Chapter 1: Introduction

(Sections 1.8)

Lecture 2

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Section 1-8: Dimensions and Dimensional Analysis

Dimension of velocity v means: what base quantities are used to express velocity.

∴ Dimensions of v are $[L/T]$ (base quantities: length, time)

This means that velocity is measured in units of m/s or cm/s or km/h, ...

Note: m, cm, km express length

s, h express time.

What are the dimensions of Force ?

Question: What are the dimensions of force?

Answer: Remember $F = ma$

$\therefore$ dimensions of force are $\left[\frac{M\,L}{T^2}\right]$

- M: base unit for mass
- L: base unit for length
- T^2: base unit for time.

We can determine if a relationship is incorrect by using a technique called dimensional analysis

Example: Is the relation

$$v_f = v_i + at^2 \quad \text{incorrect?}$$

Answer: use dimensional analysis. The dimension of v is $[L/T]$ and dimension of time is $[T]$.

$$\left[\frac{L}{T}\right] \stackrel{?}{=} \left[\frac{L}{T}\right] + \left[T^2\right]$$

same dimensions

different dimension

The first and second terms have the same dimensions.
BUT the dimensions of the third term are different.

∴ relation is incorrect.

Consider $v_f = v_i + \frac{1}{2}at$

dimensional analysis gives

$$[\tfrac{L}{T}] \stackrel{?}{=} [\tfrac{L}{T}] + [\tfrac{L}{T^2} \times T]$$

∴ $[\tfrac{L}{T}] = [\tfrac{L}{T}] + [\tfrac{L}{T}]$ All terms have the same dimensions.

This means that the relation is dimensionally correct.
BUT the equation is incorrect.
If an equation is dimensionally correct it does NOT have to be correct from the physics point of view.
The correct equation is

$v_f = v_i + at$ – correct from the physics point of view
– dimensionally correct.

Example: For a simple pendullum, the period of oscillation is

period of pendullum → $T = 2\pi\sqrt{\frac{l}{g}}$

Is the above relation dimensionally correct?

$[T] \stackrel{?}{=} \sqrt{\frac{L}{L/T^2}}$ note 2π has No dimensions

$[T] \stackrel{?}{=} \sqrt{T^2} \Rightarrow [T] = [T]$ ✓ dimensionally correct.

Q14] P 18 of the textbook.

One hector is defined as $1.000 \times 10^4\ m^2$.
One acre is defined as $4.356 \times 10^4\ ft^2$.
how many acres are in one hectar?

$$1\ \text{hectar} = 1.000\times10^4\ m^2 \times \left(\frac{ft}{0.3048\ m}\right)^2 \times \left(\frac{\text{acre}}{4.356\times10^4\ ft^2}\right)$$

$$\therefore 1\ \text{hectar} = 1.000\times10^4 \times \frac{1}{(0.3048)^2} \times \frac{1}{4.356\times10^4}\ \text{acre}$$

$$\therefore 1\ \text{hectar} = 2.471\ \text{acre}$$