**Determining the Maximum Power Available from a Cell**

**Introduction**

This investigation is intended to meet the requirement that students should be able to determine the e.m.f. and internal resistance of a cell, which is then extended to consider the maximum power transfer.

**Aims and skills covered**

* To follow written instructions
* To design and construct circuits
* To plot a current-voltage characteristic

**Links to Specifications**

**Physics A**

* 4.2.2(a) potential difference and the unit *volt*
* 4.2.2(b) electromotive force (e.m.f.) of a source such as a cell or a power supply
* 4.2.2(c) distinction between e.m.f. and p.d. in terms of energy transfer
* 4.2.3(a) resistance; ; the unit ohm
* 4.2.5(a) the equations 
* 4.3.1(e) analysis of circuits with components, including both series and parallel
* 4.3.2(a) source of e.m.f.; internal resistance
* 4.3.2(b) terminal p.d.; 'lost volts'
* 4.3.2(c)(i) the equations **E** *= I*(*R + r*) and **E** = *V* + *Ir*
* 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**

* 3.1.2a(iii) resistance and conductance, including series and parallel combinations
* 3.1.2a(iv) the effect of internal resistance and the meaning of e.m.f
* 3.1.2a(v) dissipation of power in electric circuits
* 3.1.2b(iii) graphs of current against potential difference
* 3.1.2c(i) use formulae:

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

**Practical Skills**

* 1.2.1(a) apply investigative approaches and methods to practical work
* 1.2.1(b) safely and correctly use a range of practical equipment and materials
* 1.2.1(c) follow written instructions
* 1.2.1(d) make and record observations/measurements
* 1.2.1(e) keep appropriate records of experimental activities
* 1.2.1(f) present information and data in a scientific way
* 1.2.1(g) designing, constructing and checking circuits using DC power supplies, cells, and a range of circuit components
* 1.2.1(j) use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification
* 1.2.2(b) use appropriate digital instruments to obtain a range of measurements to include current and voltage
* 1.2.2(f) correctly constructing circuits from circuit diagrams using DC power supplies, cells, and a range of circuit components, including those where polarity is important
* 1.2.2(k) use of ICT such as software to process data

**CPAC**

* (1) Follows written procedures
* (2) Applies investigative approaches and methods when using instruments and equipment
* (3) Safely uses a range of practical equipment and materials
* (4) Makes and records observations

**Mathematical skills**

* M0.1 Recognise and make use of appropriate units in calculations
* M1.1 Use an appropriate number of significant figures
* M2.3 Substitute numerical values into algebraic equations using appropriate units for physical quantities
* M2.4 Solve algebraic equations
* M3.1 Translate information between graphical, numerical and algebraic forms
* M3.2 Plot two variables from experimental or other data

**Equipment (per learner or group)**

* 1.5V D standard cell, do not use high power or high capacity cells
* 6 low voltage lamps (1.25 to 2.5V torch bulbs)
* ammeter
* voltmeter
* leads

**Health and safety**

* Safe use of electrical circuits

Before carrying out any experiment or demonstration based on this guidance, it is the responsibility of teachers to ensure that they have undertaken a risk assessment in accordance with their employer’s requirements, making use of up-to-date information and taking account of their own particular circumstances. Any local rules or restrictions issued by the employer must always be followed.

**Notes**

* These practical activities are not controlled assessments, should not be carried out in exam conditions and can be adapted by the centre. Students can collaborate during the activities which should take place as part of the normal teaching sequence. They are intended to be formative with students acquiring and practising skills throughout the course.
* To achieve a pass in the Practical Endorsement each student is required to demonstrate competence in all the skills, apparatus and techniques listed in section 1.2 of the specification and assessed against the Ofqual Common Practical Assessment Criteria (CPAC) at the end of the course.
* The skills, apparatus and techniques can be demonstrated during any practical work undertaken during the A Level course whether an OCR practical activity or not.
* CLEAPSS document R151 “*Ammeters,Voltmeters etc,for Class Use*” and the Laboratory Handbook sections 12.3.1 “*DMMs compared to analogue meters*”, 12.3.2 “*Provision of digital multimeters*” and 12.3.3 “*Which DMMs to buy*”, contain useful information on selection and use of digital multimeters.
* The teacher should determine that the lamps to be used give sufficient data points to identify the peak power transfer. This is often more easily achieved by trial, rather than identifying that the lamps should have an operating resistance of approximately one third of the internal resistance of the cell (and definitely greater than one eighth and less than one half of the internal resistance).
* Less expensive standard cells with higher internal resistance, or previously used cells, give a larger drop from e.m.f. to terminal voltage allowing determination of internal resistance. New high capacity alkaline cells are least suitable.
* This idea of maximum power transfer when load resistance is equal to internal resistance applies equally in audio systems, which is why loudspeakers are generally 8 ohm to match the output impedance of the amplifier.

**Recording**

* Learners should not need to re-draft their work but rather keep all their notes as a continuing record of Practical Activity.
* As evidence for the Practical Endorsement learners should have evidence of the data collected in a clear and logical format.

In addition, to support the assessment of practical work in the written examinations:

* Learners should have completed the tables for potential difference, current, load resistance and power.
* Learners should have plotted the graphs for voltage-current characteristic and power against load resistance.