**1.1 The Realm Of Physics**

**Orders of magnitude and Units:**

**The SI System:**

The seven basic units of SI systems are:

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | **Unit** | **Symbol** | **Definition** |
| **Length** | meter | m | The path travelled by light in vacuum during a time interval of 1/299792458 seconds. This fixes the speed of light to **exactly** 299792458 m/s. |
| **Mass** | kilogram | kg | Mass of the platinum-iridium prototype at BIPM in Sevres. |
| **Time** | second | s | On second equals 9192631770 periods of the radiation due to the transition between the two hyperfine levels of the ground state of Cesium 133. |
| **Electric Current** | ampere | A | Given two parallel, rectilinear conductors of negligible circular cross-section positioned 1 m apart in vacuum, one ampere is the electric current which, passing through both of them, makes them attract each other by the force of 2.10-7 newtons per every meter of length. This fixes the permeability of vacuum to **exactly** 2π\*10-7 H/m. |
| **Temperature** | kelvin | K | One degree K equals 1/273.16 of the thermodynamic temperature of the triple point of water. |
| **Quantity of Substance** | mole | mol | The **amount of a substance** composed of as many specified elementary units (molecules, atoms) as there are atoms in 0.012 kg of Carbon 12. |
| **Luminosity** | candela | cd |  |

Occasionally, small or large quantities can be expressed in terms of units that are related to the basic ones by power of 10. The most common prefixes are given below:

| **Factor** | **Name** | **Symbol** |  **Factor**  | **Name**  | **Symbol**  |
| --- | --- | --- | --- | --- | --- |
|  1024 | yotta | Y |  10-1 | deci | d |
| 1021 | zetta | Z |  10-2 | centi | c |
| 1018 | exa | E |  10-3 | milli | m |
| 1015 | peta | P |  10-6 | micro | µ |
| 1012 | tera | T |  10-9 | nano | n |
| 109 | giga | G |  10-12 | pico | p |
| 106 | mega | M |  10-15 | femto | f |
| 103 | kilo | k |  10-18 | atto | a |
| 102 | hecto | h |  10-21 | zepto | z |
| 101 | deka | da |  10-24 | yocto | y |

When doing physics problems, you'll often be required to determine the numerical value and the units of a variable in an equation. The numerical value usually isn't too difficult to get, but for a novice, the same can't be said for the units. This self-instruction unit deals with dimensional analysis, which is a useful method for determining the units of a variable in an equation. Another use of dimensional analysis is in checking the correctness of an equation which you have derived after some algebraic manipulation. Even a minor error in algebra can be detected because it will often result in an equation which is dimensionally incorrect.

Most physical quantities can be expressed in terms of combinations of five basic dimensions. These are **mass** (M), **length** (L), **time** (T), **electrical current** (I), and **temperature**, represented by the Greek letter theta (q). These five dimensions have been chosen as being basic because they are easy to measure in experiments. Dimensions aren't the same as units. For example, the physical quantity, speed, may be measured in units of meters per second, miles per hour etc.; but regardless of the units used, speed is always a length divided a time, so we say that the dimensions of speed are length divided by time, or simply L/T. Similarly, the dimensions of area are L2 since area can always be calculated as a length times a length. As a quick example, let's look at speed, which has dimensions of length divided by time or L/T. Its SI units are then metres divided by seconds, represented as m·s-1.

Some combinations of SI units are given special names.

For example, the unit of energy, kg·m2s-2, is given the special name **joule**, which is abbreviated as J. Study the information presented below.

|  |  |  |  |
| --- | --- | --- | --- |
| a)  | energy  | joule (J)  | kg·m2/s2 |
| b)  | force  | newton (N)  | kg·m/s2 |
| c)  | frequency  | hertz (Hz)  | (cycles)·s-1 |
| d)  | power  | watt (W)  | J/s = kg·m2/s3 |
| e)  | charge  | coulomb (C)  | A·s  |

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A common notation, which means "the dimensions of a quantity", is simply the quantity written inside square brackets []; thus, [area] = L2.

An equation in which each term has the same dimensions is said to be dimensionally correct. All equations used in any science should be dimensionally correct. The only time you'll encounter one which isn't is if there is an error in the equation. So dimensional analysis is a valuable tool in helping you to detect an equation in which you made an error in algebra, for example. Let's try this out on some equations.



where

F is force
r is radius
is length
v is speed
R is distance

What are the dimensions and SI unit of  (viscosity)?

**Solution:** We're given an equation involving force, radius, length, speed, and distance, and are asked for the dimensions and SI units of eta, (), which is a viscosity.



First, we rearrange the equation to solve for  and then convert it to an equation involving dimensions. .



Well, the correct answer for the dimensions is M·L-1·T-1. The corresponding SI unit is kg·m-1·s-1. If you didn't get this answer, try the question again. You've probably just made a simple error with your exponents.

**Order of Magnitude**

In performing rough calculations, estimates, or comparisons, we occasionally round off a number to zero significant figures - which is the nearest power of 10. **A number rounded to the nearest power of 10 is called an order of magnitude**. For example, let's say the average height of a human being is about 1.7 meters (about 5'7"). For the sake of simplicity, let's round off 1.7 meters to the nearest power of 10, which is 100 m (or 1 m). We are not saying that the average height of a person is a mere 1 meter, but rather the average height is closer to 1 meter (or 100 meters) than it is to 10 meters (or 101 meters).