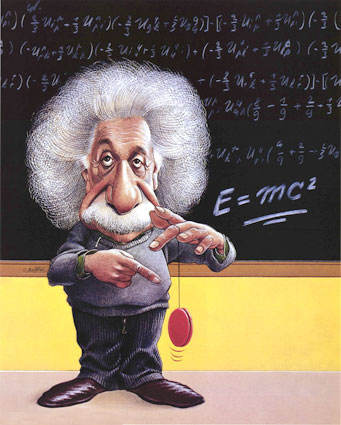
**Physics**

**Y11**



**Introduction**

**MEASUREMENTS AND UNITS:**

* Before starting we need to reflect on SI Units, prefixes, scientific notations and significant figures.

**Fundamental Units**

* In answering mathematical questions, all quantities are usually in their Standard Internationale Units (SI Units).
* These units have been agreed upon worldwide and you must use them unless told otherwise.
* All other units are derived from these SI Units.

|  |  |
| --- | --- |
| Mass *kilogram* (**kg**)  Length *metres* (**m**)  Time *seconds* (**s**)  Electric current *ampere* (**A**) | Temperature *Kelvin* (**K**)  Luminous intensity *Candela* (**cd**)  Amount of substance *mole* (**mol**) |

**Derived Units**

* A derived unit is a combination of fundamental units. Some examples of the use of symbols for derived units are: ms-2 or m/s2 (speed) kW.h (electricity) kgm-3 or kg/m3 (density) N.m (torque)

**PP App A p 418-9**

**Prefixes**

* These are helpful for large or small numbers.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Name** | **Symbol** | **Factor by which the unit is multiplied( orders of magnitude)** | | | **Description** |
| atto | a | 10-18 | = | 0.000 000 000 000 000 001 | one million million millionth |
| femto | f | 10-15 | = | 0.000 000 000 000 001 | one thousand million millionth |
| pico | p | 10-12 | = | 0.000 000 000 001 | one million millionth |
| nano | n | 10-9 | = | 0.000 000 001 | one thousand millionth |
| micro | μ | 10-6 | = | 0.000 001 | one millionth |
| mili | m | 10-3 | = | 0.001 | one thousandth |
| centi | c | 10-2 | = | 0.01 | one hundredth |
| deci | d | 10-1 | = | 0.1 | one tenth |
| deca | da | 101 | = | 10 | ten |
| hecto | h | 102 | = | 100 | one hundred |
| kilo | k | 103 | = | 1 000 | one thousand |
| myriad | my | 104 | = | 10 000 | ten thousand |
| mega | M | 106 | = | 1 000 000 | one million |
| giga | G | 109 | = | 1 000 000 000 | one thousand million |
| tera | T | 1012 | = | 1 000 000 000 000 | one million million |
| peta | P | 1015 | = | 1 000 000 000 000 000 | one thousand million million |
| exa | E | 1018 | = | 1 000 000 000 000 000 000 | one million million million |

* **Activity:** Example: μs = micro second, 10-18 boy = atto boy **Answers p 13**

|  |  |
| --- | --- |
| 1. 103g = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 2. 10-12 boo = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ 3. 10-6 phone = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_   g. 10-1 mate = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | 1. 10-3 m = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_   d. M phone = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  f. 109 lo = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  h. 1012 ferma = \_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

**Rounding Off:**

* When rounding off a number, use only the last digit to be discarded. If 5 or greater, round up, if less than 5, round down. For example:

|  |
| --- |
| **Activity**: Round the following to two decimal places:   1. 2.649 \_\_\_\_\_\_\_\_\_\_ d. 5.344 \_\_\_\_\_\_\_\_\_\_ g. 8.999 \_\_\_\_\_\_\_\_\_\_ 2. 9.813 \_\_\_\_\_\_\_\_\_\_ e. 6.145 \_\_\_\_\_\_\_\_\_\_ h. 2.456 \_\_\_\_\_\_\_\_\_\_ |

6.95 becomes 7.0

6.85 becomes 6.9

4.251 becomes 4.3

3.649 becomes 3.6

**Use of Significant Figures**

* Significant figures are those numbers that are known with certainty plus the first number that is uncertain.
* The correct number of significant figures should be used in your numerical answers to show the accuracy of your result.
* This becomes important when working on problems that involve estimations – these will occur more often in year 12 Physics.

**RULES:**

1. All non zero digits are significant.

*E.g. 7.92 has 3 significant figures (hence forth called sf)*

1. Zeros that fall between two non-zero digits are significant.

*E.g. 9.002 x 10-4 has 4 sf.*

1. Zeros to the left of a decimal point are not significant.

*Eg. 0.35 has 2 sf.*

1. Zeros to the right of the decimal point before a non-zero digit are not significant but after a non-zero digit are significant.

*Eg. 0.0710 has 3 sf as the very last zero to the right is significant*

1. Zeros at the end of a number and to the left of the decimal point are not significant unless otherwise indicated. Eg. 3500 has 2 sf. If zeros are significant then scientific notation can be used to show this. *E.g. 3.500 x 104 has 4 sf while 3.50 x 104 has 3 sf.*
2. When multiplying or dividing, the answer is given with as many significant figures as the measurement with the least number of significant figures.

*E.g. 1.4980 g ÷ 6.2 x 10-1 L (5 sf ÷ 2 sf so answer must have 2 sf)*

*= 2.316129 gL-1*

*= 2.3 gL-1 (2 sf)*

1. When adding or subtracting, the answer is quoted with as many decimal places as the measurement with the least decimal places.

*E.g. 1.49 x 102 gL-1 + 6.2 g*

*= 149 + 6.2 g (zero decimal places so answer must have zero decimal places)*

*= 155.2 g*

*= 155 g*

**PP 11.2 p 401**

* **Exercise: Answers p13**

1. How many significant figures in the following?

a. 125 \_\_\_\_\_\_ b. 0.013 \_\_\_\_\_ c. 1007 \_\_\_\_\_\_ d. 25.10 \_\_\_\_\_\_

e. 3700 \_\_\_\_\_\_ f. 0.003 \_\_\_\_\_ g. 10.030 \_\_\_\_\_\_\_ h. 630 \_\_\_\_\_\_

1. Convert the numbers in question 1 to scientific notation.

a. 125 \_\_\_\_\_\_\_\_\_\_ b. 0.013 \_\_\_\_\_\_\_\_\_\_\_ c. 1007 \_\_\_\_\_\_\_\_\_\_\_ d. 25.10 \_\_\_\_\_\_\_\_\_ e. 3700 \_\_\_\_\_\_\_\_\_\_ f. 0.003 \_\_\_\_\_\_\_\_\_\_\_\_ g. 10.030 \_\_\_\_\_\_\_\_\_ h. 630 \_\_\_\_\_\_\_\_\_\_

1. Round off the following to three significant figures and convert to scientific notation.

a. 23571 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ b. 2001 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ c. 2754 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

d. 31256 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ e. 0.31356 \_\_\_\_\_\_\_\_\_\_\_\_\_\_ f. 1244 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. Multiply 2.340 by 5.29002 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. Subtract 0.984 from 5.6 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. Classify the following quantities as either fundamental or derived:

a. area \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ b. electric charge \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ c. force \_\_\_\_\_\_\_\_\_\_\_\_\_\_

d. mass \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ e. electric current \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ f. temperature \_\_\_\_\_\_\_\_\_\_

The following information relates to questions 7 to 12. The distance between Darwin and Alice Springs is about 1.4 x 106 m. The mass of the Earth is about 5.98 x 1024 kg.

7. Convert the distance from Darwin to Alice Springs to km. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8 . Convert the distance from Darwin to Alice Springs to cm. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

9. Convert the distance from Darwin to Alice Springs to Mm. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

10. Convert the mass of the Earth to g. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

11. Convert the mass of the Earth to Gg. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

12. Convert the mass of the Earth to µg . \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The following information relates to questions 13 to 15. The dimensions of a block of wood were measured to be 10 cm x 5 cm x 130 mm.

13. Calculate the volume of the block in mm3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

14. Calculate the volume of the block in m3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

15. Calculate the total surface area of the block in m2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

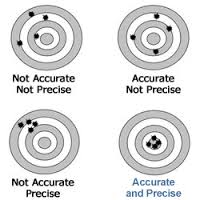
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

16. Convert the speed 90 km.h-1 to m.s-1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

17. Convert the speed 178 cm.s-1 to km.h-1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**PP App B p 420-2**

**Accuracy, Precision, Uncertainty and Absolute Error**



**Accuracy:**

* **Accuracy** relates to an instrument’s use.
* An instrument is accurate if it truly reflects the quantity being measured e.g. if you wanted to measure the width of this page you would use a ruler with millimetre markings.
* The closer a measured value is to the true or actual value, the more accurate it is.

**Precision:**

* **Precision** relates to how an instrument differentiates between slightly different quantities e.g. bathroom scales, kitchen scales and laboratory scales all measure mass and are accurate for the mass they measure.
* Measurements are precise if a set of values agree very closely or if they are spread over a narrow range.
* Laboratory scales are more precise as they can measure to 0.01 g whereas bathroom scales can measure to 0.5 kg.

**Uncertainty:**

* All measurements you make have some amount of **uncertainty**.
* The uncertainty of an instrument is usually one half of the finest scale e.g. a ruler which measures in millimetres has an uncertainty of 0.5 mm. An electronic timer usually to 0.005 s.
* The uncertainty of an instrument measure its precision. If you measure the width of this page you will get a reading of 21.1 cm. The uncertainty is 0.5 mm so the reading is 21.1 ± 0.05 cm.

**Uncertainty in common laboratory equipment:**

Metre rule ± 0.05 cm Micrometer screw gauge ± 0.005 mm

50 mL measuring cylinder ± 0.2 mL Vernier Callipers ± 0.005 cm

50 mL measuring cylinder ± 0.2 mL 10 mL measuring cylinder ± 0.1 mL

-100C – 1100C thermometer ± 0.50C (does depend on precision of thermometer)

* **Activity:**

Use a timer, ruler, thermometer and measuring cylinder to take some measurements including the uncertainty in each measurement.

|  |  |  |  |
| --- | --- | --- | --- |
| **What to measure** | **Measurement** | **Uncertainty** | **Measurement with Uncertainty** |
| Volume of water in a 50 mL measuring cylinder |  |  |  |
| Temperature of the water in the measuring cylinder |  |  |  |
| Length of the measuring cylinder |  |  |  |
| Time to walk across the classroom |  |  |  |

**Estimating the uncertainty in a result**

* An experiment or a measurement exercise is not complete until the uncertainties have been analysed.
* The report should include an estimate of the total uncertainty. This gives the reader of the report some idea of your confidence in the result.
* The following three processes are used for estimating uncertainty.
* When adding or subtracting data, add the absolute uncertainties.

e.g. ΔT (change in temperature) = 40 ± 0.5 0C - 35 ± 0.5 0C = 5 ± 1 0C

* When multiplying or dividing data, add the percentage uncertainties.
* When raising data to power *n*, multiply the percentage uncertainty by *n*.

**Measuring the power of a person.**

* One of the experiments you could do to look at uncertainties is running up steps to measure power. The formula you will use is:



Suppose you had the following data included in your results:

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | | **Absolute uncertainty** | **% Uncertainty** |
| m (student) | 81 kg | 1 kg |  |
| g \* | 9.80 ms-2 | 0.02 ms-2 |  |
| h | 1.75 m | 0.01 m |  |
| t \*\* | 2.20 s | 0.1 s |  |

\* g varies between about 9.78 ms-2 and 9.82 ms-2

\*\* t is an average time but needs to incorporate reaction time.

* You would calculate as follows



Power required to run up a set of steps is 630 watts

Uncertainty (%) = 1.2 + 0.20 + 0.57 + 4.5 = 6.5%

Hence, you would obtain the following result:

P = 630 W ± 6.5%

now 6.5% of 631.43 = 41.0

so P = 630 ± 40 W

Therefore, you could confidently say that the power of this person during this exercise was

590 W ≤ P ≤ 670 W

* You will notice that your final value has fairly large percentage error due to the timing of the run.
* You could therefore suggest a several improvements to the experiment e.g.

1. Use a more accurate timing method
2. Use a higher set of steps so the time is increased and the percentage error is smaller.

* It is always important to look at errors and uncertainties in experiments and investigations.

**PP App B p 423-6**

* **Exercise: Answers p13**

The following information relates to questions 1 -5.

You measure a TV screen with a tape measure to find the area of the screen. You obtain the following data: Height = 21 cm and Width = 28 cm.

1. What is the absolute uncertainty in each of these measurements? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. What is the relative uncertainty in each of these measurements? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. What is the area of the screen in cm2 ? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. What is the percentage uncertainty in the area of the screen ? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. What is the absolute uncertainty in the area of the screen? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

The following information relates to questions 6 – 9.

The diameter of a cylindrical piece of copper rod was measured at 24.8 ± 0.05 mm with a vernier calliper. Its length was measured at 135 ± 0.05 mm with a metre rule.

6. Calculate the percentage uncertainty in the diameter. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

7. Calculate the percentage uncertainty in the length. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

8. Calculate the percentage uncertainty in the volume of the cylinder. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

9. Calculate the absolute uncertainty in the volume of the cylinder in mm3. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Graphical analysis of data**

* A major problem with doing a calculation from just one set of measurements is that a single incorrect measurement can significantly affect the results.
* Scientists like to take a large amount of data and observe the trends in that data.
* This gives more precise measurements and allows scientists to recognise and eliminate problematic data.
* Physicists commonly use graphical techniques to analyse a set of data.
* Some relationships studied in physics are linear, while others are not.
* It is possible to manipulate non-linear data so that a linear graph reveals a measurement.

**Linear Relationships**

* Linear relationships and their graphs are fully specified with just two numbers: gradient, **m**, and vertical axis intercept, **c**. In general, linear relationships are written as:

***y = mx + c***

* The gradient, *m*, can be calculated from the coordinates of two points on the line:

**m** = =

where (x1,y1) and (x2,y2) are any two points on the line.

* Note: Don’t forget that **m** and **c** have units.

**Example:**

* Some students used a computer with an ultrasonic detector to obtain the velocity-time data for a falling tennis ball. They wished to measure the acceleration of the ball as it fell. They assumed that the acceleration was nearly constant and that the relevant relationship was **v = u + at,** where **v** is the speed of the ball at any given time, **u** was the speed when the measurements began, **a** is the acceleration of the ball and t is the time since the measurement began. Their computer returned the following data:

|  |  |
| --- | --- |
| **Time (s)** | **Speed (ms-1)** |
| 0.0 | 1.25 |
| 0.1 | 2.30 |
| 0.2 | 3.15 |
| 0.3 | 4.10 |
| 0.4 | 5.25 |
| 0.5 | 6.10 |
| 0.6 | 6.95 |

* The data is assumed linear with the relationship **v = u + at**, which can be thought of as being **v = at + u**,which makes it clear that putting v on the vertical axis and t on the horizontal axis gives a linear graph with gradient **a** and vertical intercept **u**. A graph of the data can now be drawn on the following grid.

Velocity-Time profile for a falling tennis ball.

Velocity (ms -1)

8

6

4

2

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  | **X** |  |  |  |  |
|  |  |  | **X** | **X** |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  | **X** |  |  |  |  |  |  |  |
| **X** | **X** |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| **X** |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |

0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

Time (s)

* Using computer software, the regression line is given as **y = 9.57x + 1.2857.**
* If this is rearranged and the constants are suitably rounded, the equation is **v = 1.3 + 9.6t.**
* This indicates that the ball was moving at 1.3 ms-1 at the commencement of data collection and the ball was accelerating at 9.6 ms-2.
* NOTE – if the point (0,0) is not in your data, **DO NOT** ‘force’ the line of best fit through the origin.
* When finding the gradient, use as big an area as possible. Select suitable points that are not from your data.
* Show all working on your graph.
* Suppose we were examining the relationship between two quantities **B** and **d** and had good reason to believe that the relationship between them is :

**B =**

where **k** is some constant value.

* Clearly, this relationship is non-linear and a graph of **B** against **d** will not be a straight line.
* By thinking about the relationship it can be seen that in ‘linear form’:

**B = k**  which can be seen as

**y = m x + c**

* A graph of **B** (on the vertical axis) against (on the horizontal axis) will be linear.
* The gradient of the line will be **k** and the vertical intercept, **c**, will be zero.
* The line of best fit **might** go through the origin because, in this case, there is no constant added and **c** is zero.
* **Example**

Some students were investigating the relationship between current and resistance for a new solid state electronic device. They obtained the data shown in the table.

|  |  |
| --- | --- |
| **Current, *i* (A)** | **Resistance, *R* (Ω)** |
| 1.5 | 22 |
| 1.7 | 39 |
| 2.2 | 46 |
| 2.6 | 70 |
| 3.1 | 110 |
| 3.4 | 145 |
| 3.9 | 212 |
| 4.2 | 236 |

Resistance and Current of an electronic device.

Resistance (**Ω**)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 250  200  150  100  50 |  |  |  |  |  |  |  | **X** |  |
|  |  |  |  |  |  |  | **X** |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | **X** |  |  |  |
|  |  |  |  |  | **X** |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  | **X** |  |  |  |  |  |
|  |  |  | **X** | **X** |  |  |  |  |  |
|  |  | **X** |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |

0 1 2 3 4 5

Current (A)

* According to the theory they had researched on relevant Internet sites, the students believed that the relationship between **I** and **R** is **R = d I3 + g**, where **d** and **g** are constants. From this,

**R = d I3 + g** which can be seen as

*y* = *m x + c*

* A graph of **R** on the vertical axis and **I3**on the horizontal axis would have a gradient equal to **d** and a vertical axis intercept equal to **c**.
* By appropriate manipulation and graphical techniques, find their experimental values for **d** and**g.** The following steps would be used:

1. Plot a graph of the raw data.
2. Work out what you would have to graph to get a straight line. (i.e. I3)
3. Make a new table of the manipulated data.
4. Plot the graph of manipulated data.
5. What is the equation relating *i* and *R* ? **Answers p13**

|  |  |
| --- | --- |
| **Current cubed , I3 (A3)** | **Resistance, R (Ω)** |
|  | 22 |
|  | 39 |
|  | 46 |
|  | 70 |
|  | 110 |
|  | 145 |
|  | 212 |
|  | 236 |

Resistance and Current of an electronic device.

Resistance (**Ω**)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 250  200  150  100  50 |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |

0 20 40 60 80 100

Current cubed (A3)

* Find the value of **d** and the value of **g**.
* Some students were investigating a new type of light-dependent resistor (LDR). They measured the resistance in ohms when light of varying intensity was allowed to fall on the resistor. The collected the following data:

|  |  |  |
| --- | --- | --- |
| Light intensity (lux) | Resistance R  (k**Ω**) | (lux-0.5) |
| 0.5 | 9.4 | 0.7 |
| 1.2 | 12.8 | 1.1 |
| 4.5 | 20.5 | 2.1 |
| 9.0 | 27.6 | 3.0 |
| 10.7 | 29.9 | 3.3 |
| 25.9 | 43.8 | 5.1 |
| 44.6 | 57.8 | 6.7 |

They are told, by their teacher, that the relationship between the two measured variables is R = a + b

**Answers p14**

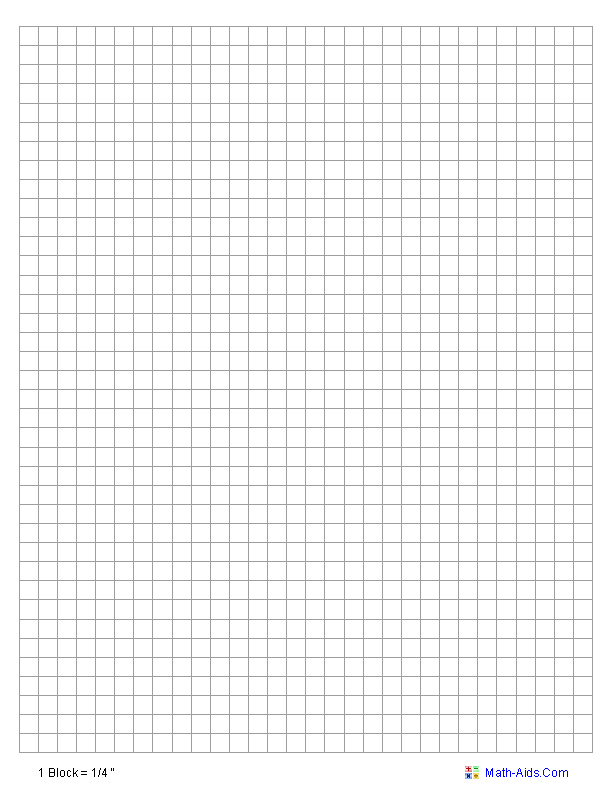
1. Complete the above table by determining for each of the values in column 1.
2. Use the data from the table to plot a straight line graph on the grid provided to demonstrate the relationship between the resistance and the square root of the light intensity (plot on the x-axis)
3. Use the graph to determine the light intensity when the resistance is 25 000 **Ω**.

(Show your working on the graph.)

1. Calculate the gradient of the graph. Include units.

(Show your working on the graph.)

1. Determine the values for a and b.
2. Write the equation expressing the relationship between resistance and light intensity for the LDR.



**1**

**2**

**3**

**4**

**5**

**6**

**7**

**(lux-0.5)**

**10**

**20**

**30**

**40**

**50**

**60**

**70**

**PP App B p 426-30**

**PP App C p 431-47 Chap 11 p 392-413**

* **Activity:** Example: μs = micro second, 10-18 boy = atto boy

|  |  |
| --- | --- |
| 1. 103g = **kilo gram** 2. 10-12 boo = **pico boo** 3. 10-6 phone = **micro phone**   g. 10-1 mate = **deci mate** | 1. 10-3 m = **milli metre**   d. M phone = **mega phone**  f. 109 lo = **giga lo**  h. 1012 ferma = **tera ferma** |

|  |
| --- |
| **Activity**: Round the following to two decimal places:   1. 2.649 **2.65** c. 5.344 **5.34** e. 8.999 **9.00** 2. 9.813 **9.81** d. 6.145 **6.15** f. 2.456 **2.46** |

* **Exercise:**

1. How many significant figures in the following?

a. 125 **3** b. 0.013 **2** c. 1007 **4** d. 25.10 **4**

e. 3700 **2** f. 0.003 **1** g. 10.030 **5** h. 630 **2**

1. Convert the numbers in question 1 to scientific notation.

a. 125 **1.25 x 102** (3) b. 0.013 **1.3 x 10-2** (2) c. 1007 1**.007 x 103** (4) d. 25.10 **2.510 x 101** (4)

e. 3700 **3.7 x 103** (2) f. 0.003 **3 x 10-3** (1) g. 10.030 **1.0030 x 101** (5) h. 630 \_**6.3 x 102** (2)

1. Round off the following to three significant figures and convert to scientific notation.

a. 23571 **2.36 x 104**  b. 2001 **2.00 x 103**  c. 2754 **2.75 x 103**

d. 31256 **3.13 x 10 4** e. 0.31356 **3.14 x 10-1**  f. 1244 **1.24 x 103**

4. Multiply 2.340 by 5.29002 **12.38**

5. Subtract 0.984 from 5.6 **4.6**

6. Classify the following quantities as either fundamental or derived:

a. area **derived** b. electric charge **derived**  c. force **derived**

d. mass **fundamental** e. electric current **derived**  f. temperature **fundamental**

7. Convert the distance from Darwin to Alice Springs to km.  **1400 km or 1.4 x 103 km**

8 . Convert the distance from Darwin to Alice Springs to cm. **1.4 x 108 cm**

9. Convert the distance from Darwin to Alice Springs to Mm. **1.4 Mm**

10. Convert the mass of the Earth to g. **5.98 x 1027 g**

11. Convert the mass of the Earth to Gg. **5.98 x 1018 Gg**

12. Convert the mass of the Earth to µg . **5.98 x 1033 µg**

13. Calculate the volume of the block in mm3.  **100 mm x 50 mm x 130 mm = 6.5 x 105 mm3**

**= 6.5 x 105 mm3 = 7 x 105 mm3 (1 sf)**

14. Calculate the volume of the block in m3. **0.10 m x 0.05 m x 0.130 mm**

**(1 m3 = 1x 109 mm3) = 6.5 x 10-4 m3 = 7 x 10-4 m3 (1 sf)**

15. Calculate the total surface area of the block in m2. **2 x 0.1 x 0.05 + 2 x 0.1 x 0.13 + 2 x 0.05 x 0.13**

**= 0.049 m2 = 0.05 m2 (1 sf)**

16. Convert the speed 90 kmh-1 to ms-1. **/3.6 = 25 ms-1**

17. Convert the speed 178 cms-1 to kmh-1. **/100 x 3.6 = 6.41 kmh-1**

* **Exercise:**

1. What is the absolute uncertainty in each of these measurements? **H = 21 ± 0.5 cm**

**W = 28 ± 0.5 cm**

2. What is the relative uncertainty in each of these measurements? **H = 21 cm ± 2.4%**

**W = 28 cm ± 1.8%**

3. What is the area of the screen in cm2 ? **A = H x W = 21 x 28 = 588 cm2**

4. What is the percentage uncertainty in the area of the screen ? **2.4 + 1.8 = 4.2%**

**588 cm2 ± 4.2%**

5. What is the absolute uncertainty in the area of the screen?  **4.2% of 588 = 24.69**

**588 ± 25 cm2**

6. Calculate the percentage uncertainty in the diameter. **0.05/24.8 x 100 = 0.202%**

7. Calculate the percentage uncertainty in the length. **0.5/135 x 100 = 0.370%**

8. Calculate the percentage uncertainty in the volume of the cylinder. **(0.202 x 2) + 0.370**

**= 0.77%**

9. Calculate the absolute uncertainty in the volume of the cylinder in mm3. **V = πr2l**

**V = π(12.4)2 x 135 = 65211 ± .77% = 65211 ± 502 mm3**

|  |  |
| --- | --- |
| **Current cubed , I3 (A3)** | **Resistance, R (Ω)** |
| **3.4** | 22 |
| **4.9** | 39 |
| **10.6** | 46 |
| **17.6** | 70 |
| **29.8** | 110 |
| **39.3** | 145 |
| **59.3** | 212 |
| **74.1** | 236 |

Resistance and Current of an electronic device.

Resistance (**Ω**)

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 250  200  150  100  50 |  |  |  |  |  |  | **X** |  |  |
|  |  |  |  |  | **X** |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  |  |  | **X** |  |  |  |  |  |  |
|  |  | **X** |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
|  | **X** |  |  |  |  |  |  |  |  |
| **X**  **X** |  |  |  |  |  |  |  |  |  |
| **X** |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |

0 20 40 60 80 100

Current cubed (A3)

* From the graph **m** = = = = 3.1 **Ω** A-3 **c** = 15 **Ω**
* From a computer based spread sheet, a graph with the following regression line was obtained:

**y = 3.1412 x + 15.092**

* This equation can be written as **y = 3.1 x + 15.1**, so the equation relating **I** and **R** is **R = 3.1 I3 + 15.1**.

Hence, the value of **d** is 3.1 **Ω**A-3 and the value of **g** is 15.1 **Ω**.

|  |  |  |
| --- | --- | --- |
| Light intensity (lux) | Resistance R  (k**Ω**) | (lux0.5) |
| 0.5 | 9.4 | **0.7** |
| 1.2 | 12.8 | **1.1** |
| 4.5 | 20.5 | **2.1** |
| 9.0 | 27.6 | **3.0** |
| 10.7 | 29.9 | **3.3** |
| 25.9 | 43.8 | **5.1** |
| 44.6 | 57.8 | **6.7** |

1. Complete the above table by determining for each of the values in column 1.
2. Use the data from the table to plot a straight line graph on the grid provided to demonstrate the relationship between the resistance and the square root of the light intensity (plot on the x-axis)
3. Use the graph to determine the light intensity when the resistance is 25 000 **Ω**.

(Show your working on the graph.)

**When R = 25 000 Ω,**  **= 2.6**

**= 6.76**

**= 7 lux**

1. Calculate the gradient of the graph. Include units.

(Show your working on the graph.)

**m = = = = 8 Ω lux-0.5**

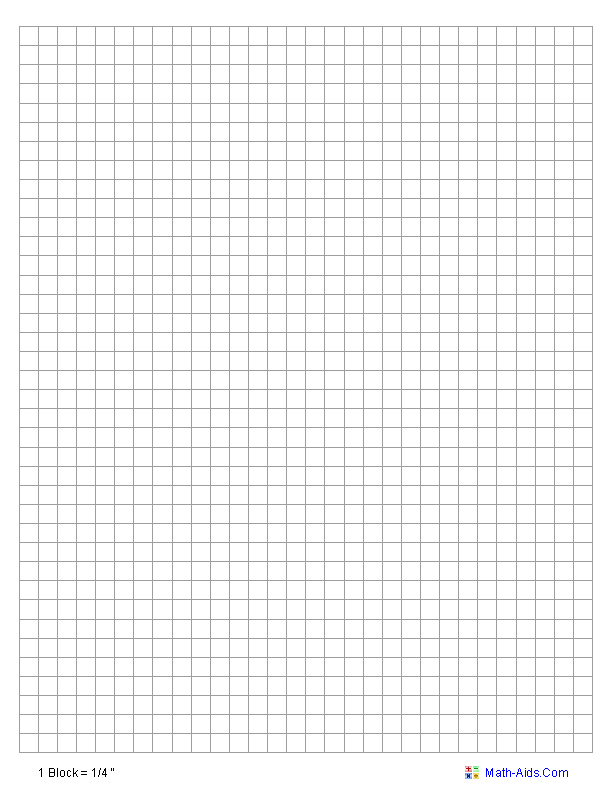
1. Determine the values for a and b.

**a = slope = 8**

**b = y intercept = 4**

1. Write the equation expressing the relationship between resistance and light intensity for the LDR.

**R = 8 + 4**



**1**

**2**

**3**

**4**

**5**

**6**

**7**

**(lux0.5)**

**10**

**20**

**30**

**40**

**50**

**60**

**70**

****

****

****

****

****

****

****

**R (x 1000 Ω)**

**Resistance and light intensity**