Qualification Accredited

OCR
Oxford Cambridge and RSA

A LEVEL

PHYSICS A
PHYSICS B (ADVANCING PHYSICS)

H556, H557

For first teaching in 2015

Practical Activities Support Guide

Version 1

www.ocr.org.uk/physics

Contents

Introduction

This Practical activities support guide provides specific support on our Practical Activity Group (PAG) activities and how they can be adapted by centres for the Practical Endorsement. There is also support for practical skills assessed in a written examination that may be used for revision. This guide supplements our existing resources regarding the Practical Endorsement, including:

- Positive about Practical
  - This page features videos outlining our PAG approach to the Practical Endorsement. It also contains links to cross-board communications relating to the Practical Endorsement and monitoring.
- Practical Endorsement FAQs
- Practical Skills Handbook
  - This is a comprehensive handbook which describes the assessment of practical skills in the AS and A Level specifications, including the requirements of the Practical Endorsement and guidance on planning a practical scheme of work.
  - The practical work required for the 1.2.1 Practical skills is detailed in pages 36-39 of the practical skills handbook.
- OCR Science Practical Endorsement Training Site
  - Lead teachers are required to have undertaken this free online training and should ensure all other teachers are familiar with the requirements. We recommend that, for the purpose of standardisation within your centre, all teachers who assess the Practical Endorsement undertake the training.
- PAG teacher and student sheets
- Science Coordinator Materials
  - This is where secure documents are held including the PAG trackers. The PAG trackers are very useful for recording candidate progress towards the endorsement.
- A Level Specifications - Physics A and Physics B
  - Most notably this includes:
    - Module 1.1 Practical skills assessed in a written examination
    - Module 1.2 Practical skills assessed in the practical endorsement
    - Section 5 Practical Endorsement appendix

For entries into the Summer 2021 series only

- The Practical Endorsement monitoring process 2019-2021
- Additional Practical Endorsement guidance – 2020-2021
- Practical Endorsement guidance for remote monitoring

The Practical Endorsement

Extract from the Practical Skills Handbook:

The Practical Endorsement is directly assessed by teachers and is a mandatory part of the A Level qualification. The assessment is certificated as Pass or Not-classified. As part of the Head of Centre declaration that centres must submit every year, any centre offering A Level Physics must declare that they have provided students with the opportunity to complete practical work towards the Practical Endorsement.

In order to achieve a Pass, candidates will need to have met the expectations set out in the Common Practical Assessment Criteria (CPAC) (see Table 2 in the specification, Appendix 5) including demonstrating competence in all the skills, apparatus and techniques in sections 1.2.1 and 1.2.2 of each specification.

Learners may work in groups, but must be able to demonstrate and record independent evidence of their competency. This must include evidence of independent application of investigative approaches and methods to practical work.

Teachers who award a Pass need to be confident that the candidate consistently and routinely exhibits the required competencies before completion of the A Level course.

The PAG Approach

Candidates can demonstrate practical skills in any practical activity undertaken throughout the course of study. The 12 OCR Practical Activity Groups (PAGs) described in the specification provide opportunities for demonstrating competence in all required skills, together with the use of apparatus and practical techniques for each subject.

Using our suggested practical activities is **not** mandatory. You can use the suggested practical activities from the Practical Activity Groups (PAGs), your own activities, or activities from other publishers to assess students' practical skills. If you use activities other than our suggested practical activities, you need to ensure that you have mapped these activities to the relevant 1.2.1 and 1.2.2 criteria and the Common Practical Assessment Criteria (CPAC) so you can track student progress in these.

You may also wish to adapt our PAG activities. It is not always necessary to do the 'full' extended practical. Often the analysis and graph skills are similar across many activities and there is ample opportunities for candidates to achieve some of the CPAC and 1.2.1 skills elsewhere. Using the 1.2.2 apparatus safely to make and record measurements must be directly observed by the teacher. Adapting some of the activities to focus on these skills can reduce the amount of class time needed.

In the OCR specifications, 12 PAGs are presented, within each PAG are 3-4 suggested activities. None of these activities are explicitly required. Instead, the PAG approach gives some possible routes for students to learn the practical skills in the AS and A Level specifications and to achieve the Practical Endorsement.

In general, planning at least one practical activity from each PAG group will satisfy the minimum requirement of 12 practical activities and give students the opportunity to demonstrate competence in all of the 1.2.1 and 1.2.2 and CPAC criteria.

At least 15% of the marks in written examinations will assess the practical skills from 1.1 of the specification. Examinations will not assume candidates have carried out all of the suggested PAG activities. However, they will assume that students are familiar with the apparatus and techniques from the 1.2.2 criteria which students will have covered during the course of the Practical Endorsement. They will also assume knowledge of the practical activities specifically mentioned as learning outcomes in modules 3 to 6 of the specification. Questions may test the application of practical skills in novel and familiar contexts.

The CPAC and our specifications

The CPAC criteria is very closely linked to our specification learning outcomes in 1.2.1 Practical skills. Below, we have mapped out how these learning outcomes map to the CPAC criteria as well as our PAG activities.

In addition, we have also mapped out how our PAG activities relate to our specification's 1.2.2 Use of apparatus and techniques learning outcomes. This information is also included in the PAG trackers available on OCR interchange.

Health and safety

For additional health and safety guidance, please refer to CLEAPPS. There are a number of useful guides. For example, Cleapss Resource GL352 provides advice and suggestions for practical activities if a laboratory is not available.

PAG vs CPAC and 1.2.1

This shows how our suggested practical activities map to the 1.2.1 specification learning outcomes and the CPAC 1-5. There are variations to the PAGs so record any adaptations made. The OCR PAG tracker is very useful for this.

	CPAC 1: Follows written procedures	**CPAC 2: Applies investigative approaches and methods when using instruments and equipment**		**CPAC 3: Safely uses a range of practical equipment and materials**		**CPAC 4: Makes and records observations**			**CPAC 5: Researches, references and reports**	
	1.2.1 Practical Skills									
PAG	**c)** follow written instructions	**a)** apply investigating approaches to practical work	**g)** use appropriate software and tools to process data, carry out research and report findings	**b)** safely use a range of practical equipment & materials	**j)** use a wide range of experimental and practical instruments, equipment and techniques	**d)** make and record observations/ measurements	**e)** keep appropriate records of experimental activities	**f)** present information and data in a scientific way	**h)** use online and offline research skills including websites, textbooks and other printed scientific sources of information	**i)** correctly cite sources of information
1.1	✓		✓	✓	✓	✓	✓			
1.2	✓			✓	✓	✓	✓	✓		
1.3	✓		✓	✓	✓	✓	✓	✓	✓	✓
2.1	✓		✓		✓	✓	✓	✓	✓	✓
2.2	✓			✓	✓	✓	✓	✓		
2.3	✓			✓	✓	✓	✓	✓		
3.1	✓			✓	✓	✓	✓	✓	✓	✓
3.2	✓	✓		✓	✓	✓	✓	✓		
3.3	✓	✓	✓	✓	✓	✓	✓	✓		
4.1	✓	✓		✓	✓	✓	✓	✓		
4.2	✓			✓	✓	✓	✓	✓		
4.3		✓	✓	✓	✓	✓	✓	✓		
5.1	✓			✓	✓	✓	✓	✓		
5.2	✓			✓	✓	✓	✓	✓		
5.3	✓			✓	✓	✓	✓	✓		
5.4	✓			✓		✓		✓		
6.1	✓			✓	✓	✓	✓	✓	✓	✓
6.2	✓			✓	✓	✓	✓	✓		

	CPAC 1: Follows written procedures	**CPAC 2: Applies investigative approaches and methods when using instruments and equipment**		**CPAC 3: Safely uses a range of practical equipment and materials**		**CPAC 4: Makes and records observations**			**CPAC 5: Researches, references and reports**	
	1.2.1 Practical Skills									
PAG	**c)** follow written instructions	**a)** apply investigating approaches to practical work	**g)** use appropriate software and tools to process data, carry out research and report findings	**b)** safely use a range of practical equipment & materials	**j)** use a wide range of experimental and practical instruments, equipment and techniques	**d)** make and record observations/ measurements	**e)** keep appropriate records of experimental activities	**f)** present information and data in a scientific way	**h)** use online and offline research skills including websites, textbooks and other printed scientific sources of information	**i)** correctly cite sources of information
6.3	✓	✓		✓	✓	✓	✓	✓		
7.1	✓		✓	✓	✓	✓	✓	✓		
7.2	✓			✓	✓	✓	✓	✓		
7.3	✓		✓	✓	✓	✓	✓	✓		
8.1	✓			✓	✓	✓	✓	✓		
8.2	✓			✓	✓	✓	✓	✓		
8.3	✓	✓	✓	✓		✓	✓	✓	✓	✓
8.4	✓	✓	✓	✓		✓	✓	✓		
9.1	✓	✓	✓	✓	✓	✓	✓	✓		
9.2	✓			✓	✓	✓	✓	✓		
9.3		✓		✓	✓	✓	✓	✓	✓	✓
10.1		✓	✓	✓	✓	✓	✓	✓		
10.2		✓	✓	✓	✓	✓	✓	✓		
10.3	✓	✓	✓	✓	✓	✓	✓	✓		
11.1		✓		✓	✓	✓	✓	✓	✓	✓
11.2		✓	✓	✓	✓	✓	✓	✓	✓	✓
11.3		✓		✓	✓	✓	✓	✓		
12.1			✓					✓	✓	✓
12.2			✓					✓	✓	✓
12.3			✓					✓	✓	✓

PAG vs 1.2.2

This shows how our suggested practical activities map to the apparatus and techniques in the 1.2.2 specification learning outcomes.

	1.2.2 (a)	1.2.2 (b)	1.2.2 (c)	1.2.2 (d)	1.2.2 (e)	1.2.2 (f)	1.2.2 (g)	1.2.2 (h)	1.2.2 (i)	1.2.2 (j)	1.2.2 (k)	1.2.2 (l)
PAG	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	use of appropriate digital instruments, including electrical multimeters, to obtain a range of measurements (to include time, current, voltage, resistance and mass)	use of methods to increase accuracy of measurements, such as timing over multiple oscillations, or use of fiducial marker, set square or plumb line	use of a stopwatch or light gates for timing	use of calipers and micrometers for small distances, using digital or vernier scales	correctly constructing circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important	designing, constructing and checking circuits using DC power supplies, cells, and a range of circuit components	use of a signal generator and oscilloscope, including volts/ division and time-base	generating and measuring waves, using microphone and loudspeaker, or ripple tank, or vibration transducer, or microwave/ radio wave source	use of a laser or light source to investigate characteristics of light, including interference and diffraction	use of ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data	use of ionising radiation, including detectors.
1.1	✓		✓	✓							✓	
1.2	✓	✓	✓	✓	✓							
1.3	✓			✓							✓	
2.1	✓	✓	✓		✓							
2.2	✓	✓	✓								✓	
2.3	✓	✓	✓									
3.1		✓			✓	✓						
3.2		✓				✓						
3.3		✓				✓					✓	
4.1		✓					✓					
4.2		✓				✓	✓					
4.3	✓	✓	✓				✓				✓	
5.1	✓									✓		
5.2	✓		✓			✓		✓	✓			
5.3	✓					✓		✓	✓			
5.4	✓									✓		
6.1		✓	✓			✓						
6.2	✓	✓	✓							✓		

	1.2.2 (a)	1.2.2 (b)	1.2.2 (c)	1.2.2 (d)	1.2.2 (e)	1.2.2 (f)	1.2.2 (g)	1.2.2 (h)	1.2.2 (i)	1.2.2 (j)	1.2.2 (k)	1.2.2 (l)
PAG	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	use of appropriate digital instruments, including electrical multimeters, to obtain a range of measurements (to include time, current, voltage, resistance and mass)	use of methods to increase accuracy of measurements, such as timing over multiple oscillations, or use of fiducial marker, set square or plumb line	use of a stopwatch or light gates for timing	use of calipers and micrometers for small distances, using digital or vernier scales	correctly constructing circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important	designing, constructing and checking circuits using DC power supplies, cells, and a range of circuit components	use of a signal generator and oscilloscope, including volts/ division and time-base	generating and measuring waves, using microphone and loudspeaker, or ripple tank, or vibration transducer, or microwave/ radio wave source	use of a laser or light source to investigate characteristics of light, including interference and diffraction	use of ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data	use of ionising radiation, including detectors.
6.3	✓	✓	✓						✓	✓		
7.1		✓									✓	✓
7.2	✓	✓	✓		✓							✓
7.3		✓		✓							✓	✓
8.1	✓											
8.2	✓		✓									
8.3	✓		✓									
8.4	✓	✓	✓		✓							
9.1		✓				✓					✓	
9.2		✓				✓						
9.3	✓	✓	✓		✓		✓					
10.1	✓	✓	✓	✓								
10.2	✓	✓	✓	✓								
10.3	✓	✓	✓	✓								
11.1		✓					✓	✓				
11.2	✓	✓	✓	✓			✓				✓	
11.3	✓	✓					✓					
12.1												
12.2												
12.3												

PAG 1: Investigating Motion

Minimum use of apparatus and techniques to be covered:

- Use of appropriate analogue apparatus to measure distance, angles[1], mass[2] and to interpolate between scale markings[3].
- Use of a stopwatch or light gates for timing.
- Use of ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data[4].
- Use of methods to increase accuracy of measurements, such as set square or plumb line.

Note: Some of the techniques/skills have individual components labelled [1,2,3,4,5,6,7,8,9,10]. These specific skills are commonly covered in multiple PAG groups as summarised on pages 14-17 of the Practical Skills Handbook.

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
1.1 Comparing methods of determining *g*	b, c, d, e, g, j	a, c, d, k
1.2 Investigating terminal velocity	b, c, d, e, f, j	a, b, c, d, e
1.3 Investigating the effect of initial speed on stopping distance	b, c, d, e, f, g, h, i, j	a, d, k

PAG1 Related practical learning outcomes in specifications

Physics A

3.1.2 (a)(ii) Techniques and procedures used to investigate the motion and collisions of objects

3.1.2 (b)(ii) Techniques and procedures used to determine the acceleration of free fall using trapdoor and electromagnet arrangement or light gates and timer.

3.2.2 (d)(ii) Techniques and procedures used to determine terminal velocity in fluids.

Physics B

4.2 (d)(i) Investigating the motion and collisions of objects using trolleys, air-track gliders etc. with data obtained from ticker timers, light gates, data-loggers and video techniques.

4.2 (d)(ii) Determining the acceleration of freefall, using trapdoor and electromagnet arrangement, lightgates or video technique.

4.2 (d)(iii) Investigating terminal velocity with experiments such as dropping a ball-bearing in a viscous liquid or dropping paper cones in air.

Overview

This Practical Activity Group offers the opportunity for candidates to make measurements of distances and times for falling objects and to practise the substitutions of their data into the relevant equation of motion. There are clear opportunities for a discussion regarding uncertainties in measurements and suggestions for improvements in the methods applied.

Please note that experiments carried out at home may not be used as evidence of '*use and application' skills 1.2.1 b,d,e,* or *'use of apparatus and techniques' skills 1.2.2.* Homework experiments allow students (absent for the class experiment) to cover the PAG topic area and be awarded some of the indirectly assessed practical skills for that PAG as well as helping prepare students for the written examinations.

Both specifications include knowledge of the trapdoor method to determine the acceleration of freefall, and also practical methods of investigating collisions. These are not in the suggested PAG activities but the support resources include some useful links.

Possible adjustments

PAG 1.1 a Comparing methods of determining *g*

Use of a student's own equipment (for example an eraser as the object, a 30 cm ruler to measure out a height on a wall, a mobile phone for a timer) will avoid the sterilisation of apparatus issue. Fewer pieces of apparatus are then required to provide for the few students who do not have a phone, ruler or eraser. The first part of PAG 1.1 (determining *g* by dropping a tennis ball) could be set as catch-up work for absent students. See the support link for this experiment below.

PAG 1.1 b Comparing methods of determining *g*

The use of light gates as switches is not a compulsory requirement of the syllabus. Schools do need at least two light gates and appropriate data logging equipment / timing equipment to carry out PAG 1.1 as it stands. There are only a few opportunities to use light gates in this course. Many centres have a limited number of light gates and so use them as part of a circus of activities. A solution to allow a class to carrying out PAG 1.1b quickly, is to ask students to cut out their own square of cardboard (weighting the lower end by taping a coin to the card), queue up in front of the light gates, (with the appropriate social distancing), drop the card through two light gates (as in PAG 1.1b) read off their times and return to their places to record and process their data.

PAG 1.2 Investigating terminal velocity method 1

The practical as it stands might be achieved more simply if the elastic bands were positioned at 10 cm intervals. The long tube of oil becomes part of a demonstration which could be led by one of the students. Each student is assigned a rubber band and stops their timer at the instant the ball reaches it. (Smart phones used as timers (or use lab. timers). The data is collated after repeats etc. and a displacement–time graph produced by each student, with the terminal velocity being achieved when the gradient is constant. This method involves all students in the measurements, while allowing them to organise their own tables etc.

PAG 1.2 Investigating terminal velocity method 2

This is a practical that lends itself to be set as homework if students have access to a timer (mobile phone), tape measure and graph paper at home. It may also be a suitable classroom activity. The investigation could be extended to using multiple bun cases and different sized bun cases. Terminal velocity has been reached when the graph of height dropped against time is linear and the gradient in this region is the terminal velocity. Please note that criteria 1.2.1 ,b, c, d and 1.2.2 a, b, c, d cannot be assessed if the experiment has not been observed by a teacher.

PAG 1.3 Investigating the effect of initial speed on stopping distance

This is an investigation into the relationship between speed and stopping distance. This is difficult to organise if the practical is not carried out in groups. Students can push their own blocks through the light gates and measure the resulting stopping distances travelled using their own rulers.

Support resources

These resources for each PAG group may be useful for teachers when planning PAG activities or for students when they are revising the 1.1 Practical skills, the 1.2.2 Use of apparatus and techniques and the learning outcomes relating to specific experiments.

Practical Skills handbook

- Measurement of time using a stopwatch. Page 42.
- Uncertainties in timing measurements. Page 42.
- Reading a ruler and associated uncertainties. Page 43.

PAG 1.1 Comparing methods of determining *g*

- PAG 1.1a is described in a video produced by Cambridge International.
- Measurement of *g* using a trap door switch from the CLEAPSS website.

  Knowledge of this practical is required by both specifications. This document describes in detail how to set up an experiment to determine accurately freefall acceleration g using 'home made' datalogging equipment. Due to the relatively low cost of the Arduino microcontroller, individuals or pairs of students can readily investigate this, helping to develop skills in practical physics and in using technology.

  The worksheet provides a method and some analysis for students to familiarise themselves with this method of determining *g*.
- This IOP worksheet contains details for a home experiment.

PAG 1.2 Investigating terminal velocity

Method 1 is shown in this YouTube clip.

PAG 1.3 Investigating the effect of initial speed on stopping distance

The PAG 1.3 experiment is described in detail in this video from A Level Physics online.

There is a useful explanation for the relationship towards the end of the clip, which will help students who are using the video to catch up with their work.

Other related resources

This IOP collection has a number of practical activities relating to collisions using ticker timers, light gates and air tracks. Many are equipment intensive but a demonstration, video or discussion on some of the methods used may be helpful in familiarising students with some practical methods for investigating collisions.

Physics classroom has a collisions lab simulation for trolleys. PhET also has an 'air hockey' style simulation. While these are both theoretical models, students can change the masses and velocities and observe the effects.

Lab simulation for a car and light gates.

Lab simulation for investigating freefall.

'Monkey and the hunter' practical demonstration video.

A video demonstrating the independence of vertical and horizontal motion.

PAG 2: Investigating properties of materials

Minimum use of apparatus and techniques to be covered:

- Use of calipers and micrometers for small distances, using digital or vernier scales[5].
- Use of appropriate analogue apparatus to measure length[6] and to interpolate between scale markings[3].
- Use of appropriate digital instruments to measure mass[2].

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
2.1 Determining the Young Modulus for a metal	c, d, e, f, g, h, i, j	a, b, c, e
2.2 Connecting springs in series and parallel	b, c, d, e, f, j	a, b, c
2.3 Investigating the properties of a plastic bag	b, c, d, e, f, j	a, b, c

PAG2 Related practical learning outcomes in specifications

Physics A

3.4.1 (d)(ii) Techniques and procedures used to investigate force–extension characteristics for arrangements which may include springs, rubber bands, polythene strips.

3.4.2 (d)(ii) Techniques and procedures used to determine the Young modulus for a metal.

Physics B

3.2 (d)(i) Plotting force–extension characteristics for arrangements of springs, rubber bands, polythene strips, etc.

3.2 (d)(ii) Determining Young modulus for a metal such as copper, steel or other wire.

Overview

This Practical Activity Group includes safe and correct use of practical equipment to deform materials and make accurate measurements of force and distance. The opportunity to make measurements using a micrometer screw gauge or vernier caliper needs to be carried out in PAG 2.1 or PAG 3.1.

Possible adjustments

PAG 2.1 Determining the Young Modulus for a metal

A micrometer screwgauge could be used to make a measurement of the diameter of the wire. A photograph could be taken of the micrometer and shared with the class or projected, allowing students to determine the reading for themselves. Of course this process would be repeated in at least two other positions along the length of the wire and an average made.

To minimise the use of equipment, this experiment could be done in larger groups (socially distancing) with a copper wire of length 5 m. The extensions would still be taken by each student in a kind of circular movement about the loaded end of the wire. The advantages are that the extensions are larger for a given load, fewer masses are required for the experiment with fewer pulleys etc.

Students frequently forget to measure the mass of each 100 g mass…..or they record a 100 g mass as 1 N. Their tables should contain all raw measurements.

Please note the CLEAPSS advice regarding the maximum size of masses (100 g) if this is being carried out in a classroom instead of a lab.

PAG 2.2 Force-extension characteristics for arrangements of springs

The topic involving different arrangements of springs is frequently tested in the terminal exam and so this is an important aspect of the course. It could be completed at home using interactive simulations such as those provided by PhET. The practical skills for 1.2.2 may not be awarded for the simulation work.

PAG 2.3 Investigating the properties of a plastic bag

The stretching of plastic is a very satisfying experiment generating conversations regarding the structure of the material. As there are individual masses, clamp stands, clamps, rulers, materials to break the fall of the masses, there might be some mileage in doing this as a qualitative experiment.

Students could be given the two strips of plastic. Students should pull the plastic with a gentle force and then carefully try to increase the force gradually. It is possible to estimate the shape of a force – extension graph. This could be repeated with the second strip to see if there is a noticeable difference.

It will not cover all of the skills of the original experiment, but will give students some experience of the shapes of force – extension graphs for polymers.

This requires just the sheets of pre-cut plastic.

Support resources

Practical Skills handbook

Graphical skills - Pages 50 - 58

PAG 2.1 Determining the Young Modulus for a metal

This Cambridge International link has a resource that supports the topic of the Young Modulus. It includes a video (with transcript) which demonstrates how to carry out the experiment. This would be of great use for a student who is absent and unable to catch up at school. If a set of readings was to be supplied, the rest of the PAG 2.1 could be completed. (The advice regarding the successful completion of practical skills above should be followed). This resource also has a teacher walkthrough version of the video which includes additional safety considerations and teacher notes, as well as the virtual experiment video with questions for students to consider throughout.

PAG 2.2 Force-extension characteristics for arrangements of springs

Students who are absent may be set work using this PhET simulation on springs. It can easily be adapted with questions directing students to investigate the spring constant of springs in series and parallel.

PAG 2.3 Investigating the properties of a plastic bag

The following video link from A Level Physics online explains some very useful tips regarding the experimental details of the stretching of plastic experiment.

Other related resources

This IOP resource on stretching elastic bands has a set of sample results provided.

Lab simulation for Hooke's Law, investigating different springs.

Short video demonstration to find the spring constant.

PAG 3: Investigating electrical properties

Minimum use of apparatus and techniques to be covered:

- Use of appropriate digital instruments, including multimeters[7], to measure current[8], voltage[9], resistance[10].
- Use calipers and micrometers for small distances, using digital or vernier scales[5].
- Correctly constructing circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components.

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
3.1 Determining the resistivity of a metal	b, c, d, e, f, h, i, j	b, d, e
3.2 Investigating electrical characteristics	a, b, c, d, e, f, j,	b, f
3.3 Determining the internal resistance and maximum power available from a cell	a, b, c, d, e, f, g, j,	b, f, k

PAG3 Related practical learning outcomes in specifications

Physics A

4.2.3 (c)(ii) Techniques and procedures used to investigate the electrical characteristics for a range of ohmic and non-ohmic components.

4.2.4 (a)(ii) Techniques and procedures used to determine the resistivity of a metal.

4.3.2 (c)(ii) Techniques and procedures used to determine the internal resistance of a chemical cell or other source of e.m.f.

Physics B

3.1.2 (d)(i) Investigating electrical characteristics for a range of ohmic and non-ohmic components using voltmeters and ammeters.

3.1.2 (d)(ii) Determining the resistivity or conductivity of a metal.

3.1.2 (d)(iv) The calibration of a sensor or instrument.

3.1.2 (d)(v) Determining the internal resistance of a chemical cell or other source of e.m.f.

Overview

This Practical Activity Group includes the practical use of voltmeters and ammeters in determining the electrical properties of components. All of the PAG activities are important as they directly fulfil many of the above syllabus requirements for both specifications as well as offering the opportunity to develop practical skills. There is significant overlap with PAG 4.

Possible adjustments

Where equipment is limited and the same apparatus is used by several students it is still important that each student makes and records their own measurements. The construction of the apparatus from circuit diagrams must be carried out at some point by each student. There are multiple opportunities to construct circuits throughout PAG 3 and PAG 4.

Electrical components, leads and cells are difficult to sterilise between classes. It is suggested that the apparatus used by a group of 2 or 3 students is put into a labelled tray and subsequently used only by this group until the experiments are finished, at which point the kit may be isolated and cleaned.

For example in PAG 3.1 the apparatus may be set up by one student in the group with measurements taken individually by all 3 members. In PAG 3.3, a different member of the group sets up the apparatus with measurements taken again individually by all 3 members and then the third member of the group setting up the apparatus in PAG 4.1

Support resources

PAG 3.1 Determining the resistivity of a metal

- PhET has produced a slide showing visually, the effect of changing the physical dimensions of a wire, on the resistance of the wire.
- It is suggested that where students are absent and unable to do this important experiment, a set of readings is given to them so that they are able to complete the PAG worksheet and cover the experiment by watching a video outlining the method. Practical use of apparatus 1.2.2 f and 1.2.2 g may be obtained later on by these students in PAGs 3.2, 3.3 or PAG4.
- There are a number of videos demonstrating this experiment on line. This video is a good example, making the point of controlling the current as well as discussing the uncertainties in the measurements. Another example is this O-level video and virtual experiment from Cambridge International Resource Plus which shows the readings for lengths of two types of wire.

PAG 3.2 investigating electrical characteristics

The PhET DC Virtual Lab allows a simulation of this PAG3.2 experiment. Students will need to be told to set up two resistors initially to act as a potential divider and to keep adding an extra resistor to one side of the potential divider between readings. The limited materials that may be investigated include a light bulb (useful), various conductors, resistors and insulators.

PAG 3.3 determining internal resistance and maximum power available from a cell.

The following links will need explanation, but could provide some remote challenge in this topic area:

- Students will need guidance with this internal resistance and e.m.f. simulation.
- By downloading the Virtual Lab in the link, it is possible to alter values of internal resistance of the cell and measure the effect on the other parameters in the circuit.
- There are a number of youtube clips that will demonstrate PAG3.3 such as this video.

Other related resources

This IOP resource for the calibration of a thermistor comes with a sample set of results.

Alternative simulation for the resistance of a wire.

Alternative simulation for investigating the internal resistance of a battery.

PAG 4: Investigating electrical circuits

Minimum use of apparatus and techniques to be covered:

- Use of appropriate digital instruments, including multimeters[7], to measure current[8], voltage[9], resistance[10]
- Correctly constructing circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important.
- Designing, constructing and checking circuits using DC power supplies, cells, and a range of circuit components.

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
4.1 Investigating resistor combinations and potential dividers	a, b, c, d, e, f, j	a, b, g
4.2 Investigating circuits with more than one source of e.m.f	b, c, d, e, f, j	b, f, g
4.3 Using non-ohmic devices as sensors	a, b, d, e, f, g, j	a, b, c, g, k

PAG4 Related practical learning outcomes in specifications

Physics A

4.2.3 (c)(ii) Techniques and procedures used to investigate the electrical characteristics for a range of ohmic and non-ohmic components.

4.3.2 (c)(ii) Techniques and procedures used to determine the internal resistance of a chemical cell or other source of e.m.f.

4.3.3 (c)(ii) Techniques and procedures used to investigate potential divider circuits which may include a sensor such as a thermistor or an LDR.

Physics B

3.1.2 (d)(i) Investigating electrical characteristics for a range of ohmic and non-ohmic components using voltmeters and ammeters.

3.1.2 (d)(iii) Use of potential divider circuits, which may include sensors such as thermistor, LDR.

3.1.2 (d)(iv) The calibration of a sensor or instrument.

3.1.2 (d)(v) Determining the internal resistance of a chemical cell or other source of e.m.f.

Overview

This Practical Activity Group offers a further opportunity to investigate a variety of circuits by constructing the circuits and taking appropriate measurements. PAG4.1 combines useful practise of resistance calculations together with actual measurement of combinations of resistance while PAG4.3 offers the opportunity to confirm the current-voltage characteristics of filament bulbs and semiconductor devices.

Possible adjustments

PAG 4 generally is heavy on quantity of equipment. Students may have to work in groups and to fulfil 1.2.2 *use of apparatus and techniques* it is necessary that each member of the group connects at least one arrangement and measures the corresponding p.d. and current…..or resistance directly from an ohmmeter.

Candidates who are absent when this PAG is completed must cover the practical topics in PAG 4 and so if a catch up session is not possible, the PhET virtual lab simulation below will allow circuits to be constructed and measurements made in order to keep the student on track.

PAG 4.1 Investigating resistor combinations and potential dividers

The practical skills (use and apparatus) in PAG4 are the same as those in PAG3.

If students are assigned individual trays of kit for PAGs 3 and 4, use of individual resistors connected by crocodile clips rather than resistance substitution boxes, means that the apparatus may be emptied into a single tray at the end of the practical lesson and left for a week in a cupboard rather than cleaned, leaving other classes to do the same with new crocodile clips and resistors.

PAG 4.2 Investigating circuits with more than one source of e.m.f.

This activity proposes some ill-advised combinations of cells and challenges teachers of larger groups to maintain the life expectancies of their sets of cells. If there are time constraints or apparatus constraints, this is the PAG in this group to omit….or complete as a simulation (see below).

PAG 4.3 Using non-ohmic devices as sensors

This activity produces data for current-voltage characteristics of components that the syllabus expects students to be able to recall, (and in the case of a light bulb, explain). Possible organisational suggestions here are the use of groups to reduce apparatus consumption and the use of the same labelled group trays of apparatus.

Support resources

PAG 4.1 Investigating resistor combinations and potential dividers

- There are a number of videos that explain experimentally, the use of potentiometers in sensors circuits. This A Level Physics online video is a good example.
- The PhET DC Virtual Lab allows a simulation of a potential divider. Students will need to be told to set up two resistors initially to act as the potential divider and then to keep adding an extra resistor to one side of the potential divider, between readings.

PAG 4.2 Investigating circuits with more than one source of e.m.f.

The PhET DC Virtual Lab allows students to carry out a simulation of PAG 4.2.

PAG 4.3 Using non-ohmic devices as sensors:

- There are a number of videos that explain experimentally, the use of potentiometers in sensors circuits: example.

PAG 5: Investigating waves

Minimum use of apparatus and techniques to be covered:

- Use of appropriate analogue[6] apparatus to measure length , angles[1] and to interpolate between scale markings[3]
- Use of a signal generator and oscilloscope, including volts/division and time-base
- Generating and measuring waves, using microphone and loudspeaker, or ripple tank, or vibration transducer, or microwave/radio wave source
- Use of a laser or light source to investigate characteristics of light, including interference and diffraction

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
5.1 Determining the wavelength of light with a diffraction grating	b, c, d, f	a, j
5.2 Determining the speed of sound in air using a resonance tube	b, c, d, e, f, j	a, c, f, h, i
5.3 Determining frequency and amplitude of a wave using an oscilloscope	b, c, d, e, f, j	a, f, h, i
5.4 Using diffraction from a CD as a means to determine wavelength	b, c, d, f	a, j

PAG5 Related practical learning outcomes in specifications

Physics A

4.4.1 (b)(ii) Techniques and procedures used to use an oscilloscope to determine frequency.

4.4.1 (f)(iii) Techniques and procedures used to observe polarising effects using microwaves and light.

4.4.3 (a)(ii) Techniques and procedures used for superposition experiments using sound, light and microwaves

4.4.3 (g)(ii) Techniques and procedures used to determine the wavelength of light using (1) a double-slit, and (2) a diffraction grating.

4.4.4 (e)(ii) Techniques and procedures used to determine the speed of sound in air by formation of stationary waves in a resonance tube.

5.5.2 (g) Transmission diffraction grating used to determine the wavelength of light.

Physics B

4.1 (d)(i) Using an oscilloscope to determine frequencies.

4.1 (d)(iii) Superposition experiments using vibrating strings, sound waves, light and microwaves.

4.1 (d)(iv) Determining the wavelength of light with a double-slit and diffraction grating.

4.1 (d)(v) Determining the speed of sound in air by formation of stationary waves in a resonance tube.

Overview

This Practical Activity Group uses measurements on both sound and light waves to determine wavelength, frequency and wave speed. There are limited opportunities for use of oscilloscopes and signal generators within the other PAG groups.

Possible adjustments

PAG 5.1 Determining the wavelength of light with a diffraction grating

This experiment could be carried out as a demonstration with apparatus set up by the teacher/technician. Students could be asked to write up a description of the method and individually invited to go to the apparatus and make measurements with their own rulers….minimising contact with equipment. Alternatively, a camera, connected to a projector, could be used to show live close-up of the distances with a fixed ruler in the optimum position to allow measurements to be made by each pupil.

PAG 5.2 Determining the speed of sound in air using a resonance tube

This practical could be carried out as a demonstration with the resonant lengths being determined by the length of the column at which most students in the group interpret the loudest sound to be heard (or use of a microphone connected to a CRO to show the position of the maximum amplitude on the display). The measurement of the length of the column could be made by several different students for each length. With the metre rule fixed in position, there is no need for any student-apparatus contact. Alternatively, a camera, connected to a projector, could be used to show live close-up of the length of the column with a fixed ruler in the optimum position to allow measurements to be made by each pupil (from the screen).

For centres tackling this PAG for the first time, it is suggested that a long glass tube, open at both ends, be inserted into a long cylindrical jar full of water. The length of the resonating column is very easily adjusted by lowering or raising the glass tube into or out of the jar, avoiding potential spills during the experiment.

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

The practical interpretation of an oscilloscope trace is a requirement. To minimise pupil-apparatus contact, the signal generator could be set up by the teacher, and while individual students adjust the CRO settings to make their measurements, the others could be practising taking appropriate measurements on a simulator as described below. The PAG suggests 30-45 minutes for this exercise. In practice, students spend less than 5 minutes taking readings and about another 10 minutes drawing their traces and CRO settings and explaining their workings. Absent candidates cannot be awarded the practical skills 1.2.2 for determining the frequency from a simulation unless completed in the presence of the teacher. (This would be similar to reading the data from a computer using CRO software and a data logger.)

PAG 5.4 Using diffraction from a CD as a means to determine wavelength

An alternative to PAG 5.1.

Support resources

PAG 5.1 Determining the wavelength of light with a diffraction grating

- The following A Level Physics online video shows the theory for PAG 5.1 and might help before watching the second link below.
- This video shows the practical PAG 5.1 from setting up each bit of apparatus to the measurements, calculations and final value for λ. This is very useful in the event that a student is unable to attend this activity.

  If additionally supplied with another student's measurements, PAG 5.1 could be written up and the topic area covered.
- This ophysics simulation allows students to change every variable in the experiment to determine and confirm the wavelength of light.

Reminder: the successful achievement of practical skills 1.2.1 b,c,d,f or techniques 1.2.2 a,j may not be awarded unless the student is present during the practical experiment.

Note: technique 1.2.2 j is a specific reference to the use of lasers in determining characteristics of light. There is limited opportunity to achieve this skill.

PAG 5.2 Determining the speed of sound in air using a resonance tube

- This ophysics simulation allows students to play with resonance of tubes that are open at both ends and also open at one end and closed at other.

- This video shows the PAG 5.2 experiment as described in the student worksheet. This experiment also shows a convenient way to adjust the length of the resonating column with minimum fuss.

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

Download the free sample simulations from the virtual physics laboratory and select the oscilloscope option.

This resource allows students to vary a signal frequency and amplitude and to measure the values using an oscilloscope trace with reference to the time-base and volt/div settings.

PAG 6: Investigating quantum effects

Minimum use of apparatus and techniques to be covered:

- Use of appropriate digital instruments, including multimeters[7], to measure current[8], voltage[9]
- Correctly constructing circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important
- Use of a laser or light source to investigate characteristics of light, including interference and diffraction
- Use of methods to increase accuracy of measurements

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
6.1 Determining the Planck constant	b, c, d, e, f, h, I, j	b, c, f
6.2 Experiments with light	b, c, d, e, f, j	a, b, c, j
6.3 Experiments with polarisation	a, b, c, d, e, f, j	a, b, c, i, j

PAG6 Related practical learning outcomes in specifications

Physics A

4.4.2 (d)(ii) Techniques and procedures used to investigate refraction and total internal reflection of light using ray boxes, including transparent rectangular and semi-circular blocks.

4.5.1 (e)(ii) Determine the Planck constant using different coloured LEDs.

4.5.2 (a)(i) Photoelectric effect, including a simple experiment to demonstrate this effect.

4.5.2 (a)(ii) Demonstration of the photoelectric effect using, e.g. gold-leaf electroscope and zinc plate.

Physics B

3.1.1 (d)(i) Determination of power or focal length of converging lenses

3.1.1 (d)(ii) Observing polarising effects using microwaves and light.

4.1 (d)(ii) Determining refractive index for a transparent block.

4.1 (d)(vi) Determining the Planck constant using different coloured LEDs.

Overview

This Practical Activity Group involves exploring properties of waves in PAG 6.2 and PAG 6.3 and introduces quantum effects in LEDs in PAG 6.1.

Possible adjustments

PAG 6.1 Determining the Planck constant

This is an important activity. Both the H556 and H557 syllabus require that candidates have specific knowledge of this experiment which uses LEDs emitting light of different colours to determine a value for the Planck constant, not just a single LED. This leads to a very specific experiment with analysis of a particular graph to obtain the Planck constant. It is recommended that students use a group set of apparatus which is not used by other students for at least three days (or has been cleaned).

Absent students who are unable to do this experiment could be furnished with one group's results and should go through the process of plotting an appropriate graph to determine the constant.

The YouTube clip in the resources below is a useful preparation, but derives an estimate from a single coloured LED.

PAG 6.2 Experiments with light

The experiments suggested in 6.2A and 6.2B support the specification learning outcomes and are essentially a revision of GCSE physics. Experiments 6.2 C and D are related to refraction of light but not directly related to the H556 learning outcomes, (introducing equations that are ex-syllabus). For H556 it is suggested that these are omitted in the event of time and apparatus constraints in the delivery of the course. H557 Physics B requires knowledge of a practical activity to determine the power of a converging lens.

PAG 6.3A Polarisation of visible light

Polarising filters are expensive and many centres have only a few for demonstration purposes that are passed around during a lesson. If there are class sets of filters (bearing in mind that three filters are required per student) it will be time-consuming to have these cleaned between classes. A suggestion for this practical is that a camera (or visualiser) connected to a projector may be mounted above a sheet of white paper. Three polarising filters, aligned so that the white paper is visible through all three, are placed between the paper and camera. The teacher may perform the filter rotations as described in the student instructions, while the students make their own observations by watching the outcome on the screen. Light from the projector is already polarised so it is not possible to merely hold the filters in front of a screen on which there is white projector light.

PAG 6.3B Polarisation of microwaves

Once again, centres are likely to have only one or two microwave transmitters and receivers. It is common for this experiment to be done as part of a circus where a student will visit the apparatus while their peers are doing some related classwork. This would involve cleaning between each student visit and may take up too much valuable teaching time. It is suggested that the teacher might follow the student instructions, rotating the transmitter or receiver as instructed. Use of a demonstration meter attached to the receiver will enable students to see the outcome from their seats. (Alternatively, a camera focused on the meter and projected on the board will help if the lab is large). The result of this exercise is qualitative. Most students should have no difficulty in making their own observations and writing up the experiment as detailed in their instructions.

Support resources

PAG 6.1 Determining the Planck constant

This YouTube clip shows an experiment with results for two different coloured light emitting diodes from which students might determine the Planck constant. It is not a substitute for carrying out the practical but will allow pupils who were away when their peers carried out the experiment, to write up a similar experiment and produce a value for the Planck constant.

PAG 6.2 Experiments with light

The following link is to a PhET simulation that allows students to simulate the passage of a ray of light from one medium into another. It is suggested that students be given specific instructions and a task to perform with readings to be made and conclusions to be drawn. There are a couple of unknown media within the simulation that students could be told to discover by simulating the passing of light through them and by making appropriate measurements, finding the refractive indices etc.

There are a number of tutorials on line to help students use this software. The following is one example.

This link shows a similar investigation with angles already measured.

PAG 6.3 Experiments with polarisation

The following link is a simulation that allows students to rotate various filters and watch the effect on the transmission of an electromagnetic light wave through the combination of filters.

This YouTube clip from physics online is really for teachers who are new to this topic. **It should be viewed prior to showing to pupils** and perhaps fast forward at the beginning through the introductory greetings of the two participants. This video is included here as it is a good demonstration of the fact that the transmitter transmits plane polarised microwaves, shows the effect of rotating the receiver as well as introducing a polarising grid and clarifying one teacher's misconception.

Other related resources

A lab simulation of the photoelectric effect.

PAG 7: Investigating ionising radiation

Minimum use of apparatus and techniques to be covered:

- Use of ionising radiation, including detectors.
- Use of ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data[4].

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
7.1 Investigating the random nature of radioactive decay	b, c, d, e, f, g, j	b, k, l
7.2 Investigating the absorption of alpha, beta and gamma by appropriate materials	b, c, d, e, f, j	a, b, c, e, l
7.3 Investigating the half-life of radioactive materials (using an ionisation chamber)	b, c, d, e, f, g, j	b, d, k, l

PAG7 Related practical learning outcomes in specifications

Physics A

6.4.3 (e)(ii) Techniques and procedures used to determine the half-life of an isotope such as protactinium.

6.4.3 (b)(ii) Techniques and procedures used to investigate the absorption of α-particles, β-particles and γ-rays by appropriate materials.

Physics B

6.2.2 (d)(i) Studying the absorption of α-particles, β-particles and γ-rays by appropriate materials.

6.2.2 (d)(ii) Determining the half-life of an isotope such as protactinium.

Overview

This Practical Activity Group involves best practise in handling radioactive sources. All three PAGs require the safe use of ionising radiations. This is one of the areas in the syllabus where skill 1.2.2 k, *the use of ICT to model a process* may be practised.

This is the only PAG in the endorsement where 1.2.2 l can be demonstrated.

Possible adjustments

The CLEAPSS advice on the use of radioactive sources in classrooms should be read before considering these PAG 7 experiments. CLEAPSS advises against movement of ionising sources into ordinary classrooms (non-labs) at this time.

Many centres already do the PAGs in this section in small groups with students making their own observations and taking readings (at a distance) directly from the (GM tube and) counter. If the counter is only able to produce a continuous count, then students could use the timers on their smart phones, or note the time from a large demonstration timer / projected internet timer. It is essential that students are exposed to safety advice prior to handling ionising sources. PAG 7.1 CLEAPSS suggests that students read the safety advice CLEAPSS L93 '*Managing Ionising Radiations and Radioactive Substances in Schools and Colleges*' (pages 21 to 23). The following single A4 summary of the safety advice is easier for students to digest: *student safety sheets 11, radioactive materials*, produced by CLEAPSS 2019.

PAG 7.1 Investigating the random nature of radioactive decay

This practical relies on the assumption that there are so many undecayed nuclei in the sample (which has a large half-life) that over the period of time being 'observed', any that have decayed make no indent into the (original) number of undecayed nuclei and hence the decay rate. If this topic is being taught in a classroom where sources are not permitted, measurements could be taken from a video of the decay of an ionising source (see resources below) by recording the number of decays over 10 second intervals, the random nature may be observed.

This radioactive balloon experiment describes one of the few classroom experiments possible for PAG7 and the activity satisfies the 1.2.2 practical requirements to use ionising radiation and detectors.

Support resources

PAG 7.1 Investigating the random nature of radioactive decay

This link is to a class demonstration in which sealed sources decay, emitting alpha, beta and gamma radiations which are detected and counted. Ignoring the data for alpha radiation (detected at a distance of 20 cm?), students are able to take measurements over time intervals of 5 or 10 s, to investigate the random nature of the decay of the samples.

PAG 7.2 Investigate the absorption of alpha, beta & gamma by differing materials

This YouTube clip shows the addition of materials between source and detector. It requires teacher input to explain which radiation is emitted by which isotope…although this could be the question that students are set as this is revisiting GCSE physics.

Please note that the above is support material for students and watching the clip does not constitute the achievement of the practical skills in this area.

PAG 7.3 Investigating the half-life of radioactive materials

- The following link is a YouTube clip describing PAG 7.3A….. the half-life of protactinium.

  This is a useful resource which acts as a simulation allowing students to take a complete set of readings from the video and to go on to complete the write-up for PAG 7.3 as it stands. It might be useful to acknowledge the presence of background radiation, which over the few minutes of recording, becomes an increasingly significant fraction of the measurements.

- PAG 7.3 B uses an ionisation chamber which comes with its own set of safety issues regarding the 'puffs of gas'. Schools that followed the Nuffield scheme in the past will have this apparatus. This link uses an ionisation chamber and may be useful preparation for students prior to the experiment PAG 7.3B.

Other related resources

Some more lab simulations for activity of a source and radioactive shielding materials.

PAG 8: Investigating gases

Minimum use of apparatus and techniques to be covered:

- Use of appropriate analogue apparatus to measure pressure, volume, temperature and to interpolate between scale markings[3].

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
8.1 Estimate a value for absolute zero from gas pressure and volume	b, c, d, e, f, j	a
8.2 Investigating the relationship between pressure and volume	b, c, d, e, f, j	a, c
8.3 Estimating the work done by a gas as its temperature increases	a, b, d, e, f, g, h, i	a, c
8.4 Verifying $pV = NkT$	a, b, c, d, e, f, g	a, b, c, e

PAG8 Related practical learning outcomes in specifications

Physics A

5.1.4 (d)(ii) Techniques and procedures used to investigate PV = constant (Boyle's law) and P/T = constant.

5.1.4 (d)(iii) An estimation of absolute zero using variation of gas temperature with pressure.

Physics B

5.2.1 (d)(ii) using appropriate apparatus to investigate the gas laws including determining absolute zero

5.2.1 (d)(iii) using apparatus to investigate the relationship of volume with pressure, measured either by pressure gauge or differential pressure monitor and data logger.

Overview

The first two PAG experiments cover two of the three gas laws, with PAG 8.3 requiring some research and design. Opportunities occur to collect data, analyse, plot graphs and evaluate the experiments in all four PAG activities..

Specific knowledge of practical methods to investigate the gas laws and determine absolute zero are required by both the H556 and H557 specifications.

PAG 8.1 While two methods are used in this PAG to estimate a value for absolute zero, the H556 syllabus specifically requires that candidates have knowledge and understanding of the second method PAG 8.1B (*the variation of gas pressure with temperature*).

PAG 8.2 is a straightforward revision of GCSE physics.

PAG 8.3 is an investigation which will either permit students to draw together the knowledge of thermal physics gained in the course, or to research methods. Given the limited apparatus list, there is only a finite number of ways to connect the kit together. Students should be reminded to cite sources used.

PAG 8.4 is an investigation to test the relationship $pV = NkT$. Using a pump, tyre and a pressure gauge is an opportunity for students to demonstrate use of appropriate apparatus to measure pressure.

Possible adjustments

The organisation of the practical work in this group will depend on the resources available to each school, the numbers of students and the time interval (number of days) between classes.

Experience suggests that students will have to work in groups. There are three important experiments in the first two PAGs. These could be operated as a circus of experiments over three lessons, with the intervening days allowing for natural sterilisation of the apparatus. Teaching might take place in the first part of each lesson the experiments in the second part and the write-ups finished at home.

PAG 8.1 Estimating absolute zero from gas pressure and volume

Use of a kettle and a single distributor (e.g. teacher / technician) of the boiling water, will minimise movement around the lab and reduce apparatus requirement.

PAG 8.1B could be set up as a demonstration with a camera focused on the thermometer and pressure monitor and projected, allowing each student to make their own measurements.

PAG 8.4 Verifying $pV = NkT$

This is an example of an activity that could be done in the classroom. The students could provide much of the equipment themselves. It is also one of the few opportunities to measure pressure for the 1.2.2. requirements.

Support resources

- There are many YouTube clips that describe the gas laws. This link gives a fairly concise summary with worked examples.
- The CLEAPSS website also has many similar experiments to the PAG activities and there are useful articles on preparing equipment to investigate the gas laws.

PAG 8.1A Estimating absolute zero from gas pressure and volume

This YouTube link follows the full OCR practical for PAG 8.1. It is a very useful resource for those students who were absent when this experiment was done.

If this is not performed in a lab., the CLEAPSS advice should be followed.

A kettle of boiling water could be brought to each group by the teacher/technician thus reducing the need for bunsens, tripods, gauzes, heat-proof mats, safety goggles.

PAG 8.1B Estimate a value for absolute zero from gas pressure and temperature

The standard apparatus for this experiment is the constant volume gas thermometer. They are expensive and schools do not usually have class sets. Below is a cheaper option to the more expensive apparatus which might enable more students in the future to make measurements involving gas pressure.

This link shows how to construct a reasonably cheap pressure monitor to record the pressure changes in air contained in a round bottomed flask full which is immersed in a water bath or beaker of water of known temperature. This monitor replaces the traditional Bourdon gauge and has a greater sensitivity. There is also a video link within the CLEAPSS page to give step by step guidance.

PAG 8.2 Investigating the relationship between pressure and volume (Boyle's Law)

- This YouTube link follows the full practical. This method could be carried out fairly simply as a class practical.
- This is a CLEAPSS video of Boyle's Law with some accompanying resources. It requires students to read the text during the video as well as watch the action. There is an accompanying worksheet outlining the method, showing the expected results and posing some questions.

PAG 8.3 Estimating the work done by a gas as its temperature increases

This YouTube link is a useful explanation of the equation that is needed to calculate the work done by the gas as it expands.

PAG 9: Investigating capacitors

Minimum use of apparatus and techniques to be covered:

- Use of appropriate digital instruments, including multimeters[7], to measure current[8], voltage[9], resistance[10].
- Use of appropriate digital instruments to measure time.
- Designing, constructing and checking circuits using DC power supplies, cells, and a range of circuit components.
- Use of ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data[4].

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
9.1 Investigating charging and discharging capacitors	a, b, c, d, e, f, g, j	b, f, k
9.2 Capacitors in series and parallel	b, c, d, e, f, j	b, f
9.3 Investigating factors affecting the capacitance of a capacitor	a, b, d, e, f, h, I, j	a, b, c, e, g

PAG9 Related practical learning outcomes in specifications

Physics A

6.1.1 (e)(ii) Techniques and procedures used to investigate capacitors in both series and parallel combinations using ammeters and voltmeters.

6.1.3 (a)(ii) Techniques and procedures to investigate the charge and the discharge of a capacitor using both meters and data-loggers.

Physics B

5.1.1 (d)(iii) Investigating the charging and discharging of a capacitor using both meters and data loggers.

Overview

This Practical Activity Group covers the structure and properties of capacitors and combinations of capacitors. PAG 9.3 offers the opportunity to confirm the spreadsheet modelling of the exponential nature of the discharging (or charging) of a capacitor.

Possible adjustments

PAG 9.1 Investigating charging and discharging capacitors

An experiment that allows students to witness the charging and discharging of a capacitor is very desirable in helping to develop concepts. Suggested adjustments to this group are organisational: e.g. groups of two or three students rather than individuals, using the same apparatus (kept in labelled trays) over several lessons.

PAG 9.2 Capacitors in series and parallel

Students could use simulations and practise the calculations. However, carrying out the practical does provide a satisfying opportunity to confirm the predicted capacitances of combinations while providing practise of a method to determine the capacitance from a discharge graph and giving students an opportunity to achieve the associated practical skills.

Support resources

PAG 9.1 Investigating charging and discharging capacitors

This first practical in the group is fundamental in the understanding of capacitors. Watching a YouTube clip of the experiment is not a substitute for carrying out the experiment but it does allow students to prepare for the experiment. It also provides support for absentees in covering the topic area and permitting them to plot a graph from the data supplied in the clip. Here is a useful simulation for charging a capacitor.

PAG 9.2 Investigating capacitors in series and parallel

The PhET capacitor Lab simulation allows a number of combinations of capacitors to be constructed. Students can measure the potential differences across the combinations, calculations of capacitance may be made and confirmation of the charge stored and capacitance may be displayed and confirmed. Students who are directed to this simulation will require some guidance and given some tasks to carry out.

PAG 9.3 Investigating factors affecting the capacitance of a capacitor

The PhET capacitor Lab simulation allows the physical dimensions of a capacitor to be varied and shows the effect that the changes make to the capacitance. Once again, students who are directed to this simulation will require some guidance, perhaps given values for the dimensions of the capacitor and questions regarding the effect on the capacitance of varying the area of overlap of the plates or the separation of the plates.

PAG 10: Investigating simple harmonic motion

Minimum use of apparatus and techniques to be covered:

- Use of appropriate digital instruments to measure time.
- Use of appropriate analogue apparatus to measure distance and to interpolate between scale markings[3].
- Use of methods to increase accuracy of measurements, such as timing over multiple oscillations, or use of fiduciary marker, set square or plumb line.
- Use of ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data[4]

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
10.1 Investigate the factors affecting simple harmonic motion	a, b, d, e, f, g, j	a, b, c, d
10.2 Observing forced and damped oscillations	a, b, d, e, f, g, j	a, b, c, d
10.3 Comparison of static and dynamic methods of determining spring stiffness	a, b, c, d, e, f, g, j	a, b, c, d

PAG10 Related practical learning outcomes in specifications

Physics A

5.3.1 (c)(ii) Techniques and procedures used to determine the period/frequency of simple harmonic oscillations.

5.3.3 (b)(ii) Observe forced and damped oscillations for a range of systems.

Physics B

5.1.1 (d)(i) Measuring the period/frequency of simple harmonic oscillations for example mass on a spring or simple pendulum and relating this to parameters such as mass and length.

5.1.1 (d)(ii) Qualitative observations of forced and damped oscillations for a range of systems.

Overview

This Practical Activity Group allows the opportunity, with the use of simple apparatus, for students to investigate simple harmonic oscillations in a spring and pendulum. In the investigation, there are opportunities to evaluate and select apparatus to maximise the accuracy of the measurements.

In the case of PAG 10.1, where no procedure is given in the student worksheet, there is an opportunity to achieve skills 1.2.1 a (investigative approaches and methods)

The PAG 10.2 practical activity is an investigation with a fair amount of design in its nature. The Barton's pendulum experiment is valuable in helping to understand resonance in systems with forced oscillations.

PAG 10.3 provides an opportunity to revise Hooke's Law. A given equation for the dynamic experiment, which may or may not be familiar to the student, is used to design an experiment which generates useful data from which a second value for the spring constant may be derived.

Possible adjustments

These activities may be completed in classrooms instead of laboratories. Students could use their own smart phones for timers, reducing apparatus requirements.

PAG 10.1 Investigate the factors affecting simple harmonic motion

The open-ended nature may cause this investigation to overrun with some students needing guidance. If teaching time is short, it is suggested that a discussion is had regarding the relationship between length and frequency for a pendulum or between mass and frequency for a given spring and depending on the group. Students might then be directed to investigate one of the relationships.

PAG 10.2 Observing forced and damped oscillations

10.2A: The Barton's Pendula method for forced oscillations is a tricky arrangement for students to set up. If one practical arrangement of the apparatus is set up, measurements could be made by each group/student in turn, if they are supplied with their own driver pendulum bob, string and croc clip.

PAG 10.2A could also be completed as a class demonstration with part B below as a student experiment.

10.2 B Damping of a spring: An excellent opportunity exists here for students to investigate whether, in a damping situation, the amplitude decreases in an exponential way with time. This might require the insertion of an instruction such as 'plot a graph of *amplitude* against *time* and take readings to confirm that the amplitude dies away exponentially with time'.

10.3 Comparison of static and dynamic methods of determining spring stiffness

This practical uses simple apparatus that is easily moved to a classroom. To minimise quantity of apparatus, students could work in pairs, use their own smart phones as timers and use their own rulers. It may be necessary to supply some instructions of varying detail to meet the needs of some students and avoid the situation where they run out of time.

Support resources

PAG 10.1 Investigate the factors affecting simple harmonic motion

The PhET simulation of simple harmonic motion is a good introduction (or useful as work set for absent students). Students will need guidance in the form of a task or given the PAG 10.1 worksheet to complete.

PAG 10.2 Observing forced and damped oscillations

The same PhET simulation as above, may be used with the friction button selected to introduce damping. If the 'slow' button is selected, the motion is slowed down and timer shows a corresponding compensation. This makes the measurements at the extremes of the oscillation easier to read.

10.3 Comparison of static and dynamic methods of determining spring stiffness

There are a number of on-line resources for this experiment. One such site P&M Tutor has supplied a set of instructions that takes students through the experiment step by step. This might be useful in the event that this work has to completed at home by a student in isolation.

PAG 11: Investigation

Minimum use of apparatus and techniques to be covered:

- Apply investigative approaches and methods to practical work.

Suggested activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
11.1 Investigating transformers	a, b, d, e, f, h, i, j	b, g, h
11.2 Determining the specific heat capacity of a material	a, b, d, e, f, g, h, i, j	a, b, c, d, g, k
11.3 Determining the magnetic field of a magnet	a, b, d, e, f, j	a, b, g

PAG11 Related practical learning outcomes in specifications

Not all practical activities in the specification learning outcomes have been assigned a PAG group. Candidates require knowledge of them for the examinations and some may be used for the investigations PAG 11 activity or as an additional activity towards the endorsement.

Physics A

4.4.1 (f)(ii) Techniques and procedures used to demonstrate wave effects using a ripple tank.

5.1.3 (b)(ii) Techniques and procedures used for an electrical method to determine the specific heat capacity of a metal block and a liquid.

5.1.3 (d)(ii) Techniques and procedures used for an electrical method to determine the specific latent heat of a solid and a liquid.

5.2.2 (d)(ii) Techniques and procedures used to investigate circular motion using a whirling bung (not allocated a PAG group but required learning)

6.3.1 (e)(ii) Techniques and procedures used to determine the uniform magnetic flux density between the poles of a magnet using a current-carrying wire and digital balance.

6.3.3 (d)(ii) Techniques and procedures used to investigate magnetic flux using search coils.

6.3.3 (f)(ii) Techniques and procedures used to investigate transformers.

Physics B

5.2.1 (d)(i) Using an electrical method to find the specific thermal capacity of a metal block or liquid.

6.1.1 (d)(i) Observing induced e.m.fs produced under varying conditions such as dropping a magnet through a coil attached to a data logger or oscilloscope.

6.1.1 (d)(ii) Determining the uniform magnetic flux density between the poles of a magnet using a rigid current carrier and digital balance.

6.1.1 (d)(iii) Investigate transformers.

Overview

This Practical Activity Group focuses on research, planning and carrying out an investigation safely. There are three suggestions from different areas of the syllabus in the OCR student worksheets for PAGs 11.1, 11.2 and 11.3. These are by no means the only acceptable topics permissible for investigation.

PAG 11.1 This provides a very useful exposure to the structure of a transformer. Students will only have seen transformers as a teacher demonstration up to this point in their education.

PAG 11.2 Specific heat capacity was studied at GCSE and should be familiar. However researching and planning a different method is encouraged here.

PAG 11.3 This is a useful experiment which helps in the understanding of the definition of magnetic flux density.

This OCR magnetic linear accelerator activity using low cost materials can be adapted into an open investigation.

Possible adjustments

The CLEAPSS advice GL352 - Managing practical work in non-lab environments (COVID-19 pandemic) recommends that power supplies should not be carried from labs and used in classrooms.

PAG 11.1 Investigating transformers

The apparatus list for this experiment is large with big items such as oscilloscopes and signal generators required. It is likely that apparatus will need to be shared if a number of students choose to investigate the same topic. In the current climate this will necessitate regular cleaning of the apparatus.

PAG 11.2 Determining the specific heat capacity of a material

The purpose of this exercise is to research and plan an investigation. It is strongly recommended that if this topic is selected by a student, the plan should not be a simple recall of the GCSE experiment carried out the previous year.

Guiding students in the direction of an alternative method, such as the method of mixtures will raise the necessary practical planning skills to the required standard.

PAG 11.3 Determining the magnetic field of a magnet

The apparatus list for this experiment includes an electronic balance. Once again, it is likely that apparatus will be shared, and the implications on the necessary cleaning should be considered.

The OCR magnetic linear accelerator activity could be suitable for classroom environments. Eye protection will be required and caution taken with magnets.

Other related resources

Lab simulation for whirling bung experiment.

A simulation for investigating magnetic induction and another simulation with graph analysis.

Support resources

PAG 11 Investigations, by their nature, require large volumes of apparatus.

Candidates should carry these investigations out individually. If students are encouraged to choose investigations that cover topic areas other than those in PAGs 11.1, 11.2, 11.3, there will be fewer apparatus requirement clashes with the larger items (oscilloscopes, etc.).

There is also an opportunity here for students to investigate (and revise) a topic area in which they struggled (e.g. PAGs 9 or 10.1).

It is not recommended that the resources below be given directly to students as this would negate the awarding of research skill 1.2.2 h.

If students need direction, they can be guided to making, for example, a 'Google search for ….. ' allowing the students to browse and select the information they believe to be relevant.

PAG 11.1 Investigating transformers

The following PhET link is to a simulation which guides students through an understanding of electromagnetic induction and moves on to a simple transformer. It might help students to develop their plan.

PAG 11.2 Determining the specific heat capacity of a material

Many explanations of methods used to determine the specific heat capacity may be found on line. One such link talks students through the method of mixtures.

PAG 11.3 Determining the magnetic field of a magnet

There are a number of different experiments to be found on line for this determination. The apparatus list in the OCR student sheet directs students to a particular experiment (that uses an electronic balance) which is described in this link.

PAG 12: Research skills

Minimum use of apparatus and techniques to be covered:

- Use online and offline research skills
- Correctly cite sources of information

Suggested PAG activities	1.2.1 practical skills covered	1.2.2 apparatus and techniques covered
12.1 Materials presentation	f, g, h, i	n/a
12.2 Research report	f, g, h, i	n/a
12.3 Documenting How Science Works	c, f, g, h, i	n/a

Overview

This Practical Activity Group provides a practical based context where students can demonstrate their ability to research, perform an investigation and reference their research appropriately. There are many ways throughout the other PAGs where students could meet the 1.2.1 practical skills required by PAG 12.

Possible adjustments

There are endless possibilities with PAG 12 as long as the focus remains on students researching and performing an investigation and referencing their research appropriately. There are of course a number of accepting techniques for referencing research and any of these are accepted for PAG 12. If it is being completed when students are investigating Universities it could be an option for them to look up and use one of their potential University's referencing guide.

Support resources

These resources may be useful for teachers when planning how students may meet the research and referencing element of this PAG.

- **Practical Skills handbook**

Appendix 7 Referencing – page 59.

- **Referencing guide** - The Open University

Need to get in touch?

If you ever have any questions about OCR qualifications or services (including administration, logistics and teaching) please feel free to get in touch with our customer support centre.

Call us on
01223 553998

Alternatively, you can email us on
support@ocr.org.uk

For more information visit
- **ocr.org.uk/qualifications/resource-finder**
- **ocr.org.uk**
- **/ocrexams**
- **/ocrexams**
- **/company/ocr**
- **/ocrexams**

We really value your feedback

Click to send us an autogenerated email about this resource. Add comments if you want to. Let us know how we can improve this resource or what else you need. Your email address will not be used or shared for any marketing purposes.

I like this **I dislike this**

Please note – web links are correct at date of publication but other websites may change over time. If you have any problems with a link you may want to navigate to that organisation's website for a direct search.

CAMBRIDGE
UNIVERSITY PRESS & ASSESSMENT