A2 Physics at Globe Academy

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Name_____

Edexcel Course

Physics *(from Ancient Greek: φυσική (ἐπιστήμη) phusikḗ (epistḗmē) "knowledge of nature", from φύσις phúsis "nature") is the natural science that involves the study of matter and its motion through space and time, along with related concepts such as energy and force.*

Physics Refresher

Objectives:
- *To give you the skills needed for the successful study of Physics.*
- *To help you to identify areas in which you might need help.*

There are several areas in which students struggle:
- Use of symbols;
- Use of SI units;
- Use of a calculator;
- Use of formulae;
- Presentation of data;
- Plotting of the data in a graph;
- Interpretation of graphical data.

These notes and activities are to help you to become confident with these basic skills, which will help your studies to be more productive and enjoyable.

Using Symbols

An **equation** is a mathematical model that sums up how a system behaves. For example, we know that, if we have a current flowing through a wire and double the voltage, the current will double as well. We know that the quantities of current and voltage are related by the simple rule:

$$V = IR$$

In physics problems we are given certain quantities and use them to find an unknown quantity with an equation. <u>Always</u> in every problem you will have only one unknown. At AS level you will <u>never</u> be expected to tackle a problem with two or more unknowns. That said you may need to look up some quantities from the data sheet.

There are some basic equations that you will have to learn for the exams. These are written down for you at the back of the **Physics Guide**.

1. Write down three equations that you can remember from GCSE (3)

Symbols

In GCSE you were often given equations in words:

$$\text{Distance (m)} = \text{speed (m/s)} \times \text{time (s)}$$

You will notice from the data sheet at the end of these notes that the equations are given in **symbols**, which in my notes I refer to as **Physics Code**. The symbols all mean something; they are abbreviations. The symbols used in exams and most textbooks are those agreed by the Association of Science Education.

Some symbols are easy; V stands for voltage. Some are not so easy. I for current comes from the French *intensité du courant*, since it was a French physicist who first worked on it. In print you will always find the codes written in *italics*. In my notes, I do try to, but sometimes I miss it. As you can't do italics in normal handwriting, then don't worry.

2. What are the meanings for these symbols? (7)
a
A
F
m
I
p
Q

You will come across codes written in Greek letters. The normal (Latin) alphabet has 26 characters. No codes are used which are like ä (a – umlaut) or ê (e – circumflex). The Greek alphabet adds another 24.

3. How many separate Physics Codes might it be possible to get from the Latin and Greek alphabets? Explain your answer. (2)

The Greek Alphabet is this:

Greek	Name	Letter	Greek	Name	Letter
α	alpha	a	ν	nu	n
β	beta	b	ξ	xi	x
γ	gamma	g	o	omicron	Short o (ŏ)
δ (Δ)	delta	d (D)	π	pi	p
ϵ	epsilon	Short e (ĕ)	ρ	rho	r
ζ	zeta	z	σ (Σ)	sigma	s (S)
η	eta	Long e (ē)	τ	tau	t
θ	theta	th	υ	upsilon	u
ι	iota	i	ϕ (Φ)	phi	ph [or f (F)]
κ	kappa	k	χ	chi	ch
λ (Λ)	lambda	l (L)	ψ (Ψ)	psi	ps
μ	mu	m	ω (Ω)	omega	Long o [ō (Ō)]

The ones in grey are the ones you won't generally come across in A-level. You will come across the others in the context of:

- Particles – many particles are given Greek letters, e.g. π meson.
- Physics codes, e.g. $c = f\lambda$

4. The wave equation is $c = f\lambda$. What do the codes refer to? (3)
c
f
λ

The most common uses of Greek letters are:

- α – as in alpha particle;
- β – as in beta particle;
- γ – as in gamma ray;
- Δ – change in (Δt is time interval);
- θ – angle;
- π – 3.1415…;
- Σ – sum of.

5. Find two other formulae in the data sheet that use Greek letters (2)

In Question 3 you worked out that there are 100 different letters available to measure quantities. There are many hundreds of quantities that can be measured in Physics. Therefore it doesn't take a genius to see that some codes are duplicated, for example *I* for current, and *I* for energy intensity.

6. Write down two other letters where the same letter stands for different quantities. Write what they mean and the equations in which they are used. (6)

When you use an equation, you will need to know exactly what each term means. But don't worry; the terms will be explained when the formula is introduced to you.

Units

Physics formulae use **SI** (Système International) **units** based on seven **base units**:

- **Distance** – metre (m);
- **Mass** – kilogram (kg);
- **Time** – second (s);
- **Temperatur**e – Kelvin (K);
- **Current** – ampere (A);
- **Amount of substance** – mole (mol);
- **Intensity of light** – candela (cd) [which you will not come across at A-level.]

Many physics formulae will give you the right answer ONLY if you put the quantities in SI units. This means that you have to convert. You will often find units that are prefixed, for example kilometre. The table below shows you the commonest prefixes and what they mean:

Prefix	Symbol	Meaning	Example
pico	p	$\times 10^{-12}$	1 pF
nano	n	$\times 10^{-9}$	1 nF
micro	⍰	$\times 10^{-6}$	1 ⍰g
milli	m	$\times 10^{-3}$	1 mm
centi	c	$\times 10^{-2}$	1 cm
kilo	k	$\times 10^{3}$	1 km
Mega	M	$\times 10^{6}$	1 M⍰
Giga	G	$\times 10^{9}$	1 GWh

When converting, it is perfectly acceptable to write the number and the conversion factor. For example:

$$250 \text{ nm} = 250 \times 10^{-9} \text{ m} = 2.5 \times 10^{-7} \text{ m}$$

7. Convert the following quantities to SI units: (5)	
15 cm	
500 g	
3 km	
35 mV	
220 nF	

When you write out your answer, you must always put the correct **unit** at the end. The number 2500 on its own is meaningless; 2500 J gives it a meaning.

Failure to put units in loses 1 mark in the exam, which is 2 %. Repeated across a paper, it can mean the difference of two grades.

This little character is about to walk into a **bear trap**. In the notes you will see him where there are common bear traps such as failing to convert into SI units.

Converting areas and volumes causes a lot of problems.

$1 \text{ m}^2 \neq 100 \text{ cm}^2$.
$1 \text{ m}^2 = 100 \text{ cm} \times 100 \text{ cm} = 10\,000 \text{ cm}^2 = 10^4 \text{ cm}^2$

8. Convert the following:	(4)
$1 \text{ m}^2 =$	mm^2
$0.45 \text{ mm}^2 =$	m^2
$1 \text{ cm}^3 =$	m^3
$22.4 \text{ dm}^3 =$	m^3

Standard Form

Standard form consists of a number between 1 and 10 multiplied by a **power** of 10. For big numbers and very small numbers standard form is very useful.

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9. Comment on what happens if you try to put the following numbers into your calculator as they are. Can you do any calculations on them?
   (a) 3200
   (b) 5 600 000
   (c) 2 800 000 000 000
   (d) 0.000000000000341   (2)

You should have found that very small numbers entered into a calculator are read as 0, unless they are entered as standard form. The following number is shown in standard form:

$$3.28 \times 10^5$$
$$= 3.28 \times 100\ 000 = 328\ 000$$

Look at this number:

$$4\ 505\ 000\ 000\ 000\ 000\ 000$$

Start counting from here to get the power of 10.

We find that there are 18 digits after the first digit, so we can write the number in standard form as:

$$4.505 \times 10^{18}$$

For fractions we count how far back the first digit is from the decimal point:

$$0.00000342$$

In this case it is six places from the decimal point, so it is:

$$3.42 \times 10^{-6}$$

A negative power of ten (negative index) means that the number is a fraction, i.e. between 0 and 1.

10. Convert these numbers to standard form: (7)
86
381
45300
1 500 000 000
0.03
0.00045
0.0000000782

There is no hard and fast rule as to when to use standard form in an answer. Basically if your calculator presents an answer in standard form, then use it. I generally use standard form for:
- numbers greater than 100 000
- numbers less than 0.001

When doing a **conversion** from one unit to another, for example from millimetres to metres, I consider it perfectly acceptable to write:

$$15 \text{ mm} = 15 \times 10^{-3} \text{ m}$$

Using a Calculator

A **scientific calculator** is an essential tool in Physics, just like a chisel is to a cabinet-maker.   A calculator geared just to money is fine for an accounts clerk, but quite useless to a physicist. All physics exams assume you have a calculator, and you should always bring a calculator to every lesson. They are not expensive, so there is no excuse for not having one.

The calculator should be able to handle:
- **standard form**;
- **trigonometrical** functions;
- **angles** in **degrees** and **radians**;
- **natural logarithms** and **logarithms to the base 10**.

Most scientific calculators have this and much more.

There are no hard and fast rules as to what calculator you should buy:
- Get one that you are happy with. I use an ancient thing that is nearly thirty years old, but it works.
- Make sure it is accurate; I have known some calculators to get an answer plain wrong!
- Avoid machines that need a hefty instruction manual.
- For the exam, there are certain types of calculator that are NOT allowed, for example those with QWERTY keypads.   Make sure that your calculator is an allowable type.
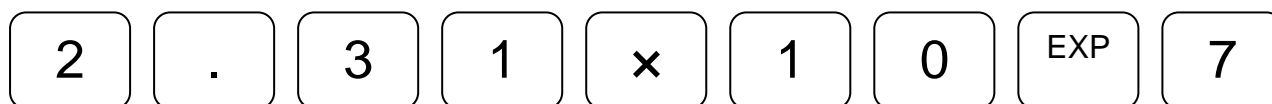
I am assuming that you know the basic functions of your calculator, but I need to draw your attention to a couple of points:

Misuse of the EXP key:
Suppose we have a number like 2.31×10^7. You key it in like this:

$$\boxed{2} \quad \boxed{.} \quad \boxed{3} \quad \boxed{1} \quad \boxed{\text{EXP}} \quad \boxed{7}$$

Do NOT key it in like this:

$$\boxed{2} \quad \boxed{.} \quad \boxed{3} \quad \boxed{1} \quad \boxed{\times} \quad \boxed{1} \quad \boxed{0} \quad \boxed{\text{EXP}} \quad \boxed{7}$$

This will give you 2.31×10^8. Misuse of the calculator will always cost marks.

Too Many Significant Figures

Consider this calculation:

$$Vrms = \frac{13.6}{\sqrt{2}}$$

Your calculator will give the answer as Vrms = 9.6166526 V

There is no reason at all in A-level Physics to write any answer to any more than 3 significant figures. Three significant figures is claiming accuracy to about one part in 1000. Blindly writing your calculator answer is claiming that you can be accurate to one part in 100 million, which is absurd.

The **examination mark schemes** give answers that are no more than 2 significant figures. So our answer becomes:

$$Vrms = 9.62 \text{ V (3 s.f.)}$$
$$Vrms = 9.6 \text{ V (2 s.f.)}$$

Do any **rounding** up or down at the end of a calculation. If you do any rounding up or down in the middle, you could end up with rounding errors.

11. Use your calculator to do the following calculations. Write your answers to no more than three significant figures. (10)	
	ANSWER
(a) $\dfrac{3.4 \times 10^{-3} \times 6.0 \times 10^{23}}{235}$	
(b) $\dfrac{27.3^2 - 24.8^2}{\sqrt{38}}$	
(c) 1.4509^3	
(d) sin 56.4	
(e) $\cos^{-1} 0.4231$	
(f) $\tan^{-1} 2.143$	
(g) $\sin^{-1} 1.00052$	
(h) Reciprocal of 2.34×10^5	
(i) $\log_{10} 200$	
(j) 45 sin 10	

Some other tips on use of calculators:
- On most calculators the number is keyed in before the function (sin, cos, log)
- Take one step at a time and write intermediate results.
- It is easy to make a mistake such as pressing the × key rather than the ÷ key. It is a good idea to do the calculation again as a check.
- As you get more experienced, you will get a feel for what is a reasonable answer. 1000 N is a reasonable force that a car would use to accelerate; 2×10^{-10} N is most certainly not.

Transposition of Formulae

The **transposition** (or **rearrangement**) of formulae is a skill that is essential for successful study of Physics. A wrong transposition of a formula will lead to a **physics error** in the exam and you will lose all the marks available in that part of the question. (However, if you use your incorrect answer correctly in subsequent parts, your error will be carried forward and you will gain the credit.)

Some students find rearrangement very difficult and it hampers their progress and enjoyment of the subject. They try to get round it by learning all the variants of a formula, which is a waste of brain power.

It is far better to get into the habit of rearranging formulae from the start. The best thing to do is to practise.

Key Points:
- What you do on one side you have to do on the other side. It applies whether you are working with numbers, symbols, or both.
- Don't try to do too many stages at once.

Transposing Simple Formulae

Simple formulae are those that consist of three quantities, taking the form A = BC. A typical example is $V = IR$

12. Write down two other formulae of this kind. (2)

A simple trick is to use the **formula triangle**. Some physics teachers sneer at this method. I don't, as long as you are aware that it <u>only</u> works for three term equations.
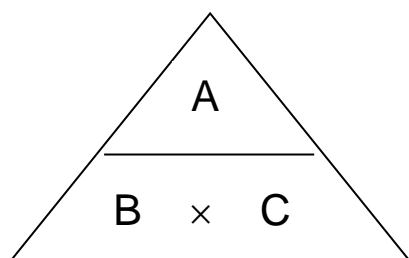
You put your finger over the term you want to be **subject** of the formula (what you want to find) and then the rest follows:
$B = A/C$

However it is better that you follow a more orthodox method. Suppose we are using the equation $V = IR$ and wanted to know I.

We want to get rid of the R on the RHS so that I is left on its own.

So we divide both sides by R which gives us:

$$\frac{V}{R} = \frac{IR}{R}$$

The Rs on the RHS cancel out because $R/R = 1$. So we are left with:

$$\frac{V}{R} = I$$

It does not matter which way the equation ends up, as long as it is rearranged properly.

13. Rearrange these equations:		(4)
Equation	**Subject**	**Answer**
$V = IR$	R	
$p = mv$	v	
$\rho = \dfrac{m}{V}$	m	
$Q = CV$	C	

Formulae with Four Terms

Triangle methods will not work with these. Do the same method as above. Consider this formula:

$$R = \frac{\rho l}{A}$$

Make ⬚ the subject.

Get rid of the l by dividing the whole equation by l.

$$\frac{R}{l} = \frac{\rho l}{Al}$$

The l terms cancel to give:

$$\frac{R}{l} = \frac{\rho}{A}$$

To get rid of the A downstairs we need to multiply both sides by A:

$$\frac{AR}{l} = \frac{A\rho}{A}$$

The A terms cancel to give us our final result:

$$\rho = \frac{AR}{l}$$

14. Rearrange these equations:		(4)
Equation	**Subject**	**Answer**
$pV = nRT$	V	
$Ep = mg\Delta h$	Δh (Δh is a single term)	
$V = \dfrac{-GM}{r}$	G	
$\lambda = \dfrac{ws}{D}$	D	

Equations with + or -

If there are terms which are added or subtracted, we need to progress like this:

$$Ek = hf - \Phi$$

We want to find *h*.

To get rid of the Φ term we need to add it to both sides of the equation:

$$Ek + \Phi = hf - \Phi + \Phi$$
$$Ek + \Phi = hf$$

Now we can get rid of the *f* on the RHS by dividing the whole equation by *f*:

$$\frac{(Ek + \Phi)}{f} = \frac{hf}{f}$$

Which gives us our final result of:

$$h = \frac{(Ek + \Phi)}{f}$$

15 Rearrange these equations:		(2)
Equation	**Subject**	**Answer**
$v = u + at$	t	
$E = V + Ir$	r	

Dealing with Squares and Square Roots

If we have a square root, we get rid of it by squaring. If there is a square, we get rid of it by taking the square root.

Consider this formula:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Suppose we want to find *g*.

Get rid of the square root by squaring the whole equation:

$$T^2 = 4\pi^2\frac{l}{g}$$

Now bring *g* upstairs by multiplying the equation on both sides and cancelling:

$$gT^2 = 4\pi^2 l$$

Now get rid of the T^2 by dividing the whole equation by T^2 and cancelling.

$$g = \frac{4\pi^2 l}{T^2}$$

16. Rearrange these equations: (6)		
Equation	**Subject**	**Answer**
$Ek = \frac{1}{2}mv^2$	*v*	
$T = 2\pi\sqrt{\dfrac{m}{k}}$	*k*	
$f = \dfrac{1}{2\pi\sqrt{(LC)}}$	*C*	

Harder (for a bonus of 5):

$$V = V_0 e^{-t/RC}$$

Make t the subject.

Presentation of Data

The chances are that you were told how to present data in **tables** when you were in Year 7 (1st Year). It is clear that many students weren't listening, because the **presentation** of tables of data causes many problems and lost marks in the practical exam. It shouldn't; it is dead easy. Even if you know no physics, you can still pick up several marks for making sure that your data are presented well.

- Make sure you make a **table**.
- It should be **boxed in** with ruled lines, please.
- There should be **headings** for each column.
- With **units**.
- Data should be to <u>no more</u> than three significant figures.

In an experiment you should get into the habit of taking two or three repeat readings. This helps to reduce anomalous results (those that don't fit into the pattern). Show these in your table and do an average.

In an experiment every student is expected to have their own copy of the results.

It is depressing how often the excuse is made that "Dean's got my results."

Dealing with Uncertainty

In experimental there is always a certain amount of **uncertainty**. Some books call it **error**, but error implies operator carelessness, which is not always the case. Uncertainty can be:

- **Random**, where there is no pattern. For example a digital meter takes readings every 0.2 s. Was the result caught exactly as the stopwatch read 10 s?
- **Systematic**, where there is uncertainty in the calibration of an instrument. A school voltmeter may read 3.45 V, but the real voltage could be 3.41 V.

In general, a school physics experiment will produce <u>at best</u> accuracy of one part in 100. Therefore it makes no sense mindlessly to reproduce all ten digits from a calculator.

Graphical Skills

On their own, numbers do not mean a lot. A table of numbers can be confusing. A graph allows us to see a picture of how the numbers relate to each other.

1. Always use a sharp pencil and a ruler.
2. Draw the axes
3. **Label** the axes with the quantity and the units
4. When you plot *Quantity 1* **against** *Quantity 2*, you put *Quantity 2* on the horizontal axis.
5. Look for the highest value in each range. You **calibrate** (put numbers on) your axes to the nearest convenient step above your highest value.
6. Use a sensible scale.
7. **Plot** your points with **crosses** (+ or ×). Points get lost.
8. Join your points with a line, but not dot-to-dot!

It can be difficult to decide whether a set of results is a straight line or a curve. If it's clearly a straight line, draw your **line of best fit** with a ruler. If the graph is a curve, then try to make a smooth curve. A flexi-curve can help you with this.
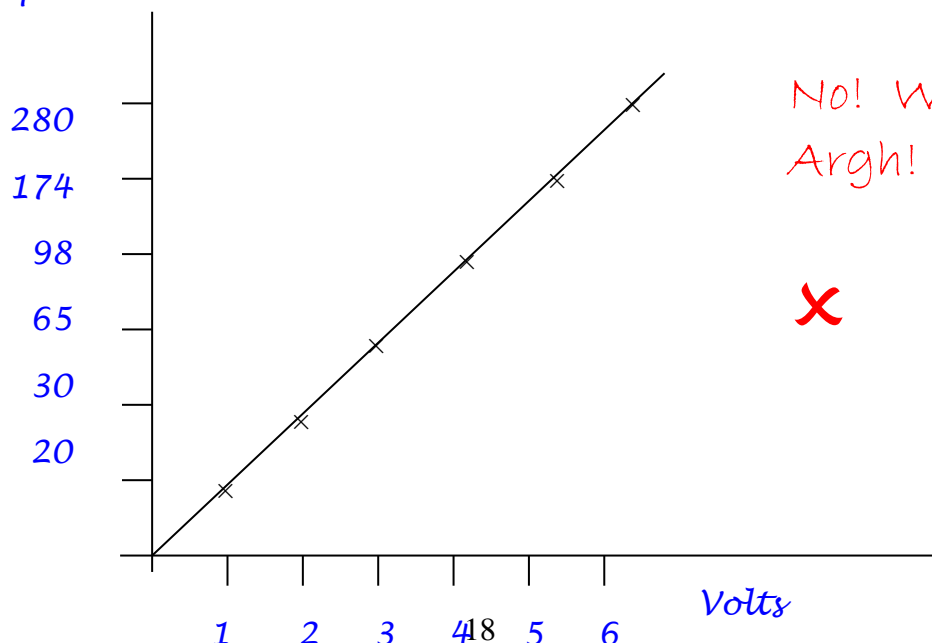
If a point is way out from the rest, then it's probably an **anomalous result**. If you can, recheck the data or do that part of the experiment again. If not, ignore it.

The table below shows some data to plot:

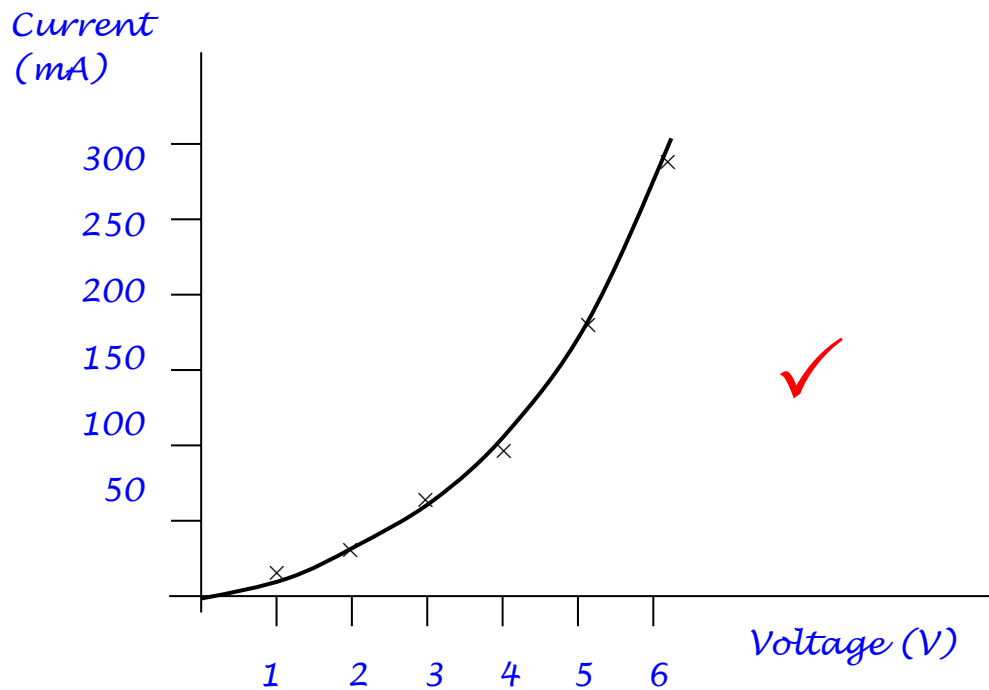| Voltage (V)	Current (mA)
0	0
1	20
2	30
3	65
4	98
5	174
6	280

Please do not do this!

This graph is nonsense. Can you see why? Although graphs drawn like this are quite useless, they are depressingly common.

The correct graph is shown below:

Notice:
- Axes labelled with quantities and units;
- Scales are sensible;
- Line of best fit drawn through the points. No dot-to-dot. Please.

17. Use the data below to plot a graph of Reactance against Frequency. Remember the rules!   (8)

Frequency (Hz)	Reactance (Ω)
500	100
1000	200
1500	310
2000	396
2500	420
3000	600
4000	820
5000	1040

What is the value of the reactance at a frequency of 4200 Hz?	(2)
What frequency gives a value of reactance of 700 ohms?	(2)

Reading values off the graph is called **interpolating**.

18. Work out the gradient of your graph. Show on your graph how you got the gradient.   (4)
Bonus: Write down the units you think the value of gradient should have.   +2

19. (Harder) This graph shows the variation of the reactance of an inductor (a coil of wire) with the frequency of an electrical signal. The formula is $X_L = 2\pi fL$ where: • X_L is the reactance in ohms   • f is the frequency in Hertz   • L is the inductance in Henrys   Use the answer to 15 to work out the value of the inductor.   (4)

The graph above was a straight line. The reactance was **directly proportional** to the frequency. A straight-line graph has the general equation $y = mx + c$ where *m* is the gradient and *c* is the **intercept**, the point at which the line cuts the vertical axis.

20. Extend the line on your graph to reach the vertical axis. What is the value of the intercept?   (2)

20

When we extend the graph, we are **extrapolating**.

Not all graphs are a straight line, as in the following example. The data show the power dissipated by a resistor as voltage increases.

Voltage (V)	Power (W)
0	0
2.5	2.0
5.0	4.1
7.5	18.4
10.0	31.8
12.5	52.1
15.0	72.6
17.5	100
20.0	128

21. Plot the data and join the points with a line of best fit. Note that there is an anomalous result. (8)

22. Which is the anomalous result? What would you do to avoid anomalous results? (2)

Total = 100 marks

Review	Score =	%

My Grade is:	
What I did well:	
My Target	

Record any additional notes below:

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