



Y12 'Bridging' tasks

Outline of preparation

1. Prepare a A4 ring binder, with paper (both graphical and lined) and plastic wallets.
2. Buy the course textbook - shorturl.at/gBJW8
3. Download the CGP Head Start book - <https://www.amazon.co.uk/Head-Start-level-Physics-Level/dp/1782942815> (It is currently free).
4. Work through this workbook, including the worksheets at the very end, completing roughly 2 sections each week. Each section covers important core mathematical skills which will be essential from the beginning of our course
5. Read through the 'AQA Transition Guide' for further guidance on how best to prepare for the course
6. Optional – Extra viewing to prepare and expand your interest.
 - MinutePhysics - excellent, accessible videos to a great many A-Level standard concepts, many of which we use in lessons – their section on Relativity is brilliant! - <https://www.youtube.com/user/minutephysics>
 - Since many of you will be joining us at CERN in 2022, why not take a look over the Standard Model – how much of the universe do you recognise!? - <https://www.youtube.com/watch?v=V0KjXsGRvoA>
 - I am big fan of Jim Al Khalili and have seen him talk several times on subjects such as Quantum Biology. He has produced many exceptional documentaries for the BBC, two of which have especially strong links to our AQA course. I highly recommend them!
 - Atom: Clash of the Titans - <https://www.youtube.com/watch?v=GOJFznzSZhM>
 - Entropy (Order and Disorder) - <https://www.youtube.com/watch?v=b7iuFIKmkN4&t=3112s>

Physics Year 12 Induction

Objectives:

- To give you the skills needed for the successful study of Physics at A level.
- To help you to identify areas in which you might need help.

There are several areas in which students struggle at A level:

- Use of symbols;
- Use of SI units;
- Use of a calculator;
- Use of formulae.

These notes and activities are to help you to become confident with these basic skills, which will help the start of your Physics 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.

Symbols

At GCSE you were often given equations in words: *Distance = speed × time*

At A level you will be provided with a data sheet in your examinations. The data sheet will provide you with equations that are given in **symbols**. 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 these symbols written in *italics*.

| |
|---|
| 1. What are the meanings for these symbols? |
| <i>a</i> |
| <i>v</i> |
| <i>F</i> |

| |
|-----|
| t |
| Q |

You will come across symbols written in Greek letters. The normal (Latin) alphabet has 26 characters. No symbols, with accents are used such as ä (a – umlaut) or ê (e – circumflex). The Greek alphabet adds another 24.

The Greek Alphabet is this:

| Greek | Name | Greek | Name |
|--------------|-------------|--------------|-------------|
| α | alpha | ν | nu |
| β | beta | π | pi |
| γ | gamma | ρ | rho |
| δ | delta | σ | sigma |
| ε | epsilon | τ | tau |
| η | eta | φ | phi |
| θ | theta | χ | chi |
| λ | lambda | ψ | psi |
| μ | mu | ω | omega |

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 equations, e.g. $c = f\lambda$

| |
|--|
| 2. The wave equation is $c = f\lambda$. What do the symbols refer to? |
| 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.

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** (**Read your Measurement and their Errors notes**)

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 most common prefixes and what they mean:

| <i>Prefix</i> | <i>Symbol</i> | <i>Meaning</i> | <i>Example</i> |
|---------------|---------------|-------------------|----------------|
| pico | p | $\times 10^{-12}$ | 1 pF |
| nano | n | $\times 10^{-9}$ | 1 nF |
| micro | μ | $\times 10^{-6}$ | 1 μ 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 μ |
| Giga | G | $\times 10^9$ | 1 GWh |

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

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

| 3. Convert the following quantities to SI units: | |
|--|--|
| 15 cm | |
| 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 %.

Converting areas and volumes often causes a lot of problems.

Area:

$$1m^2 \neq 100cm^2$$

$$1m^2 = 100cm \times 100cm = 10,000cm^2 = 10^4cm^2$$

Volume:

$$1m^3 = 100cm \times 100cm \times 100cm = 1000,000cm^3 = 10^6cm^3$$

| | |
|-----------------------------|-----------------|
| 4. Convert the following: | |
| 1 m ² = | mm ² |
| 45 000 mm ² = | m ² |
| 6 000 000 cm 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.

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:

$$\begin{aligned} & \mathbf{3.28 \times 10^5} \\ & = 3.28 \times 100\,000 = 328\,000 \end{aligned}$$

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.

| |
|--|
| 5. Convert these numbers to standard form: |
| 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. 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, 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. 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.

Your calculator must 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.
- Make sure it is accurate; we 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.

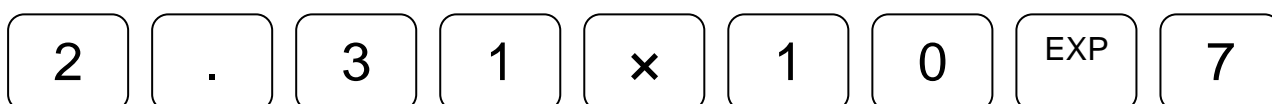
We are assuming that you know the basic functions of your calculator, but we need to draw your attention to a couple of points on the next page.

Misuse of the EXP key:

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



Do **NOT** key it in like this:



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

Too Many Significant Figures

Consider this calculation:

$$V_{rms} = \frac{13.6}{\sqrt{2}}$$

Your calculator will give the answer as $V_{rms} = 9.6166526$ V

There is no reason at all in A-level Physics to write any answer to any more than 4 significant figures. Four significant figures is claiming accuracy to about one part in 10000. 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 either 2, 3 or 4 significant figures. So our answer above could be written as:

$$V_{rms} = 9.617 \text{ V (4 s.f.)}$$

$$V_{rms} = 9.62 \text{ V (3 s.f.)}$$

$$V_{rms} = 9.6 \text{ V (2 s.f.)}$$

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.

| 6. Use your calculator to do the following calculations. Write your answers to three significant figures. | |
|--|---------------|
| | ANSWER |
| (a) $\frac{3.4 \times 10^{-3} \times 6.0 \times 10^{23}}{235}$ | |
| (b) $\frac{27.3^2 - 24.8^2}{\sqrt{38}}$ | |
| (c) 1.4509^3 | |
| (d) $\sin 56.4^\circ$ | |
| (e) Reciprocal of 2.34×10^5 | |
| (f) $45 \sin 10^\circ$ | |

Some other tips on use of calculators:

- Take one step at a time and write intermediate results.
- It is easy to make a mistake such as pressing the \times key rather than the \div 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.

Rearranging of Formulae

The **rearrangement** of formulae is a skill that is essential for successful study of Physics. A wrong rearrangement of a formula can result in losing all the marks available in that part of the question. (However, if you use your incorrect answer correctly in subsequent parts, your error may 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.

Rearranging Simple Formulae

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

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 R s 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.

| 7. Rearrange these equations: | | |
|-------------------------------|---------|--------|
| Equation | Subject | Answer |
| $V = IR$ | R | |
| $p = mv$ | v | |
| $\rho = \frac{m}{V}$ | m | |
| $Q = CV$ | C | |

Formulae with Four Terms

| 8. Rearrange these equations: | | |
|-------------------------------|--|--------|
| Equation | Subject | Answer |
| $pV = nRT$ | V | |
| $E_p = mg\Delta h$ | Δh (Δh is a single term) | |
| $V = \frac{-Gm}{r}$ | G | |
| $\lambda = \frac{ws}{D}$ | D | |

Equations with + or -

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

$$Ek = hf - \square$$

We want to find h .

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

$$Ek + \square = hf - \square + \square$$

$$Ek + \square = hf$$

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

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

Which gives us our final result of:

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

| 9. Rearrange these equations: | | |
|-------------------------------|---------|--------|
| Equation | Subject | Answer |
| $v = u + at$ | t | |
| $E = V + Ir$ | r | |

Now mark your work. Ensure that you have written up your corrections.

Which exercises I found the easiest and why?

Which exercises I found the hardest and why?

Concerns I have about the AS Physics course in Year 12:

ANSWERS

1. What are the meanings for these symbols?

a acceleration

v velocity

F force

t time

Q amount of charge

2. The wave equation is $v = f\lambda$. What do the symbols refer to?

c speed

f frequency

λ wavelength

3. Convert the following quantities to SI units:

| | |
|-------|----------------|
| 15 cm | <i>0.015 m</i> |
| 3 km | <i>3000 m</i> |
| 35 mV | <i>0.035 V</i> |

| | |
|--------|-----------------------|
| 220 nF | $2.2 \times 10^{-7}F$ |
|--------|-----------------------|

| | |
|------------------------------|--------------------------|
| 4. Convert the following: | |
| $1 \text{ m}^2 =$ | $1000\ 000 \text{ mm}^2$ |
| $45\ 000 \text{ mm}^2 =$ | 0.045 m^2 |
| $6\ 000\ 000 \text{ cm}^3 =$ | 0.06 m^3 |

| | |
|--|-----------------------|
| 5. Convert these numbers to standard form: | |
| $86 =$ | 8.6×10^1 |
| $381 =$ | 3.81×10^2 |
| $45300 =$ | 4.53×10^4 |
| $1\ 500\ 000\ 000 =$ | 1.5×10^9 |
| $0.03 =$ | 3.0×10^{-2} |
| $0.00045 =$ | 4.5×10^{-4} |
| $0.0000000782 =$ | 7.82×10^{-8} |

| | |
|---|-----------------------|
| 6. Use your calculator to do the following calculations. Write your answers to no more than three significant figures. | |
| (a) $\frac{3.4 \times 10^{-3} \times 6.0 \times 10^{23}}{235}$ | 8.68×10^{18} |
| (b) $\frac{27.3^2 - 24.8^2}{\sqrt{38}}$ | 7.44×10^4 |
| (c) 1.4509^3 | 3.05 |
| (d) $\sin 56.4^\circ$ | 0.833 |
| (e) Reciprocal of 2.34×10^5 | 4.27×10^{-6} |
| (f) $45 \sin 10^\circ$ | 7.81 |

| | | |
|-------------------------------|-----|-------------------|
| 7. Rearrange these equations: | | |
| $V = IR$ | R | $R = \frac{V}{I}$ |
| $p = mv$ | v | $v = \frac{p}{m}$ |
| $\rho = \frac{m}{V}$ | m | $m = \rho V$ |
| $Q = CV$ | C | $C = \frac{Q}{V}$ |

| |
|-------------------------------|
| 8. Rearrange these equations: |
|-------------------------------|

| | | |
|--------------------------|--|-----------------------------|
| $pV = nRT$ | V | $V = \frac{nRT}{p}$ |
| $E_p = mg\Delta h$ | Δh (Δh is a single term) | $\Delta h = \frac{E_p}{mg}$ |
| $V = \frac{-Gm}{r}$ | G | $G = -\frac{Vr}{m}$ |
| $\lambda = \frac{ws}{D}$ | D | $D = \frac{ws}{\lambda}$ |

| | | |
|-------------------------------|-----|-----------------------|
| 9. Rearrange these equations: | | |
| $v = u + at$ | t | $t = \frac{v - u}{a}$ |
| $E = V + Ir$ | r | $r = \frac{E - V}{I}$ |

Algebraic Manipulation

1. Simplify the following as far as possible

- | | |
|-------------------------|--------------------------------|
| a) $3ab + 2a - 3b - ab$ | b) $2x^2 + 3x - 4x + 5 + 6x^2$ |
| c) $2a \times 3a$ | d) $e^2 \times 4e^3$ |
| e) $3ab \times 2a$ | f) $\frac{2x^2}{x}$ |
| g) $\frac{6ab}{2ac}$ | h) $\frac{a+b}{c-b}$ |

2. Multiply out the following brackets, and simplify the answer as far as possible

- | | | |
|-----------------------|------------------------|----------------------|
| a) $3a(2 - b)$ | b) $x(3x - 4)$ | c) $-4y(2 + 5y)$ |
| d) $-3a^2(4b - a)$ | e) $(x + 2)(x - 3)$ | f) $(2x - 5)(x - 7)$ |
| g) $(1 - 4x)(2 + 7x)$ | h) $(x^2 + 2)(2x + 5)$ | |

3. Rearrange each of the following to make the letter indicated the subject

- | | | | |
|--|-------|--------------------------|-----|
| a) $s = ut + \frac{1}{2} at^2$ | u | b) $F = \frac{GMm}{r^2}$ | m |
| c) $F = \frac{GMm}{r^2}$ | r | d) $I = \frac{Q}{t}$ | t |
| e) $T = 2\pi \sqrt{\frac{L}{g}}$ | L | f) $y = \frac{2-x}{3+x}$ | x |
| g) $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ | R_1 | h) $2as = v^2 - u^2$ | v |

4. In the following examples, the equation is given to you. Rearrange the equation for each of the other quantities. The first line shows an example of this.

| Equation | First Rearrangement | Second Rearrangement |
|--|---------------------|----------------------|
| (Power of lens) $P = \frac{1}{f}$ | $1 = Pf$ | $f = \frac{1}{P}$ |
| (Magnification of lens) $m = \frac{v}{u}$ | $v =$ | $u =$ |
| (refractive index) $n = \frac{c}{v}$ | $c =$ | $v =$ |
| (current) $I = \frac{\Delta Q}{\Delta t}$ | | |
| (electric potential) | | |

| | | | |
|---|-------|--|------------|
| $V = \frac{\Delta E}{\Delta Q}$ | | | |
| (power) $P = \frac{\Delta E}{\Delta t}$ | | | |
| (power) $P = VI$ | | | |
| (power) $P = I^2 R$ | | | |
| (power) $P = \frac{V^2}{R}$ | | | |
| (stress) $\sigma = \frac{F}{A}$ | $F =$ | | $A =$ |
| (strain) $\varepsilon = \frac{x}{l}$ | $x =$ | | $l =$ |
| (conductance) $G = \frac{\sigma A}{L}$ | | | |
| (resistance) $R = \frac{\rho L}{A}$ | | | |
| (phase angle) $\theta = 2\pi ft$ | $f =$ | | $t =$ |
| (displacement) $y = a \sin \theta$ | $a =$ | | $\theta =$ |
| (Young's interference) $x = \frac{\lambda L}{d}$ | | | |
| (electron wavelength) $\lambda = \frac{h}{mv}$ | | | |

Standard Form

1. Convert these numbers into normal form.

- a) 5.239×10^3 b) 4.543×10^4 c) 9.382×10^2 d) 6.665×10^6
- e) 1.951×10^2 f) 1.905×10^5 g) 6.005×10^3

2. Convert these numbers into standard form.

a) 65345 b) 28748 c) 548454 d) 486856

e) 70241 f) 65865758 g) 765

3. Convert these numbers into normal form.

a) 8.34×10^{-3} b) 2.541×10^{-8} c) 1.01×10^{-5}

d) 8.88×10^{-1} e) 9×10^{-2} f) 5.05×10^{-9}

4. Convert these numbers to standard form.

a) 0.000567 b) 0.987 c) 0.0052

d) 0.0000605 e) 0.008 f) 0.0040302

5. Calculate, giving answers in standard form,

a) $(3.45 \times 10^{-5} + 9.5 \times 10^{-6}) \div 0.0024$

b) $(2.31 \times 10^5 \times 3.98 \times 10^{-3}) + 0.0013$

Making Estimates

1. Define the term Order of Magnitude

2. For the following, estimate to the nearest order of magnitude:

| Example | Order of Magnitude Estimate |
|-------------------------|-----------------------------|
| Height of a human in m | |
| Height of a human in cm | |

| | |
|------------------------------------|--|
| Mass of a human in kg | |
| Weight of an apple in N | |
| Thickness of a piece of paper in m | |
| Height of a house in m | |
| Diameter of a dinner plate in m | |
| The length of a lesson in s | |
| Volume of a pencil in m^3 | |
| Mass of a standard car in kg | |
| Wavelength of visible light in m | |

3. Make order of magnitude estimates of the following quantities:

a. Surface area of a door in m^2

b. Volume of a raindrop in m^3

c. Density of wood in kgm^{-3}

d. Work done in lifting a physics textbook in J

| Quantity | Quantity | Alternative Unit | Unit Symbol | Value in SI Units |
|----------|----------|--------------------|-------------|--------------------------|
| Energy | E | electron volt | eV | 1.6×10^{-19} J |
| Charge | Q | charge on electron | e | 1.6×10^{-19} C |
| Mass | m | atomic mass unit | u | 1.67×10^{-27} J |
| Mass | m | tonne | t | 10^3 kg |
| Time | t | hour | hr | 3,600 s |
| Time | t | year | yr | 3.16×10^7 s |
| Distance | d | miles | miles | 1,609 m |
| Distance | d | astronomical unit | AU | 3.09×10^{11} m |
| Distance | d | light year | ly | 9.46×10^{15} m |
| Distance | d | parsec | pc | 3.09×10^{16} m |

e. E
energy
transferr
ed by
passing

through a 2kW kettle to make a cup of tea, in J

f. Impact force on a football ($F = \text{change in momentum} / \text{impact time}$) in N

Converting Units

Many quantities are commonly represented by units other than their base units, for a variety of reasons.

Convert the following quantities:

1. What is 13.6 eV expressed in joules?
2. What is a charge of 6e expressed in coulombs?
3. An atom of Lead-208 has a mass of 207.9766521 u, convert this mass into kg.
4. What is 2.39×10^8 kg in tonnes?
5. It has been 49 years since England won the World Cup, how long is this in seconds?
6. A TV program lasts 2,560s, how many hours is this?
7. The semi-major axis of Pluto's orbit around the Sun is 5.91×10^{12} m, what is this distance in AU?

8. Convert 0.023 km s^{-1} into ms^{-1} .
9. Express 3456 m hr^{-1} into km hr^{-1}
10. What is 30 miles hr^{-1} in ms^{-1} ?
11. What is 50 ms^{-1} in miles hr^{-1} ?
12. Convert 33 km hr^{-1} into ms^{-1} .
13. Express $234 \text{ miles hr}^{-1}$ in km hr^{-1} .