Description: Dimensions introduced, finding dimension of physical quantities

Constants | Periodic Table

Learning Goal:

To introduce the idea of physical dimensions and to learn how to find them.

Physical quantities are generally not purely numerical: They have a particular *dimension* or combination of dimensions associated with them. Thus, your height is not 74, but rather 74 inches, often expressed as 6 feet 2 inches. Although feet and inches are different *units* they have the same *dimension--length*.

Part A

In classical mechanics there are three base dimensions. Length is one of them. What are the other two?

▸ **View Available Hint(s)** (1)

ANSWER:

- ○ acceleration and mass
- ○ acceleration and time
- ○ acceleration and charge
- ◉ mass and time
- ○ mass and charge
- ○ time and charge

There are three dimensions used in mechanics: length (l), mass (m), and time (t). A combination of these three dimensions suffices to express any physical quantity, because when a new physical quantity is needed (e.g., velocity), it always obeys an equation that permits it to be expressed in terms of the units used for these three dimensions. One then derives a unit to measure the new physical quantity from that equation, and often its unit is given a special name. Such new dimensions are called derived dimensions and the units they are measured in are called derived units.

For example, area A has derived dimensions $[A] = l^2$. (Note that "dimensions of variable x" is symbolized as $[x]$.) You can find these dimensions by looking at the formula for the area of a square $A = s^2$, where s is the length of a side of the square. Clearly $[s] = l$. Plugging this into the equation gives $[A] = [s]^2 = l^2$.

Part B

Find the dimensions $[V]$ of volume.

Express your answer as powers of length (l), mass (m), and time (t).

▸ **View Available Hint(s)** (1)

ANSWER:

$[V] = l^3$

Part C

Find the dimensions $[v]$ of speed.

Express your answer as powers of length (l), mass (m), and time (t).

▸ **View Available Hint(s)** (2)

ANSWER:

$[v] = \frac{l}{t}$

The dimensions of a quantity are not changed by addition or subtraction of another quantity with the same dimensions. This means that Δv, which comes from subtracting two speeds, has the same dimensions as speed.

It does not make physical sense to add or subtract two quanitites that have different dimensions, like length plus time. You *can* add quantities that have different units, like miles per hour and kilometers per hour, as long as you convert both quantities to the same set of units before you actually compute the sum. You can use this rule to check your answers to any physics problem you work. If the answer involves the sum or difference of two quantities with different dimensions, then it must be incorrect.

This rule also ensures that the dimensions of any physical quantity will *never* involve sums or differences of the base dimensions. (As in the preceeding example, $\mathrm{l} + \mathrm{t}$ is not a valid dimension for a physical quantitiy.) A valid dimension will only involve the product or ratio of powers of the base dimensions (e.g. $\mathrm{m}^{2/3}\mathrm{l}^2\mathrm{t}^{-2}$).

Part D

Find the dimensions $[a]$ of acceleration.

Express your answer as powers of length (l), mass (m), and time (t).

▸ **View Available Hint(s)** (1)

ANSWER:

$$[a] = \frac{l}{t^2}$$