Defining and calculating dimensions

Starter

1. A car of mass 950 kg moves along a horizontal road with its engine working at a constant rate of 25 kW. The car accelerates from 14 m/s to 18 m/s. Assuming there is no resistance to motion, calculate the time taken.

Working: The average velocity is 16 m/s

Using $P = Fv$: $25000 = F \times 16 \Rightarrow$ Average force $= 1562.5$

Using $F = ma$: $1562.5 = 950a \Rightarrow a = \dfrac{125}{76}$

Acceleration $= \dfrac{\text{change in velocity}}{\text{time}}$: $\dfrac{125}{76} = \dfrac{18-14}{t}$

$t = 2.432$

The time taken is acceleration is 2.432.

E.g. 2 By considering the formula $s = r\theta$, where s is the arc length of a sector and r is its radius, decide what the dimensions of angles are.

Working: $\theta = \dfrac{s}{r}$ so $[\theta] = \dfrac{\mathsf{L}}{\mathsf{L}}$

Angles are dimensionless (but they do have units)

E.g. 3 Find the dimensions of force.

Working: The units of force are newtons. If that doesn't help you, use a formula.

Using $F = ma$: $[F] = [ma] = \mathsf{MLT}^{-2}$

The dimensions of force are MLT^{-2}.

E.g. 4 Find the dimensions of: (a) kinetic energy (b) power

Working: (a) The units of kinetic energy is joules. Maybe try a formula.

Using $KE = \dfrac{1}{2}mv^2$: $[KE] = \left[\dfrac{1}{2}mv^2\right] = \mathsf{M}(\mathsf{LT}^{-1})^2$

$= \mathsf{M}(\mathsf{LT}^{-1})^2$

$= \mathsf{ML}^2\mathsf{T}^{-2}$

The dimensions of kinetic energy are $\mathsf{ML}^2\mathsf{T}^{-2}$.

(b) The units of power are watts, which are J/s so $[P] = \mathsf{ML}^2\mathsf{T}^{-3}$

...or...

Using $P = Fv$: $[P] = [Fv] = \mathsf{MLT}^{-2}\mathsf{LT}^{-1} = \mathsf{ML}^2\mathsf{T}^{-3}$

The dimensions of kinetic energy are $\mathsf{ML}^2\mathsf{T}^{-3}$

Video: Dimensions of quantities and units

Video: Dimension anaylsis example A

Video: Dimension anaylsis example B

Solutions to Starter and E.g.s

Exercise

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