



**Hardenhuish School**  
*'A High Performing Specialist Academy'*



# A Level Physics Induction Task

**Introduction:** Welcome to A level Physics. The first few months of the A Level course are quite a step up from GCSE. After a two month break this can be quite a shock to the system so we have produced an activity to warm up your brain again before returning to lessons. This activity is supposed to be difficult, but please try to complete all questions to the best of your ability. You will have two teachers for year 12, each teaching half of the course. Mr Rogers will cover the waves and electricity sections and Mr Winter or Miss Murphy will cover the forces and materials sections.

**Task:** The attached worksheet should allow you to practice some of the skills required for the A Level Physics course.

If you are interested in starting the A Level Physics course, complete all the questions on paper (remembering to show all necessary working out) and bring your work along to your first lesson in September.

You also spend any spare time reading New Scientist to improve your background knowledge of the subject.

**Additional:** No additional resources are needed from school to complete this task

**Due:** In your first lesson in September with Miss Murphy/ Mr Winter .

**Set by:** If you have any queries regarding the task set, please contact Christine Murphy ([cmm@hardenhuish.wilts.sch.uk](mailto:cmm@hardenhuish.wilts.sch.uk))

**Expected Time Commitment:** 2 hours – You need to show all of your calculations and research questions 7 and 8 carefully to ensure your definitions are detailed and concise.



Had we measured the force in dynes (c.g.s.) and the area in  $\text{cm}^2$  our unit for pressure would be the  $\text{dyne/cm}^2$ . Get the picture? A system of units is built up using equations which define the new physical quantities to give the new units as well.

### Which comes first, the chicken or the egg?

Because all physical quantities are defined based on others there has to be a starting point. So some physical quantities are defined not to depend on any others and are defined in a rather offhand, arbitrary way. These quantities are determined base quantities (or *dimensions*) and their units base units. There are seven of these, but only six are in common use in A level syllabuses.

| Quantity(dimension) | Symbol   | S.I. Unit | Unit Symbol |
|---------------------|----------|-----------|-------------|
| length              | L        | metre     | m           |
| mass                | M        | kilogram  | kg          |
| time                | T        | second    | s           |
| electric current    | I        | ampere    | A           |
| thermodynamic temp  | $\Theta$ | kelvin    | K           |
| amount of substance | N        | mole      | Mol         |

These units are often defined in intriguing ways and in a special order since some of them depend on others. For example: The definition of a metre used to run like this 'One metre is the length equal to 1 650 763.73 wavelengths in a vacuum of the radiation (light) corresponding to the transition between the levels  $2p_{10} - 5d_5$  of the krypton-86 atom'. and the kilogram 'One kilogram is equal to the mass of the international prototype kilogram'. (a cylinder of platinum-iridium kept at the Bureau Internationale des Poids et Mesures (BIPM), Sevres, Paris. All other 1kg masses have to be compared to this one.

### So what??

All very interesting I hear you say but how is this going to get me an A level in Physics??? All of the more complex units like newtons, hertz, etc. are built up from the basic six above and are called derived units. to get from basic units to derived units you need to know the formula linking the physical quantities. You can also use this to check that formulae are 'dimensionally correct' and the units of constants in formulae.

Example: Could the equation  $v = f\lambda$  correctly describe the relationship between  $v$ ,  $f$  and  $\lambda$  for a wave?

We must break each of the quantities down into its base quantities which can be represented by the dimensions M, L, T etc. We usually write dimensions in square brackets so as not to get ourselves confused between M the mass dimension and m the length unit!!

$$\text{Velocity} = \frac{\text{displacement}}{\text{time}} = \frac{\text{frequency (number of vibrations)}}{\text{time}} \times \text{length}$$

$$= \frac{[L]}{[T]} = \text{a number} \times [L]$$

$$\text{SO} \quad \frac{[L]}{[T]} = \frac{[L]}{[T]} \quad \text{OK sigh of relief!}$$

This equation is dimensionally correct, just as well since we've been using for the last few years!. All equations have to be dimensionally correct - it would be nonsense to say that mass x length = time for example!

However it is possible that the correct relationship between velocity, frequency and wavelength is something like  $v = 6 f\lambda$ , because this method of looking at equations cannot deal with numbers (constants) that have no units (dimensions).

### What about the constants?

In some equations, like the example above, there is no constant or rather the constant is equal to 1. However this is not always true. For example let us look at the stretching of a spring. The formula which links the extension of the spring to the force applied to it is called the Hooke law.

$$F = k x$$

$$\text{force} = \text{constant} \times \text{extension}$$

since  $F = ma$  (Newton's second law, you remember!) we have:-

$$ma = \text{constant} \times \text{extension}$$

Putting in the dimensions we have:

$$\frac{[M] [L]}{[T^2]} = \text{constant} \times [L]$$

On the face of it this looks dimensionally incorrect - not allowed - but what if the constant itself has dimensions.

$$\frac{[M] [L]}{[T^2]} = ?? \times [L]$$

$$\frac{[M] [L]}{[T^2]} = \frac{[M]}{[T^2]} \times [L]$$

So the constant, k, in the Hooke law must have dimensions  $\frac{[M]}{[T^2]}$ .

Rearranging the equation we can see that  $k = F/x = \text{force/extension} = \text{newtons/metre}$ . Check that the dimensions of newton/metre are  $[M]/[T^2]$

BINGO !! AND WELL DONE MR HOOKE!

## More Questions for you to do!

- 1 What is the mass of a blue whale in SI units (approx)?
- 2 Which formula defines the new physical quantity force in newtons?
- 3 Use the method of dimensions to show that the formula  $F = \frac{G M_1 M_2}{r^2}$  is dimensionally correct when  $F$  = gravitational force,  $M_1$  and  $M_2$  are masses,  $r$  is the distance between the masses and  $G$  is a constant whose units are  $\text{Nm}^2\text{kg}^{-2}$ .
- 4 Amazingly pressure  $P = h\rho g$  where  $h$  is depth of fluid,  $g$  is gravitational field strength, and  $\rho$  is the density (mass per unit volume)

Rearrange the equation, put in the units, and find out the units of  $g$ .  $g$  can also be measured in  $\text{ms}^{-2}$ . Use the method of dimensions to check that the equation is still correct.

- 5 You may be surprised to note that the joule is not a base unit. There are several equations which could be used to define the physical quantity energy. You should be able to find at least two of them.
- 6 Use one of your equations from question 5 to find the combination of base units equivalent to the joule.

### Initiative exercises!

- 7 Use the library or other sources to find the definitions of the six base quantities in the SI system.
- 8 Give the new definition of the metre and try to explain why it is better than the old one.
- 9 Name one problem with using a prototype metre as a standard of length.
- 10 One of the base quantities was omitted from the list - what is it and what is its definition?