AQA qualification training

A-level Physics Practical endorsement

Pre-event reading

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Physics: A-level practical assessment

Practical work is at the heart of physics, so we have placed it at the heart of this specification.

Practical assessments have been divided into those that can be assessed in written exams and those that can only be directly assessed whilst students are carrying out experiments.

A-level grades will be based only on marks from written exams.

A separate endorsement of practical skills will be taken alongside the A-level. This will be assessed by teachers and will be based on direct observation of students' competency in a range of skills that are not assessable in written exams.

Use of apparatus and techniques

All students taking an A-level Physics qualification are expected to have had opportunities to use the following apparatus and develop and demonstrate these techniques. These apparatus and techniques are common to all A-level Physics specifications.

Carrying out the 12 required practicals in Section 8.2 means that students will have experienced use of each of these apparatus and techniques. However, teachers are encouraged to develop students' abilities by inclusion of other opportunities for skills development, as exemplified in the right hand column of the content section of this specification.

	Apparatus and techniques
ATa	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
ATb	use appropriate digital instruments, including electrical multimeters, to obtain a range of measurements (to include time, current, voltage, resistance, mass)
ATc	use methods to increase accuracy of measurements, such as timing over multiple oscillations, or use of fiduciary marker, set square or plumb line
ATd	use stopwatch or light gates for timing
ATe	use calipers and micrometers for small distances, using digital or vernier scales
ATf	correctly construct circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important
ATg	design, construct and check circuits using DC power supplies, cells, and a range of circuit components
ATh	use signal generator and oscilloscope, including volts/division and time-base
ATi	generate and measure waves, using microphone and loudspeaker, or ripple tank, or vibration transducer, or microwave / radio wave source
ATj	use laser or light source to investigate characteristics of light, including interference and diffraction
ATk	use ICT such as computer modelling, or data logger with a variety of sensors to collect data, or use of software to process data
ATl	use ionising radiation, including detectors

Physics: A-level required practical activities

The following practicals must be carried out by all students taking this course. Written papers will assess knowledge and understanding of these, and the skills exemplified within each practical.

Required activity	Apparatus and technique reference
1 Investigation into the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the string.	a, b, c, i
2 Investigation of interference effects to include the Young's slit experiment and interference by a diffraction grating.	a, j
3 Determination of g by a free-fall method	a, c, d, k
4 Determination of the Young modulus by a simple method.	a, c, e
5 Determination of resistivity of a wire using a micrometer, ammeter and voltmeter.	a, b, e, f
6 Investigation of the emf and internal resistance of electric cells and batteries by measuring the variation of the terminal pd of the cell with current in it.	b, f, g
7 Investigation into simple harmonic motion using a mass-spring system and a simple pendulum.	a, b, c, h, i
8 Investigation of Boyle's (constant temperature) law and Charles's (constant pressure) law for a gas.	a
9 Investigation of the charge and discharge of capacitors. Analysis techniques should include log-linear plotting leading to a determination of the time constant RC.	b, f, g, h, k
10 Investigate how the force on a wire varies with flux density, current and length of wire using a top pan balance.	a, b, f
11 Investigate, using a search coil and oscilloscope, the effect on magnetic flux linkage of varying the angle between a search coil and magnetic field direction.	a, b, f, h
12 Investigation of the inverse-square law for gamma radiation.	a, b, k, l

Teachers are encouraged to vary their approach to these practical activities. Some are more suitable for highly structured approaches that develop key techniques. Others allow opportunities for students to develop investigative approaches.

This list is not designed to limit the practical activities carried out by students. A rich practical experience for students will include more than the 12 required practical activities. The explicit teaching of practical skills will build students' competence. Many teachers will also use practical approaches to the introduction of content knowledge in the course of their normal teaching. Students' work in these activities can also contribute towards the endorsement of practical skills.

CPAC Pen portraits

A series of pen portraits have been written to clarify what is meant by 'not achieved', 'achieved' and ‘achieved at a level of competence exceeding the CPAC standard’.

These exemplars have been developed in collaboration between the four Awarding Bodies: AQA, Eduqas, OCR and Pearson.
They are intended for guidance and training purposes, and to give an indication of the standard necessary for each CPAC statement.

Note that, although these pen portraits show (in the most part) CPAC skills in isolation, many practical exercises are likely to involve CPAC strands being assessed in combination.

CPAC 1: Follows written instructions

Not achieved	Achieved	Exceeds standard
Context Chemistry (Year 12): Make up a volumetric solution and carry out a simple acid-base titration **Observed** The practical lesson started with a full teacher demonstration and safety reminder in addition to all learners being provided with a detailed set of written method steps. Working in pairs, glassware and other equipment was collected and set up. One learner was responsible for the titration, the other for the preparation of the volumetric solution. There were several requests for reassurance from the teacher, particularly in the initial stages (the steps for the correct weighing procedure were very confused) leading to lots of teacher intervention and a spot demonstration of the drop-wise addition of burette solution towards endpoint. Although the method steps were being followed in the correct order, neither of the learners were working independently of the teacher and it was difficult to ascertain the degree of input from each individual learner throughout the practical as a whole. Students requested apparatus that was not needed to carry out the written method steps, indicating a lack of forward planning following reading the method.	**Context** Chemistry (Year 12): Make up a volumetric solution and carry out a simple acid-base titration **Observed** The learner was provided with a full of written method steps for the practical. This was supported by a brief class discussion at the start to highlight the safety requirements. **Independently**, the learner methodically and confidently followed the method steps in the correct order; firstly to make the volumetric solution, then to carry out the titration work. They generated a set of expected titre volumes of sodium hydrogensulfate solution. Prior to the rough titration, the learner asked the teacher for clarification about the number of drops of indicator to add (“2-3 drops” advised on the sheet) and decided to go with 3 drops to enable the end point to be seen more clearly. The learner proceeded to carry out a further three titration runs, sufficient to ensure that two results were concordant.	**Context** Chemistry (Year 12): Make up a volumetric solution and carry out a simple acid-base titration **Observed** The class was provided with a simple outline of the practical method steps as all the learners had carried out a number of titration practicals in previous lessons and did not need the heavy ‘scaffold’. Safety information was discussed verbally. Prior to starting, learners could be seen reading the outline in full before selecting apparatus independently from a range of glassware provided on a trolley. Both elements of the practical work – making up the standard solution and titration work – were carried out efficiently, methodically and **independently** with little reference to the written practical outline. The students demonstrated a developing degree of fluency with the techniques and apparatus being used. Learners designed and completed a table, the learner checking for obvious anomalous titres after each attempt and ensuring that a sufficient amount of results had been collected to achieve concordant titres. All method steps were carried out in the correct order, readings were ‘double checked’ (this was not asked for) and expected outcomes were generated. It was clear that learners had developed clear routines e.g. use of balance, addition of washings, re-filling of burette, end point addition etc that were fully embedded in their titration practical work.

Context Chemistry (Year 12): Preparation of a soluble salt using a titration **Observed** The teacher demonstrated how to use titration apparatus. A learner attempts to follow detailed written instructions but the teacher intervenes on a number of occasions to correct the learner. Learner is not working independently to follow instructions correctly as demonstrated by teacher intervention	**Context** Biology (Year 12): Extraction of DNA from living material **Observed** The class opened with a discussion about the principles of extraction of DNA. The specific detail of the method to be followed by learners was not discussed other than a reminder about safety issues. Learners worked individually to complete the task. A learner followed the written procedure carefully, confidently and without intervention by teacher.	**Context** Chemistry (Year 13): Estimation of copper(II) salts **Observed** The learner read the instructions through prior to starting the practical. He weighed accurately using 'weighing-by-difference' the mass of copper(II) sulfate and was able to use good technique to accurately make up the standard solution. At all points he worked efficiently and was able to complete the practical with minimal viewing of the instruction sheet. The learner was able to interpret instructions and use good techniques to meet their demand. The learner shows advanced skills in being able to interpret simple instructions by 'adding flesh to the bones'. He was able to correctly interpret where mass readings needed to be accurate (weighing copper sulfate) and approx. (weighing potassium iodide) and needed no prompting to use appropriate weighing techniques.
Context Biology (Year 12): Qualitative testing for biological molecules – glucose **Observed** The teacher reminds the class about the main points of the procedure, including safety matters. However, the learner does not manage to follow the instructions in the correct order and does not add Benedict's solution prior to heating in the water bath for the first test. This has to be pointed out by the teacher.	**Context** Biology (Year 12): Qualitative testing for biological molecules – glucose **Observed** The teacher reminds the class about the main points of the procedure, including safety matters. The learner then works independently to collect the expected set of results. All procedural points are carried out in the correct order and the learner is methodical and confident in their approach to the task. The teacher does not have to have any involvement.	**Context** Biology (Year 12): Qualitative testing for biological molecules – glucose **Observed** The teacher reminds the class about the main points of the procedure, including safety matters. Following this, the learner works without intervention from the teacher and collects the expected set of results, having followed all of the method points in the correct order. The learner engages in a discussion with the teacher about the temperature the water bath needs to be maintained at to see a result with Benedict's test and it is agreed that the instructions could be modified slightly.

Context Physics (Year 12): Determine the electrical resistivity of a material **Observed** A student is working a part of a pair. The student asks the teacher for reassurance that the apparatus provided is correct for the experiment. He takes no part in the setting-up of the circuit, leaving this task to his partner. The worksheet tells students to collect a reading every 10cm along a 1-metre length of wire. The student collects three readings only, and asks his teacher if this is enough data.	**Context** Physics (Year 12): Determine the electrical resistivity of a material **Observed** A student is working a part of a pair. The student reads the instructions provided for the practical. She is able to use the circuit diagram from the apparatus provided. With her partner, she asks her teacher to check the circuit, which is correct. At the end of the practical session, she has collected sufficient data, together with her partner, as outlined in the method on the worksheet.	**Context** Physics (Year 12): Determine the electrical resistivity of a material **Observed** The student is provided with an outline of the experiment, where some steps are given in outline only. He reads through the instructions provided and is able to formulate a correct method for the task. He finds all the apparatus independently (CPAC 2d). He sets up the circuit, and checks that it is correct before turning on the power pack. He works methodically to collect the data required, ensuring that is tabulated and checked as he goes along (CPAC 4b).

CPAC 2: Applies investigative approaches and methods when using instruments and equipment

Not achieved	Achieved	Exceeds standard
Context Biology (Year 12): Investigation into the effect of a named variable on the rate of an enzyme-controlled reaction **Observed** In groups of three, learners were invited to plan and carry out an investigation to find out the effect of temperature on the rate of trypsin enzyme. One of the learners immediately took the lead and started to write things down. One of the others quickly joined in but the third, who was less familiar with enzyme work through recent absence from school, took a backseat. After a while it was clear to the teacher that little progress was being made as the group were unsure both how to measure trypsin action (dependent variable) or what variables to control so they gave the group a prescriptive set of method steps to follow. The students then chose appropriate equipment. They set up water baths using beakers and the started the procedure but, due to a lack of concentration and urgency demonstrated within the group, the data generated did not reflect the trend expected and so the teacher needed to intervene to help them to get back on track. For example, the teacher pointed out that the water baths were cooling. In this group, despite one of the learners being able to discuss the reasons for the method steps being carried out, the group as a whole were not convincingly able to express an understanding of what they were doing and how their work related either to the hypothesis or the expected conclusion.	**Context** Biology (Year 12): Investigation into the effect of a named variable on the rate of an enzyme-controlled reaction **Observed** An individual learner was invited to investigate the effect of temperature on the rate of trypsin action. Using previous lesson theory and practical notes, they devised a potential set of simple method steps that would enable sufficient data to be generated. The learner asked the teacher to consider what they had done before modifying their method for control of temperature, recognising with little prompting that electrostatically controlled water baths would be a better choice than beakers. From that point, the learner chose all the necessary apparatus and prepared all the enzyme and substrate test tubes independently, allowing all tubes to equilibrate in the water baths for 10 minutes prior to mixing. The learner investigated 5 different temperatures with 10 degree intervals and repeated each temperature three times. It was clear that this learner had also recognised that the thickness of the pen used to draw the cross on to the test-tube glass was a control variable as they were seen using a fine marker prior to their use of a black board marker. This was as a result of the first set of enzyme – substrate tubes being mixed. When questioned by his teacher about why they had changed marker pens, the learner explained that they had found it difficult to fully judge the disappearance of the cross and so a modification of method steps was necessary and the first set of tubes was fully repeated. The learner produced a set of data that	**Context** Biology (Year 12): Investigation into the effect of a named variable on the rate of an enzyme-controlled reaction **Observed** The teacher gave all the learners in the class an open choice of which independent variable they might like to investigate when considering how trypsin enzyme reacts. She provided a list of apparatus and chemicals that would be available to them, plus an indication of the lesson time that would be dedicated to the task. The learners had been asked to carry out some research for homework to enable them to independently write a set of method steps to investigate their written hypothesis. Learners were then given the opportunity to carry out some preliminary practical work to enable them to tighten their written method. One learner, who decided to investigate the effect of temperature, carried out a trial experiment to decide the % concentration of trypsin enzyme to use (to ensure the experimental runs carried out at higher temperatures were measurable and not too fast). The learner was also keen to ensure that the overall volume of enzyme-substrate mixture was not too great to ensure that the contents of each tube were fully submerged in the water bath at the desired working temperature. Through questioning, the teacher could clearly evidence that the learner had a full understanding of what they were doing, could justify all their actions and link them to the expected outcome. Repeats had been considered to allow the mean data to generate the expected trend. The data table designed provided evidence of an understanding of accurately

	was showed the expected trend.	recording the independent variable, temperature. For example, despite the water bath dial being set at 20 °C, the temperature recorded was 21 °C, taken from a thermometer in the water bath.
Context Biology (Year 13): Investigation into the abundance and distribution of plants in a habitat. **Observed** The learners were asked to work in groups of three to plan and carry out the investigation. One of the learners appeared to have more input into the groups plan while the other two appeared to be more easily distracted and allowed the first candidate to lead. They were clearly distracted and consequently worked less methodically than they could have. Appropriate equipment was used by the members of the group although they demonstrated a somewhat cavalier approach to collecting the information. There was also some confusion over recording information. One learner in the group was able to give a rationale for the way in which they completed the investigation but the other two seemed less clear. It was difficult to be certain who contributed what to the investigation. One learner clearly took the lead but the group work was poorly managed which lead to some failures in the 'doing' of the activity. While group work may be allowable under certain circumstances, it is important that the contribution of each learner is clearly identifiable and that the learners can evidence the key aspects of the CPAC2 skills. In this case, the best that can be said is that one learner was working towards aspects of the assessment criteria while the other two showed little evidence.	**Context** Chemistry (Year 13): Planning a sequence of tests to identify organic compounds **Observed** A learner devised a suitable testing sequence that would allow for the identification of the compounds in relatively few steps. He was able to follow the steps, choosing appropriate reagents for each of the identified tests with minimal assistance. He recognised that one of the steps in his sequence was not necessary when testing compound 'V' – (benzenecarbaldehyde) and he modified his testing sequence accordingly. He was able to give reasons for his testing sequence and understood what he was doing.	**Context** Physics (Year 13): Measurement of *g* with a pendulum **Observed** The learners were given a box of equipment and asked to device a method to measure *g* using only equipment from the box. A learner illustrated the method that she would follow by drawing a simple diagram and by outlining the steps she proposed to follow. The learner first chose to make two trial runs to measure the time of a period for both the longest and shortest length in order to check the range of values and also to determine whether the shortest length could be measured without significant error. She decided to increase the length of the pendulum of her shortest run in the light of her experience. The learner understood what she was doing and could give clear reasoning for the method she proposed. The learner recognised the need to take multiple readings for each period of the pendulum and could give reasons for variations in the period for each length.

Context Physics (Year 13): Potential divider investigation **Observed** Students working in pair are unable to get their circuit to operate. The teacher leaves them for fifteen to twenty minutes to try and overcome their difficulties before stepping in to guide them to assembling a correctly functioning circuit.	**Context** Physics (Year 13): Potential divider investigation **Observed** Students working in pair are unable to get their circuit to operate. The students work though their circuit and after fifteen to twenty minutes overcome their difficulties and are able to collect data as required. (Achieves the use of instruments and equipment although not investigative 2a, b)	**Context** Physics (Year 13): Potential divider investigation **Observed** Students working in pair set up their apparatus with no issues, each participating and communicating with each other. They collect data as required and have completed the task set within twenty minutes. The teacher then asks them to determine the best value for the fixed resistor in their circuit to optimise the range of potential difference output. (Achieves the use of equipment and investigative nature 2a, b, c)
Context Biology (Year 12): Investigate a factor affecting the initial rate of an enzyme controlled reaction. **Observed** Although the student is following a clear outline of the experiment, it is evident that he does not know which variables should be controlled, so ends up varying the temperature, but failing to have a constant amount of enzyme in each experiment. The experimental steps are not carried out in a logical order, and the data collected is to a variety of significant figures.	**Context** Biology (Year 12): Investigate a factor affecting the initial rate of an enzyme controlled reaction. **Observed** The method followed by the student tells them to vary the concentration of the substrate. The student knows that temperature must be controlled, and sets up a beaker to use as a water bath, to control the temperature (CPAC 2c). The student correctly sets up a series of different substrate concentrations and, before adding the enzyme, places her test-tubes in the water bath, the water level rises; so the student then changes this to a larger beaker (CPAC 2b).	**Context** Biology (Year 12): Investigate a factor affecting the initial rate of an enzyme controlled reaction. **Observed** The worksheet used by the student contains an outline of the experiment. The student decides to investigate temperature as the factor, and plans to ensure that other factors (concentration of substrate, amount of enzyme used) are kept the same (CPAC 2c). Without prompting, he is able to find, in a text book, a suitable method to follow and selects and sets up appropriate apparatus for the experiment (CPAC 2d). When the teacher comes around to check, the student is already collecting data, and his blank results table shows that he is controlling concentration and planning to collect results at 5 different temperatures, using a water bath (CPAC 2c). Although he has planned to collect results every 10 °C, the teacher can see that the current experiment is using a water bath at 29 °C, and the student has already corrected the results table (CPAC 2b).

CPAC 3: Safely uses a range of practical equipment and materials

Not achieved	Achieved	Exceeding CPAC standard
Context Chemistry (Year 12): Carry out simple test-tube reactions to identify cations and anions in aqueous solution **Observed** The learner set up three test-tube racks of test-tubes, one for each of the parts of the experiment. In haste a couple of the test-tubes fell in their attempt to carry them over to the work space and broken glass was evident on the floor. Keen to get on with the practical steps, the learner did not deal with the incident and was seen gently kicking the glass under the desk. Other students expressed their concern as they were walking on it and carrying around the laboratory floor and so the teacher intervened and brushed up the broken glass. Later on during the practical lesson the same learner carried a stock dropper bottle of concentrated H_2SO_4 from the fume cupboard to use at their workspace. Others around them started to cough, drawing the teacher's attention to the action, again requiring immediate intervention. On both occasions the learner had failed to consider and therefore minimise risk or harm to themselves or other learners around them. There was a lack of consideration of health and safety procedure and too many prompts were required by the teacher to ensure safe working practice.	**Context** Chemistry (Year 12): Carry out simple test-tube reactions to identify cations and anions in aqueous solution **Observed** The learner had carefully set up an organised workspace and collected all the glassware, other equipment and reagents to limit the need for a lot of walking around the laboratory once the procedures started. Two of the reagents were located in the fume cupboard and the learner was fully aware both of that and had identified any hazards and risks associated with the practical as a whole. The learner handled the equipment confidently and sensibly, disposing of each of the reacted tubes as directed by their teacher. During Part 1 they accidentally spilled a small amount of limewater on the desk but without fuss, wiped it up with a paper towel. One of the learners on the same desk had left a stopper off one of the reagent bottles and they needed little prompting to replace it when they realised. When pupils worked in pairs it was clear that they had an understanding of any medical issues that might need consideration eg asthma. On one occasion the learner asked for clarification about how much solid a 'small spatula measure of solid potassium chloride' was, realising that this had a safety implication.	**Context** Chemistry (Year 12): Carry out simple test-tube reactions to identify cations and anions in aqueous solution **Observed** The learner was keen to write a full, detailed risk assessment to cover all aspects of the practical work. The number of reagents involved gave the learner an opportunity to gain more understanding about the hazards associated with a range of different chemicals. This exceeded the requirement as learners simply need to *be able to identify hazards and risks in their work and be able to address those accordingly.* The learner carried out the practical 3-part procedure confidently in a well organised work place with no need for teacher intervention. Mid-way through the lesson they noticed that another learner had brought a fume cupboard reagent across to their desk and left the dropper bottle stopper of it. They calmly went over and pointed it out to the student, replaced the stopper and offered to take it back to the fume cupboard before alerting the teacher after they saw another learner do exactly the same thing minutes later. It was clear that they had a full understanding of how to deal with an incident should it occur. The same student, when completing a part of the investigation using solid halides was seen halving the amount of solid that they had originally poured into the reaction tube, amending the procedure slightly to make it safer.

Context Chemistry (Year 12): Indirect determination of an enthalpy change of reaction **Observed** A learner breaks a mercury thermometer in the course of an experiment and is seen putting the broken thermometer in a draw. No attempt is made to deal with any spilt mercury. The learner continues with his work and does not report the incident to class teacher. The incident is mentioned to the teacher who intervenes. The learner has failed to minimise risk of harm to himself or others in the class.	**Context** Physics (Year 13): Measurement of the specific heat capacity for a solid by the method of heat transfer **Observed** A learner identifies hazards and risks associated with their procedure. His work space is well organised. He works safely and handles equipment confidently and competently. The practical period is completed without incident.	**Context** Chemistry (Year 13): Planning a sequence of tests to identify organic compounds **Observed** A learner prepares a detailed (suitable and sufficient) risk assessment covering all aspects of the practical work. The learner completes the investigation safely in accordance with laboratory requirements and risk assessment. At all times she works confidently and without need of intervention. Her work space is well organised. She spills a small amount of ethanamide in the fume cupboard but warns those working near her and then reports this to the teacher (laboratory rules specify that spills are to be reported to teacher who deals with situation). Learners are expected to identify hazards and risks in work. A detailed risk assessment exceeds this requirement.
Context Biology (Year 12): Investigation into the effect of exercise on pulse rate **Observed** The learner starts the investigation without consideration of the impact of the exercise on those participating. One participant has an asthma attack and has to stop and take medication and it is determined, in hindsight, that this individual should not have been asked to exercise.	**Context** Biology (Year 12): Investigation into the effect of exercise on pulse rate **Observed** The learner asks the individuals participating in the exercise if they have any relevant health concerns. He then proceeds with the investigation without incident once it has been established that no one suffers from a heart or lung condition.	**Context** Biology (Year 12): Investigation into the effect of exercise on pulse rate **Observed** The learner considers detailed risks and hazards with the investigation including whether any participant has a relevant health concern and the safety of the exercise to be carried out. One participant is asked not to take part as she has a heart condition. When the participants start the exercise (running up and down a flight of stairs), the learner decides that this is actually quite risky as there is more foot traffic in the school than originally anticipated. Therefore, he changes the exercise to a longer period of star jumps on the spot. A detailed risk assessment is provided as part of the investigation.

Context Chemistry (Year 12): Finding the concentration of a solution of hydrochloric acid by titration **Observed** The student reads the worksheet provided, which gives some information on safety for this experiment. The student collects safety glasses, but they spend the majority of the time pushed up on her head – she only pushes them down over her eyes when prompted by her teacher. She turns around to talk to someone else in the laboratory during the practical, and knocks over a conical flask as she turns. She does not notice the spillage.	**Context** Chemistry (Year 12): Finding the concentration of a solution of hydrochloric acid by titration **Observed** The student looks at the method given, and follows the instructions about correct use of lab coat and safety glasses. He tells his teacher how he attached the pipette filler to the pipette – this method is safe, and the teacher confirms this. Once he has used the pipette, he detaches the filler and puts the pipette somewhere where it will not roll off the lab bench. When he is washing up after the experiment, he accidentally pours some acid on his skin. He washes it off with plenty of water, and then tells his teacher what has happened: no further action is necessary.	**Context** Chemistry (Year 12): Finding the concentration of a solution of hydrochloric acid by titration **Observed** On being told that the experiment is a titration, the student knows that the safety equipment required will be a lab coat, eye protection and a pipette safety filler. The student is working in a pair, and she reminds her lab partner of the safe method of attaching the pipette filler to the pipette. She remembers all the key points for safely filling a burette, including bringing the burette down to a safe working level before filling. When her teacher asks what she would do in the event of a spillage, she is able to describe a safe method of clearing it away.

CPAC 4: Makes and records observations

Not achieved	Achieved	Exceeding CPAC standard
Context Biology (Year 12): Production of a dilution series of a solute to produce a calibration curve with which to identify the water potential of plant tissue **Observed** A learner prepared all the dilutions of sucrose solution from 1.0M stock solution as directed and correctly completed a given table to show volumes of both stock sucrose and water they added to make up the required 20 cm^3 of all concentrations in the desired range. They then proceeded to use the cork borer to remove equally sized, peel free chips and blot them to remove excess moisture. Feeling tired and slightly pushed for time the learner quickly scribbled down a results table. Each of the variable headings was present but without units, in fact some values had units on the same line as the value, others did not. Unfortunately the learner did not consistently use the appropriate number of decimal places with some data recorded to only one decimal place and others to two, which was more appropriate. When this became obvious to the teacher towards the end of the practical lesson it was too late to repeat the tests.	**Context** Biology (Year 12): Production of a dilution series of a solute to produce a calibration curve with which to identify the water potential of plant tissue **Observed** A learner designed a results table for their raw data that was complete with variable headings and units to the format expected outlined in their practical handbook. After blotting dry the chips the learner weighed each one, recording the initial masses to 2 decimal places as it was being collected. This number of significant figures appropriate for the weighing balance was used.	**Context** Biology (Year 12): Production of a dilution series of a solute to produce a calibration curve with which to identify the water potential of plant tissue **Observed** The learner on this occasion was keen to reduce the uncertainty in their data and so wanted to carry out a number of repeats for each sucrose concentration. They had planned to use a number of sets of sucrose tubes and chips and demonstrated the ability to both make and record multiple readings throughout the procedure. Their data table had variable headings and units to the expected format and, in addition to their raw data, the table had columns housing processed data. This included both gain in mass and % gain in mass, enabling them to then draw their graph as directed.

Context Biology (Year 12): Preparation and scientific drawing of onion cells including calibration of actual size and magnification of drawing. **Observed** Three cells are drawn but these appeared out of proportion with cells viewed by candidate. Very little observation of the image was made by the learner who appeared to draw what she thought should be present. The learner was clearly distracted from the task by chatting to her neighbour. No indication of length in eye piece units was given. The candidate forgot to record the magnification of the drawing.	**Context** Chemistry (Year 12): Back titration - determination of calcium carbonate in limestone. **Observed** A learner accurately records data from the titration. He determines the mass weighed by difference. He records all readings at the time of taking them. His readings are recorded into suitable tables to an appropriate number of decimal places taking into account the resolution of the apparatus (e.g. burette readings were to 2dp with second figure as '0' or '5'). On one titre reading he omitted to write down '0'. This appeared to be an oversight by the candidate who recognised his error when his attention was brought to it.	**Context** Physics (Year 13): Measurement of g with a pendulum **Observed** She made two trial runs to measure the time of a period for the longest and shortest length she proposed to use in order to check the range of values and also determine whether the shortest length could be made measured without significant error. She increased the length of the pendulum of her shortest run in the light of her experience. The candidate then made multiple readings of the period of the pendulum at a total of six lengths approximately evenly spaced over the range she determined. She took period readings for six different lengths. She recorded all information immediately into suitable table to an appropriate precision with units correctly recorded. Her tables also facilitated the recording of processed data. This is a capable candidate who displays the full range of making and recording skills in one procedure. It is possible that different aspects of these skills could have been demonstrated in more than one experiment. It is not necessary to record processed data – only raw data- in an appropriate table so this candidate has exceeded the standard.

Context Biology (Year 12): An investigation into the water potential of potato **Observed** As part of the investigation, the learner is expected to draw an accurate results table. In this case, the learner confuses the dependent and independent variables and draws a table where the units are repeated in each line of data. This is pointed out by the teacher in discussion with the learner and the learner is then able to draw a more suitable table and know the format for the next time this skill is required.	**Context** Biology (Year 12): An investigation into the water potential of potato **Observed** The learner uses a balance to 2dp to weigh and record the mass of her potato chips. The table used has the variables and headings correctly labelled. The learner is reminded of the importance of recording all readings at the time of taking them and so does this for all readings after the first one.	**Context** Biology (Year 12): An investigation into the water potential of potato **Observed** The learner records the mass of potato chips accurately using a balance to 2dp and writes them down in a suitable table as they are weighed. The table has all headings and variables correctly labelled but the table is rough and sketched in the learner's lab book. The learner then goes on to draw a further table for processed data to include the percentage gain or loss of water of each chip and the mean. This is all recorded correctly.
Context Physics (Year 12): Determine the Young modulus of a material **Observed** The student takes a measurement of the diameter of the wire, but is not familiar enough with using a micrometer, and only takes a single reading. Only two different loads are used in the experiment, so the student simply records two forces and two extensions. It is not clear from the student's results what the units are for either measurement.	**Context** Physics (Year 12): Determine the Young modulus of a material **Observed** The student is competent in the use of the micrometer and reads the scale correctly to record the diameter of the wire. The student keeps a rough table of the mass used in each experiment (in grams) and the extension of the wire (in mm). In the time available, the student collects five* data points. His graph does have an outlier, but he draws a line of best fit and calculates a value for the test wire. The value does not match the data book, but the teacher is confident that the data has been collected as accurately as the apparatus allows and that the correct gradient has been calculated from the graph. *the exact number of data points to meet CPAC 4 may vary from experiment to experiment	**Context** Physics (Year 12): Determine the Young modulus of a material **Observed** The student takes two or three measurements of the diameter of the wire, using the micrometer with accuracy, and calculates a mean value. The student records extension and load, with units, in a suitable table and makes a rough plot of force versus extension as data is collected. The student continues to take readings up to the elastic limit of the test wire. The value that the student calculates does not match the data book value, but the student carries out an error analysis to help explain why the value may not match that in the literature.

CPAC 5: Researches, references and reports

Not achieved	Achieved	Exceeding CPAC standard
Context Physics (Year 12): Determination of *g* by free-fall method **Observed** The learner completed their experiment and was asked by his teacher to report his findings. It was evident after a while that they were having difficulty processing their raw data using the calculator and there was some lack of understanding and so the teacher needed to intervene. Despite a lot of support, the report produced was very brief and still contained some of the processed errors that the teacher had supported the learner managing. This, coupled with the fact that there is no evidence of any research conducted by the learner to support them with either the practical work or calculation work, led to an unsatisfactory write up on this occasion.	**Context** Physics (Year 12): Determination of *g* by free-fall method **Observed** Independent processing of raw data collected through the practical lesson was followed by a short, concise report being produced by the learner in their own words. They commented on the value of *g* obtained through calculation, the report commenting on the significance of uncertainty. Several, relevant research resources were included in the report, detailed to include the full url address and the time and date accessed so they could be accessed again if necessary. It was evident that the learner had accessed more information than the teacher had shared through this research.	**Context** Physics (Year 12): Determination of *g* by free-fall method **Observed** A full, detailed report had been completed in the learners own words, heavily supported by the extensive, relevant research resources that they had used to support them in practical work. The learner used the Harvard system to reference. The learner had been keen to minimise uncertainty in the data collection and so had considered several ways of adapting the procedure e.g. the use of a *g* ball with an integrated timer, the use of a millisecond timer electromagnetic circuit. Full, scientific terminology had been used correctly and a calculator used without error to process raw data to calculate *g*.
Context Chemistry (Year 12): Determination of an enthalpy change of combustion **Observed** The learners were asked to report their findings. The learner observed had some difficulties calculating the enthalpy change and needed assistance from the teacher. The final report was brief and contained some processing errors. There was no evidence of research (e.g. checking literature values for enthalpy changes).	**Context** Biology (Year 12): Investigation into the effect of temperature on enzyme activity **Observed** The learners were asked to write a report on their findings. The learner observed was able to process results to obtain an appropriate graph of rate (1/t) against temperature. His report commented on the significance of the findings and contained two relevant websites whose URLs and date accessed were recorded. The report was written in his own words and was not simply 'cut and pasted' from websites.	**Context** Physics (Year 12): Determination of *h* using LEDs **Observed** The learner completed a formal and detailed report of his findings using their own words. The learner correctly used a calculator to find relevant values. The report contained suitable graphs plotted using Excel to correctly determine *h*. The report also contained references to critically chosen websites and a textbook. The references were recorded using Harvard system. There is no requirement to use the Harvard System or to formally write-up an experiments findings and therefore the learner's work exceeds requirements.

Context Any subject or Year: Materials Report **Observed** Student presents information, which may be correct, but without any references or evidence of additional knowledge found from researching.	**Context** Any subject or Year: Materials Report **Observed** Student has identified a minimum amount of new information relevant to the material being studied and linked it to understanding from teaching. The references do not follow a standard format, but would allow the reader to locate the information.	**Context** Any subject or Year: Materials Report **Observed** Student has taken the project seriously and researched a wide range of additional data to support how the internal structure of a material lends that material to a particular use. The references follow an accepted pattern and are complete.
Context Biology (Year 12): Investigation of plant mineral deficiencies **Observed** As part of the preparatory work in advance of the practical, students are asked to undertake some research concerning the factors that could be investigated in this investigation. The student's research is poor: his only source of information is the textbook and, although he has read up on some of the theory, he has not considered how this would affect the practical work to be undertaken. No written record is made by the student to say which sources were used in his research.	**Context** Biology (Year 12): Investigation of plant mineral deficiencies **Observed** As part of the preparatory work in advance of the practical, students are asked to undertake some research concerning the factors that could be investigated in this investigation. The student uses Wikipedia as a source, along with her textbook, and she writes some notes in her lab book that show some factors that could be investigated. Her written report includes the URL for Wikipedia, along with the data and time accessed; and the title of the textbook used, the author, and the pages from which she obtained the information. When questioned, she acknowledges that Wikipedia is not always a reliable source, but says that the information on the website agreed with her textbook.	**Context** Biology (Year 12): Investigation of plant mineral deficiencies **Observed** As part of the preparatory work in advance of the practical, students are asked to undertake some research concerning the factors that could be investigated in this investigation. The student writes some notes in his lab book, based on the use of two different websites, and back up by two different textbooks. All sources used are accurately referenced. He uses these sources to state the main factors, and then goes on to outline a possible plan for the experiment, including some excellent experimental detail on apparatus and quantities.

AQA

CPAC assessment support document

What I am looking for when I am assessing each competency is …….

This aide memoire should **not** be used as a tick list. It is designed to help teachers in thinking about what they will look for in their students' practical work. Blanks have been left in each section for teachers to add their own criteria.

This document should be used **after** completing the endorsement training, available on the AQA website.

Common Practical Assessment Criteria (CPAC)	I am looking for my students to be able to …
1. Follows written instructions	• follow a set of written instructions that are appropriate to the level of familiarity to equipment or techniques • carry out steps in the correct order • generate a set of data that is expected. This might be close to my own value or that expected from a data trend seen in a secondary source • work independently, in pairs or small groups but they must carry out practical steps • feel confident to seek clarification when carrying out method steps, when either using an unfamiliar set of apparatus or carrying out a new technique • -- • -- • -- • -- • --

2. Applies investigative approaches and methods when using instruments and equipment	• be able to select the most appropriate apparatus (including chemicals etc) to do this (this can be from a list, and could be done in written form) • use of ICT/dataloggers and be able to explain what they are doing • be able to identify areas that might be improved to allow the collection of more accurate data and note these in their lab records (these practical issues might be discussed with me before suitable adjustments being made) • work methodically • demonstrate the developing ability to 'multi-task' (carrying out one test while preparing for the repeat test is a good example of this) • understand the terminology 'independent, dependent and control variable' and write and/or follow method steps to allow a hypothesis to be tested • to consider which apparatus will support the collection of accurate data to allow them to read data using an appropriate scale • -- • -- • -- • -- • -- • -- • -- • -- • --

3. Safely uses a range of practical equipment and materials	• be able to identify the hazards and the risks associated with those hazards before carrying out the method steps • treat equipment and materials with respect and demonstrate confidence in handling them • be both very aware of their own personal work space and that of others around them • deal with an incidents calmly and effectively • amend the method steps to enable them to collect data more safely when appropriately. For example using smaller quantities or moving equipment to a safer position • wear safety goggles/clothing as standard when appropriate and without prompting. • --- • --- • --- • --- • --- • --- • --- • --- • --- • --- • --- • ---

4. Makes and records observations	• design a data table to record their data as they collect it • record raw data in their data table • if using rough tables, these should be retained • put data table columns in order ie independent, control, dependent. • choose appropriate ranges for data to be collected • collect data at specific points across the full range in sequence to enable a pattern to be identified. • write headings clearly and units are written in the format as directed by the Practical handbook. • present data to the correct number of significant figures • take an appropriate number of repeats, based on the equipment used. • -- • -- • -- • -- • -- • -- • -- • -- • --

5. Researches, references and report	• write a short, concise report, inclusive of data tables, calculations (when appropriate), graphs, conclusion and evaluation • give enough detail that someone else could repeat the work • do not plagiarise • process data using software/tools and present calculations logically • research ideas linked to the scientific knowledge that is being studied at A-level or above if appropriate • use an appropriate referencing style (either in the body of the report or at the end), including full details • -- • -- • -- • -- • -- • -- • -- • -- • -- • --

CPAC Worksheets and student exemplars

CPAC 1 and 4 EMF of a cell

CPAC 1 and CPAC 4
Name………………………………

Class………………………………

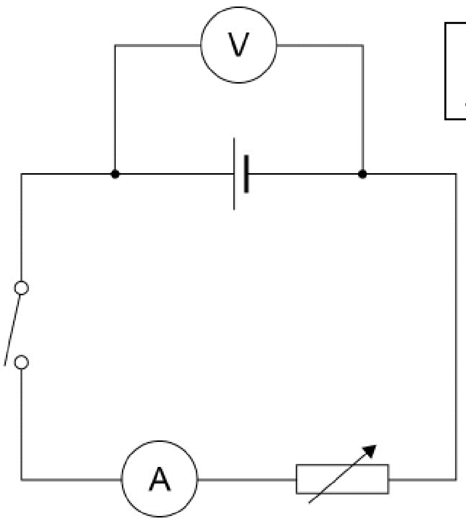
Date………………………………

A-level Physics required practical No 6

Investigation of the emf and internal resistance of electric cells and batteries

Materials and equipment

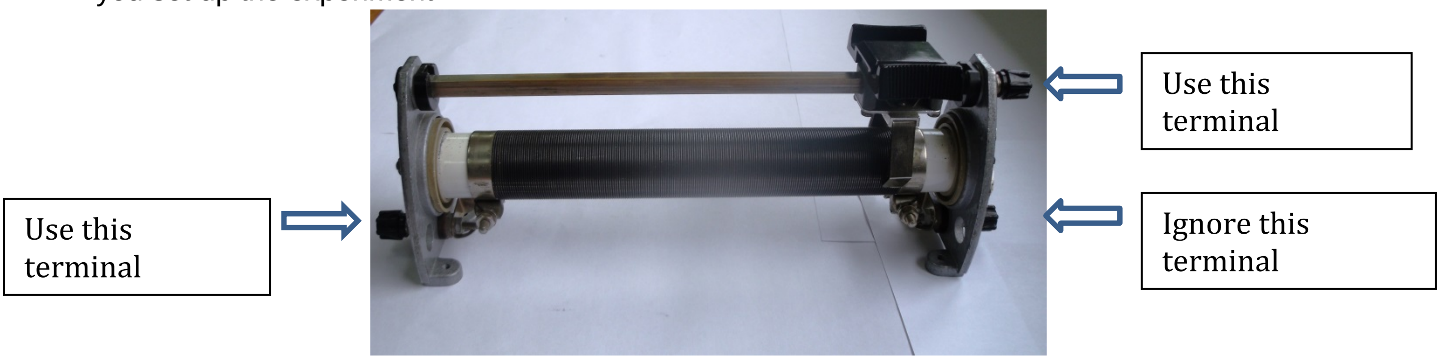
- Cell holder with cell
- variable resistor - wire wound rheostat
- digital voltmeter (set on 20V dc)
- digital ammeter (set on 2A dc))
- switch
- connecting lea



NB – Connect circuit to **only** **one** cell in the battery pack

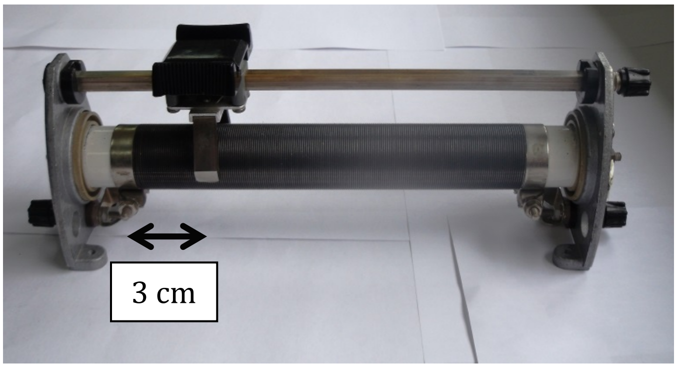
Method

- Set up the circuit as shown in the diagram. Set the variable resistor at its maximum value. **(Note the position of the slider in the photo below**.) You teacher will explain which terminals to use before you set up the experiment



- With the switch open record the reading, V, on the voltmeter.
- Close the switch and take the readings of pd, V, on the voltmeter and current, I, on the ammeter.
- Record your readings in a suitable table in your lab book

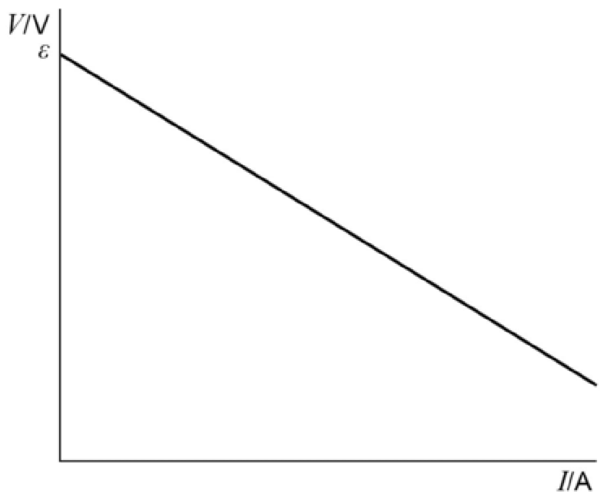
- Adjust the variable resistor to obtain pairs of readings of V and I, over the widest possible range but do not slide the slider nearer than about 3 cm away from the end of the resistor. You will need to plot a graph so you should ensure that you have taken a minimum of 7 readings for this experiment



- Open the switch after each pair of readings. Only close it for sufficient time to take each pair of readings.
- Plot a graph of V on the y-axis against *I.*

Using $\varepsilon = I\,(R+r)$ and $V = I\,R$
Gives $\varepsilon = V + I\,r$
Rearranging $V = \varepsilon - I\,r$

A graph of *V* against *I* will have a gradient = - *r* and an intercept ε on the *y*-axis



Staff guidelines

CPAC 1 assessment

What would I expect to see

	green
Voltmeter and ammeter connected correctly and on correct settings	
Correct terminals on variable resistor with minimal prompting	
Only one cell used without prompting	
EMF reading taken when open circuit	
Full range of readings taken from full extent of variable resistor to 3cm of end (by observation of expt)	
Observe student switches off between readings (by observation)	

CPAC 4

Minimum of seven readings	
Suitable table with headings and units V/V I / A	
Readings to same precision in table with minimal prompting	
Range of readings	
Graph axes labelled with quantity and unit	
Suitable line of best fit drawn	

Green or Orange depends on level of prompting for this expt.

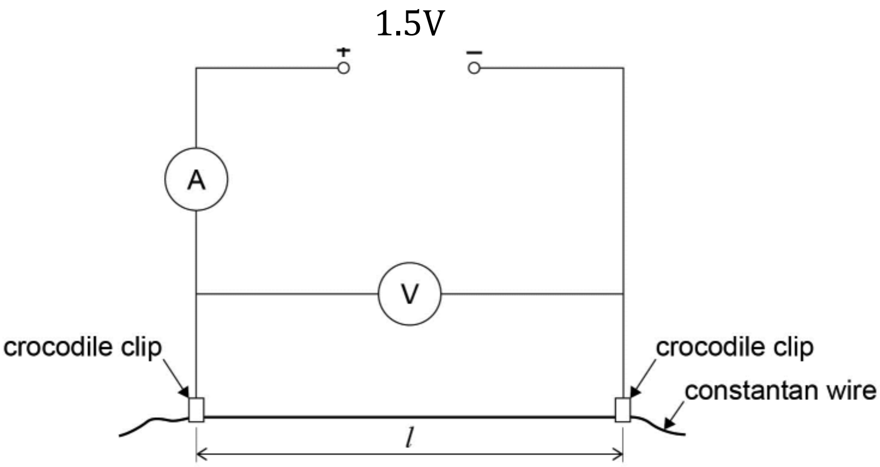
CPAC1 Resistivity of a wire

CPAC 1
Name…………………………………………..
Date ……………………………………………
Class………………………………………..

A-level Physics required practical no.5

Determination of resistivity of wire using a micrometer, ammeter, voltmeter

You have been provided with a length of constantan wire which is fixed to a ruler. You may attach leads to the wire using crocodile clips. Set up the following circuit.



Method

- Measure the thickness of the constantan wire using the micrometer in at least 5 places. Record your results in a suitable table in your yellow notebook. Find the mean diameter and record this in the table.
- Attach the crocodile clips so that l= 0.200m. Make sure the ammeter is set on the 2A DC range and the voltmeter is set on the 20V DC range.
- Take the current reading and the voltage reading and record them in a suitable table in your yellow notebook. As soon as you have finished taking the readings unplug the battery so that the wire does not overheat. Find the value of R and record it in your table
- Repeat the procedure for l= 0.300, 0.400, 0.500, 0.600, 0.700, 0.800, 0.900 m
- Obtain a second set of results by repeating the experiment and find the mean value of R for each value of l.
- Plot a graph of the mean R against l.
- Draw the best straight line of best fit through the points and find the gradient. (The graph should be a straight line through the origin but do not force it through the origin)
- Calculate the cross sectional area of the wire A = $\pi d^2/4$

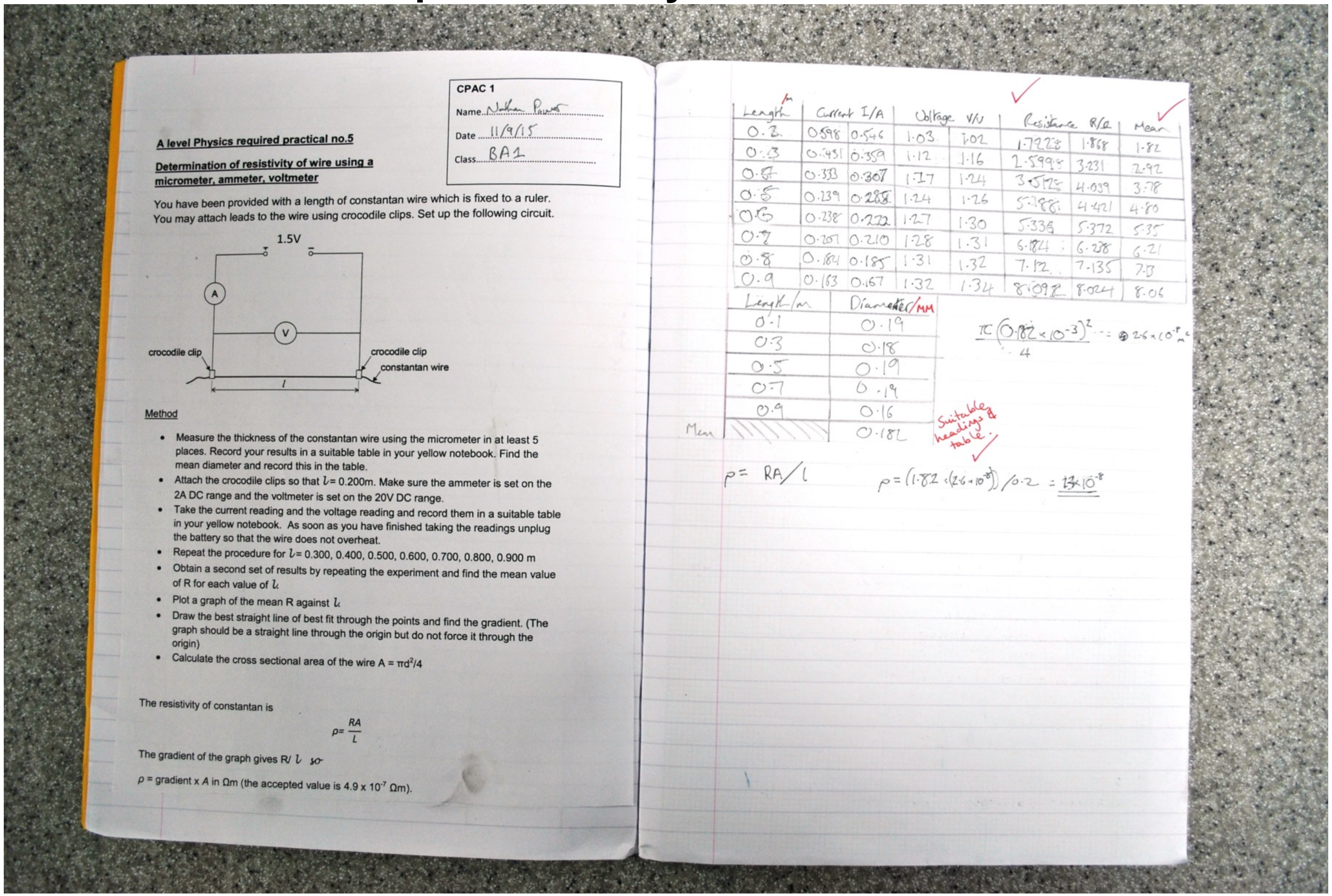
The resistivity of constantan is

$$\rho = \frac{RA}{L}$$

The gradient of the graph gives R/ l so

ρ = gradient x A in Ωm (the accepted value is 4.9×10^{-7} Ωm).

CPAC1 Student exemplar resistivity of a wire



CPAC2 Play dough

CPAC 2
Name…………………………………………..
Date …………………………………………..
Class…………………………………………..

Investigation into how resistance depends on the dimensions of conducting putty

Play dough will conduct electricity. You are provided with a certain volume of play dough and you are to design an experiment to investigate how the dimensions of a sample of play dough affect its resistance.

In particular you are to find

- How resistance varies with length
- How resistance varies with cross sectional area.

You are provided with 1.5V cell and multimeters which can be used as voltmeters or ammeters.

You may also use other commonly available equipment such as leads, croc clips. metal discs etc.

You will probably need to split the experiment into two parts A and B

In your plan for each part of the experiment you need to include the following information.

- What your independent and dependent variables are for each part of the experiment
- What your control variables are – ie what you are going to keep the same
- A clearly labelled diagram showing how you are going to connect the leads to the sample
- What measurements are you going to take and what are you going to take them with
- How are you going to ensure that the experiment is as accurate as possible
- What graphs are you going to plot

Are there any external variables in your experiment which could affect your reading but which you cannot easily control?

Title...

Diagram

Method – clearly identify part A and part B

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Expt part A Expt part B

Independent variable……………………………………………………………………….

Dependent variable………………………………………………………………………..

Control variables…………………………………………………………………………

Precautions to ensure results are as accurate as possible……………………………...

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Graphs…………………………………………………………………………………..

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Any other comments…………………………………………………………………….

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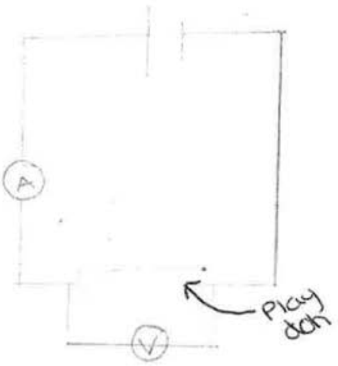
What would I expect to see for the student to be awarded the skill

	Green	Orange
Diagram of voltmeter and across play dough and ammeter in series	√	√
Student identifies suitable connection for attaching crocodile clips to sample	√	
Student identifies changing length and measuring resistance expt A	√	√
Student identifies keeping cross sectional area constant Expt A	√	√
Student identifies measure R with A – expt B	√	√
Student identifies keeping length constant expt B	√	√
Student identifies a way of measuring diameter using suitable instrument	√	√
Student identifies how to work out A from readings	√	√
Student realises that multiple readings need to be taken for diameter and then averages	√	√
Student identifies graphs of R vs l and R vs A (or R vs 1/A)	√	
Student identifies some other factors which may affect the expt - eg temperature, rolling out putty to constant cross sectional area.	√	

CPAC2 Student exemplar

Title How dimensions effect resistance

Diagram



✓

best choice?

Method – clearly identify part A and part B

First roll out the playdoh and measure the diameter in 5places using a micrometer and the length 5 times then work out averages. Then use $A = \frac{\pi d^2}{4}$ to work out the cross sectional area. After that set up the circuit shown above and measure the voltage and current in a suitable table. Then change the length (Part A) of the ~~putty~~ playdoh (ensuring the diameter is the same) by chopping it up. Repeat the experiment at various lengths. ✓
(Part B) Then roll out the playdoh so it is ~~an~~ has the same dimentions as the original (first) test used. This time change the diameter of the playdoh and keep the length the same and repeat at various diameters. ~~After that change the resistance of the variable resistor and repeat the experiment.~~
Finally use the equation $R = \frac{V}{I}$ to work out the resistance and plot a graph of I/A + V/V

	Expt part A	Expt part B
Independent variable	Length	Diameter
Dependent variable	Current , Voltage	Current , Voltage
Control variables	Diameter	length

Precautions to ensure results are as accurate as possible... Take more than one diameter and length then work out an average. Ensure the control variables are kept the same.

You only have one reading of I & V for each length

Graphs. Plot a graph for Current and voltage for part A and a seperate one for part B.

Plot 2 Seperate graphs one for resistance in Ω and cross sectional area/m² and another for resistance/Ω and length/m.

Any other comments...

Ensure the temperature is kept constant as it will affect results.

Other factors affecting results?

Diameter is constant - 0.03m

Length/m	Voltage/V	Current/A	Resistance/
0.15	6.20	0.0460	135
0.12	6.18	0.0730	84.7
0.09	6.16	0.0910	67.7
0.06	6.11	0.127	48.61
0.03	6.01	0.134	44.9

[illegible] /m					[illegible] /m
1	2	3	4	5	
.029	.033	.030	.028	.030	0.030

Diameter/m	Voltage/V	Current/A	Resistance/Ω
0.040	6.16	0.098	63.0
0.035	6.16	0.095	65.0
0.030	6.18	0.094	66.0
0.025	6.22	0.067	93.0
0.020	6.23	0.062	100
0.015	6.28	0.030	209
0.010	6.30	0.010	~~6f~~630

Cross sectional area/m^2

1.26×10^{-3} 1.767×10^{-4}
9.62×10^{-4} 7.85×10^{-5}
7.07×10^{-4}
4.891×10^{-4}
3.14×10^{-4}

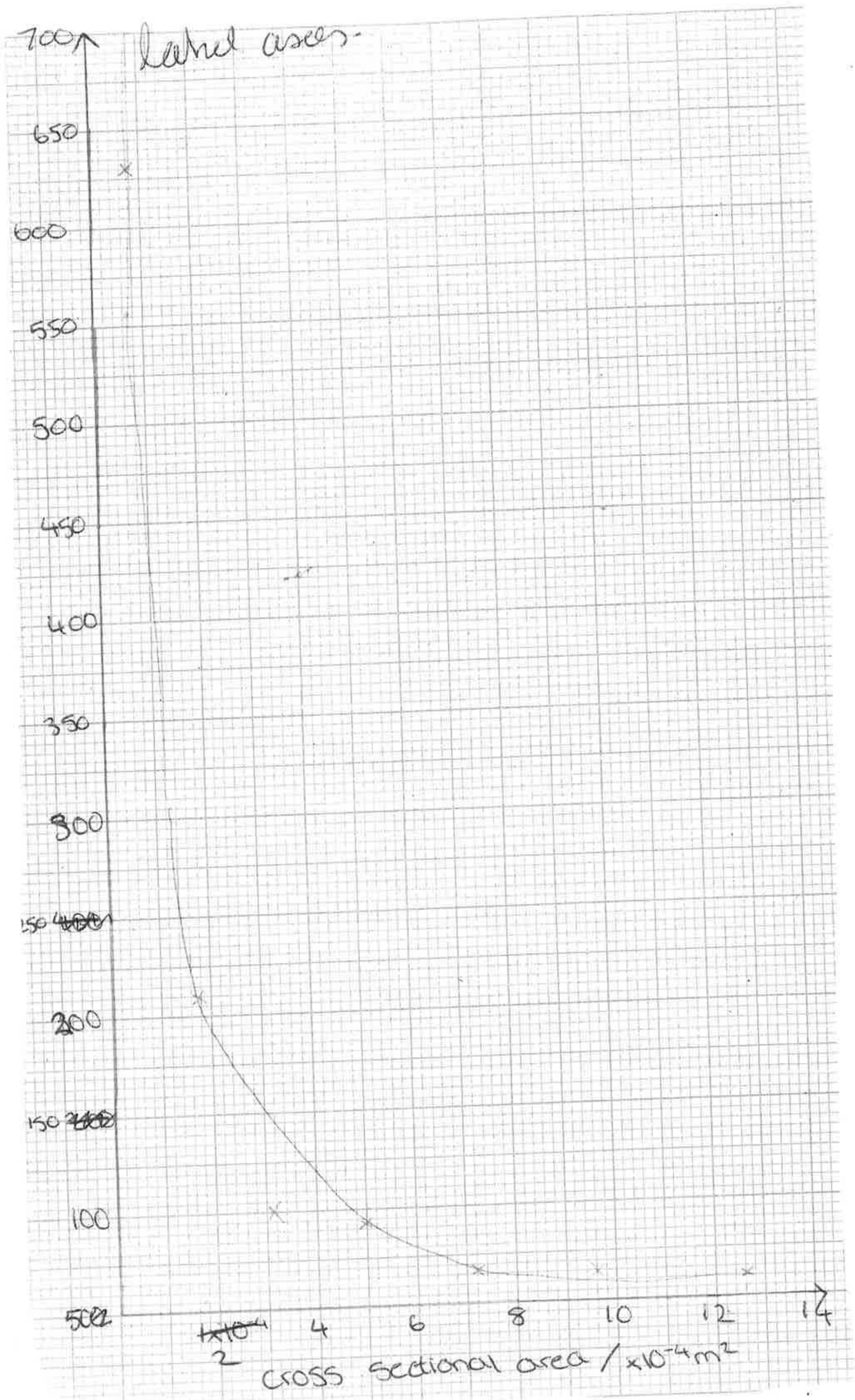
Conclusion

Resistance and length

The first graph showed that resistance is proportional to length. In my graph there is an anomoly at a length of 0.15 this could have been caused by many factors. ~~These~~ it could be because there was difficulty in making the shape uniform, we did try to minimise this by doing multiple diameter readings and working out averages. There could also have been a temperature change and the contacts we used may have affected it.

For the second graph as the cross sectional area increases the resistance decreases. The same factors affect both graphs.

Where is your R vs L graph?

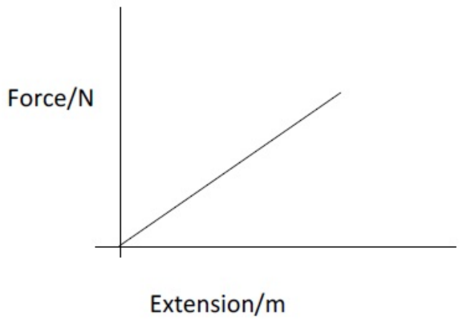

label axes.
700
650
600
550
500
450
400
350
300
250
200
150
100
50
2
4
6
8
10
12
14
cross sectional area / x10^-4 m^2

CPAC5 Stretching a rubber band

CPAC 5 assessment

Name…………………………………………
Date…………………………………………..
Class…………………………………………..

Stretching a rubber band



We have already seen that the force – extension graph for a spring which has not been stretched beyond its elastic limit looks like the graph above.

State what the gradient represents………………………………………………………..

In the space below carefully sketch the shape of the graph you obtained for loading and unloading the elastic band. Label the loading line and the unloading line. (Your actual graph should be stuck in you lab book.)

Comment on how your graph compares to graphs obtained by other experimenters.

Give a reference you used to help with your comparison

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Discuss how the shape of the graph can be explained in terms of the arrangement of the molecules of the rubber. You may use diagrams to help with your explanation.

Give references for any web sites or books that you used to help you with your answer.

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State what the area under the loading line represents……………………………………

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State what the area under the unloading line represents………………………………

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Explain how you could use your graph to find the energy lost during loading and unloading

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State the references you used to help you with the questions above………………….

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