Advanced Level Physics: Practical Endorsement

PAG		Title	Date	Criteria Covered		
				1.2.1	1.2.2	CPAC
1	1	Comparing methods of determining g		b-f, j	a-e	1,3,4
	2	Investigating Terminal Velocity		b-f, j	a-e	1,3,4
2	1	Determining Young Modulus for a Metal		c-i	a-c,e	1,3,4,5
3	1	Determining the Resistivity of a Metal		b-f, h-j	b, e, f	1,3,4
	2	Investigating Electrical Characteristics		a-g, j	b, f, g	1,2,3,4
	3	Determining the internal resistance of a PSU		a-g, j	b,f,k	1,2,3,4
4	1	Investigating Resistance		a-f, j	b	1,2,3,4
5	1	Determining the Wavelength of Light		b-d	a,j	1,3,4
	3	Frequency and Amplitude with CRO		a-f, I,j	a,f,h,i	1,3,4
6	1	Determining the Plank Constant		b-f, h, i	b,c,f	1,3,4,5
	3	Experiments with Polarisation		a-f, j	a-c, i, j	1,3,4
	4	Determining the Focal Length of a Lens		b-g	a,c	1,3,4
7	2	Absorption of α β γ by materials		b-f, j	a-c, e, l	1,3,4
8	1	Absolute Zero from gas P and V		a-g, j	a-c, k	1,2,3,4
	2	PV – Boyles Law		a-g, j	a-c, k	1,2,3,4
9	1	Investigating the discharging of capacitors		a-g,j	b,f,k	2,3,4
10	3	Static and SHM method to determine k		a-g, j	a-d	1,2,3,4
11	2	Determining SHC of a material		a,b, d-j	a-d, g	2,3,4,5
12	2	Particle Physics Presentation		f-i		4,5

Add a • for each time a criterion has been met.

	a	b	c	d	e	f	g	h	i	j	k	l
1.2.1												
1.2.2												

CPAC	1	2	3	4	5

1.2.1 Practical skills

Independent thinking

(a) apply investigative approaches and methods to practical work

Use and application of scientific methods and practices

(b) safely and correctly use a range of practical equipment and materials
(c) follow written instructions
(d) make and record observations/measurements
(e) keep appropriate records of experimental activities
(f) present information and data in a scientific way
(g) use appropriate software and tools to process data, carry out research and report findings

Research and referencing

(h) use online and offline research skills including websites, textbooks and other printed scientific sources of information
(i) correctly cite sources of information

Instruments and equipment

(j) use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification.

Through use of the apparatus and techniques listed below, and a minimum of 12 assessed practicals, learners should be able to demonstrate all of the practical skills listed within 1.2.1 and CPAC as exemplified through:

1.2.2 Use of apparatus and techniques

(a) use of appropriate analogue apparatus to record a range of measurements (to include length/ distance, temperature, pressure, force, angles and volume) and to interpolate between scale markings
(b) use of appropriate digital instruments, including electrical multimeters, to obtain a range of measurements (to include time, current, voltage, resistance and mass)
(c) use of methods to increase accuracy of measurements, such as timing over multiple oscillations, or use of fiduciary marker, set square or plumb line
(d) use of a stopwatch or light gates for timing
(e) use of callipers and micrometres for small distances, using digital or vernier scales
(f) correctly constructing circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important
(g) designing, constructing and checking circuits using DC power supplies, cells, and a range of circuit components
(h) use of a signal generator and oscilloscope, including volts/division and time-base
(i) generating and measuring waves, using microphone and loudspeaker, or ripple tank, or vibration transducer, or microwave/radio wave source
(j) use of a laser or light source to investigate characteristics of light, including interference and diffraction
(k) use of ICT such as computer modelling or data logger and sensors to collect data, or use of software to process data
(l) use of ionising radiation, including detectors.

Common Practical Assessment Criteria, CPAC

(1) Follows written procedures	a) Correctly follows instructions to carry out experimental techniques or procedures.
(2) Applies investigative approaches and methods when using instruments and equipment	a) Correctly uses appropriate instrumentation, apparatus and materials (including ICT) to carry out investigative activities, experimental techniques and procedures with minimal assistance or prompting.
	b) Carries out techniques or procedures methodically, in sequence and in combination, identifying practical issues and making adjustments when necessary.
	c) Identifies and controls significant quantitative variables where applicable, and plans approaches to take account of variables that cannot readily be controlled.
	d) Selects appropriate equipment and measurement strategies in order to ensure suitably accurate results.
(3) Safely uses a range of practical equipment and materials	a) Identifies hazards and assesses risks associated with these hazards, making safety adjustments as necessary, when carrying out experimental techniques and procedures in the lab or field.
	b) Uses appropriate safety equipment and approaches to minimise risks with minimal prompting.
(4) Makes and records observations	a) Makes accurate observations relevant to the experimental or investigative procedure.
	b) Obtains accurate, precise and sufficient data for experimental and investigative procedures and records this methodically using appropriate units and conventions.
(5) Researches, references and reports	a) Uses appropriate software and/or tools to process data, carry out research and report findings.
	b) Cites sources of information, demonstrating that research has taken place, supporting planning and conclusions.

PAG 1.1 Investigation to compare methods of determining *g*

Introduction

In this experiment, you will be comparing different methods of determining the acceleration of free fall, the acceleration *g* due to gravity. This will allow you to evaluate the outcome of each experiment and consider the factors involved which give rise to differing values achieved. You are expected to be familiar with the basic formulae involving acceleration: $a = (v - u) / t$ *and* should be able to use $s = ut + ½ at^2$ where *s* is distance, *u* is initial velocity, *a* is acceleration and *t* is time. The aims are given below.

- To determine a value for g using a variety of methods and compare the results obtained.
- To follow the instruction given and demonstrated by your physics teacher.

	Ticker tape timer	Falling ball and electronic timer	Light gates and datalogger	Manual timing
Measurements and Settings				
Calculations				
Result g/ms^{-2}				
Sources of uncertainty				
Conclusions				

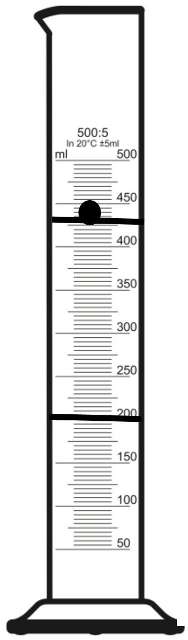
PAG 1.2 Investigating Terminal Velocity

In this experiment, you will measure the terminal velocity of a ball bearing as it falls through a viscous liquid with the possibility of using this value to determine the viscosity as an extension task.

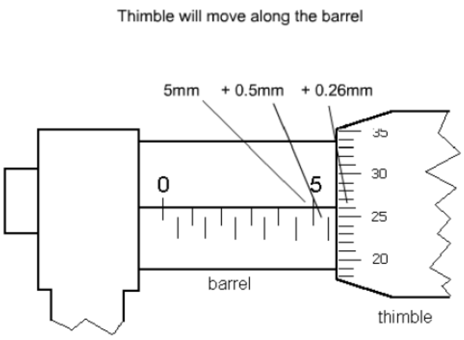
Aim To determine terminal velocity for an object falling through a viscous liquid

Equipment measuring cylinder**,** beaker containing viscous liquid**,** access to a balance and micrometer screw gauge**,** tube filled with viscous liquid**,** elastic bands or other method of marking distances along tube**,** steel ball bearings**,** magnet**,** metre rule**,** stopwatch, paper towels

Suggested Procedure



1. Measure the mass of an empty measuring cylinder. Pour some of the viscous liquid into the measuring cylinder. Record the volume of liquid and the new mass of the measuring cylinder.
2. Determine the density of the liquid. $\rho = m/v$
3. Measure and record the mass (m) and diameter (d) of the ball bearings.
4. Carefully drop a ball bearing into the centre of the liquid and watch it fall as shown in Fig. 1. Establish how far the ball bearing needs to travel in order to reach terminal (constant) velocity.
5. Place a pair of elastic bands a known distance apart positioned so that the ball bearing travels at its terminal velocity between them. Use a stopwatch to measure the time it takes for the ball bearing to travel between them.
6. Carry out a suitable number of repeats.
7. Adjust the distance between the bands and repeat the procedure.
8. Repeat for at least 8 distances covering as wide a range as possible.
9. Plot a scatter graph with time on the x-axis and distance on the y-axis.
10. Calculate a best value for the terminal velocity from the gradient of a line of best fit on the graph.
11. Identify the range of values for terminal velocity using lines of worst fit and calculate the maximum percentage variation from your best value.



Recording

As evidence for the Practical Endorsement you should have the data collected from your group in a clear and logical format. All work should be clearly dated. In addition, to support the assessment of practical skills in the written examination and to help you develop your understanding, you have used the data collected to plot a graph to determine the terminal velocity of the ball.

PAG 2.1 Determining the Young Modulus of a Metal

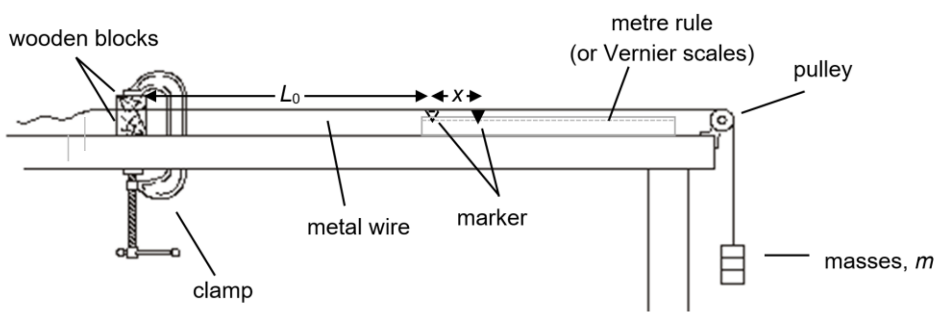
In this experiment, you will be taking measurements of different orders using a range of techniques. There are alternative physical layouts for the experiment, but the procedure follows the same pattern. You are expected to be familiar with the concept of the application of a force leading to the extension of an elastic material in tension and the further concepts of stress and strain giving a measure for the material, independent of the sample length or cross sectional area. There is an opportunity for evaluation of potential uncertainties in readings and the combination of individual uncertainties into the uncertainty of the final result.

Equipment : test wire (for example 28 swg copper)**,** fixed wire to hold measuring apparatus, Vernier measurement system to measure extension**,** metre rules**,** masses**,** bench pulley (if working horizontally along bench)**,** G clamp (if working horizontally along bench)**,** micrometer**,** safety goggles to EN166F.

Health and Safety : Safety goggles or spectacles (as provided by the centre) must be worn at all times due to the risk of the tensioned wire snapping and causing damage to the eyes. Your teacher will have determined a maximum load to be applied to the wire to reduce the risk of breaking. Avoid standing next to the masses and make provision to cushion their landing.

Procedure

The apparatus is set up as shown below. In each case the original length, L_0, extension, *x*, and mass, *m*, should be identified. Note that L_0 should be as long as practical for your particular arrangement.



1. Measure the diameter of the test wire using a micrometer detailing the steps you have taken to improve the repeatability of your result.
2. Use this measurement to calculate the cross-sectional area of the wire. Record the result clearly with the appropriate units.
3. The original length L_0 of the test wire is established and clearly marked or measured at that length so that any extension can be established. This may require a small load on the wire to straighten it.
4. The load is increased in stages up to a maximum determined by your teacher.
5. Record your results of mass, force applied (calculated from the mass), extension, stress and strain in a table, complete with all units appropriately detailed.
6. Plot a graph of stress (on the *y*-axis) against strain (on the *x*-axis).
7. Calculate the value of the gradient with appropriate units. This is the Young modulus.

Evaluation: Detail the percentage uncertainty in *F*, *A*, *x* and L_0 showing how you determine each value.
Combine these uncertainties to give a percentage uncertainty for the Young modulus. Compare your value to an accepted value from a table of materials data. Comment on the comparison between your result and the accepted value, taking your estimated uncertainty into account.

Recording: As evidence for the Practical Endorsement you should have the data collected from your group and additionally any class data required to allow graphical representation in a clear and logical format. All work should be clearly dated.

In addition, in preparation for the assessment of practical work in the written examinations and to help develop your understanding of physics, you should have used the data collected to calculate a value for the Young modulus, explaining clearly how you have used the data in the calculation. You should be able to calculate the percentage difference between your calculated values and the accepted value.
You should be able to identify sources of uncertainty in each method and combine them to give an overall assessment of uncertainty.

PAG 3.1 Investigation to Determine the Resistivity of a Metal

Introduction
In this experiment, you will measure the current through different lengths of a metal wire. You will then determine the resistivity of the metal wire. The p.d., *V,* across the wire is related to the length, *L,* of the wire by the expression $V / I = \rho L / A$ where *I*, ρ and *A* are constants for the experiment. *I* is the current in the wire, ρ is the resistivity of the wire and *A* is the cross sectional area of the wire. This expression may also be written as $V = (\rho I / A) \times L$

Aim: To determine the resistivity of a metal
Equipment: 1 m length of resistance wire, micrometer, crocodile clips, connecting leads, power supply, multimeters.
Health and safety: The metal wire may get hot.

Record your planned procedure to minimise this hazard and get it authorised by your teacher before proceeding with the experiment.

Procedure

1. Set up the circuit shown below in Fig.1, so that the d.c. supply is in series with the metal wire. The length of wire in the circuit is adjusted and connected into the circuit using crocodile clips.

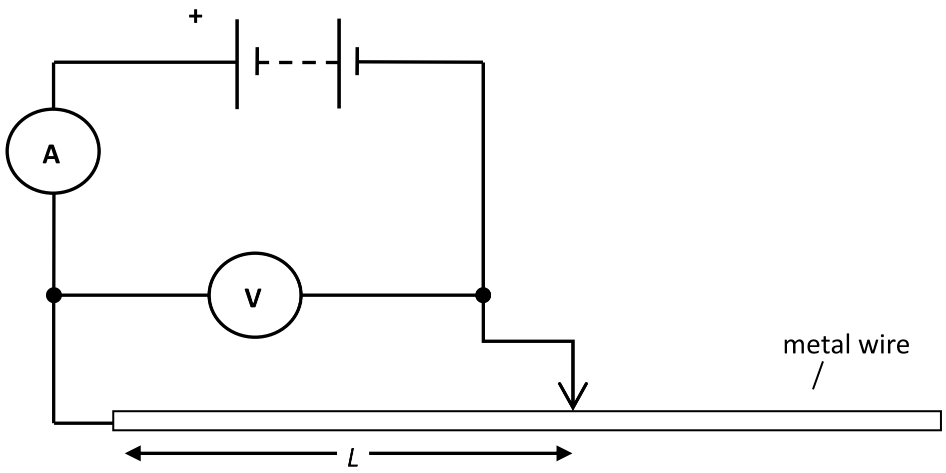


Fig. 1

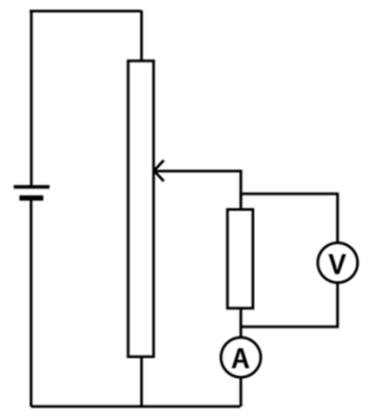
2. Connect the circuit as shown above.
3. Adjust the length, *L*, of wire in the circuit so that it is 50.0 cm.
4. Adjust the power supply so that the reading on the voltmeter is around 3.0 V.
5. Note the reading on the ammeter. This must be kept constant throughout the experiment.
6. Record the reading on both the ammeter and voltmeter for a range of different lengths of the metal wire. (Remember, the ammeter reading should always be the same.)
7. Tabulate your data in a table.
8. Plot a graph of V against *L*.
9. Determine the gradient of your graph.
10. By taking appropriate measurements with the micrometre, determine the diameter of the metal wire.
11. Calculate the cross-sectional area, A, of the metal wire.
12. Use your answers to steps 4, 5 and 10 to determine a value for the resistivity. Compare with a data book value. Include references to your sources.

PAG 3.2 Investigating Electrical Characteristics

In this experiment, you will be determining the current – voltage characteristic of an electrical component.

Aims: To set up the circuit correctly**.** To obtain an appropriate set of data. To plot the characteristic Equipment (per group) power supply (max 12V) rheostat, multimeters, leads, test component (filament lamp, diode, resistor)

Task



1. To measure the characteristic curve for a component you must change the voltage and measure the current, this should include reversing the polarity of the supply to obtain readings for negative voltage.
2. Find the maximum and minimum values of voltage that give appropriate readings of current, and then select the steps needed to give the required number of values.
3. Measure the current as the voltage is changed across the component.
4. Draw the current – voltage curves for your component.
5. Calculate the resistance of the component at any point.
6. Describe the characteristic of the component with relation to potential difference, current and resistance.
7. If there is time, complete a characteristic for both a resistor and diode.

To submit

For this piece of work to count towards Practical Activity Group 3 of the GCE Physics Practical Endorsement you should have evidence of the data collected from your group in a clear and logical format.
You should have a graph and your description of this characteristic.

PAG 3.3 Determining the Internal Resistance of a Power Supply

Introduction
In this experiment, you will be determining the e.m.f. of a power supply, its internal resistance and considering the maximum power available from the supply.

Aim
- To set up the circuit correctly
- To obtain an appropriate set of data
- To interpret the data to give values for e.m.f. and internal resistance
- To plot a graph and comment on the conditions for the transfer of maximum power from the power supply.

Equipment (per group) Low voltage low current (1.5A max) PSU, Rheostat, multimeters, leads.

Health and safety
Ensure the safe use of electrical circuits at all times.
Work within the limits of voltage and current provided by your teacher.

Procedure
1. With no load connected to the power supply, measure the potential difference across the terminals.
2. Using a rheostat as a variable resistor, vary the load, record the potential difference across the supply and total current flowing from it. Collect at least 8 pairs of data. Do not significantly exceed the power supplies current rating.
3. Plot a graph of potential difference, *V*, against current, *I*.
4. What is the e.m.f. of the cell? Justify your response.
5. What is the maximum current that the cell can provide?
6. What is the power delivered in points 5 and 6 above?
7. The value of the internal resistance is given by the value of the gradient of the graph, calculate this value.
8. An alternative way to calculate the internal resistance is to use two sets of values from the table, normally that with no load and that with a load, calculate this and compare.
9. Add load resistance and power as the two additional columns in your table.
10. Plot a graph of power (y-axis) against resistance (x-axis)
11. Identify the value of resistance at which maximum power is transferred.

Recording
As evidence for the Practical Endorsement you should have the data collected from your group in a clear and logical format. All work should be clearly dated.

Additionally, plotting the graph and completing the calculations will support your preparation for the written examination.

PAG 4.1 Combining Resistors

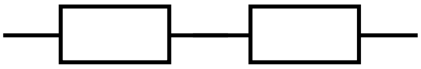
Equipment: multimeter + 2 leads + 4 (or more) 1kΩ resistors + 5 croc clips

Label each resistor A, B, C or D with a small strip of sticky label.
Measure the combined resistance of the following combinations.

1. Each resistor on its own.

A	B	C	D

2. Pairs of resistor in series

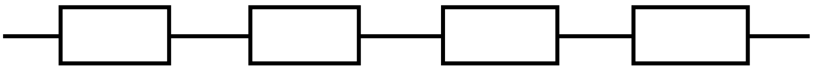


AB	BA	AC	AD

3. Three resistors in series

ABC	ACB	CAB	BCA

4. Four resistors in series



ABCD	ACBD	DCAB	BDCA

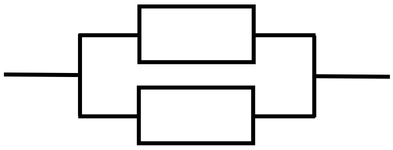
Describe any patterns you have found for resistors in series.

____

____

____

5. Two resistors in parallel



AB	BC	AC	DA

6. Three resistors in parallel

ABC	ABD	ACD	BCD

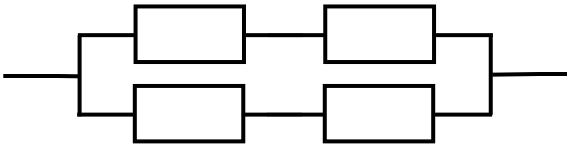
7. All four in parallel

ABCD

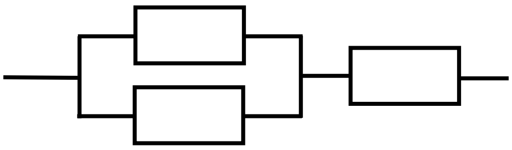
What pattern have you found? ____

____

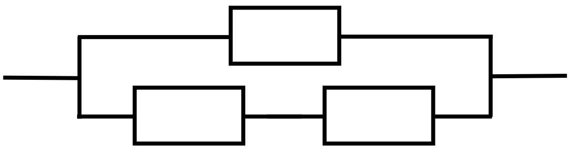
Now predict the resistance of the following combinations and see if you are correct.



Prediction = ____________ Measured Value = ____________

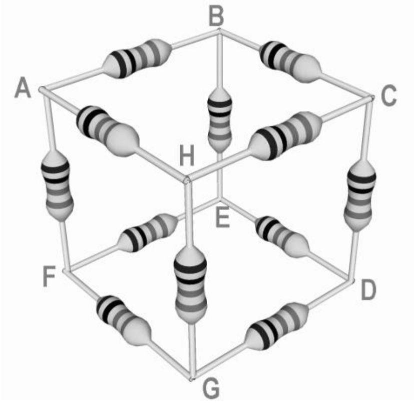


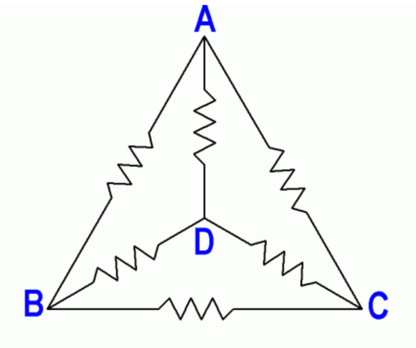
Prediction = ____________ Measured Value = ____________

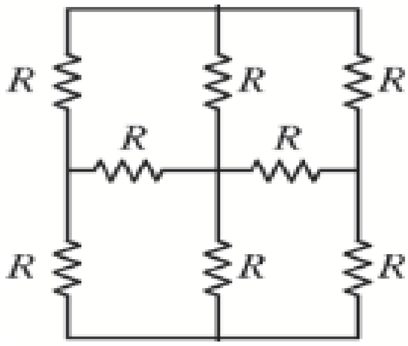


Prediction = ___________ Measured Value = ____________

Now investigate the resistances across a 2D or 3D arrangement of resistors such as one of the ones below.







Resistor Arrangement Chosen

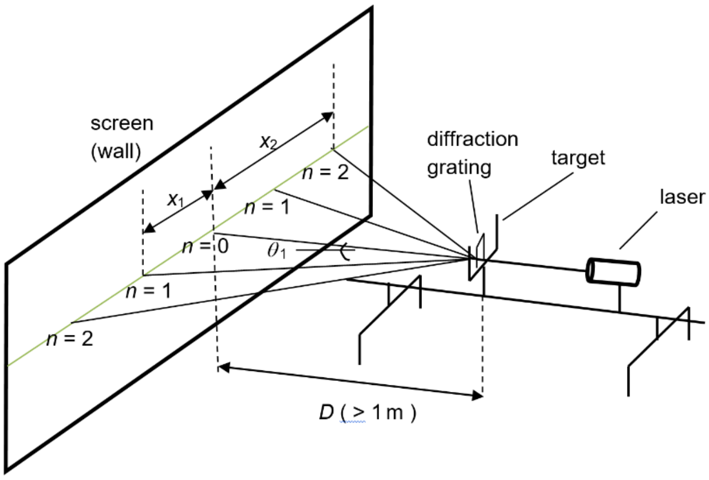
Record your findings below.

Conclusions

PAG 5.1 Determining the Wavelength of Light with a Diffraction Grating

Introduction
In this experiment you will be determining the wavelength of light emitted by a laser. The laser beam will pass through a diffraction grating resulting in a pattern of light on a screen at a distance from the grating. By taking simple measurements of distances with magnitudes in the order of cm and m you will determine a result which is of an order significantly less than that which is directly measurable. You are expected to be familiar with the formula $n\lambda = d \sin\theta$ relating the angle of the bright spot from the central position to the wavelength.

The aims are to determine the wavelength of the laser light, to consider uncertainty and to consider the effect of qualitative changes
Equipment: laser, class 2, <1mW, diffraction grating of known lines per mm, stand, clamp and boss to support diffraction grating, metre rules



Health and safety . Do not target the laser towards any students or surfaces which could reflect the beam towards the class.
Ensure that the target area is a matt surface with no potential for reflection.
Do not look into the laser beam.

1. Set up the apparatus as shown.
2. Measure the distance D to the screen.
3. Measure the distance x_1 from the central bright spot to the first bright spot, $n = 1$.
4. Calculate the angle ϑ_1 using these two measurements.
5. Calculate the distance d, for the spacing of the slits in the diffraction grating based on the data given for your particular grating. This is normally given in *"lines per mm".*
6. Now use the formula $n\lambda = d \sin\theta$ to calculate λ.
7. Repeat the calculations for $n = 2$, the second bright spot.

Evaluation
1. Compare the value for λ given by each calculation.
2. Which has the least uncertainty in measurement?
3. How can you reduce that uncertainty?

Extension Opportunities
What effect will the following have on the pattern produced? Explain your reasoning.
- increasing distance to screen, D
- changing from red light to green light
- rotating the diffraction grating through ninety degrees
- using a point source of white light

Recording
As evidence for the Practical Endorsement you should have your measurements and the collected information from the class in a clear and logical format. All work should be clearly dated. In addition, in preparation for the assessment of practical work in the written examinations and to help you develop your understanding, you should:

- have used the data collected to calculate a value for the wavelength, explaining clearly how you used the data in the calculation and showing all working,
- discuss the uncertainty and ways to reduce this,
- consider the extension opportunities and write a reasoned response to each point.

PAG 5.3 Determining frequency and amplitude of a wave using an oscilloscope

In this experiment you will be determining the frequency and amplitude of a signal using an oscilloscope. You are expected to be familiar with the terminology of “volts per centimetre” and time-base as the descriptors for the scales of the display. You are also expected to be able to interpolate between markings to determine the most precise value. You should also be familiar with the formula linking frequency and period.

Equipment: signal generator, loudspeaker, microphone, oscilloscope, keyboard

Procedure (working in pairs)
Set up the apparatus connecting the output of the signal generator to a loudspeaker and to an input of the oscilloscope. Arrange the equipment such that one student can see the face of the signal generator and the other cannot. The first student sets the signal generator at their chosen setting. The second student then uses the oscilloscope to determine both the frequency and amplitude of the signal.
Exchange places and repeat. Using the microphone as a source for the oscilloscope, work in your pair to determine the frequency of a note from a musical instrument.

Recording
As evidence for the Practical Endorsement you should have evidence of your measurements. All work should be clearly dated. In addition, in preparation for the assessment of practical work in the written examinations and to help you develop your understanding, you should have used the data collected to calculate a value for the frequency and amplitude, explaining clearly how you have used the data in the calculation and showing all working.

PAG 6.1 Determining the Planck constant using LEDs

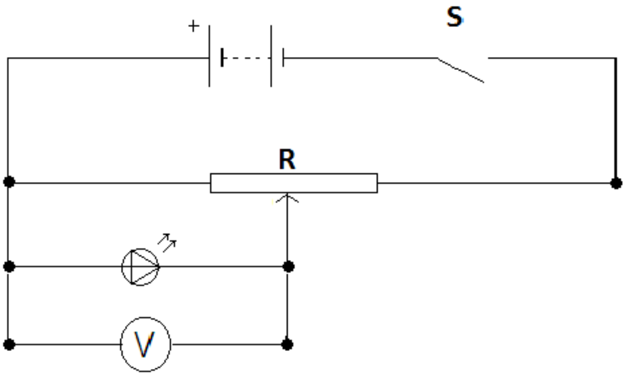
In this experiment, you will measure the minimum p.d. across a number of light-emitting diodes which will just cause each diode to emit photons of light. You will then process the data and derive a value for the Planck constant.

At the junction of the p-type and n-type semiconductors in a light-emitting diode, electrons in the n-type material receive energy from the cell and are able to jump into the holes in the p-type semiconductor, enabling the diode to conduct. In doing so, they emit photons of light.

The minimum energy of an electron of charge, e, moving through a p.d., *V,* is given by the product of charge and p.d. (*eV*) that is just converted into a photon energy hc/λ where λ is the wavelength of the emitted light photon, *c* is the speed of light in a vacuum and h is the Planck constant is given by $eV = hc / \lambda$

Equipment: Plank constant apparatus, power supply and multimeters or…
a variety of different coloured light-emitting diodes (LEDs), connecting leads, two cells or power supply limited to 3V rheostat for use as a potential divider, digital voltmeter, card or black paper

The focussed beam of certain LEDs can be damaging or irritating to the eyes. Do not look directly at an LED at full intensity. The major risk to equipment is damaging the LED with excessive current. Consider how this risk can be reduced.



Procedure

1. Connect the rheostat to the power supply so that the output p.d. measured by the voltmeter across the rheostat is variable and in the approximate range of 0 to 3 V.
2. Set the output p.d. to about 0.5 V.
3. Connect one of the LEDs to the output p.d. and adjust the rheostat to increase the p.d. until the LED just starts to conduct (as judged by the LED just producing a faint glow). Viewing the LED through a tube of matt black paper or card reduces the interfering light level, and allows this judgement to be carried out more precisely.
4. Record the values of minimum p.d. required to produce light and the corresponding wavelength of the light emitted.
5. Plot a graph of minimum p.d. against $1 / \lambda$ draw a 'best fit' line.
6. Find the gradient of your graph and hence determine a value for the Planck constant.

Extension Opportunities

1. Draw error bars on your graph or draw a worst acceptable line of best fit.
2. Calculate the gradient of this line and hence a worst acceptable value for the Planck constant.
3. Give a final answer for the Planck constant with a tolerance within which there is confidence that the value lies.
4. Research a value for the Planck constant. Quote your sources.
5. Calculate the percentage difference between your value for the Planck constant and the researched value.
6. Comment on the accuracy of your experiment.

Recording

As evidence for the Practical Endorsement you should have the measurements collected in a clear and logical format. All work should be clearly dated.

In addition, in preparation for the assessment of practical work in the written examinations and to help you develop your understanding, you should have used the data collected to calculate a value for the Planck constant, explaining clearly how you have used the data in the calculation and showing all working.
You should calculate the accuracy as detailed and comment on your findings.

PAG 6.3 Experiments with Polarisation

Introduction
These practical activities allow you to observe effects of the polarisation of electromagnetic waves.
You may already be aware of the principles of polarisation, or your teacher may be using this activity to introduce the necessary theory.

Aim
- To observe polarising effects using light and microwaves

Equipment (per group)
Refraction using a semi-circular block
- ray box or similar light source
- three polarising filters
- microwave emitter and receiver
- polarising grid for microwaves

Health and safety
- Note that lamp bulbs will be very hot

Procedure
1) Look through a polarising material and rotate it to observe any direct effects.
2) Look through two polarising filters and identify when they are in the same plane and mark this position.
3) What happens whilst either filter is rotated through 90º?
4) Investigate what happens with three filters.
   i) Filter 1 and 3 in the same plane, rotate filter 2.
   ii) Filter 1 and 3 at 90º to each other. Rotate filter 2.
5) Note your observations

Polarisation of microwaves
All electromagnetic waves may be polarised. This can be demonstrated using a simple microwave transmitter and receiver which use a wavelength of approximately 3cm. The transmitter emits a polarised wave, which is detected by the receiver and, depending on your centre's equipment, may give a reading on an analogue meter, digital meter or a sound with varying intensity.
1) Try rotating the receiver slowly through 180º. Note your observations.
2) If your centre has a metal grid place this between transmitter and receiver. Rotate the grid and observe the maximum and minimum points of output. Can you make an assumption about the direction of polarisation of the waves and substantiate it based on your observations?

Recording
As evidence for the Practical Endorsement you should have evidence of your observations and measurements taken in a clear and logical format. All work should be clearly dated.

In addition, in preparation for the assessment of practical work in the written examinations and to help develop your understanding of physics, you should have drawn conclusions from the measurements taken and presented your information in a scientific way.

PAG 6.4 Measuring the Focal Length of a Lens

For a lens $1/u + 1/f = 1/v$ which means a graph of $1/u$ vs $1/v$ will have x and y intercepts of $1/f$ the power of the lens. Additionally, for each pair of measurements, the power $1/f = 1/v - 1/u$. By measuring a series of u and v values the power and focal length can be established.

Set up a lamp, lens in a lens holder and a screen aligned along a pair of meter rules. Use the lamp's filament as your object. Collect a series of u and v values that give a sharp image. The basic method will be demonstrated to you. Record your measurements to a suitable number of significant figures in an appropriate table. Include columns in your table to record the results of your calculations of $1/v$, $1/u$, P and f.

For each pair of measurements calculate a value for the power, P of the lens and f, its focal length. Record the answers in your table. Plot a graph of $1/u$ vs $1/v$ and establish the x and y intercepts. Use these to calculate the focal length. Make your working clear. Estimate the uncertainty in your value for f and justify this estimate.

PAG 7.2 Investigating the Absorption of Gamma Rays by Lead

Introduction
In this experiment you will be using a Geiger-Műller tube and counter to take measurements of the absorption of gamma rays by differing materials or by various differing thicknesses of lead.

Aim To obtain evidence to support a conclusion of the effect of materials placed between radioactive source and detector. To use radioactive materials safely. To use detectors of radioactive decay

Equipment
- radioactive source (gamma) and associated stands and handling equipment
- Geiger-Műller (GM) tube
- counter
- materials to place between source and detector
- micrometer or Vernier caliper

Health and safety
Standard operating procedures, as detailed in CLEAPSS L93 (pages 21 to 23), should be issued to students. Staff should ensure students are responsible enough to follow them, that they have been shown how to use them, and that they have seen and understood the relevant standard operating procedures.

Procedure: Changing the thickness of material between source and detector.

1. Set up the source and detector to allow suitable space for your investigation, with due regard for your own safety and the safety of those around you.
2. Ensure that the detector is giving a suitable range of readings
3. Take sufficient readings for your required investigation.
4. Present the data in such a way as to support your observations. Establish the "half-thickness" for lead.

Extension Opportunities - Evaluating the Outcome
1. Detail the safety considerations taken in carrying out this activity
2. Make a written comment on your measurements
3. Can you observe or identify any pattern?
4. How have you taken into account the effect of background radiation on this activity?

Recording
As evidence for the Practical Endorsement you should have evidence of the data collected from your group in a clear and logical format. Additionally, you should have created a graphical representation of the data and if relevant, then incorporated class data. All work should be clearly dated.

Having demonstrated an awareness of the safety procedures necessary when using radioactive materials, you could make notes of what is advisable to reduce risk. This, along with your observations from the data, will support your preparation for the written examinations.

PAG 8.1 & 8.2 GAS Laws

Eye protection should be worn whilst carrying out practical work with gases under pressure, heated glassware or with mercury.

1. Use the PhET Gas Properties applet to collect data to establish relationships between P,V,T and N. Record data in suitable tables and plot graphs (in excel) to establish the relationships between:

a) P and V at constant T and N
b) P and T at constant V and N
c) T and V at constant P and N
d) P and N at constant T and V

Use the relationships shown by the graphs to write mathematical expressions linking the parameters.

2. Use the Boyles Law apparatus to make measurement of how the volume of a gas depends on its pressure. Record your experimental data in suitable tables and plot a graph to show the relationship between P and V.

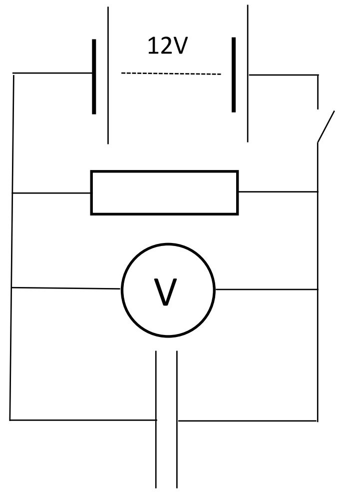
3. Use the Charles' Law apparatus to make a set of measurements of how the volume of a gas varies with temperature. A mercury spillage kit is available. You must notify your teacher immediately if there is a spillage of mercury. Plot a graph of volume against temperature and extrapolate a line of best fit to zero volume to establish a value for absolute zero.

4. Use the pressure Law apparatus to make measurements of how the pressure of a gas at constant volume varies with temperature. Record your results in a suitable table. Plot a graph of pressure against temperature and extrapolate a line of best fit to zero pressure to establish a value for absolute zero.

For the experimental work record the ambient temperature and pressure. (Smart phones often have pressure sensors.) You may also use additional data from other groups to reduce the uncertainty in your findings.

Does your experimental data and the PhET simulation show the same relationships?
Does your experimental data and your values for absolute zero agree with established theory?

PAG 9.1 Discharge of a Capacitor and Timer



Stopwatch
12V DC Power Supply
470 μF capacitor rated to at least 16V
Resistance box covering range of around 100kΩ to 470kΩ
Multi-meter set to 20V DC
Red and Black leads.

Without connecting the positive terminal of the power supply.
Connect up all the electrical components in parallel ensuring the correct polarity of the capacitor. **Check the polarity of the capacitor again. It may explode if it's wrong.**

Set the resistance box to 470kΩ (or as close to this as possible)
Connect the supply and wait for the p.d. across the capacitor to settle.
Start the stopwatch as you unplug the positive of the power supply.
Record the potential difference across the capacitor as it discharges through the resistor in a suitably formatted table with appropriate headings and units in Excel.

Plot a graph in of p.d. against time in Excel.
Fit an exponential curve to the data and display the equation of the line of best fit on the chart.
Use the equation to determine the time constant for the RC pair.

Repeat the experiment for R = 220kΩ and 100kΩ adding the data and lines of best fit to the same graph.

Your challenge is then to use an RC circuit to time an interval of between 30s and 120s which will be given to you a few minutes before the timing challenge.

PAG 10.3 Comparing static and dynamic methods of determining spring stiffness

Introduction

This practical activity is intended to be carried out as an investigation rather than being a defined set of instructions.

Aims

- To determine the spring constant, *k*, using *F= kx*
- To determine the spring constant for the same spring using a dynamic method (SHM) where the spring oscillates vertically with period, T, with a mass, m, suspended from it following the formula,

  $$T = 2\pi\sqrt{\frac{m}{k}}$$

- To obtain data to allow calculation of values for k using the two methods
- To analyse and evaluate that data

Equipment: set of masses, metre rule, spring, stand, boss and clamp, stop clock

Procedure

- Write a method with enough detail to replicate you results.
- Calculate values for the spring constant, *k*, using the two methods.
- Analyse and comment on your results.

Recording

As evidence for the Practical Endorsement you should have detailed your method and the variables which you took into account. You should have evidence of the data collected in a clear and logical format followed by your calculations and an analysis and evaluation of your results using appropriate scientific terminology. All work should be clearly dated.

PAG 11.2 Determining the Specific Heat Capacity of a Material

This practical activity is intended to be carried out as an investigation in which you plan and implement work to demonstrate your investigative skills.

Aims: To demonstrate investigative skills
To make quantitative observations
To research, plan and implement a practical activity
To relate observations to research or theory

Equipment (per group)
sample of material whose SHC is to be determined, electric heater (low voltage), low voltage power supply joulemeter, leads, beaker, kettle, thermometers, insulating material, heatproof mat, electronic balance

Health and safety
Be aware of hot objects and liquids and take appropriate care.

Procedure
Determine a strategy to enable you to determine the SHC of the material. Detail your plan. Obtain and record results. Calculate a value and evaluate your findings.

Recording
As evidence for the Practical Endorsement you should have detailed your method and the variables which you took into account. You should have evidence of the data collected in a clear and logical format. All work should be clearly dated. In addition, in preparation for the assessment of practical work in the written exam you should record your calculations and an analysis and evaluation of your results.

Measuring the Heat Capacity of a Metal

$$\Delta E = mc_p\Delta\theta$$

Investigating the efficacy of school physics laboratory methodology.
*Below are some things you **may** want to do / think about.*

Use laptops to research the accepted value for the metal you plan to use.
Research several sources and quote the values with appropriate units and uncertainties if available.
Fully reference each source.

Measure the power output of your heater at a range of supply voltages up to a maximum of 12V.
Estimate the rate of change of temperature at each input power.
Decide upon and justify the input power you plan to use.

Heat up a block by placing it in hot water in sink for 10min. Dry block thoroughly.
Record data to establish a cooling curve for the block.

Carry out some online research to establish the standard school physics laboratory methodology.
Report on your findings. Fully reference each source.

Determine the resolution of each of your measuring instruments.
Decide how you will minimise the uncertainty in your final value.
Use calculations to justify the size of your final uncertainty.

Determine the likely systematic error in your measurements by comparing instruments making the same measurement. Report your findings.

Using the preparatory work completed so far develop and justify your final strategy.
Think carefully about the method and how you can minimise error and uncertainty.
Write a clear method including the settings and variables you plan to use.
Explain fully how your method will minimise or account for unwanted energy transfers.

Carry out your planned method. Record your experimental data fully and in a clear format.
Process your data graphically or numerically to establish your final value.

Make a comparison of your final value with the accepted value.
Comment on the efficacy of your methodology.

PAG 12.2 Particle Physics Presentation

This piece of work is intended to introduce the skills of researching and referencing information from books, journals and the internet. The topic links the study of materials and their properties with practical applications of the material.

Aim
To produce a suitable (e.g. Powerpoint) presentation of up to ten slides, detailing an aspect of particle physics that interest you. Your report should include information found by research in books, journals or on-line, along with appropriate references allowing the reader to locate the sources of information. Resources: books, journals, internet access

Research your chosen material and its application.
Produce a Powerpoint presentation of up to ten slides.
You may include relevant information taken from resources, but you must appropriately cite the sources of any information that you quote or use.
If appropriate, you may wish to provide supporting printed handout material for your audience.

Present the information to your class colleagues and teacher in a suitable manner.

Recording
As evidence for the Practical Endorsement you should have a Powerpoint (or similar) presentation that meets the brief. You should have also have maintained contemporaneous notes of your research and references to the sources used. All work should be clearly dated.