GCE AS

eduqas
Part of WJEC

WJEC Eduqas GCE AS in

PHYSICS

ACCREDITED BY OFQUAL

TEACHER HANDBOOK

Teaching from 2015



wjec
cbac

This Ofqual regulated qualification is not available for candidates in maintained schools and colleges in Wales.

INTRODUCTION

The **WJEC Eduqas AS Physics** qualification, accredited by Ofqual for first teaching from September 2015, is available to:

- All schools and colleges in England
- Schools and colleges in independent regions such as Northern Ireland, Isle of Man and the Channel Islands

The AS will be awarded for the first time in Summer 2016, using grades A – E.

The qualification provides a broad, coherent, satisfying and worthwhile course of study. It encourages learners to develop confidence in, and a positive attitude towards, physics and to recognise its importance in their own lives and to society.

The specification is intended to promote a variety of styles of teaching and learning so that the course is enjoyable for all participants. The optional topics have been developed to allow learners to gain an insight into topics in the world of work which use physics on a daily basis.

Practical work is an intrinsic part of physics, and is highly valued by higher education. It is imperative that practical skills are developed throughout this course and that an investigatory approach is promoted.

Additional ways that WJEC Eduqas can offer support:

- Specimen assessment materials
- Face-to-face CPD events
- Question paper database
- Examiners' reports on each question paper
- Free access to past question papers and mark schemes via the secure website
- Direct access to the subject officer
- Free online resources
- Exam Results Analysis
- Online Examination Review

If you have any queries please do not hesitate to contact:

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Subject Officer - Physics and Electronics
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KEY ASPECTS OF THE SPECIFICATION FROM 2015

COMPONENT 1: MOTION, ENERGY AND MATTER	
AREA OF STUDY	**DESCRIPTION**
1.1 Basic Physics	Provides amplification of statements in the specification, with links to related resources. Here you will also find links to the related specified practical work documents "Measurement of the density of solids" and "Determination of unknown masses by using the principle of moments".
1.2 Kinematics	Provides amplification of statements in the specification, with links to related resources. Here you will also find links to the related specified practical work documents "Measurement of g by freefall".
1.3 Dynamics	Provides amplification of statements in the specification, with links to related resources. Here you will also find links to the related specified practical work document "Investigation of Newton's 2nd law".
1.4 Energy Concepts	Provides amplification of statements in the specification, with links to related resources.
1.5 Solids Under Stress	Provides amplification of statements in the specification, with links to related resources. Here you will also find links to the related specified practical work documents "Determination of Young modulus of a metal in the form of a wire" and "Investigation of the force–extension relationship for rubber".
1.6 Using Radiation to Investigate Stars	Provides amplification of statements in the specification, with links to related resources.
1.7 Particles and Nuclear Structure	Provides amplification of statements in the specification, with links to related resources.

	SPECIFICATION STATEMENT	COMMENT
(a)	The 6 essential base SI units (kg, m, s, A, mol, K)	See terms, definitions and units booklet.
(b)	Representing units in terms of the 6 base SI units and their prefixes	Candidates will be expected to know how units such as the newton, joule and watt can be expressed in terms of base units.
(c)	Checking equations for homogeneity using units	
(d)	The difference between scalar and vector quantities and to give examples of each – displacement, velocity, acceleration, force, speed, time, density, pressure etc.	See terms, definitions and units booklet. Note: pressure is not an example of a vector.
(e)	The addition and subtraction of coplanar vectors, and perform mathematical calculations limited to **two** perpendicular vectors	
(f)	How to resolve a vector into two perpendicular components	See terms, definitions and units booklet.
(g)	The concept of density and how to use the equation the concept of density and how to use the equation $\rho = \frac{m}{V}$ to calculate mass, density and volume	See terms, definitions and units booklet. In both theoretical and practical contexts.
(h)	What is meant by the turning effect of a force	Familiarity with the terms *torque* and *moment* (used interchangeably). See terms, definitions and units booklet.



Select the image (left) for "Measurement of the density of solids" practical work.



Select the image (left) for "Determination of unknown masses by using the principle of moments" practical work.

Continued on next page

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

	SPECIFICATION STATEMENT	COMMENT
(i)	The use of the principle of moments	See terms, definitions and units booklet.
(j)	The use of centre of gravity, for example in problems including stability: identify its position in a cylinder, sphere and cuboid (beam) of uniform density	See terms, definitions and units booklet.
(k)	When a body is in equilibrium the resultant force is zero and the net moment is zero, and be able to perform simple calculations	These are the conditions for a body to remain in equilibrium.



Select the image (left) for "Measurement of the density of solids" practical work.



Select the image (left) for "Determination of unknown masses by using the principle of moments" practical work.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 1 . 1 BASIC PHYSICS EXAM LEVEL: AS

NAME OF EXPERIMENT:

Measurement of the Density of Solids

THEORY:

The density of regularly shaped solids can be determined by measuring their mass, m, and calculating their volume, V. The density, ρ, can then be found using: $\rho = \frac{m}{V}$

APPARATUS:

Various regularly shaped solids both rectangular and circular
30 cm ruler (resolution ± 0.1 cm)
Vernier calipers/micrometer (resolution ± 0.01 mm)
Balance (resolution ± 0.1 g/1 g)

FURTHER GUIDANCE FOR TECHNICIANS:

Possible objects to include could be steel ball bearings of various sizes, an optical glass/perspex block, blocks of various metals, wood, polystyrene sphere etc.

Experimental Method:

Determine the mass of the object using the balance. The volume of a rectangle can be found by measuring the length, l, width, w, and height, h. Calculate the volume, V using:
$V = l \times w \times h$. The volume of a sphere is found by measuring the diameter to find the radius, r, and then calculate the volume using: $\boldsymbol{V = \frac{4}{3}\pi r^3}$.

In both cases calculate the density using: $\boldsymbol{\rho = \frac{m}{V}}$.

Extension:

This is an excellent opportunity to introduce the concept of uncertainty to the students.
This could be extended to determine the density of irregular objects by putting them in water and measuring the volume of water displaced.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH3 2008 Q3

PH3 2014 Task A1

PH3 2013 Task A1

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Related practical past questions

COMPONENT: 1 . 1 BASIC PHYSICS EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of Unknown Masses by Using the Principle of Moments

THEORY:

Apply the principle of moments to a metre rule to first determine its mass and then determine the mass of an unknown object.

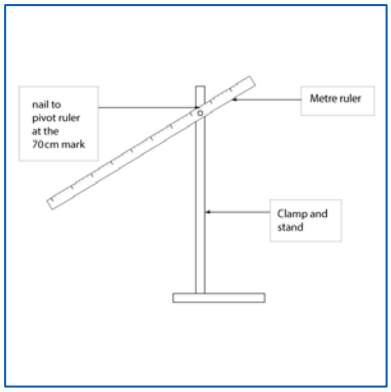
APPARATUS:

Metre rule
Clamp and stand
Nail
200 g mass and hanger
150 g mass (covered in tape and labelled as W) and hanger
Loops of thread

FURTHER GUIDANCE FOR TECHNICIANS:

An alternative would be to pivot the metre rule off-centre on a prism. The unknown weight could be a mass with the real value covered, a reel of wire or a glass bottle top.

Experimental Method:



Loop a 200 g (1.96 N) mass over the metre rule and adjust it until the ruler is horizontal. **Select the image (*left*)** for a larger diagram.

Note down the distance, l, of the mass from the pivot. The mass (or weight) of the metre rule can now be calculated using the principle of moments:

0.20 $\times$ metre rule weight = $l \times 1.96$

Now remove the 200 g mass and replace it with the unknown weight, W, and again adjust the position of the weight until the ruler balances. Measure the distance, d, of the unknown weight from the pivot. The unknown weight can again be calculated by applying the principle of moments:

0.20 $\times$ metre rule weight = $d \times$ unknown weight

The unknown weight can be converted into a mass (in kilograms) by dividing by 9.81. This can then be checked using a top pan balance.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Terms, definitions and units booklet

Eduqas > AS Physics > Related practical past questions

COMPONENT: 1 . 1 BASIC PHYSICS

EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of Unknown Masses by Using the Principle of Moments

EXTENSION:

The practical can be used to familiarise students with calculating uncertainties and combining percentage uncertainties. It can be further extended to include equilibrium of forces.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH3 2004 Experiment 1

PH3 2009 Task A2

PH3 2013 Task A2

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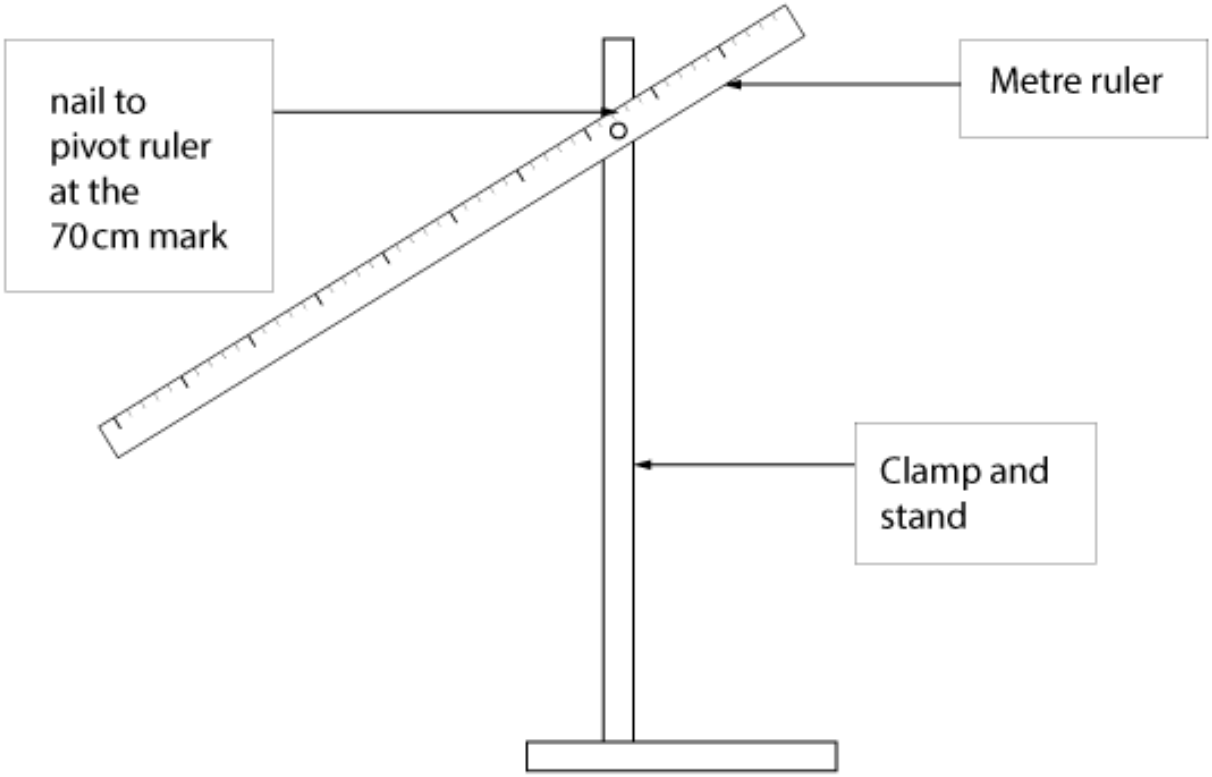
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Eduqas > AS Physics > Related practical past questions

COMPONENT: 1 . 1 BASIC PHYSICS EXAM LEVEL: AS

DIAGRAM:

Determination of Unknown Masses by Using the Principle of Moments



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Eduqas > AS Physics > Terms, definitions and units booklet

Eduqas > AS Physics > Related practical past questions

	SPECIFICATION STATEMENT	COMMENT
(a)	What is meant by displacement, mean and instantaneous values of speed, velocity and acceleration	See terms, definitions and units booklet.
(b)	The representation of displacement, speed, velocity and acceleration by graphical methods	
(c)	The properties of displacement-time graphs, velocity-time graphs, and interpret speed and displacement-time graphs for non-uniform acceleration	Candidates will need to be familiar with acceleration–time graphs.
(d)	How to derive and use equations which represent uniformly accelerated motion in a straight line	It is expected that candidates approach these derivations by both graphical and algebraic methods.
(e)	How to describe the motion of bodies falling in a gravitational field with and without air resistance - terminal velocity	See terms, definitions and units booklet.
(f)	The independence of vertical and horizontal motion of a body moving freely under gravity	Applies to projectile motion for objects being launched either horizontally or at an angle to the ground.
(g)	The explanation of the motion due to a uniform velocity in one direction and uniform acceleration in a perpendicular direction, and perform simple calculations	



Select the image (left) for "Measurement of *g* by freefall" practical work.

Continued on next page

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 1 . 2 KINEMATICS EXAM LEVEL: AS

NAME OF EXPERIMENT:

Measurement of g by Freefall

THEORY:

An equation of motion can be used to calculate the acceleration due to gravity, g.

$$s = ut + \tfrac{1}{2}at^2$$

Where: u = initial velocity = 0,
s = height, h and
a = acceleration due to gravity, g

This gives $h = \tfrac{1}{2}gt^2$

If a graph of height, h (y-axis), is plotted against time squared, t^2 (x-axis), the gradient will equal $g/2$, or $g = 2 \times$ gradient.

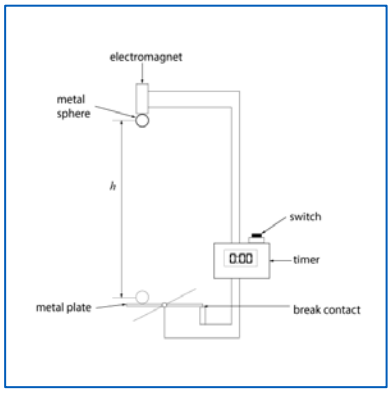
APPARATUS:

Electromagnet	Metal plate
Metal sphere	Timer
Switch	Break contact

FURTHER GUIDANCE FOR TECHNICIANS:

A metre rule of resolution ± 0.001 m will be needed to record the height, h. A ball bearing of diameter 1–2 cm will work well.

Experimental Method:



The apparatus should be set up as shown. **Select the image (*left*)** for a larger diagram.

When the switch is pressed it disconnects the electromagnet releasing the metal sphere. At the same instant the timer starts. When the sphere hits the magnetic switch it breaks the circuit stopping the timer, thus recording the time it takes for the sphere to fall through a height, h. The time taken for the ball bearing to fall through a range of different heights needs to be measured. Plot a graph of height, h (y-axis), against time squared, t^2 (x-axis), and calculate the value of g using: $g = 2 \times$ gradient.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Terms, definitions and units booklet

Eduqas > AS Physics > Related practical past questions

NAME OF EXPERIMENT:

Measurement of g by Freefall

EXTENSION:

Students could progress to use their value for g to estimate the mass of the Earth, M_E.

From $F = \frac{GM_E m}{r^2}$ and $F = mg$ we get: $M_E = \frac{gR^2}{G}$

Where:

M_E = mass of the Earth

R = radius of the Earth (6.38×10^6 m)

G = gravitational constant (6.67×10^{-11} N m^2 kg^{-2})

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use calipers and micrometers for small distances, using digital or vernier scales.
- Correctly construct circuits from circuit diagrams using D.C. power supplies, cells, and a range of circuit components, including those where polarity is important.
- Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH6 2014 Data analysis task

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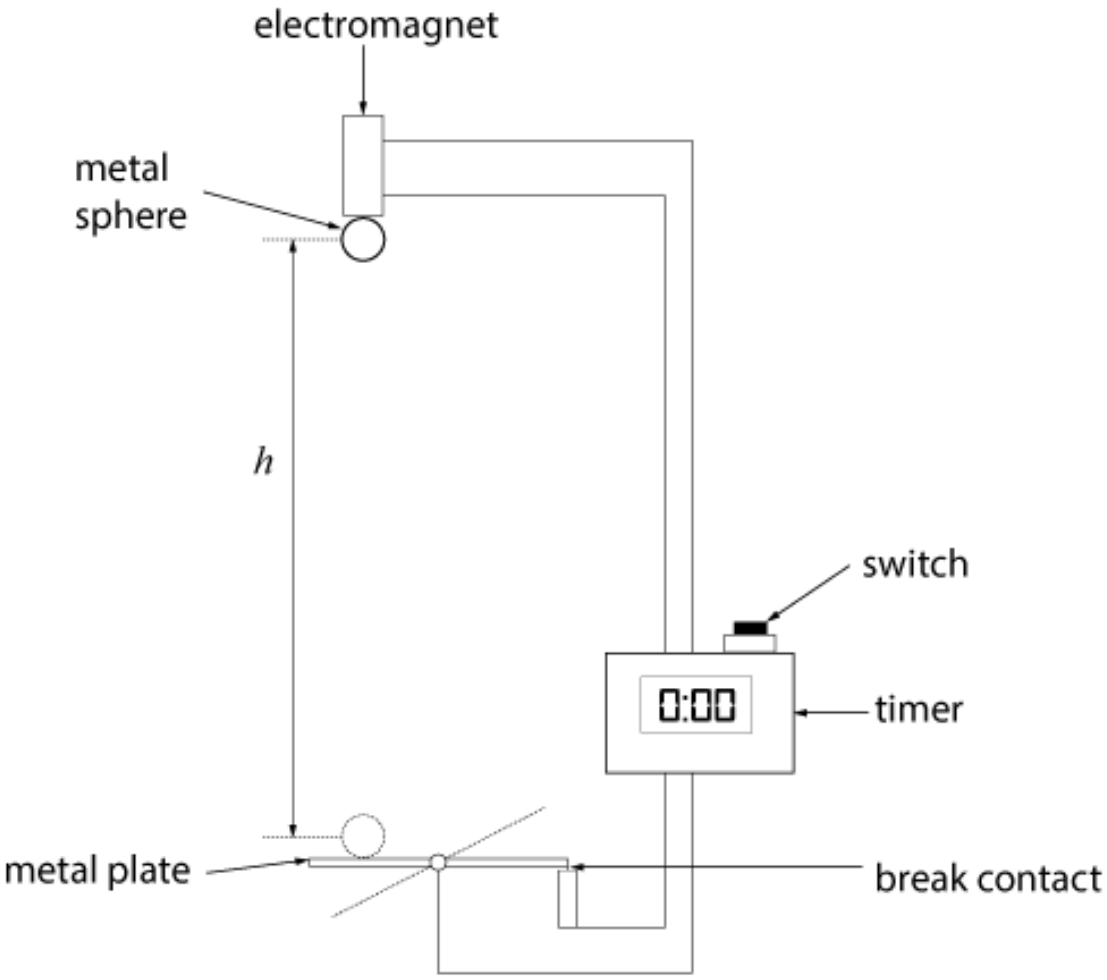
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COMPONENT: 1 . 2 KINEMATICS EXAM LEVEL: AS

DIAGRAM:

Measurement of g by Freefall



USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Terms, definitions and units booklet

Eduqas > AS Physics > Related practical past questions

	SPECIFICATION STATEMENT	COMMENT
(a)	The concept of force and Newton's 3rd law of motion	In addition to being able to state Newton's 3rd law, candidates should be able to understand the key rules for identifying Newton's 3rd law pairs of forces. See terms, definitions and units booklet.
(b)	How free body diagrams can be used to represent forces on a particle or body	Candidates will be expected to draw or complete free body diagrams as well as to be able to interpret and use diagrams provided for them.
(c)	The use of the relationship $\sum F = ma$ in situations where mass is constant	See terms, definitions and units booklet.
(d)	The idea that linear momentum is the product of mass and velocity	See terms, definitions and units booklet.
(e)	The concept that force is the rate of change of momentum, applying this in situations where mass is constant	See terms, definitions and units booklet. Candidates should be able to show how $\sum F = ma$ arises from F = rate of change of momentum.
(f)	The principle of conservation of momentum and use it to solve problems in one dimension involving elastic collisions (where there is no loss of kinetic energy) and inelastic collisions (where there is a loss of kinetic energy)	See terms, definitions and units booklet. Candidates should be able to calculate loss of kinetic energy where appropriate.



Select the image (left) for "Investigation of Newton's 2nd law" practical work.

Continued on next page

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 1 . 3 DYNAMICS EXAM LEVEL: AS

NAME OF EXPERIMENT:

Investigation of Newton's 2nd Law

THEORY:

The gravitational force of the slotted masses attached via the pulley causes the entire mass of the system to accelerate. That is the mass of the rider, M, and the total mass of the slotted masses, m. Newton's second law, therefore, can be written as:

$$mg = (M + m)a$$

and so the acceleration of the system is:

$$a = \frac{mg}{(M + m)}$$

We can use this to test Newton's second law. If the total mass of the system (M + m) remains constant, then the acceleration, a, should be proportional to the gravitational force, mg.

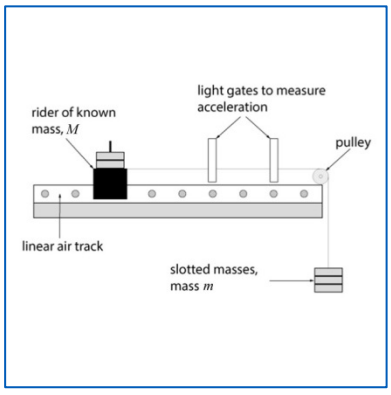
APPARATUS:

Linear air track
Pulley
Slotted masses, mass m
Rider of known mass, M
Light gates to measure acceleration

FURTHER GUIDANCE FOR TECHNICIANS:

It is possible to use just one light gate set to measure the final velocity, v, if two are not available. If the starting velocity is taken to be zero then the acceleration, $a = \frac{v^2}{2s}$. Where s is the distance measured from the starting point of the rider to the light gate.

Experimental Method:



The apparatus should be set up as shown. **Select the image (*left*)** for a larger diagram.

Fix the thread to the rider and attach five slotted 5 gram masses to the other end as shown in the diagram. Set the light gates to record the acceleration and allow the slotted masses to fall to the ground. Record the gravitational force, mg and the acceleration, a. Remove one of the slotted masses and place it on the rider (so keeping the total mass of the system constant).

Repeat the experiment until all the different accelerating masses have been removed. Plot a graph of acceleration (y-axis) against gravitational force, mg (x-axis). This should be a straight line through the origin.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Terms, definitions and units booklet

Eduqas > AS Physics > Related practical past questions

NAME OF EXPERIMENT:

Investigation of Newton's 2nd Law

EXTENSION:

By finding the gradient of the graph it is possible to get a value for the mass of the rider, M.

$$\text{gradient} = \frac{1}{(M+m)}$$

Where m = 25 grams – the total mass of the slotted masses.

This set up can also be used to investigate many collision and momentum problems.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use appropriate digital instruments, including electrical multimeters, to obtain a range of measurements (to include time, current, voltage, resistance, mass).
- Use stopwatch or light gates for timing.
- Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

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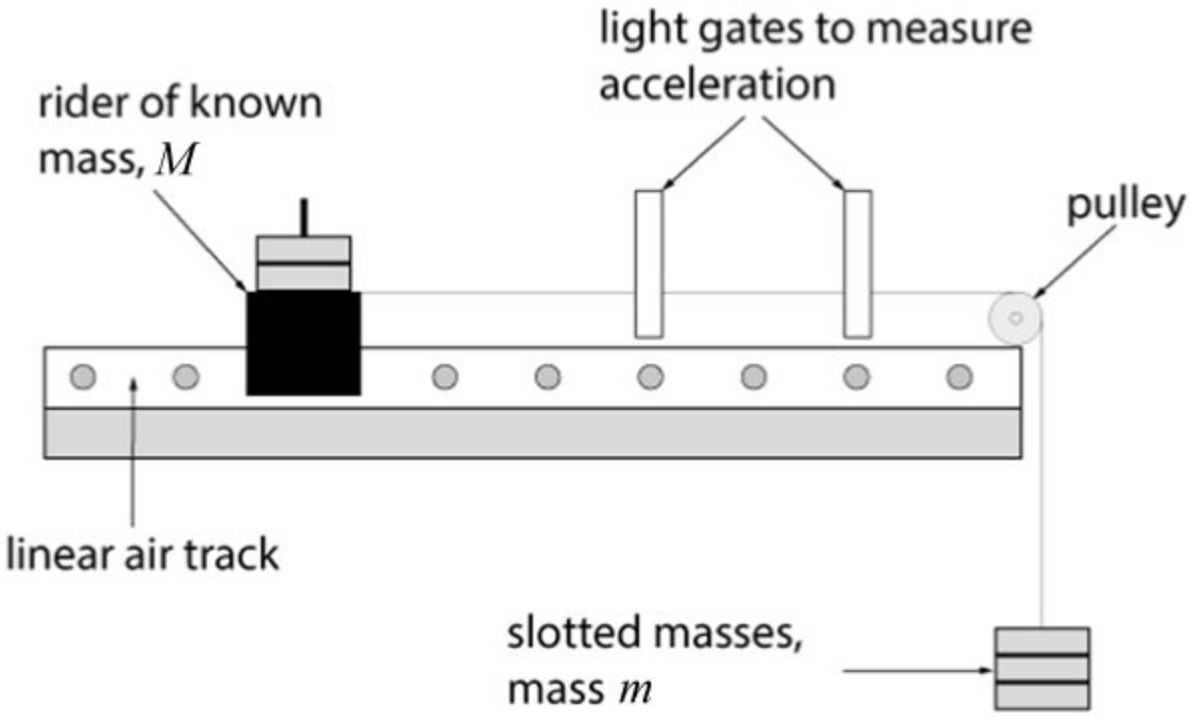
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COMPONENT: 1 . 3 DYNAMICS EXAM LEVEL: AS

DIAGRAM:

Investigation of Newton's 2nd Law



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Eduqas > AS Physics > Related practical past questions

	SPECIFICATION STATEMENT	COMMENT
(a)	The idea that work is the product of a force and distance moved in the direction of the force when the force is constant	See terms, definitions and units booklet.
(b)	The calculation of the work done for constant forces, when the force is not along the line of motion (work done = $Fx\cos\theta$)	
(c)	The principle of conservation of energy including knowledge of gravitational potential energy $(mg\Delta h)$, elastic potential energy $(\frac{1}{2}kx^2)$ and kinetic energy $(\frac{1}{2}mv^2)$	See terms, definitions and units booklet.
(d)	The work–energy relationship: $Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$	See terms, definitions and units booklet.
(e)	Power being the rate of energy transfer	See terms, definitions and units booklet.
(f)	Dissipative forces, for example friction and drag, cause energy to be transferred from a system and reduce the overall efficiency of the system	
(g)	The equation: efficiency = $\frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$	

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Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

	SPECIFICATION STATEMENT	COMMENT
(a)	Hooke's law and use $F = kx$ where the spring constant k is the force per unit extension	Candidates will be expected to be able to state Hooke's law. See terms, definitions and units booklet.
(b)	The ideas that for materials the tensile stress, $\sigma = \frac{F}{A}$ and the tensile strain, $\varepsilon = \frac{\Delta l}{l}$ and the Young modulus, $E = \frac{\sigma}{\varepsilon}$ when Hooke's law applies	See terms, definitions and units booklet. Candidates need an understanding that the gradient of a stress–strain curve for a material represents the Young modulus of the material.
(c)	The work done in deforming a solid being equal to the area under a force-extension graph, which is $\frac{1}{2}Fx$ if Hooke's law is obeyed	Appreciate that $W = \frac{1}{2}Fx$ and $F = kx$ may be combined to give $W = \frac{1}{2}kx^2$
(d)	The classification of solids as crystalline, amorphous (to include glasses and ceramics) and polymeric	See terms, definitions and units booklet.
(e)	The features of a force–extension (or stress–strain) graph for a metal such as copper, to include • elastic and plastic strain • the effects of dislocations, and the strengthening of metals by introducing barriers to dislocation movement, such as foreign atoms, other dislocations, and more grain boundaries • necking and ductile fracture	Candidates should be able to identify (or label) the key features of these graphs, namely: • elastic limit • limit of proportionality • elastic/plastic regions • yield point • breaking point. See terms, definitions and units booklet.



Select the image (left) for "Determination of Young modulus of a metal in the form of a wire" practical work.



Select the image (left) for "Investigation of the force–extension relationship for rubber" practical work.

Continued on next page

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 1 . 5 SOLIDS UNDER STRESS — EXAM LEVEL: AS

	SPECIFICATION STATEMENT	COMMENT
(f)	The features of a force–extension (or stress–strain) graph for a brittle material such as glass, to include • elastic strain and obeying Hooke's law up to fracture • brittle fracture by crack propagation, the effect of surface imperfections on breaking stress, and how breaking stress can be increased by reducing surface imperfections (as in thin fibres) or by putting surface under compression (as in toughened glass or pre-stressed concrete)	See terms, definitions and units booklet.
(g)	The features of a force–extension (or stress–strain) graph for rubber, to include • Hooke's law only approximately obeyed, low Young modulus and the extension due to straightening of chain molecules against thermal opposition • hysteresis	See terms, definitions and units booklet. An understanding of permanent set in the context of hysteresis is expected.



Select the image (left) for "Determination of Young modulus of a metal in the form of a wire" practical work.



Select the image (left) for "Investigation of the force-extension relationship for rubber" practical work.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

NAME OF EXPERIMENT:

Determination of Young Modulus of a Metal in the Form of a Wire

THEORY:

Young modulus $E = \frac{\text{Stress}}{\text{Strain}}$ or $E = \frac{F/A}{x/l}$ rearranging $E = \frac{Fl}{xA}$

F = applied load
A = area of cross-section of the wire
x = extension
l = original length

If a graph of applied load, F (y-axis), is drawn against extension, x (x-axis), the gradient is $\frac{F}{x}$ and so:

$$E = \text{gradient} \times \frac{l}{A}$$

The original length l can be measured and the area of the wire found using $A = \pi r^2$ hence E can be determined.

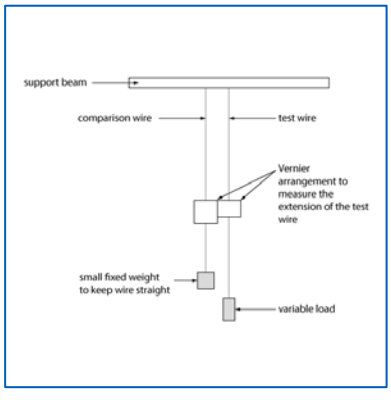
APPARATUS:

Support beam
Comparison wire
Test wire
Variable load
Small fixed weight to keep wire straight
Vernier arrangement to measure the extension of test wire

FURTHER GUIDANCE FOR TECHNICIANS:

The wires are usually steel and should be as long as is convenient, typically up to 2 metres and also as thin as possible in order to obtain a measurable extension. A micrometer will also be needed to measure the diameter of the wire. Suggested loads could be up to 60 N in 5 N steps.

Experimental Method:



Select the image (left) for a larger diagram.

Hang two identical wires from a beam and attach a scale to the first wire and a small weight to keep it straight. Also put a small weight on the second wire to straighten it and a vernier scale linking with the scale on the comparison wire. Measure the original length, l, of the test wire and its diameter at various points along its length. Use this to calculate the mean cross-sectional area A.

Then place a load of 5 N on the test wire and find the extension, x. Repeat this in 5 N steps up to at least 50 N. Plot a graph of load (y-axis) against extension (x-axis) and calculate the gradient. Use this to find a value for the Young modulus.

COMPONENT: 1 . 5 SOLIDS UNDER STRESS

EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of Young Modulus of a Metal in the Form of a Wire

EXTENSION:

By comparing the Young modulus to known constants it would be possible to determine the type of metal the wire was made from.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use calipers and micrometers for small distances, using digital or vernier scales.
- Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH3 2005 Q3

PH6 2012 Experimental task

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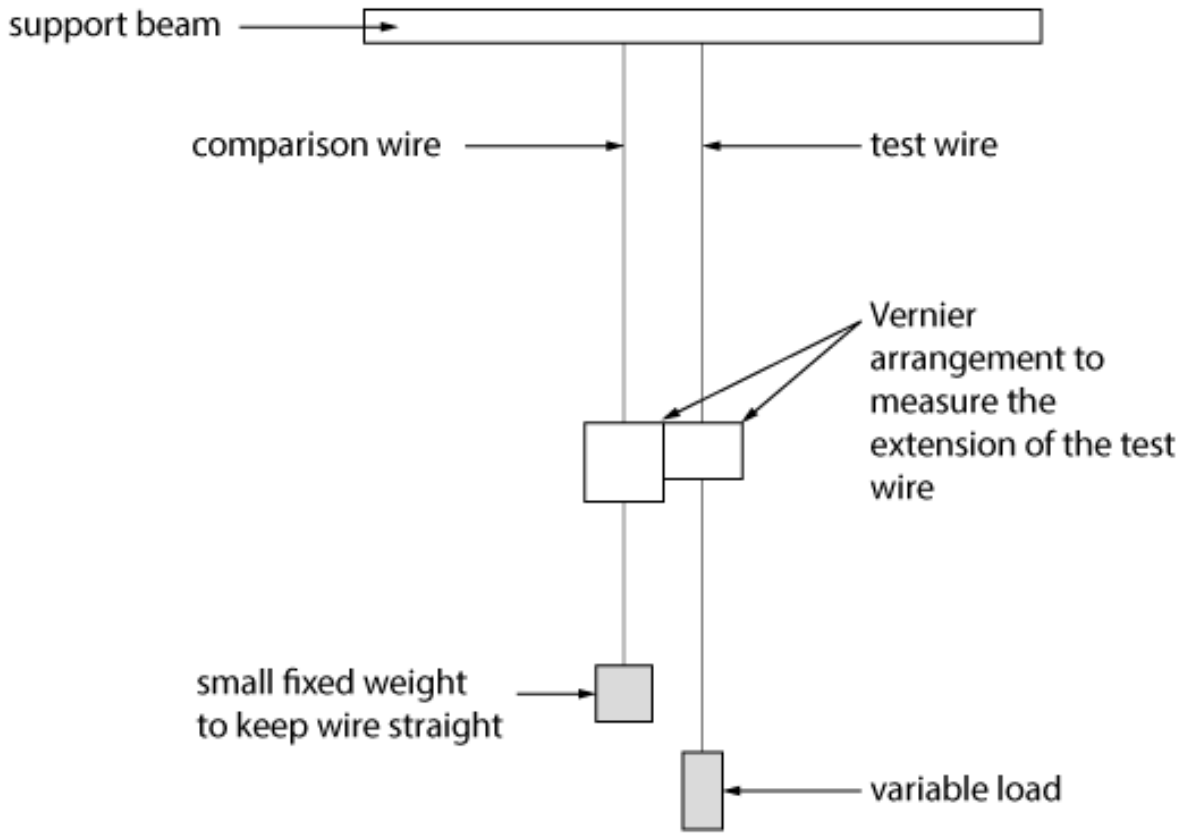
Eduqas > AS Physics > Terms, definitions and units booklet

Eduqas > AS Physics > Related practical past questions

COMPONENT: 1 . 5 SOLIDS UNDER STRESS EXAM LEVEL: AS

DIAGRAM:

Determination of Young Modulus of a Metal in the Form of a Wire



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Eduqas > AS Physics > Terms, definitions and units booklet

Eduqas > AS Physics > Related practical past questions

COMPONENT: 1 . 5 SOLIDS UNDER STRESS — EXAM LEVEL: AS

NAME OF EXPERIMENT:

Investigation of the Force–Extension Relationship for Rubber

THEORY:

Rubber – an example of a polymer with weak cross bonds. Natural rubber is a polymer of the molecule isoprene. It has weak van der Waals cross bonds and only a few covalent (strong) cross bonds.

APPARATUS:

Clamp and stand
Metre rule (resolution ± 0.001 m)
Optical pin (for use as a pointer if required)
Rubber band of cross-section approximately 1 mm by 2 mm
G-clamp to secure (if required)
Micrometer (resolution ± 0.01 mm)
50 g mass holder plus a number of 50 g masses

FURTHER GUIDANCE FOR TECHNICIANS:

Hoffmann clips are useful to suspend the rubber band, and, if you wish, to attach the masses. The dimensions of the elastic band are only approximate and don't need to be exact.

Experimental Method:

Hang a (cut) rubber band of (approximate) cross-section 1 mm by 2 mm vertically from a stand, boss and clamp. The base of the stand should be secured using a G-clamp. Hang a 50 gram mass holder from the band. Place a metre rule as close as possible to the mass holder. The length can be read using an optical pin attached to the base of the mass holder.

Measure the length, width and thickness of the rubber when it is supporting the 50 gram holder. Try to avoid squashing the rubber with the micrometer screw gauge.

Increase the mass in 50 gram steps, measuring the extension each time. Continue until the band breaks.

Plot the force–extension curve and determine the Young modulus from the linear section.

EXTENSION

A similar experiment could be carried out on polyethene and a comparison of the two curves made. Another investigation could be made comparing the properties of the plastic shopping bags from various supermarkets. Measurements could be taken when unloading both the rubber band and the polyethene and the hysteresis determined.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings
- Use methods to increase accuracy of measurements such as timing over multiple oscillations, or use of fiducial marker, set square or plumb line.
- Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

COMPONENT: 1 . 6 USING RADIATION TO INVESTIGATE STARS — EXAM LEVEL: AS

	SPECIFICATION STATEMENT	COMMENT
(a)	The idea that the stellar spectrum consists of a continuous emission spectrum, from the dense gas of the surface of the star, and a line absorption spectrum arising from the passage of the emitted electromagnetic radiation through the tenuous atmosphere of the star	Through analysis of a star's stellar spectrum, candidates will be expected to be able to identify the electromagnetic radiation emitted from the star.
(b)	The idea that bodies which absorb all incident radiation are known as black bodies and that stars are very good approximations to black bodies	See terms, definitions and units booklet.
(c)	The shape of the black body spectrum and that the peak wavelength is inversely proportional to the absolute temperature (defined by: T (K) = θ (°C) + 273.15)	
(d)	Wien's displacement law, Stefan's law and the inverse square law to investigate the properties of stars – luminosity, size, temperature and distance [N.B. stellar brightness in magnitudes will not be required]	See terms, definitions and units booklet.
(e)	The meaning of multiwavelength astronomy and that by studying a region of space at different wavelengths (different photon energies) the different processes which took place there can be revealed	Useful links are: http://herschel.cf.ac.uk/education http://blogs.cardiff.ac.uk/physicsoutreach/resources/star-in-a-box/

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

	SPECIFICATION STATEMENT	COMMENT
(a)	The idea that matter is composed of quarks and leptons and that there are three generations of quarks and leptons, although no questions will be set involving second or third generations	See terms, definitions and units booklet. See introduction to particle physics notes.
(b)	The idea that antiparticles exist for the particles given in the table above, that the properties of an antiparticle are identical to those of its corresponding particle apart from having opposite charge, and that particles and antiparticles annihilate	
(c)	Symbols for a positron and for antiparticles of quarks and hadrons	
(d)	The idea that quarks and antiquarks are never observed in isolation, but are bound into composite particles called hadrons. There are three types of hadron: the baryon (combinations of 3 quarks), or antibaryons (combinations of 3 antiquarks) or mesons (quark–antiquark pairs)	See terms, definitions and units booklet.

	leptons		quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)	up (u)	down (d)
charge (e)	–1	0	$+\frac{2}{3}$	$-\frac{1}{3}$

Continued on next page

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

<table>
<tr><th></th><th>SPECIFICATION STATEMENT</th><th>COMMENT</th></tr>
<tr><td>(e)</td><td>The quark compositions of the neutron and proton</td><td></td></tr>
<tr><td>(f)</td><td>How to use data in the table above to suggest the quark make-up of less well-known first generation baryons and of charged pions</td><td>To include the neutral pion (π^0).</td></tr>
<tr><td>(g)</td><td>The properties of the four forces or interactions experienced by particles as summarized in the table below:
<table>
<tr><th>Interaction</th><th>Experienced by</th><th>Range</th><th>Comments</th></tr>
<tr><td>gravitational</td><td>all matter</td><td>infinite</td><td>very weak – negligible except between large objects such as planets</td></tr>
<tr><td>weak</td><td>all leptons, all quarks, so all hadrons</td><td>very short</td><td>only significant when the e-m and strong interactions do not operate</td></tr>
<tr><td>electromagnetic (e-m)</td><td>all charged particles</td><td>infinite</td><td>also experienced by neutral hadrons, as these are composed of quarks</td></tr>
<tr><td>strong</td><td>all quarks, so all hadrons</td><td>short</td><td></td></tr>
</table></td><td>Neutrino involvement is a sign of weak interactions which typically take 10^{-8} s.
The absorption or emission of photons is a sign of e-m interactions. The total quark number is conserved in e-m interactions. These interactions typically take 10^{-16} s.
Strong interactions are not felt by leptons and the total quark number is conserved. Strong interactions occur in times of the order of 10^{-23} s.</td></tr>
<tr><td>(h)</td><td>How to apply conservation of charge, lepton number and baryon number (or quark number) to given simple reactions</td><td></td></tr>
<tr><td>(i)</td><td>The idea that neutrino involvement and quark flavour changes are exclusive to weak interactions</td><td></td></tr>
</table>

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Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

KEY ASPECTS OF THE SPECIFICATION FROM 2015

COMPONENT 2: ELECTRICITY AND LIGHT	
AREA OF STUDY	**DESCRIPTION**
2.1 Conduction of Electricity	Provides amplification of statements in the specification, with links to related resources.
2.2 Resistance	Provides amplification of statements in the specification, with links to related resources. Here you will also find links to the related specified practical work documents "Investigation of the I–V characteristics of the filament of a lamp and a metal wire at constant temperature", "Determination of the resistivity of a metal" and "Investigation of the variation of resistance with temperature for a metal wire".
2.3 D. C. Circuits	Provides amplification of statements in the specification, with links to related resources. Here you will also find links to the related specified practical work documents "Determination of the internal resistance of a cell".
2.4 The Nature of Waves	Provides amplification of statements in the specification, with links to related resources.
2.5 Wave Properties	Provides amplification of statements in the specification, with links to related resources. Here you will also find links to the related specified practical work documents "Determination of wavelength using Young's double slits" , "Determination of wavelength using a diffraction grating" and "Determination of the speed of sound using stationary waves".
2.6 Refraction of Light	Provides amplification of statements in the specification, with links to related resources. Here you will also find links to the related specified practical work documents "Measurement of the refractive index of a material".
2.7 Photons	Provides amplification of statements in the specification, with links to related resources. Here you will also find links to the related specified practical work documents "Determination of h using LEDs".
2.8 Lasers	Provides amplification of statements in the specification, with the links to detailed laser notes and additional resources.

	SPECIFICATION STATEMENT	COMMENT
(a)	The fact that the unit of charge is the coulomb (C), and that an electron's charge, e, is a very small fraction of a coulomb	See terms, definitions and units booklet.
(b)	The fact that charge can flow through certain materials, called conductors	
(c)	Electric current being the rate of flow of charge	
(d)	The use of the equation $I = \frac{\Delta Q}{\Delta t}$	Includes idea that area under an I–t graph gives charge flow. See terms, definitions and units booklet.
(e)	Current being measured in ampères (A), where A = C s^{-1}	
(f)	The mechanism of conduction in metals as the drift of free electrons	
(g)	The derivation and use of the equation $I = nAve$ for free electrons	Diagram of cylindrical wire would help derivation.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

	SPECIFICATION STATEMENT	COMMENT
(a)	The definition of potential difference	See terms, definitions and units booklet.
(b)	The idea that potential difference is measured in volts (V) where $V = JC^{-1}$	
(c)	The characteristics of $I-V$ graphs for the filament of a lamp, and a metal wire at constant temperature	Candidates will be expected to be able to sketch these graphs.
(d)	Ohm's law, the equation $V = IR$ and the definition of resistance	See terms, definitions and units booklet.
(e)	Resistance being measured in ohms (Ω), where $\Omega = VA^{-1}$	See terms, definitions and units booklet.
(f)	The application of $P = IV = I^2R = \frac{V^2}{R}$	Candidates will be expected to be able to derive these equations.
(g)	Collisions between free electrons and ions gives rise to electrical resistance, and electrical resistance increases with temperature	



Select the image (left) for "Investigation of the I-V characteristics of the filament of a lamp and a metal wire at constant temperature" practical work.



Select the image (left) for "Determination of the resistivity of a metal" practical work.



Select the image (left) for "Investigation of the variation of resistance with temperature for a metal wire" practical work.

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USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

	SPECIFICATION STATEMENT	COMMENT
(h)	The application of $R = \frac{\rho l}{A}$, the equation for resistivity	See terms, definitions and units booklet.
(i)	The idea that the resistance of metals varies almost linearly with temperature over a wide range	Over a wide range *of temperatures.*
(j)	The idea that ordinarily, collisions between free electrons and ions in metals increase the random vibration energy of the ions, so the temperature of the metal increases	
(k)	What is meant by superconductivity, and superconducting transition temperature	Familiarity with a sketch graph of resistance against temperature showing the transition. No theory required (e.g. Cooper pairs). See terms, definitions and units booklet.
(l)	The fact that most metals show superconductivity, and have transition temperatures a few degrees above absolute zero (–273 °C)	Values of transition temperatures not needed.
(m)	Certain materials (high temperature superconductors) having transition temperatures above the boiling point of nitrogen (–196 °C)	No examples of high temperature superconductors need be known.
(n)	Some uses of superconductors, for example MRI scanners and particle accelerators	These machines need very strong magnetic fields; candidates do not need to know the reasons why. If ordinary wire were used in the electromagnets, too much power would be dissipated.



Select the image (left) for "Investigation of the *I-V* characteristics of the filament of a lamp and a metal wire at constant temperature" practical work.



Select the image (left) for "Determination of the resistivity of a metal" practical work.



Select the image (left) for "Investigation of the variation of resistance with temperature for a metal wire" practical work.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 2 . 2 RESISTANCE EXAM LEVEL: AS

NAME OF EXPERIMENT:

Investigation of the I–V Characteristics of a Filament Lamp and a Metal Wire at Constant Temperature

THEORY:

Ohm's law states that for a conductor the current, I, is directly proportional to the potential difference, V, provided physical factors such as temperature and pressure remain constant. Therefore by plotting the I–V characteristic of a metal wire and of a filament lamp, the validity of Ohm's law, as applicable to each of these components, can be determined. A graph of I against V is linear for a metal wire and non-linear for a filament of a lamp.

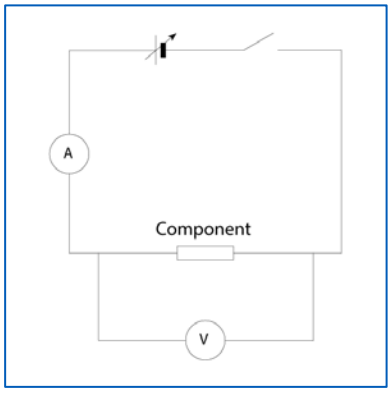
APPARATUS:

Variable D.C. voltage supply
Switch
Ammeter
Voltmeter
Component either in the form of a filament bulb, e.g. 12 V, 24 W bulb or a metal wire, e.g. 1 m length of constantan – mounted on a wooden batten

FURTHER GUIDANCE FOR TECHNICIANS:

The variable D.C. voltage supply can be constructed from 1.5 V cells and a rheostat. The resolution of the voltmeter and ammeter depend on the D.C. voltage supply used in the circuit.

Experimental Method:



The circuit should be set up as shown. **Select the image (*left*)** for a larger diagram.

Starting with the output of the variable D.C. voltage supply set to its minimum value, slowly increase the value of the applied voltage. The current through the component and the potential difference across the component should be recorded for a range of values of the applied voltage. A graph of current against voltage should then be plotted. This procedure can be repeated for different components.

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Eduqas > AS Physics > Terms, definitions and units booklet

Eduqas > AS Physics > Related practical past questions

COMPONENT: 2 . 2 RESISTANCE

EXAM LEVEL: AS

NAME OF EXPERIMENT:

Investigation of the I–V Characteristics of a Filament Lamp and a Metal Wire at Constant Temperature

EXTENSION:

The I–V characteristics of other components such as a semiconductor diode or an electrolytic solution such as copper sulfate could be investigated.

Data Logging: Digital ammeters or voltmeters could be used as part of a data logging set-up.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use calipers and micrometers for small distances, using digital or vernier scales.
- Correctly construct circuits from circuit diagrams using D.C. power supplies, cells, and a range of circuit components, including those where polarity is important.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH3 2005 Q2

PH3 2010 Task A3

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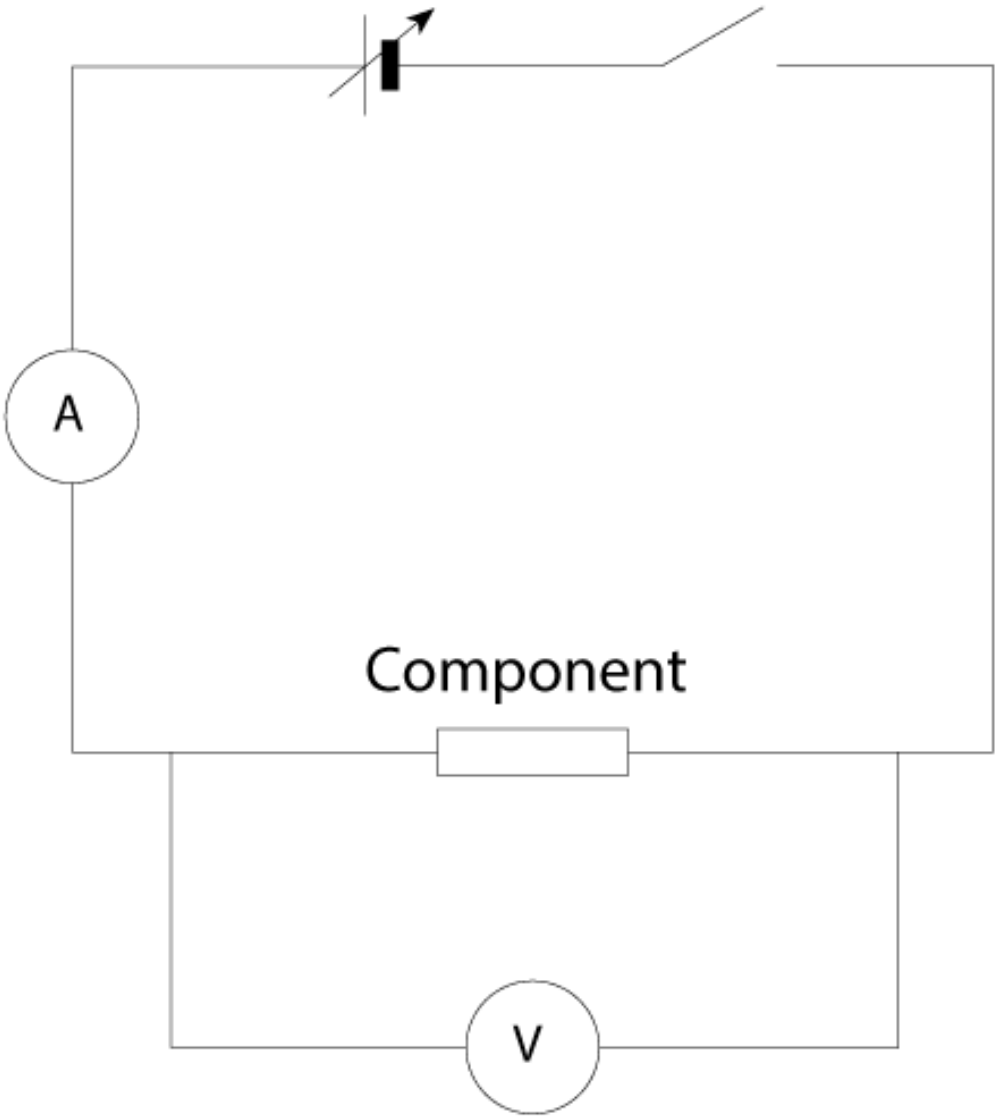
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COMPONENT: 2 . 2 RESISTANCE EXAM LEVEL: AS

DIAGRAM:

Investigation of the I–V Characteristics of a Filament Lamp and a Metal Wire at Constant Temperature



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COMPONENT: 2 . 2 RESISTANCE — EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of the Resistivity of a Metal Wire

THEORY:

Resistivity, ρ can be found using the equation $R = \rho\frac{l}{A}$ where l is the length of the wire, A the cross-sectional area and R the resistance. This can be compared with the equation for a straight line $y = mx + c$. A graph plotted of R (y-axis) against l (x-axis) will be a straight line through the origin of gradient $\frac{\rho}{A}$. The cross sectional area can be found using $A = \pi r^2$ and the resistivity calculated by ρ = gradient $\times A$.

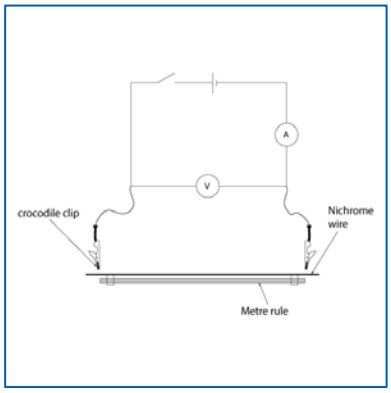
APPARATUS:

- 7 × 4 mm leads
- Voltmeter
- Metre rule
- Micrometer/vernier calipers (resolution ± 0.01 mm)
- Ammeter
- 1.5 V 'D' type battery
- 110 cm length of nichrome wire
- 30 cm ruler (resolution ± 0.001 m)

FURTHER GUIDANCE FOR TECHNICIANS:

Wires of SWG 24 to 28 will give accurate results whilst still being robust enough not to snap when adding or removing the crocodile clips. If nichrome is not available, then constantan is a suitable alternative. The ammeter should have a resolution of ± 0.01 A and the voltmeter a resolution of ± 0.01 V

Experimental Method:



Select the image (left) for a larger diagram of the circuit.

Leaving one crocodile clip fixed at one end of the wire, the other clip should be moved along at suitable intervals, e.g. every 10 cm/20 cm to cover the whole range of the wire. Readings on the voltmeter and ammeter should be noted for each length and the resistance determined using $R = \frac{V}{I}$.

The diameter of the wire can be found using a micrometer or vernier calipers and the cross-sectional area determined. Plot a graph of R (y-axis) against l (x-axis) and calculate the resistivity using: ρ = gradient $\times A$.

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COMPONENT: 2 . 2 RESISTANCE

EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of the Resistivity of a Metal Wire

EXTENSION:

By comparing the resistivity value obtained to known constants, it is possible to determine the type of metal making up different wires.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use appropriate digital instruments, including electrical multimeters, to obtain a range of measurements (to include time, current, voltage, resistance, mass).
- Use calipers and micrometers for small distances, using digital or vernier scales.
- Correctly construct circuits from circuit diagrams using D.C. power supplies, cells, and a range of circuit components, including those where polarity is important.
- Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH3 2009 Task A3

PH3 2014 Task B4

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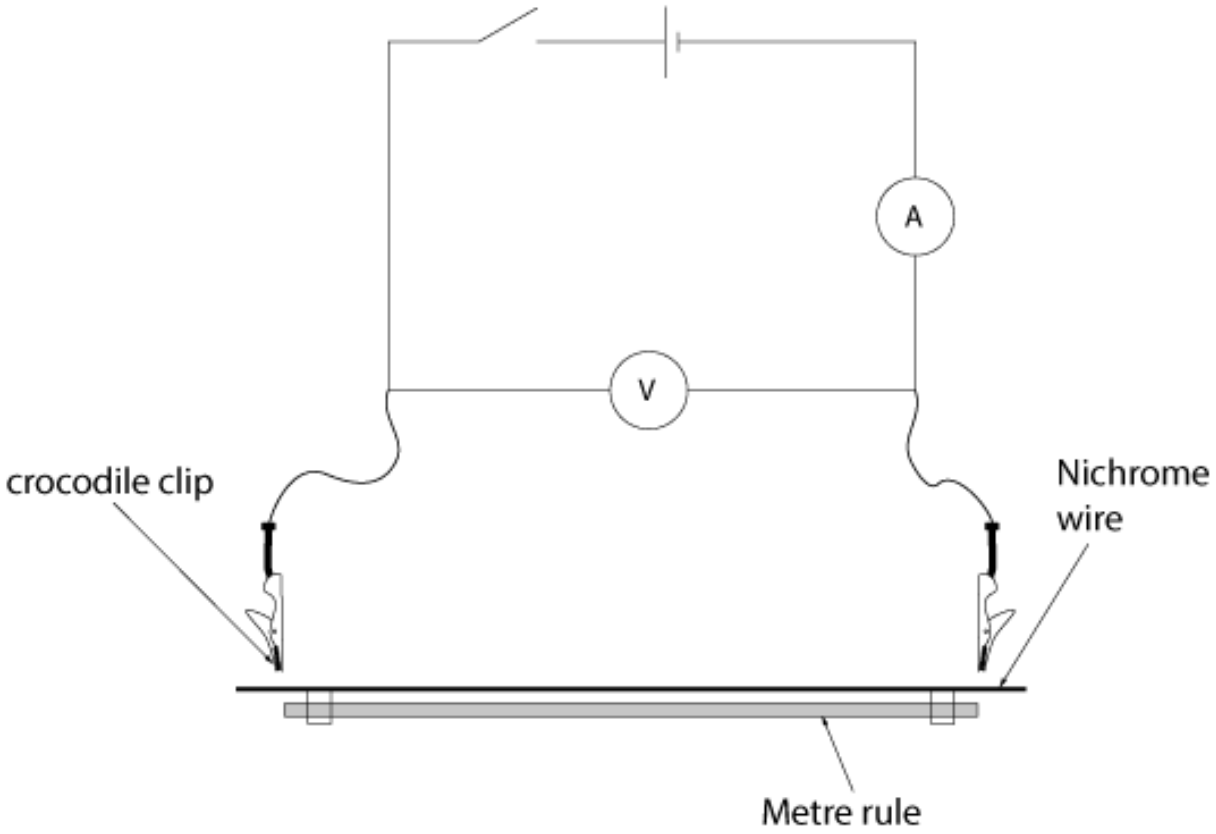
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COMPONENT: 2 . 2 RESISTANCE EXAM LEVEL: AS

DIAGRAM:

Determination of the Resistivity of a Metal Wire



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COMPONENT: 2 . 2 RESISTANCE — EXAM LEVEL: AS

NAME OF EXPERIMENT:

Investigation of the Variation of Resistance with Temperature for a Metal Wire

THEORY:

Resistance increases with temperature for metals in a linear relationship.This practical will enable data to be obtained to investigate this relationship.

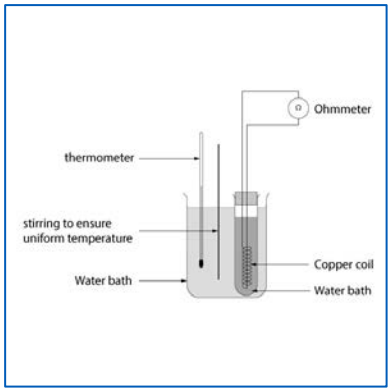
APPARATUS:

Bunsen burner	Stand and clamp
Tripod	Gauze and stand
Ice	250 ml beaker of water or water bath with heating element
Thermometer 0–100 ^{o}C	Multimeter set on ohm range to measure resistance
Copper coil	Stirrer

FURTHER GUIDANCE FOR TECHNICIANS:

A fixed D.C. voltage supply can be used with an ammeter and voltmeter instead of the ohmmeter, if preferred. The resistance can be determined by using $R = \frac{V}{I}$. The coil can be placed in a boiling tube full of oil and then placed in the water bath or in ice.

Experimental Method:



The apparatus should be set up as shown. **Select the image (*left*)** for a larger diagram.

The water bath should be heated and the water stirred continuously in order to ensure an even temperature throughout the water bath. Once the required temperature has been reached, then remove the heat and record the reading of resistance or take the ammeter and voltmeter readings. This process should be repeated at intervals until the water boils.

Repeat the experiment during cooling. Plot a graph of resistance (y-axis) against temperature (x-axis). This should be a straight line through the origin.

An ice water mixture can be used to record the resistance at a temperature of 0 ^{o}C.

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Eduqas > AS Physics > Related practical past questions

COMPONENT: 2 . 2 RESISTANCE

EXAM LEVEL: AS

NAME OF EXPERIMENT:

Investigation of the Variation of Resistance with Temperature for a Metal Wire

EXTENSION:

The variation of resistance with temperature for a thermistor could also be investigated.

Data Logging: Digital ammeters, voltmeters and thermometers could be used that are part of a data logging set-up.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use calipers and micrometers for small distances, using digital or vernier scales.
- Correctly construct circuits from circuit diagrams using D.C. power supplies, cells, and a range of circuit components, including those where polarity is important.
- Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH6 2014 Data analysis task

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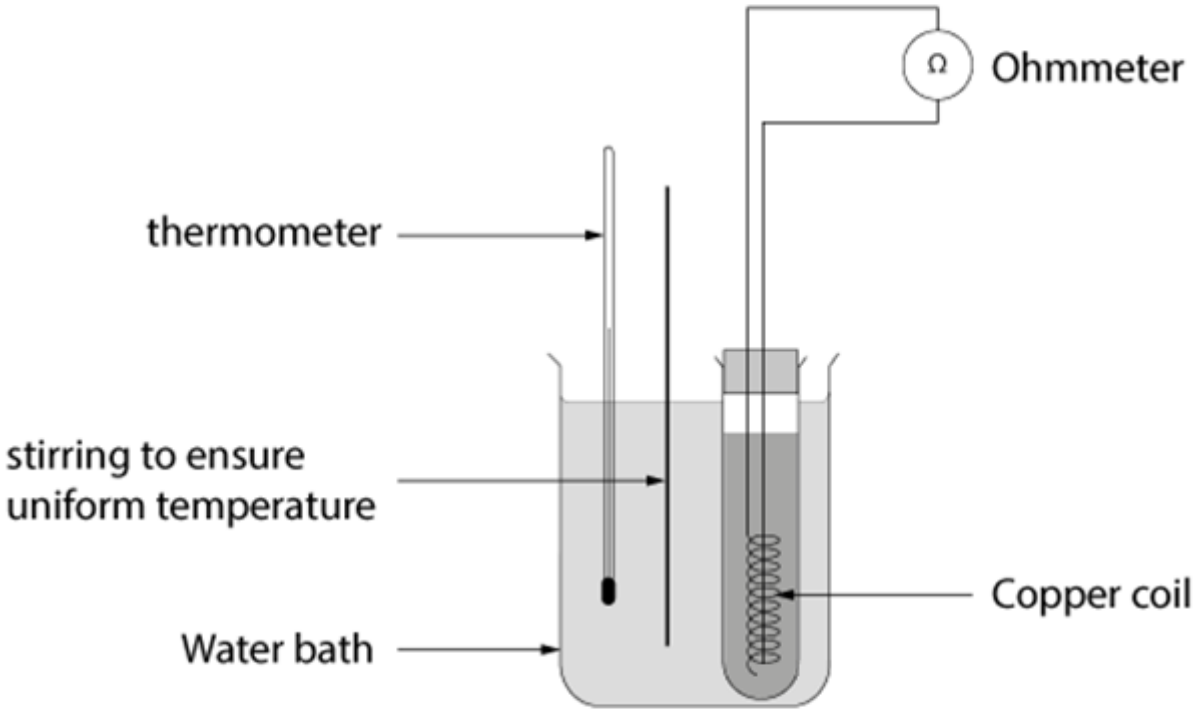
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COMPONENT: 2 . 2 RESISTANCE EXAM LEVEL: AS

DIAGRAM:

Investigation of the Variation of Resistance with Temperature for a Metal Wire



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	SPECIFICATION STATEMENT	COMMENT
(a)	The idea that the current from a source is equal to the sum of the currents in the separate branches of a parallel circuit, and that this is a consequence of conservation of charge	See terms, definitions and units booklet.
(b)	The sum of the potential differences across components in a series circuit is equal to the potential difference across the supply, and that this is a consequence of conservation of energy	
(c)	Potential differences across components in parallel are equal	
(d)	The application of equations for the combined resistance of resistors in series and parallel	
(e)	The use of a potential divider in circuits (including circuits which contain LDRs and thermistors)	Quantitative analysis expected. When one element is an LDR or thermistor, the other will be a fixed resistor.
(f)	What is meant by the emf of a source	
(g)	The unit of emf is the volt (V), which is the same as that of potential difference	See terms, definitions and units booklet.
(h)	The idea that sources have internal resistance and to use the equation $V = E - Ir$	Sometimes V or I will have to be calculated from other data, such as 'load' resistance.
(i)	How to calculate current and potential difference in a circuit containing one cell or cells in series	



Select the image (left) for "Determination of the internal resistance of a cell" practical work.

Continued on next page

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 2 . 3 D.C. CIRCUITS EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of the Internal Resistance of a Cell

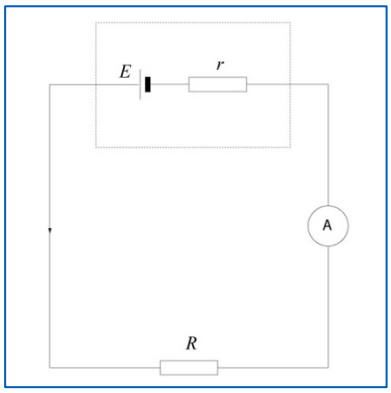
THEORY:

The equation used for determining the internal resistance is $V = E - Ir$ where V is the terminal p.d. of a cell; E is the emf of the cell; I is the current flowing in the circuit and r is the internal resistance. $V = IR$ and the equation can be rewritten as $R = \frac{E}{I} - r$. Therefore a graph of R against $\frac{1}{I}$ should be linear.

APPARATUS:

Switch
Cells, e.g. 3 or 4 × 1.5 V "D" type batteries connected in series
Ammeter or multimeter set to A range ± 0.01 A
Various resistor values 0–60 Ω

Experimental Method:



The circuit should be set up as shown. **Select the image (*left*)** for a larger diagram.

The resistor values should be varied and the current values recorded.

Plot a graph of R (y-axis) against $\frac{1}{I}$ (x-axis). The graph should be a straight line with the intercept on the y-axis which is equal to the value of the internal resistance.

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Edugas > AS Physics > Related practical past questions

COMPONENT: 2 . 3 D.C. CIRCUITS

EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of the Internal Resistance of a Cell

EXTENSION:

The current can also be varied and the terminal potential difference measured. A graph of potential difference against current should be linear and the emf of the cell could be determined.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use calipers and micrometers for small distances, using digital or vernier scales.
- Correctly construct circuits from circuit diagrams using D.C. power supplies, cells, and a range of circuit components, including those where polarity is important.
- Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH3 2007 Q2

PH3 2011 Task B4

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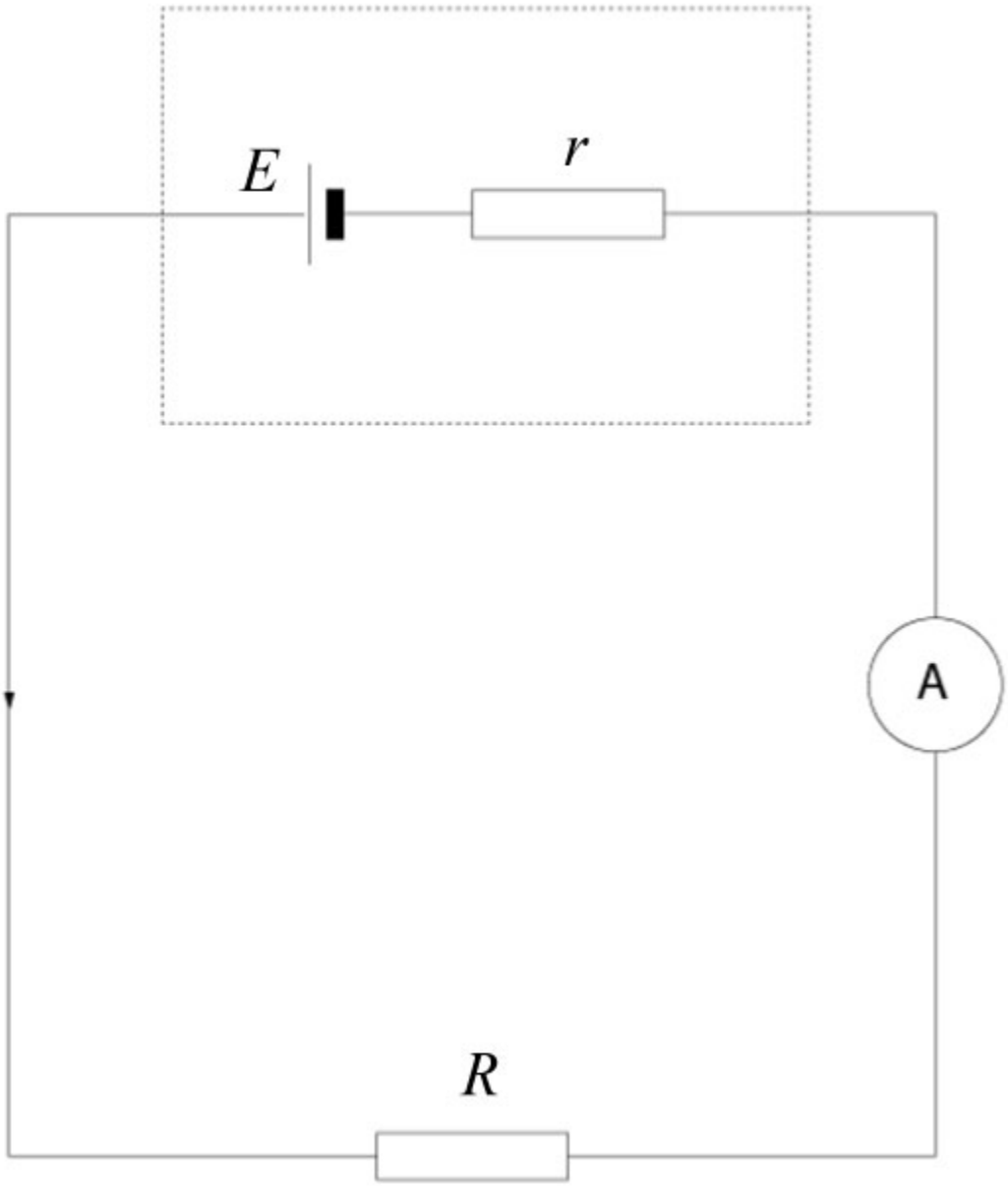
Edugas > AS Physics > Terms, definitions and units booklet

Edugas > AS Physics > Related practical past questions

COMPONENT: 2 . 3 D.C. CIRCUITS EXAM LEVEL: AS

DIAGRAM:

Determination of the Internal Resistance of a Cell



USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Terms, definitions and units booklet

Eduqas > AS Physics > Related practical past questions

COMPONENT: 2 . 4 THE NATURE OF WAVES — EXAM LEVEL: AS

	SPECIFICATION STATEMENT	COMMENT
(a)	The idea that a progressive wave transfers energy without any transfer of matter	See terms, definitions and units booklet.
(b)	The difference between transverse and longitudinal waves	See terms, definitions and units booklet.
(c)	The term polarisation	See terms, definitions and units booklet.
(d)	The terms in phase and in antiphase	See terms, definitions and units booklet.
(e)	The terms displacement, amplitude, wavelength, frequency, period and velocity of a wave	See terms, definitions and units booklet.
(f)	Graphs of displacement against time, and displacement against position for transverse waves only	See terms, definitions and units booklet.
(g)	The equation $c = f\lambda$	See terms, definitions and units booklet. In both theoretical and practical contexts.
(h)	The idea that all points on wavefronts oscillate in phase, and that wave propagation directions (rays) are at right angles to wavefronts	Familiarity with the terms *torque* and *moment* (used interchangeably). See terms, definitions and units booklet.



Select the image (left) for "Measurement of the intensity variations for polarisation" practical work.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 2 . 4 THE NATURE OF WAVES — EXAM LEVEL: AS

NAME OF EXPERIMENT:

Measurement of the Intensity Variations for Polarisation

THEORY:

The light waves in a ray of light from a lamp have vibrations in all planes and directions.The light is unpolarised. When the light passes through a polaroid filter, the vibrations will be in one plane or direction only. In the experiment with two pieces of polaroid, the first polarises the light. The light will then not pass through the second polaroid if the direction in which the second filters polarises light is at right angles to the polarising direction of the first polaroid.

APPARATUS:

Two pieces of polaroid
Lamp, e.g. 24 W
12 V bulb in holder

FURTHER GUIDANCE FOR TECHNICIANS:

Fluorescent lights from the room can be used instead of a lamp.

Experimental Method:

Investigate the variation in intensity by looking through the lamp through both polaroids and rotating one of the polaroids through 360^{o}. Note the change in intensity that occurs.

EXTENSION:

Microwaves could be used instead of light with 3 metal plates used to create a double-slit arrangement.

A transmitter and a suitable receiver could be used with an analogue measuring instrument to show the intensity variations corresponding to the fringes.

PRACTICAL TECHNIQUES:

- Generate and measure waves, using microphone and loudspeaker, or ripple tank, or vibration transducer, or microwave/radio wave source.

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Eduqas > AS Physics > Terms, definitions and units booklet

	SPECIFICATION STATEMENT	COMMENT
(a)	Diffraction occurring when waves encounter slits or obstacles	See terms, definitions and units booklet.
(b)	The idea that there is little diffraction when λ is much smaller than the dimensions of the obstacle or slit	
(c)	The idea that if λ is equal to or greater than the width of a slit, waves spread as roughly semicircular wavefronts, but if λ is less than the slit width, the main beam spreads through less than 180°	
(d)	How two source interference occurs	For example, for water waves, sound, microwaves, light.
(e)	The historical importance of Young's experiment	Earliest demonstration of the wave-like properties of light.
(f)	The principle of superposition, giving appropriate sketch graphs	See terms, definitions and units booklet.
(g)	The path difference rules for constructive and destructive interference between waves from in phase sources	
(h)	The use of $\lambda = \frac{a\Delta y}{D}$	
(i)	The derivation and use of $d\sin\theta = n\lambda$ for a diffraction grating	Derivation by considering parallel rays leaving the slits (and interfering at a very distant point).



Select the image (left) for "Determination of wavelength using Young's double slits" practical work.



Select the image (left) for "Determination of wavelength using a diffraction grating" practical work.



Select the image (left) for "Determination of the speed of sound using stationary waves" practical work.

Continued on next page

USEFUL INTERACTIVE RESOURCES

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Eduqas > AS Physics > Terms, definitions and units booklet

	SPECIFICATION STATEMENT	COMMENT
(j)	The idea that for a diffraction grating a very small d makes beams ("orders") much further apart than in Young's experiment, and that the large number of slits makes the bright beams much sharper	See terms, definitions and units booklet.
(k)	The idea that coherent sources are monochromatic with wavefronts continuous across the width of the beam and, (when comparing more than one source) with a constant phase relationship	
(l)	Examples of coherent and incoherent sources	Laser is the only example needed of a coherent source.
(m)	The idea that for two source interference to be observed, the sources must have a zero or constant phase difference and have oscillations in the same direction	See terms, definitions and units booklet.
(n)	The differences between stationary and progressive waves	In terms of variation of phase and amplitude with distance, and in terms of energy transport.
(o)	The idea that a stationary wave can be regarded as a superposition of two progressive waves of equal amplitude and frequency, travelling in opposite directions, and that the internodal distance is $\frac{\lambda}{2}$	Contexts could include waves on a string, sound waves in air, microwaves. Candidates should know that there are nodes at the ends of a string if these are fixed. The distinction between pressure and displacement nodes and antinodes for stationary sound waves is not required. See terms, definitions and units booklet.



Select the image (left) for "Determination of wavelength using Young's double slits" practical work.



Select the image (left) for "Determination of wavelength using a diffraction grating" practical work.



Select the image (left) for "Determination of the speed of sound using stationary waves" practical work.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 2 . 5 WAVE PROPERTIES EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of Wavelength Using Young's Double Slits

THEORY:

The fringe spacing, Δy is given by the equation $\Delta y = \frac{\lambda D}{d}$ where λ is the wavelength of the light; D is the distance from the slits to the screen where the fringes are viewed and d is the distance between the slits. A graph of Δy against D should be a straight line and the gradient can be used to determine the wavelength of the light.

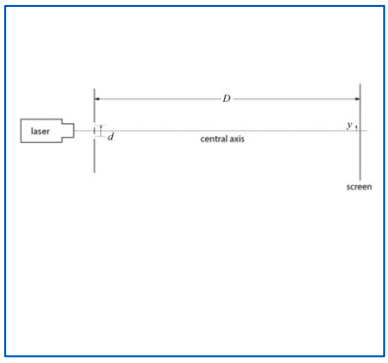
APPARATUS:

Laser pen
Stand and clamp
Double slit
Screen
Metre rule
30 cm ruler or digital calipers

FURTHER GUIDANCE FOR TECHNICIANS:

The value of d can be given to students when using the apparatus. The experiment can be undertaken in the main laboratory and does not require darkroom facilities.

Experimental Method:



The apparatus should be set up as shown. **Select the image (*left*)** for a larger diagram.

Measure the fringe spacing Δy, the spacing between the double slits, d, and the distance, D, from the slits to the screen using either the ruler or digital calipers. Vary the distance, D in equal intervals. Plot a graph of the fringe spacing Δy (y-axis) against the slit-screen distance D (x-axis). This should be a straight line through the origin.

If the fringes are close together; Δy can be determined by measuring the separation of a number of fringes. So determine Δy by dividing the distance by the number of fringes measured.

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Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 2 . 5 WAVE PROPERTIES EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of Wavelength Using Young's Double Slits

EXTENSION:

Microwaves could be used instead of light with 3 metal plates used to create a double-slit arrangement.

A transmitter and a suitable receiver could be used with an analogue measuring instrument to show the intensity variations corresponding to the fringes.

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use laser or light source to investigate characteristics of light, including interference and diffraction.

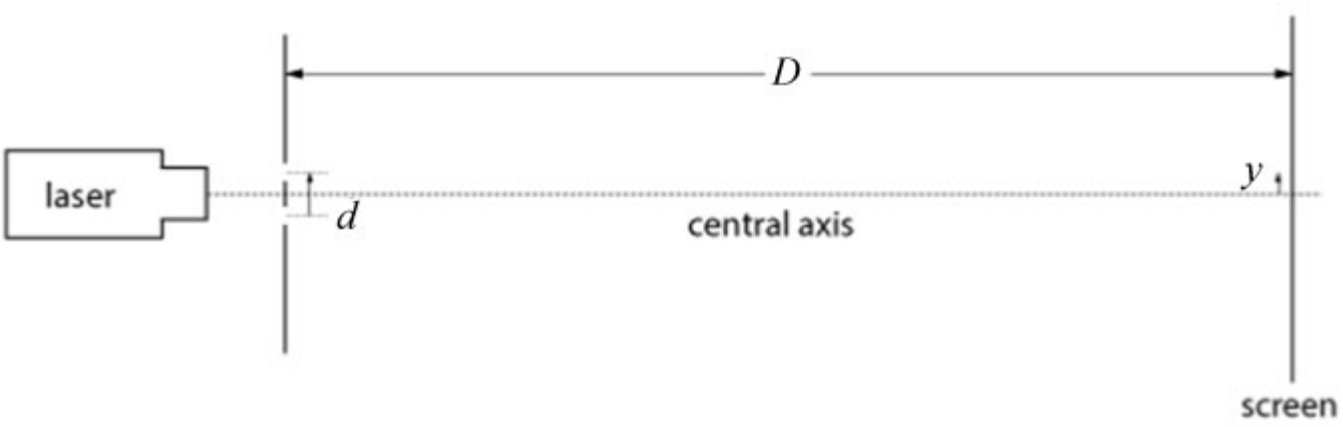
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Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 2 . 5 WAVE PROPERTIES EXAM LEVEL: AS

DIAGRAM:

Determination of Wavelength Using Young's Double Slits



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COMPONENT: 2 . 5 WAVE PROPERTIES EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of Wavelength Using a Diffraction Grating

THEORY:

The diffraction grating equation is given by $n\lambda = d\sin\theta$. The spacing between the lines in a diffraction grating is usually specified or can be found from the grating ruling. By measuring the angle θ, the wavelength of the light can be determined.

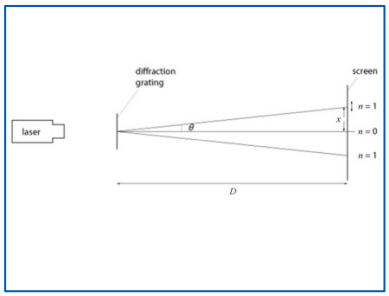
APPARATUS:

Laser pen
Diffraction grating of known d value or ruling e.g. 300 lines cm^{-1}
Metre rule
Screen
Stand and clamp for laser pen and grating

FURTHER GUIDANCE FOR TECHNICIANS:

The experiment can be undertaken in the main laboratory and does not require dark room facilities.

Experimental Method:



The apparatus should be set up as shown. **Select the image (*left*)** for a larger diagram.

The value of θ can be determined from $\tan\vartheta = \frac{x}{D}$.

Using the equation $n\lambda = d\sin\vartheta$ then the wavelength can be determined for various orders of diffraction.

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COMPONENT: 2 . 5 WAVE PROPERTIES

EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of Wavelength Using a Diffraction Grating

EXTENSION:

A spectrometer could be used with different spectra lamps and the wavelength of various lines in the spectra could be determined.

PRACTICAL TECHNIQUES:

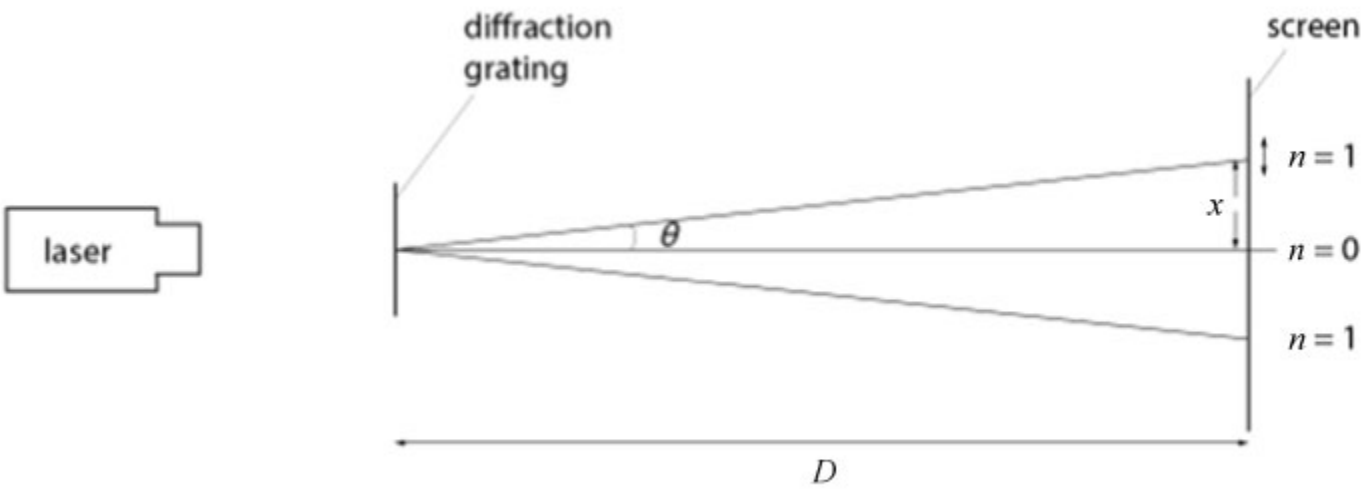
- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use laser or light source to investigate characteristics of light, including interference and diffraction.

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DIAGRAM:

Determination of Wavelength Using a Diffraction Grating



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COMPONENT: 2 . 5 WAVE PROPERTIES EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of the Speed of Sound Using Stationary Waves

THEORY:

When resonance first occurs, the length of air in the tube, l, plus a small end correction, e (to account for the position of the tuning fork above the tube) will be equal to a quarter of a wavelength. Hence:

$$l + e = \frac{\lambda}{4} \quad \text{but} \quad \lambda = \frac{c}{f} \qquad \text{so} \quad l = \frac{c}{4f} - e$$

If a graph is plotted of l (y-axis) against $\frac{1}{f}$ (x-axis) it should be a straight line with a small negative y-intercept.

The gradient of the graph equals $\frac{c}{4}$, and so the speed of sound, c, can be found. The small negative intercept will give the end correction.

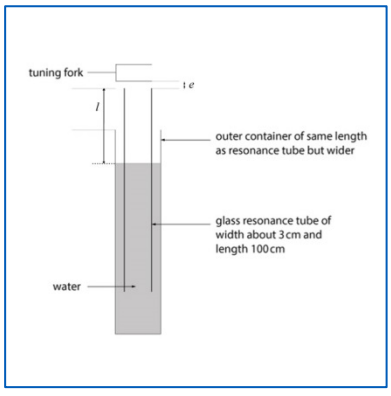
APPARATUS:

A range of at least five different tuning forks
Glass resonance tube of width about 3 cm and length 100 cm
Outer container of same length as resonance tube, but wider
Water

FURTHER GUIDANCE FOR TECHNICIANS:

An alternative to the above would be to use a very wide burette (about 3 cm diameter) and allow the water to drain out as the tuning fork is held over the top of it.

Experimental Method:



The apparatus should be set up as shown. **Select the image (*left*)** for a larger diagram.

Initially place the resonance tube as deep as possible into the water. Then gradually raise it. As this is being done hold a vibrating tuning fork over the top. When resonance occurs (a loud sound will be heard), measure the length of the tube above the water level.

Repeat the above for each of the tuning forks. Plot a graph of length (y-axis) against $\frac{1}{\text{frequency}}$ (x-axis). Use the gradient to determine a value for the speed of sound.

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NAME OF EXPERIMENT:

Determination of the Speed of Sound Using Stationary Waves

EXTENSION:

The resonance tube could be raised past the first resonance point until the second resonance point is reached. The results could then be used to show that for the two resonant lengths l_1 and l_2 then:

Speed of sound, $c = 2f(l_2 - l_1)$

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use signal generator and oscilloscope, including volts/division and time-base.
- Generate and measure waves, using microphone and loudspeaker, or ripple tank, or vibration transducer, or microwave/radio wave source.

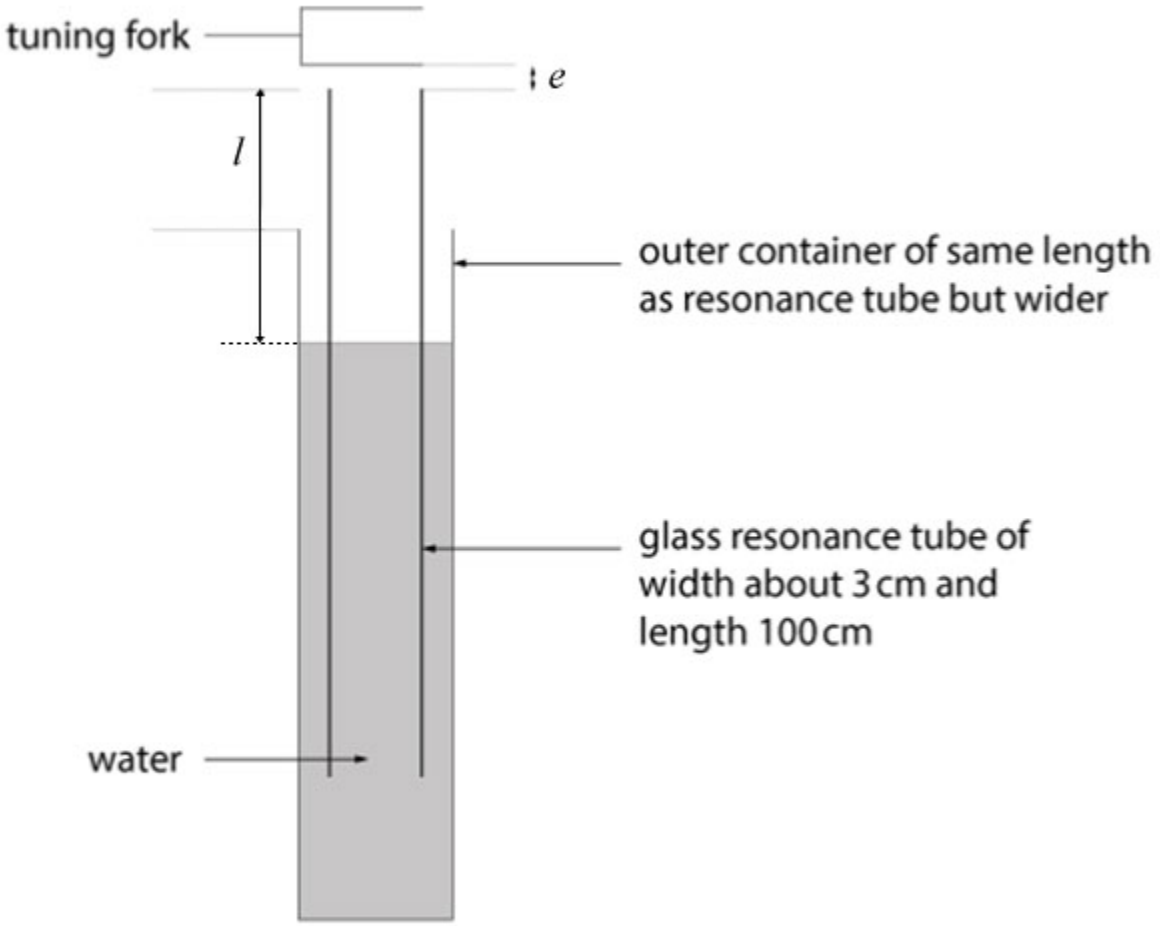
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DIAGRAM:

Determination of the Speed of Sound Using Stationary Waves



USEFUL INTERACTIVE RESOURCES

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COMPONENT: 2 . 6 REFRACTION OF LIGHT — EXAM LEVEL: AS

	SPECIFICATION STATEMENT	COMMENT
(a)	The refractive index, n, of a medium being defined as $\frac{c}{v}$, in which v is the speed of light in the medium and c is the speed of light in a vacuum	See terms, definitions and units booklet.
(b)	The use of the equations: $n_1 v_1 = n_2 v_2$ and $n_1 \sin\theta_1 = n_2 \sin\theta_2$ (regarded as Snell's law)	See terms, definitions and units booklet.
(c)	How Snell's law relates to the wave model of light propagation and for diagrams of plane waves approaching a plane boundary obliquely, and being refracted	Huygens' principle is not needed, but the ability to perform time and distance calculations on incident and refracted wavefronts is required.
(d)	The conditions for total internal reflection	
(e)	The derivation and use of the equation for the critical angle $n_1 \sin\theta_C = n_2$	See terms, definitions and units booklet
(f)	How to apply the concept of total internal reflection to multimode optical fibres	
(g)	The problem of multimode dispersion with optical fibres in terms of limiting the rate of data transfer and transmission distance	Candidates need to be able to perform calculations based on the transit times of pulses via the straight path and a zigzag path.
(h)	How the introduction of monomode optical fibres has allowed for much greater transmission rates and distances	Includes the knowledge that monomode fibres are very thin: their diameters are only a few wavelengths of the near infra-red radiation they transmit.



Select the image (left) for "Measurement of the refractive index of a material" practical work.

USEFUL INTERACTIVE RESOURCES

Eduqas > AS Physics > Specification from 2015

Eduqas > AS Physics > Terms, definitions and units booklet

COMPONENT: 2 . 6 REFRACTION OF LIGHT EXAM LEVEL: AS

NAME OF EXPERIMENT:

Measurement of the Refractive Index of a Material

THEORY:

The refractive index, n, of a material can be determined from the equation $\sin\theta_i = n\sin\theta_r$ where n = refractive index, θ_i is the angle of incidence and θ_r is the angle of refraction. The above equation assumes that the incident ray is travelling in air. A graph of $\sin\theta_i$ (y-axis) against $\sin\theta_r$ (x-axis) will give a straight line through the origin and the gradient is equal to the refractive index, n.

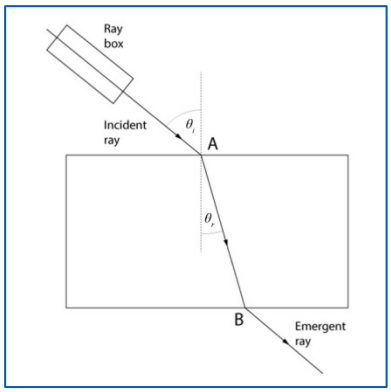
APPARATUS:

Suitable white light source, e.g. ray box fitted with a single slit to produce a narrow parallel beam of light
Power supply for ray box and connecting leads
Rectangular block of glass or Perspex
1 or 2 sheets of plain paper
Protractor
30 cm ruler

FURTHER GUIDANCE FOR TECHNICIANS:

The investigation may be conducted in normal laboratory lighting. A dark room is not required.

Experimental Method:



The arrangement should be set up as shown. **Select the image (*left*)** for a larger diagram.

The angle of refraction θ_r can be measured by drawing in the line joining the incident and emergent rays for different values of the angle of incidence. The angles can be measured using the protractor after drawing in the normals. A graph of $\sin\theta_i$ (y-axis) against $\sin\theta_r$ (x-axis) can be plotted, which should give a straight line. A value of n can then be determined from the gradient.

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Eduqas > AS Physics > Related practical past questions

COMPONENT: 2 . 6 REFRACTION OF LIGHT

EXAM LEVEL: AS

NAME OF EXPERIMENT:

Measurement of the Refractive Index of a Material

PRACTICAL TECHNIQUES:

- Use appropriate analogue apparatus to record a range of measurements (to include length/distance, temperature, pressure, force, angles, volume) and to interpolate between scale markings.
- Use laser or light source to investigate characteristics of light, including interference and diffraction.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH3 2012 Task A2

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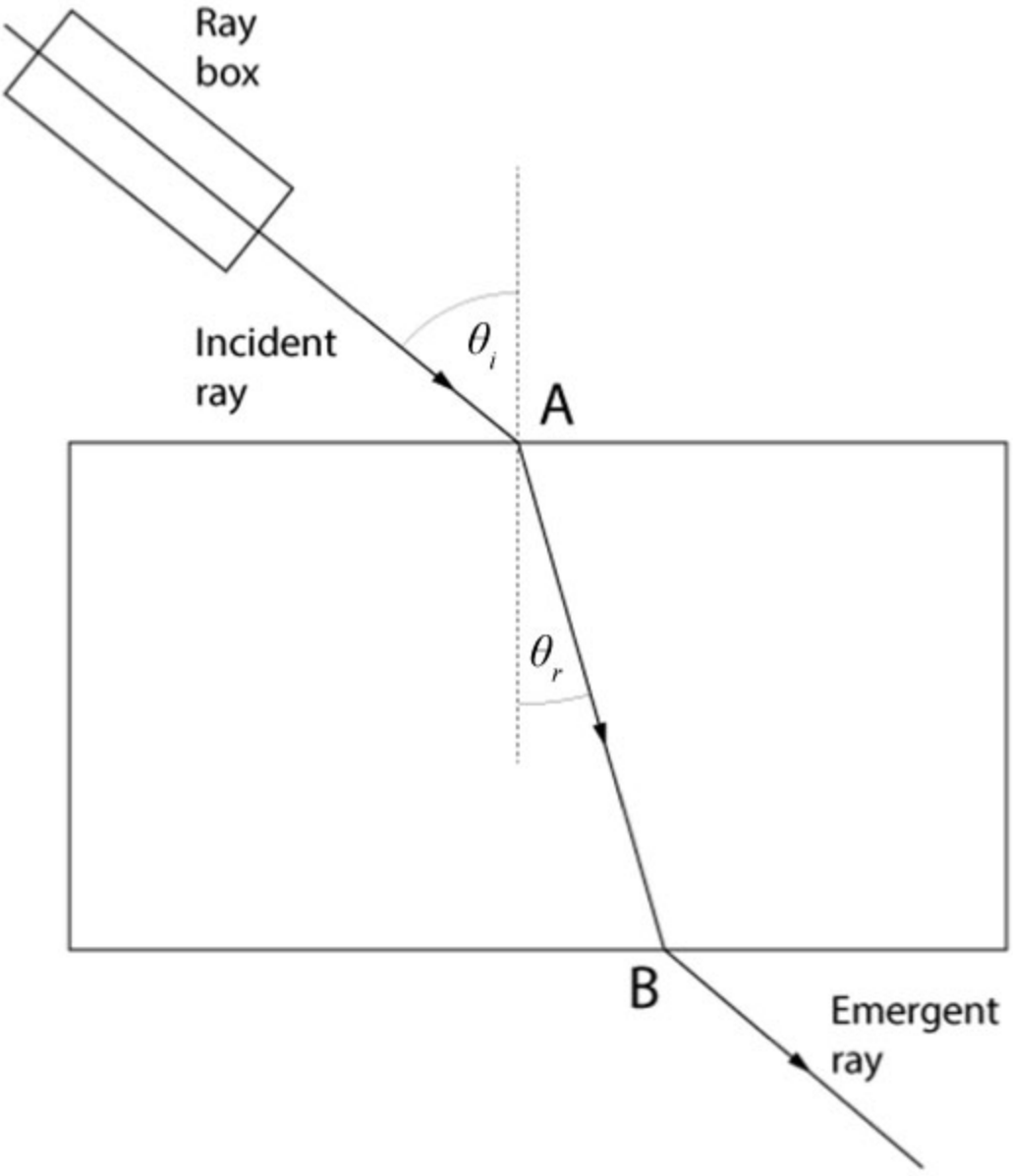
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COMPONENT: 2 . 6 REFRACTION OF LIGHT EXAM LEVEL: AS

DIAGRAM:

Measurement of the Refractive Index of a Material

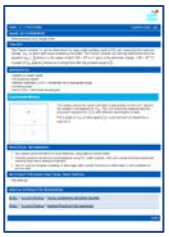


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Eduqas > AS Physics > Related practical past questions

	SPECIFICATION STATEMENT	COMMENT
(a)	The fact that light can be shown to consist of discrete packets (photons) of energy	
(b)	How the photoelectric effect can be demonstrated	For example, with electroscope or vacuum photocell. See terms, definitions and units booklet.
(c)	How a vacuum photocell can be used to measure the maximum kinetic energy, $E_{k\,max}$, of emitted electrons in eV and hence in J	
(d)	The graph of $E_{k\,max}$ against frequency of illuminating radiation	
(e)	How a photon picture of light leads to Einstein's equation, $E_{k\,max} = hf - \phi$, and how this equation correlates with the graph of $E_{k\,max}$ against frequency	Includes determining h from graph gradient and ϕ from intercept. See terms, definitions and units booklet.
(f)	The fact that the visible spectrum runs approximately from 700 nm (red end) to 400 nm (violet end) and the orders of magnitude of the wavelengths of the other named regions of the electromagnetic spectrum	
(g)	Typical photon energies for these radiations	Need to know or be able to calculate from typical wavelength.
(h)	How to produce line emission and line absorption spectra from atoms	Line emission spectrum produced by bombarding atoms with electrons (no practical details needed) or (for example in a flame) by other atoms.
(i)	The appearance of such spectra as seen in a diffraction grating	



Select the image (left) for "Determination of h using LEDs" practical work.

Continued on next page

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	SPECIFICATION STATEMENT	COMMENT
(j)	Simple atomic energy level diagrams, together with the photon hypothesis, line emission and line absorption spectra	Energy levels could be in J or eV. See terms, definitions and units booklet
(k)	How to determine ionisation energies from an energy level diagram	See terms, definitions and units booklet
(l)	The demonstration of electron diffraction and that particles have a wave-like aspect	
(m)	The use of the relationship $p = \frac{h}{\lambda}$ for both particles of matter and photons	
(n)	The calculation of radiation pressure on a surface absorbing or reflecting photons	Candidates will be expected to be able to use the equations for photon energy and momentum. Therefore they should be able, for example, to calculate the momentum arriving per second at a surface when a beam of light of a given power strikes the surface normally. According to Newton's 2nd and 3rd laws, this gives the force on the surface if it doesn't reflect. If the surface is 100% reflecting, then the force is double because momentum is a vector and the change in momentum of the photons is double when their momentum is reversed. Pressure is calculated as normal force divided by (beam) area.



Select the image (left) for "Determination of *h* using LEDs" practical work.

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COMPONENT: 2 . 7 PHOTONS EXAM LEVEL: AS

NAME OF EXPERIMENT:

Determination of h using LEDs

THEORY:

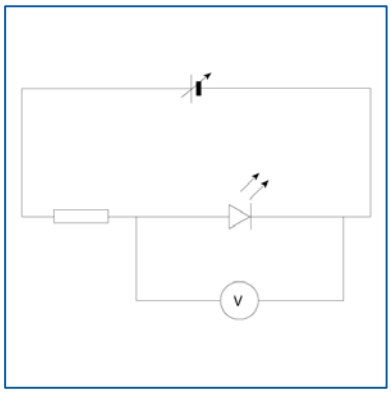
The Planck constant, h, can be determined by using a light-emitting diode (LED) and measuring the minimum voltage, V_{min}, at which light is just emitted by the diode. The Planck constant can then be determined from the equation $V_{min} = \frac{hc}{e\lambda}$ where c is the speed of light 3.00×10^8 m s^{-1} and e is the electronic charge, 1.60×10^{-19} C.

A graph of V_{min} against $\frac{1}{\lambda}$ should be a straight line with the gradient equal to $\frac{hc}{e}$.

APPARATUS:

Variable D.C. power supply
1 kΩ protective resistor
Voltmeter (resolution ± 0.01 V) [multimeter set to appropriate range]
Connecting leads
Various LEDs – with known wavelengths

Experimental Method:



The voltage should be varied until light is just emitted by the LED. Record the voltage to which it corresponds, namely $V_{min.}$

The LED should be replaced and the procedure repeated for LEDs with different wavelengths of light.

Plot a graph of V_{min} (x-axis) against $\frac{1}{\lambda}$ (y-axis) and use it to determine a value for h.

PRACTICAL TECHNIQUES:

- Use calipers and micrometers for small distances, using digital or vernier scales.
- Correctly construct circuits from circuit diagrams using D.C. power supplies, cells, and a range of circuit components, including those where polarity is important.
- Use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data.

RELEVANT PREVIOUS PRACTICAL PAST PAPERS:

PH3 2006 Q2

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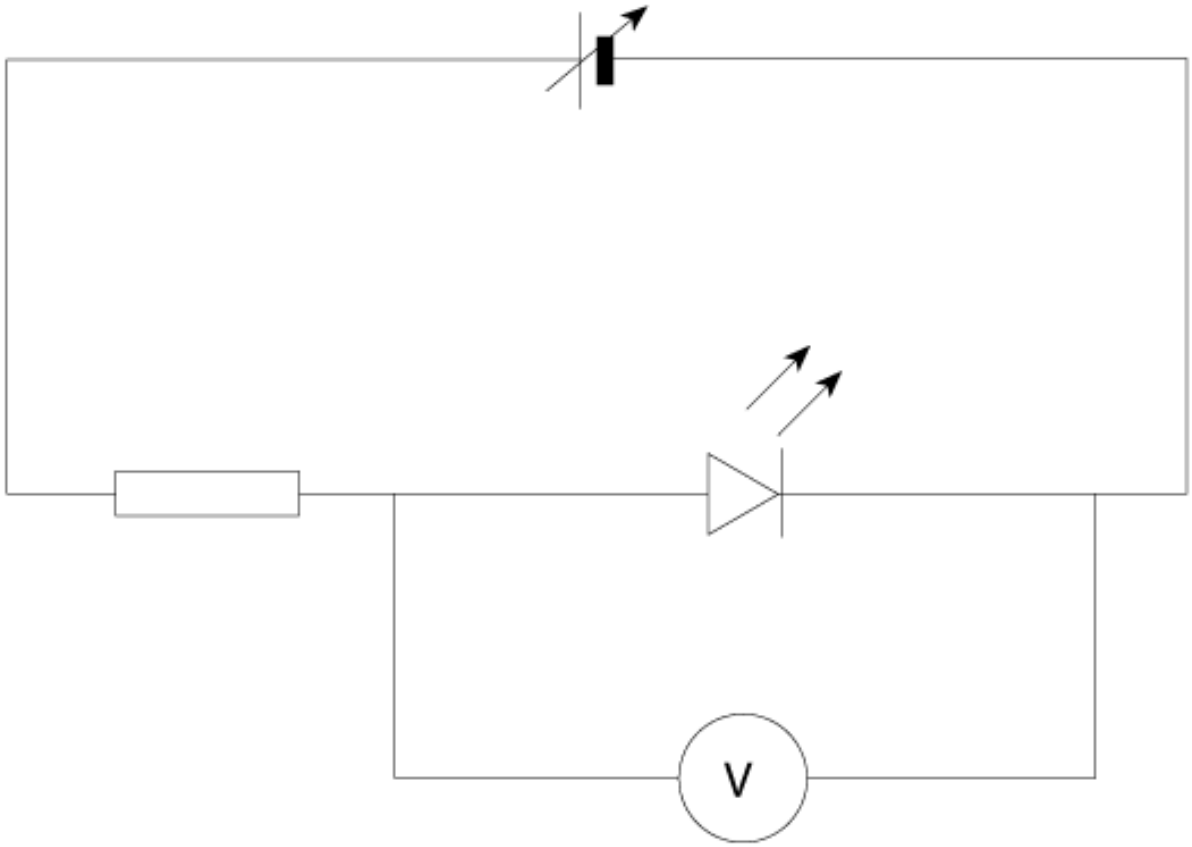
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Eduqas > AS Physics > Related practical past questions

COMPONENT: 2 . 7 PHOTONS EXAM LEVEL: AS

DIAGRAM:

Determination of h using LEDs



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Eduqas > AS Physics > Related practical past questions

COMPONENT: 2 . 8 LASERS — EXAM LEVEL: AS

	SPECIFICATION STATEMENT	COMMENT
(a)	The process of stimulated emission and how this process leads to light emission that is coherent	See detailed laser notes. See terms, definitions and units booklet.
(b)	The idea that a population inversion ($N_2 > N_1$) is necessary for a laser to operate	See terms, definitions and units booklet.
(c)	The idea that a population inversion is not (usually) possible with a 2-level energy system	
(d)	How a population inversion is attained in 3 and 4-level energy systems	
(e)	The process of pumping and its purpose	See terms, definitions and units booklet.
(f)	The structure of a typical laser, i.e. an amplifying medium between two mirrors, one of which partially transmits light	Diagrams of the structure of a laser diode are not required.
(g)	The advantages and uses of a semiconductor laser, i.e. small, cheap, far more efficient than other types of laser, and it is used for CDs, DVDs, telecommunication, etc.	

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