Dimensional Analysis

IB PHYSICS | MOTION

Conversions

Convert the Following:

26.2 miles → kilometers

1 Mile = 1.609 Kilometers

$$26.2\ \cancel{\text{mi}} \times \frac{1.609\ \text{km}}{1\ \cancel{\text{mi}}} = \boxed{\mathbf{42.2\ km}}$$

Conversions with fractions

Convert the Following:

35 mi hr^{-1} → m s^{-1}

1 Mile = 1609 meters

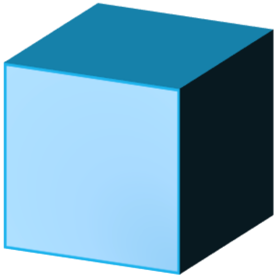
$$\frac{35\ \cancel{\text{mi}}}{1\ \cancel{\text{hr}}} \times \frac{1609\ \text{m}}{1\ \cancel{\text{mi}}} \times \frac{1\ \cancel{\text{hr}}}{60\ \cancel{\text{min}}} \times \frac{1\ \cancel{\text{min}}}{60\ \text{s}} = \boxed{\mathbf{15.6\ m\ s^{-1}}}$$

Conversions with Exponents

How many cm^2 are there in 1 m^2?

$$100 \times 100 = 100^2 = \mathbf{10,000\ cm^2}$$

How many cm^3 are there in 1 m^3?



$$100 \times 100 \times 100 = 100^3 = \mathbf{1,000,000\ cm^2}$$

Conversions with Exponents

Convert the Following:

$0.05\ \text{km}^2 \rightarrow \text{m}^2$

$$0.05\ \text{km}^2 \times \frac{1000\ \text{m}}{1\ \text{km}} \times \frac{1000\ \text{m}}{1\ \text{km}} = \boxed{\mathbf{50,000\ m^2}}$$

$$0.05\ \text{km}^2 \times \left(\frac{1000\ \text{m}}{1\ \text{km}}\right)^2 = \boxed{\mathbf{50,000\ m^2}}$$

Conversions with Exponents

Convert the Following:

1 meter = 3.28 feet

5 m^2 → ft^2

$$5\ \mathrm{m}^2 \times \left(\frac{3.28\ \mathrm{ft}}{1\ \mathrm{m}}\right)^2 = \boxed{\mathbf{53.8\ ft^2}}$$

5 m^3 → ft^3

$$5\ \mathrm{m}^3 \times \left(\frac{3.28\ \mathrm{ft}}{1\ \mathrm{m}}\right)^3 = \boxed{\mathbf{176.4\ ft^3}}$$

Dimensional Analysis

Start with the formula and substitute units in for variables

$$v = \frac{d}{t} \qquad \left[\frac{m}{s}\right] = \frac{[m]}{[s]}$$

Is this formula valid?

$$d = at \qquad [m] = \left[\frac{m}{s^2}\right][s]$$

not valid

$$\cancel{[m] = \left[\frac{m}{s}\right]}$$

Dimensional Analysis

We can use equations with units that we know to find units that we don't.

$$p = m \times v$$

$$= [\text{kg}] \left[\frac{\text{m}}{\text{s}}\right]$$

Variable	Unit
Momentum **p**	kg m s^{-1}
Mass **m**	Kilogram [kg]
Velocity **v**	Meters per second [ms^{-1}]

Dimensional Analysis

Constants have units too! That’s what makes our equation valid

$$F = G\frac{m_1 m_2}{d^2}$$

$$G = \frac{Fd^2}{m_1 m_2} = \frac{[\mathrm{N}][\mathrm{m}]^2}{[\mathrm{kg}][\mathrm{kg}]}$$

$$= \frac{[\mathrm{N}][\mathrm{m}]^2}{[\mathrm{kg}]^2}$$

Variable	Unit
Force **F**	Newton [N]
Mass **m_1** and **m_2**	Kilogram [kg]
Distance **d**	Meter [m]
Universal Gravitation Constant **G**	N m^2 kg^{-2}

Normalized Scientific Notation

Helpful for very **big** numbers

89,000,000 = 8.9×10^{7} or 8.9E7

750,000,000,000 = 7.5×10^{11} or 7.5E11

8,759,000,000 = 8.759×10^{9} or 8.759E9

Normalized Scientific Notation

Helpful for very **small** numbers

0.00125 = 1.25×10^{-3} or 1.25E-3

0.0000008255 = 8.255×10^{-7} or 8.255E-7

0.00000082550 = 8.2550×10^{-7} or 8.2550E-7

Lesson Takeaways

- ❑ I can convert fraction units and exponential units using Dimensional Analysis
- ❑ I can use dimensional analysis to verify a formula
- ❑ I can use dimensional analysis to determine the units for a solution
- ❑ I can represent large and small numbers using scientific notation