Mark Scheme 2823/03
June 2005

Planning Exercise - Skill P

A1 Workable procedure **P1**
(i.e. measure temp. and resistance across faces P and Q, vary temp. and measure new resistance. Could be in a table)

A2 Suitable method for achieving temperature of brick (e.g. oven/kiln) **P1**
Do not allow 'Bunsen burner' methods

A3 Allow time for temperature of brick to stabilise **P1**
Do not award this mark if brick is removed from kiln.

A4 Use of appropriate thermometer (e.g. thermocouple/thermistor/platinum resistance radiation pyrometer). Do not allow mercury-in-glass or alcohol thermometers. Do not allow vague **P1**
reference to datalogger - detail such as thermocouple probe needed.

B1 Correct circuit diagram. Accept use of ohmmeter. "Multimeter" needs further detail. **P1**

B2 Method of measuring small current (e.g. edspot galvanometer/microammeter) **P1**
Milliammeter or ammeter scores zero. Could be shown on the diagram.
If a ohmmeter has been employed, then this mark may be scored from a discussion of the range of the ohmmeter (e.g. set to high resistance value).

B3 Method of electrical contact with faces P and Q **P1**
(e.g. wires connected to a conducting medium e.g plate, foil, gel, rods and medium is firmly attached to brick e.g. G-clamp, springs, conducting glue).

C1/2 Two separate relevant safety precautions use of high voltages/temperatures **P2/1/0**
High Voltages (>99V):switch off when not in use; keep away from equipment when switched on;
no bare leads or crocodile clips
High Temperatures: handle brick with tongs or gloves; wait for brick to cool down before moving;
use bare wire in oven so rubber/plastic does not catch fire, safety screen.
Do not allow vague statements such as 'great care should be taken with the experiment as electricity is very dangerous' or 'protective clothing'.

R1/2 Evidence of the sources of the researched material **P2/1/0**
Two or more (vague) references and/or one detailed reference score one mark.
Two or more detailed references scores two marks.
Detailed references should have page or be internet pages.

D Any further relevant detail. Examples of creditworthy points might be; **P3/2/1/0**
Place thermometer near to brick to allow for local variations in temperature
Value quoted for resistivity of brick
Calculation of resistance from resistivity
Use solder or choice of metal with a high melting point
Use high voltage (E.H.T. or H.T.) supply (to give measurable current)
Evidence of preliminary experimental work in laboratory/good use of research
Problems with variable moisture content of brick below 100 °C
Discussion of resistance problems e.g. with surface on which brick rests or contact etc.
Different types of house bricks may perform differently
Do not allow vague 'repeat readings' ideas.

Underline and tick each relevant point in the body of the text. The ticks must have a subscript showing which marking point is being rewarded (e.g. $\checkmark_{D1}$).

Q1/2 Quality of written communication **P2/1/0**

This is for the organisation and sentence construction. Accounts that are rambling, or where the material is not presented in a logical order will not score these marks. Do not award both of these marks if the word count exceeds the recommended length by more than 50%.

16 marks total

Question 1

(a) Circuit set up correctly with no help **I2**
Minor correction made by Supervisor (e.g. reverse connections to milliammeter, or help with one of the resistor arrangements) scores 1.
Circuit constructed for candidate, or help with combination of more than one set of resistors: score zero.

(b) First value of current in range 9 mA to 11 mA **I1**

(c) Measurements: **I2**
Write the number of readings as a ringed total next to the table of results.
6 sets of readings for *I* and *R* scores two marks.
5 sets scores one mark.
Less than five sets scores zero.

(c) Values of 1/*I* and *R* **I2**
Check a value for 1/*I*. If correct award one mark. Underline checked value.
Ignore small rounding errors. Tick if correct. If incorrect, write in correct value and score zero.

Check values for *R*. If correct award one mark.
These should be 15.7/23.5/31.3/47/70.5/94/141 (any six will do)

(c) Column headings in the table **I2**
One mark for correct column heading and unit for *R*.
One mark for correct column heading and unit for 1/*I* e.g. for unit allow A^{-1}
Ignore units in the body of the table.

(c) Consistency of raw readings and Significant figures **I2**
Consistency of *I* only. All the readings must be given to the same number of decimal places.

Significant figures in 1/*I*
The sf in 1/*I* must be the same as, or one better than, the sf in *I*. (e.g. 2sf in *I*, 2 or 3 sf in 1/*I*)

(d) Axes
A2/1/0
Sensible scales must be used. Awkward scales (e.g. 3:10, 6:10, 7:10) are not allowed.
The scales must be labelled with the quantities plotted. Ignore units.
Do not allow more than three large squares without a scale label.
Plotted points must occupy at least half the graph grid in both *x* and *y* directions (i.e. 4 x 6)
One mark for each correct axis.
Tick each axes if correct.
Circle origin or write FO if a false origin.

(d) Plotting of points **A2/1/0**
All observations must be plotted on the grid.
Count the number of plots and write as a ringed number. Zero marks if not all points plotted.
Check a suspect plot. Tick if correct otherwise indicate the correct position.
If the plot is accurate $\leq$ half a small square, then two marks awarded.
One mark if the plot is out by > half a small square and < than one small square.

(d) Line of best fit **A1**
Judge by scatter of points about the line.
There must be a fair scatter of points either side of the line of best fit.
Allow line through five trend plots for full credit (if done well).
Do not allow a line through a curved trend.

(d) Quality of results **I1**
Judge by scatter of points about the line of best fit.
Five trend plots needed for one mark to be scored.
Large scatter/wrong trend/only four trend plots (or less) will score zero.

(d) Gradient **A2/1/0**
The hypotenuse of the Δ must be ≥ half the length of the drawn line. 1 mark.
Read-offs must be accurate to half a small square and ratio correct. 1 mark.

(d) *y*-intercept **A1**
Expect the value to be read from the *y*-axis to an accuracy of half a small square.
Or correct substitution from point on line into $y = mx + c$.

(e) Justification of sf in 1/*I* **E2/1/0**
Expect to see sf in *I* related to sf in 1/*I*.
Vague answers relating to 'raw data' can score one mark.
Do not allow answers in terms of decimal places or related to graph (score zero).
Ignore table values.

(f) Value of *E* **A2/1/0**
Gradient equated with $\frac{1}{E}$ scores 1 mark
Value of *E* (= 1/gradient) in the range 1.2 V to 1.8 V.
Do not allow this mark if the gradient has not been used.

(f) Value of *X* **A2/1/0**
y-intercept equated with $\frac{X}{E}$ scores one mark
Value of *X* (= *E* x *y*-intercept)
Do not allow this mark if the *y*-intercept has not been used. Method must be valid.
Allow ecf.
Beware of errors of factors of 1000.

(f) Significant figures and units for *X* and *E* **A2/1/0**
Accept 2 or 3 sf only for both values. Ignore trailing zeros. This scores one mark.
Both units must be correct for this mark to be awarded. This scores one mark.

28 marks total. Write total as in a ring at the bottom of page 5.

N.B. If the *y*-intercept is zero (candidate had possibly removed *X*) then in part (d) the quality of results is zero and the 2nd mark for the value of *X* is zero.

Question 2

(b) Measurement of both lengths **I1**

(c) Method of measuring d **I1**
How tip of pencil was located or position of meniscus

(d) Percentage uncertainty in d **E2/1/0**
Δd in the range 1 mm to 10 mm (one mark)
Ratio idea correct and x 100 (one mark)

(f) Method of calculation of k for both sets of data **A1**
Check initial substitution. Evidence of calculating two numerical values needed for this mark.
Conclusion consistent candidate's numerical values following valid method **A1**
(e.g. k values significantly different, hence relationship does not hold)
(References to proportionality loses this second mark)

(g) Evaluation of procedure **E8**
Relevant points must be underlined and ticked with the appropriate marking letter.

	Problem	**Solution**
A	Human error in measuring h and/or d	Use two people to perform the experiment (as it is difficult to release the pencil and watch the water at the same time) Video methods / Scale on container Clamp rule so distances can be found more easily
B	Parallax /meniscus problems Meniscus changes during experiment (by displacement)	Eye to be level Use fiducial marker to locate position of tip of pencil
C	Difficulty with release e.g. wobble/angle/friction	Cut with scissors Burn through thread
D	Difficulty with motion of pencil e.g. not vertical/ colliding sides of container/ Possible friction between thread and metal hook/Drag from cotton will be variable	Thread needs to be attached to the centre axis Use thin thread
E	Water absorption by pencil	Paint or waterproof pencils/use similar pencils/use saturated pencils
F	Two readings are not enough to verify the relation between h and d	Take many readings of a range of h and d and plot a graph (i.e. d v h or d^2 v h)

One mark for each box to a maximum of 8.

No credit for simple 'repeats', 'movement of pencil', 'light gates', 'use a smaller/larger vessel' or 'micrometer screw gauge/vernier callipers/travelling microscope'.

Quality of written communication (i.e. spelling, sentence construction, grammar) **E2**
Capital letters at the beginning of sentences, full stops at the end scores one mark
Correct spelling scores one mark. Allow max two errors.

16 marks total

Sample results and theory for unknown resistance experiment

Ignoring the resistance of the milliammeter and the internal resistance of the cell, Kirchhoff's law gives

$$E = IR + IX$$

$$\therefore \frac{1}{I} = \left(\frac{1}{E}\right)R + \frac{X}{E}$$

Hence a graph of 1/I against R gives a straight line of gradient $\frac{1}{E}$ *and y-intercept* $\frac{X}{E}$.

R/Ω	*I*/mA	I^{-1}/A^{-1}
16	13.3	74.9
24	12.5	79.9
31	11.8	84.7
47	10.4	96.2
71	9.1	110
94	8.0	125
141	6.5	155

From graph, gradient is 0.64; hence E = 1/0.64 = 1.56 V.

y-intercept = 64.7 = X/E; hence X = 64.7 x 1.56 = 101 Ω.

Sample results for falling pencil experiment

h_1 *= 5.0 cm;* d_1 *= 15.0 cm;* h_2 *= 10.0 cm;* d_2 *= 19.5 cm.*

L = 8.5 cm.

Substituting into the expression to give two values of k (2.0 and 2.8). The values are significantly different, and therefore the suggested relation does not hold.

It is very difficult to measure d to a reasonable degree of accuracy.

Summary of shorthand notation which may be used in annotating scripts:

SFP	Significant figure penalty
ECF	Error carried forward
AE	Arithmetical error
POT	Power of ten error
NV	Not valid
NR	Not relevant
GAP	Insufficient scale markings on an axis
NBL	Not best line
FO	False origin
NGE	Not good enough
BOD	Benefit of the doubt
R	Point repeated (no further credit)
NA	Not allowed
SV	Supervisor's value
SR	Supervisor's report
OOR	Candidate's value is out of range
CON	Contradictory physics (not to be credited)
✓Δ	Used to show that the size of a triangle is appropriate (gradient calculation)
✓C	Used to show that the raw readings are consistent
✓SF	Used to show calculated quantities have been given to an appropriate number of significant figures
^	Piece of work missing (one mark penalty)
^^	Several pieces of work missing (more than one mark penalty)
↔	Scale can be doubled in the x-direction
↕	Scale can be doubled in the y-direction