacing for this distance from the slits to the screen.
18. Discuss whether your experiment is reliable or not.

To include in your write up:

Describe how you would carry out an experiment to investigate how sound behaves with a two-slit type of arrangement. You should discuss the apparatus you would use, the readings you would take and how you would carry out the experiment.

Don't forget a clear labelled diagram. Write a brief risk assessment for this new experiment. Make sure you quote any references you used in your investigation.

Physics AS Practical 2b: Diffraction grating experiment



Preparation

You should research the use of a diffraction grating and explain how it works. You must note your reference sources including any websites with date of access.

Method

1. A partially darkened laboratory is required. Please ensure lasers are used safely. Write down a risk assessment accordingly.
2. Which diffraction grating did you choose? What are the number of lines per mm on tis grating?
3. Set up the apparatus as shown in the diagram, with the laser illuminating the diffraction grating and the screen a distance *D* of initially about 1 metre. Explain how you ensured the laser was horizontal and record your initial value of D with the appropriate uncertainty.
4. Carefully adjust the position of the diffraction grating so that the diffraction grating is perpendicular to the beam of light from the laser. (A large set square might be useful).
5. The diffraction pattern should be visible on the screen. The number of orders shown will depend on the line spacing of the diffraction grating.
6. The angles Θ_1 and Θ_2 can be determined by measuring the distances h_1 , h_2 and D. (This gives the tangent of the angles, and hence the angles can be calculated). Explain clearly how this is done.
7. The formula $n\lambda = d \sin\Theta$ can be used to determine the wavelength of the laser light.
   - n is the order of the diffraction pattern
   - d is the grating spacing = 1/number of lines per metre
   - λ is the wavelength of light

8. The values of Θ for each order, both above and below the zero order, should be measured. A mean value for λ can be calculated from the data.
9. Quote your value for λ with its absolute uncertainty, explaining clearly how you arrived at the value for the uncertainty.

To include in your write up

How would you modify the experiment and the analysis to determine d when you have various known wavelengths of light available as your source? You should discuss the apparatus you would use, the readings you would take and how you would carry out the experiment. Don't forget a clear labelled diagram. Write a brief risk assessment and make sure you quote any references you used in your investigation.

Physics AS Practical 3: Measurement of g using freefall

Objective : To calculate g to an appropriate level of accuracy, using a freefall method

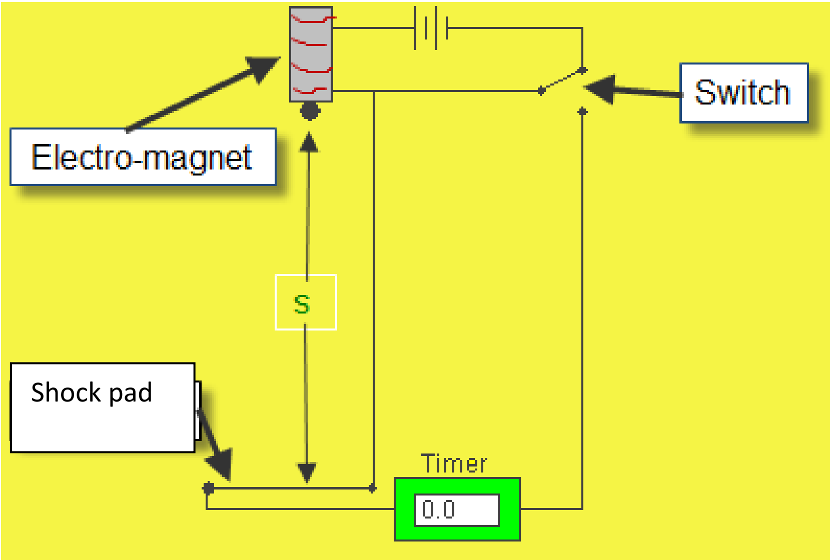
Background reading and preparation

1. Watch this video beforehand:

https://www.youtube.com/watch?v=6MVPUUHzGlk

2. Show that the units of g can be both Nkg^{-1} and ms^{-2}.

Diagram



Procedure

3. Set up the apparatus as shown in the diagram. You may need to adjust the distance of fall and the point at which the ball strikes the pad.

4. Arrange the timer so that it starts when the electromagnet is switched off and stops when the ball hits the pad.

5. Measure the distance *s* from the bottom of the ball to the pad. Be careful to avoid parallax error in this measurement and explain what is meant by parallax error.

6. Measure the fall time three times and find the average. Remember to record your time t in **seconds** and that you should record **s** in **metres**. You will need to do this in a table.

7. Create a column in your table for $\mathbf{t^2}$ (s^2) and calculate this quantity too.

8. Repeat step 4 for a range of heights between 0.2 m and 1.0 m.

Risk assessment

9. Write a risk assessment for this experiment. Include precautions you need to take and highlight any additional safety equipment that would help to further minimise the risks.

Analysis and write up

10. Draw a labelled diagram of your apparatus, explaining the key features.

11. Plot a graph of s (m) against t^2 (s^2), using error bars as appropriate. You may use appropriate graphing software. Theory shows that

$$s = \frac{gt^2}{2}$$

12. Find the gradient and state the units of the gradient m. Also calculate the uncertainty in the gradient (using best gradient – worst gradient). The value of the gradient should be equal to g/2. How does your experimental value compare with the theoretical value of $9.81ms^{-2}$?

13. Explain why $\Delta g/g = \Delta s/s + 2\Delta t/t$. Use the average uncertainties for s and t to calculate another value for the uncertainty in g. Is this uncertainty consistent with your previous calculation?

14. Does the line of best fit go through the origin? If not, why do you think this might be?

15. What are the sources of a) systematic error and b) random error? How can these be minimised? How would you use your graph to estimate the systematic error in t?

To include in your write up

Find out about other ways of measuring g and comment on any advantages or disadvantages of using ONE of these methods compared to the one you have just undertaken.

You should discuss the apparatus you would use, the readings you would take and how you would carry out the experiment. Don't forget to include a clear, labelled diagram.

Write a brief risk assessment for this new practical. Make sure you quote any references you used in your investigation. If you use websites, be sure to also include the access date.

Physics AS Practical 4: Young's modulus of a wire

NOTE

There is a risk of the wire snapping if overloaded.

You must wear safety goggles throughout the practical work.

Suspend the slotted weights over a box containing cloths

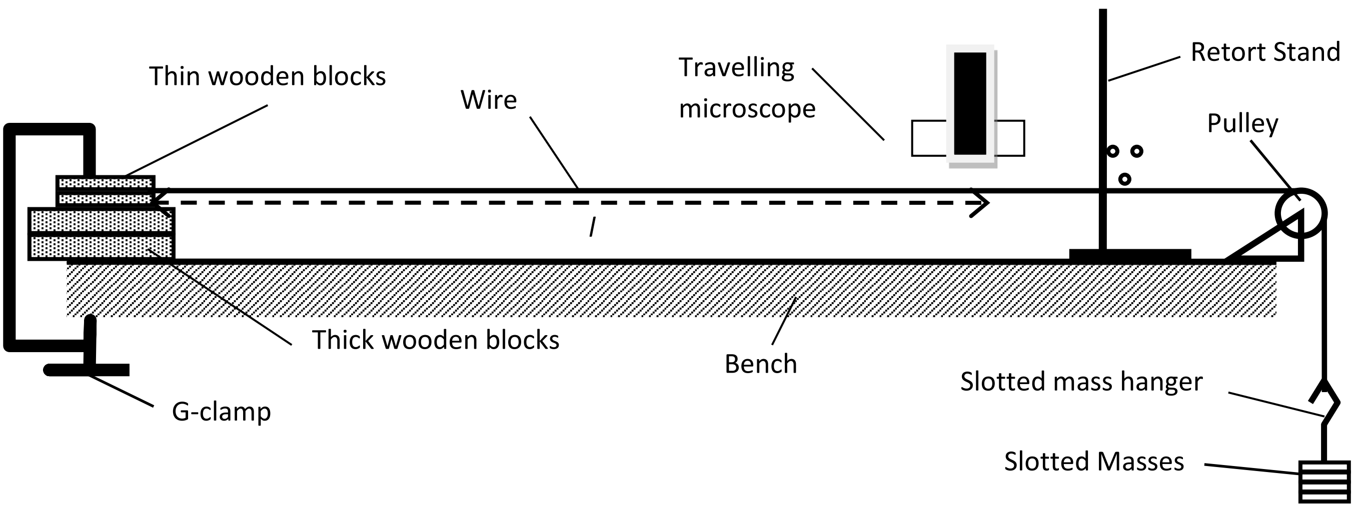
to avoid the weight falling on someone's foot or damaging the laboratory

Background reading

1. Watch this video:

https://www.youtube.com/watch?v=U5SOFeZJelY

2. Why do we plot stress against strain instead of force against extension?



Procedure

3. Choose a type of wire and make a note of which wire you are testing.

4. Choose a suitable instrument and measure the diameter of the wire at several points. Record your measurements.
5. Before continuing you must put on safety goggles to protect your eyes in the event of a wire breaking.
6. Set up the apparatus as shown in the diagram above.

i. Fasten one end of wire between two thin wooden blocks (rough sides together) and clamp firmly in place on top of two thick wooden blocks.
ii. Unwind the wire and hang it over the pulley.
iii. Hang a slotted mass hanger from the free end of the wire, secure it in place by twisting a 5cm length of wire back on itself. You can count this as zero load.

7. Measure the original length l of the wire from the wooden block to a marker on the wire, using a suitable instrument. Use the marker to track the extension of the wire (e.g. sticky paper tab). You will need to record your results to the nearest 0.1 mm.
8. Load the wire with a 10g slotted mass and measure the extension of the wire using the Vernier scale on the travelling microscope. Increasing the load in 10g steps recording the extension each time, up to a **total load of 10 slotted masses**. (Remember the force on the wire is the weight of the load hanging from the wire and W = mg where m is in kg and g=9.8ms^{-2}.
9. Unload the wire making sure you note where you will start your readings again on the Vernier scale. Then reload the wire to take repeat readings of the extension.

NOTE: the image in the travelling microscope works in the opposite direction to the actual object!

Analysis and write up

10. Work out the cross-sectional area of your wire. Remember you recorded the diameter of the wire, (which you need to convert into the radius first) and record the area in units of **m^2**.
11. Make a table of **stress** (load/area) in **Nm^{-2}** and **strain** (extension/original length) for the wire (what are the units of strain?)
12. What is the percentage uncertainty in your load? What is the percentage uncertainty in your diameter?
13. Show that for stress S, load L and diameter D, $\Delta S/S = \Delta L/L + 2\Delta D/D$. What is the maximum percentage error in the stress (this will come from the smallest possible values for D and L)?
14. Produce a plot of stress (*y*-axis) against strain (*x*-axis). You may use appropriate graphing software if you wish.
15. Work out Young's Modulus E for the metal by finding the gradient of your graph. This can be found from the equation

$$E = \text{Stress/Strain } (\text{Nm}^{-2})$$

16. Repeat the experiment for a different type of wire.
17. Write a comprehensive risk analysis and suggest additional ways to minimise the risks with any necessary equipment and procedures.

Evaluation

18. What was your independent variable?
19. What was your dependent variable?

20. This question is about your measurement of the diameter of the wire.
    a. What instrument did you use to measure the diameter of the wire?
    b. Explain why you chose this instrument?
    c. What was the precision of this instrument?
21. What was the sensitivity of the ruler you used to measure the length of the wire?
22. Calculate the percentage error on the extension for the smallest load.
23. Explain why it was important to use a long length of wire.
24. Explain why it was necessary to limit the load on the wire.
25. Use the internet or a book to find the accepted value of Young's Modulus for the material you have studied.
    a. Record the accepted value and note the source of reference.
    b. Calculate the percentage error on your measurement using the valued you measured and the accepted value, using the equation below.

$$\text{Percentage error} = \frac{\text{Measured Value} - \text{Accepted Value}}{\text{Accepted Value}} \times 100\%$$

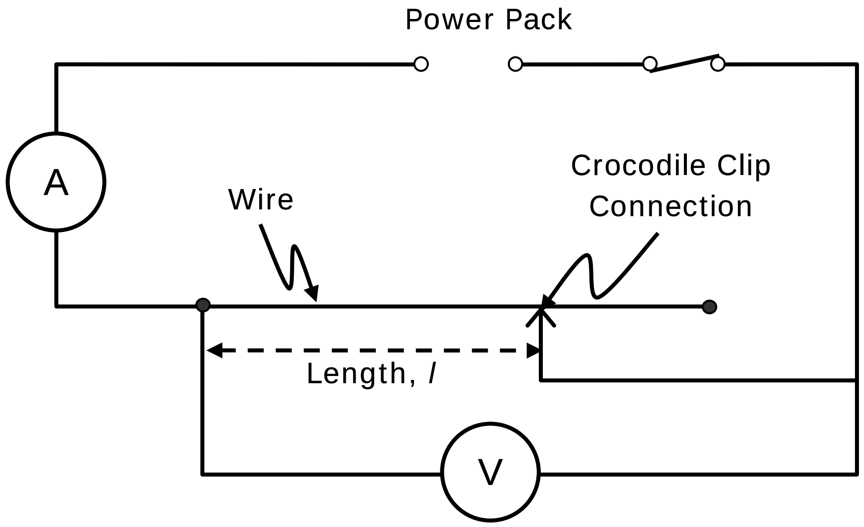
To include in your write up

Another way to measure Young's Modulus is with Searle's apparatus. Find out about this method and then explain how it works and compare it with the method you have just used.

Don't forget a clear labelled diagram.

Write a brief risk assessment for this new experiment. Make sure you quote any references you used in your investigation. If you use websites, be sure to include the access date.

AS Physics Practical 5: Resistivity of a wire



Theory

The resistance, *R*, of a length of wire, *l*, is given by

$$R = \frac{\rho l}{A}$$

Where *A* is the cross-sectional area of the wire and *ρ* is the resistivity of the wire.

A graph of R against l should be a straight line through the origin with gradient = *ρ/A*.

Preparation

1. Define resistivity and explain what it represents
2. Watch this video:

   https://www.youtube.com/watch?v=Tt-_7nfAJ5U

3. What happens to the resistance of a wire if it is extruded to three times its original length?

Risk Assessment

Write a risk assessment for this experiment. Suggest precautions that need to be taken and any equipment or procedures that will minimise these risks.

Method

1. Select a piece of wire and record what material it is made from.
2. Measure the diameter of the wire at several points and find the average diameter.
3. Set up the circuit as shown in the diagram above with the power pack set to 2V.
4. Set up the ammeter correctly using the appropriate full scale deflection setting. Explain what is meant by this and why you chose this setting. Also explain the reason for the mirror on the scale.
5. For a series of different values of length of wire, l, work out the resistance, R, of the wire as follows:

- Record the voltage across the wire and current through the wire in a table similar to that below.

- Using a different voltage, but for the same lengths as before, take the readings again.

- Calculate and record the resistance of the wire from each of the readings of voltage and current.

Length/m	Voltage/V			Current/A			Resistance/Ω
	V_1	V_2	<V>	I_1	I_2	<I>	

Analysis and write up

6. Plot a graph of resistance, R, against length, l. You may use graphing software if you wish.
7. Given that R=V/I find the maximum value $\Delta R/R$. $\Delta R/R = \Delta V/V + \Delta I/I$
8. Work out the gradient m of the best fit line and also the gradient of the worst fit line. What is the percentage error in the gradient m?
9. Work out the cross-sectional area of your wire. Remember you recorded the diameter of the wire, which you need to convert into the radius. Record the area in units of m^2. Show that the uncertainty in the area A is given by $\Delta A/A = 2\Delta r/r$ where r is the radius.
10. Calculate the resistivity of the wire.
11. Show that $\Delta \rho/\rho = \Delta m/m + \Delta A/A$ and hence calculate the uncertainty in ρ.

Evaluation

12. What is your independent variable in this experiment?
13. What is your dependent variable?
14. What instrument did you use to measure the diameter of the wire? Explain why you chose this instrument.

15. Suggest two reasons for the range of lengths you selected for your measurements.
16. Calculate the spread error on your measurements of resistance for your smallest length.
17. Using your spread error, calculate the percentage error on the resistance for your smallest length.
18. Explain whether your measurements are reliable.
19. The measured resistivity of the wire will be higher when a large current is passed through the wire compared to a small current.
    a. Explain why.
    b. Explain why this could introduce a systematic error for short lengths of wire.
    c. Suggest an improved method that would minimise this source of systematic error.

To include in your write up

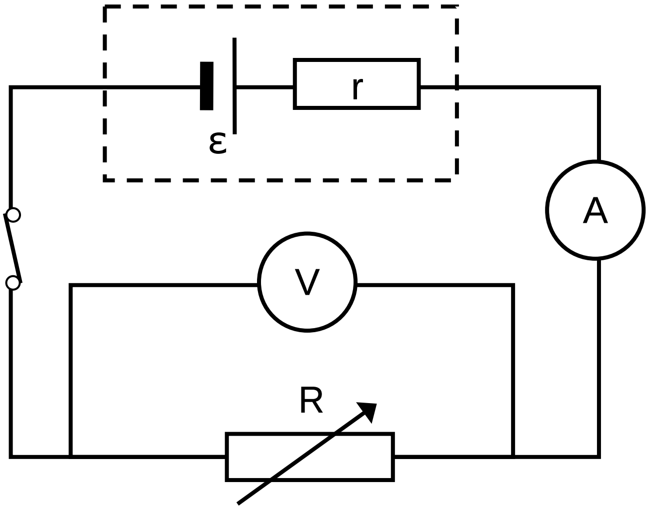
Explain how you would conduct an experiment to measure the resistivity of a rectangular block of material. You should discuss the apparatus you would use, the readings you would take and how you would carry out the experiment.

Don't forget to include a clear, labelled diagram.

Write a brief risk assessment for this new experiment. Make sure you quote any references you used in your investigation.

AS Physics Practical 6: Measuring the EMF and internal resistance of a cell

Theory



The terminal voltage, *V*, of a power supply (either a cell or a power pack) can be measured using the circuit shown in the diagram on the right, and is given by

$$V = \varepsilon - Ir = IR$$

Where

V = terminal voltage

ε = EMF of the cell

I = current drawn from the cell

r = internal resistance of the cell

R = the load resistance

A graph of V against I should be a straight line.

Comparison with the formula for a straight line

$y = mx + c$

where x = I and y = V shows that:

- the gradient (*m*) of the graph = -r
- the y-intercept (*c*) of the graph = ε

Background reading and preparation

1. Define what is meant by the EMF of a cell?
2. How is the EMF of a cell measured?
3. What happens when cells are in a) series and b) parallel?

Method

You will need to construct a table to record measurements of current and voltage.

4. Connect the circuit as shown in the diagram above.
5. Adjust the variable resistor (or rheostat) to give a small current.
6. Record the voltage across the variable resistor (which is equal to terminal voltage of the power supply).
7. Adjust the variable resistor, R, to obtain a new current and record the new voltage.
8. Take repeat readings for the different currents you have selected.

Analysis

9. What is the precision of your meters?
10. Plot a graph of V against I. You may use appropriate software.
11. Use the graph to find the EMF of your power supply.
12. Use the graph to find the internal resistance of your power supply. Also use the uncertainty in your gradient to find the uncertainty in r.

Evaluation

Answer the following questions about your experimental work

13. What was your independent variable?
14. What was your dependent variable?
15. What was the range of your ammeter?
16. What was the precision of your voltmeter?
17. On which measurement of voltage would you expect the percentage error to be largest?
18. By looking at your repeat readings, discuss whether the precision of your voltmeter gives a reasonable estimate of the random errors on your measurements.
19. Suggest two possible systematic errors which could affect your measurement of the EMF of the power supply, and suggest ways you could minimise these errors.
20. Discuss the reliability of your experiment.
21. Discuss whether your experiment is reproducible? What aspects determine the reproducibility of an experiment?
22. Write a brief risk assessment and include any precautions and equipment that will minimise the risks.

To include in your write up

Explain how you would modify the practical to investigate how power in a resistor varies with the resistance. You should discuss the apparatus you would use, the readings you would take and how you would carry out the experiment.

Don’t forget a clear labelled diagram. Write a brief risk assessment for this new experiment. Make sure you quote any references you used in your investigation.

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