N4

Wave Relationships

Speed, distance and time

From the definition: speed = $\frac{\text{distance}}{\text{time}}$

In symbol form: $\mathbf{v} = \frac{\mathbf{d}}{\mathbf{t}}$ $\mathbf{t} = \frac{\mathbf{d}}{\mathbf{v}}$

$\mathbf{d = vt}$

Quantity	Symbol	SI Units
speed	v	ms^{-1} or m/s
distance	d	m
time	t	s

The Wave Equation:

Speed = frequency x wavelength

In symbol form: $\mathbf{v} = \mathbf{f} \times \boldsymbol{\lambda}$

Quantity	Symbol	SI Units
speed	v	ms^{-1} or m/s
frequency	f	Hz
wavelength	λ	m

Examples: A wave travels 90 metres in 30 seconds. Calculate the speed of the wave.

d = vt	d = 90m
90 = v x 30	t = 30s
v = 90 / 30	v = ?
v = 3 metres per second	

A wave has a wavelength of 0.5 metres and a frequency of 4 hertz. What is its speed?

v = fλ	f = 4Hz
= 4 x 0.5	λ = 0.5m
= 2 metres per second	v = ?

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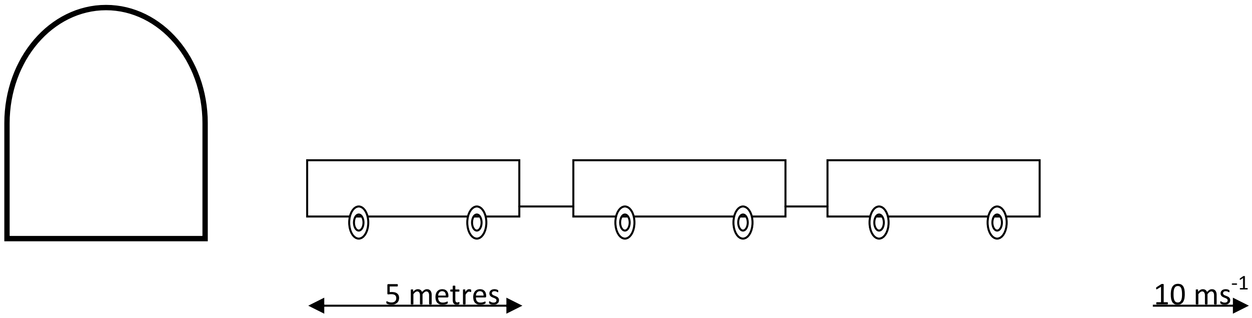
A wave analogy

Suppose a goods train is coming out of a tunnel at a speed of 10 metres per second and the trucks are 5 metres long.



Every second, **10 metres** of train exits the tunnel.
Every second **2**carriages exit the tunnel.
The frequency of the carriages is **2** per second.
Each “carriage length” is **5** metres.
The speed of the train is **10** metres per second.
The link between speed, frequency of the carriages and carriage length is:
Speed = frequency x carriage length
If the carriage length were replaced with wavelengths the equation becomes:
Speed = frequency x wavelength
v = f x λ

A mathematical derivation

If you are watching waves in a pond, you can time how long it takes a whole wavelength to pass a point by timing from one crest to the next. You can also measure the distance from one crest to the next to find the wavelength.

Using these measurements the speed of the wave can be calculated from:

$$\mathbf{v} = \frac{\mathbf{d}}{\mathbf{t}}$$

Since you measured one wave, d = λ (the wavelength) and t = T (the period).
Therefore,

$$\mathbf{v} = \frac{\lambda}{\mathbf{T}}$$

But we know that $\mathbf{T} = \frac{1}{\mathbf{f}}$

Therefore,

$$\mathbf{v} = \frac{\lambda}{\left(\frac{1}{\mathbf{f}}\right)}$$

So

$$\boxed{\mathbf{v} = \mathbf{f} \times \lambda}$$