

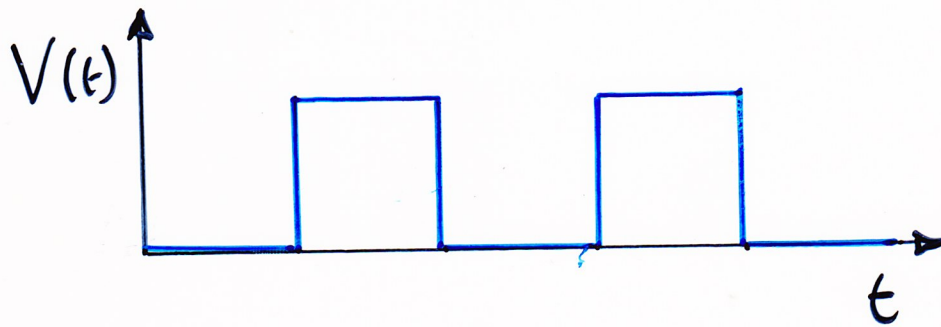
Definition of Signals

- What is a signal?

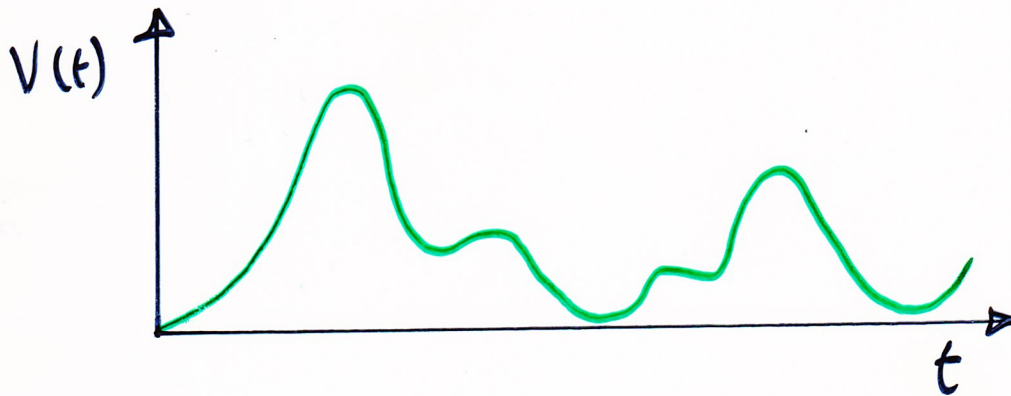
Characteristics

- Convey information
- Need a source
- Medium of propagation
- Destination

Signal types: Periodic & non-periodic

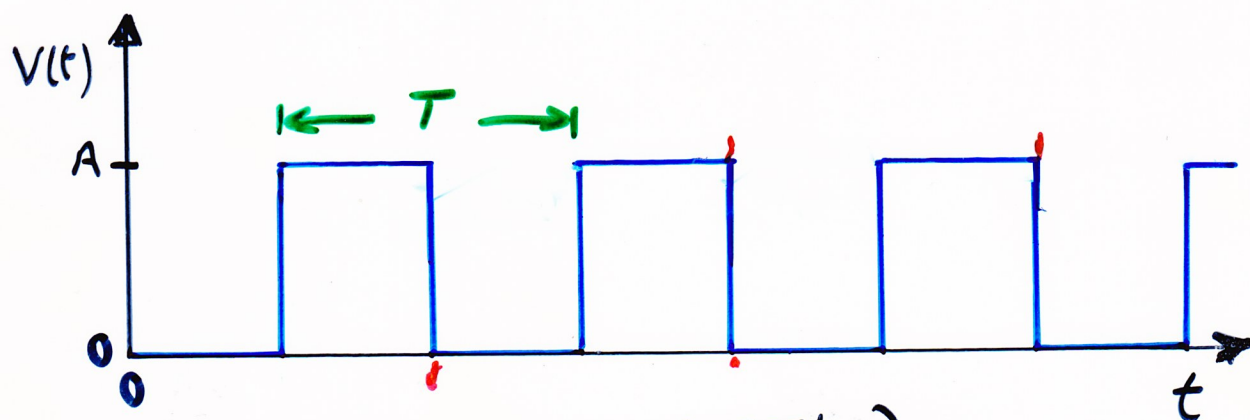


Periodic



Non-periodic
(aperiodic)

Considering periodic signal



$$\left. \begin{aligned} V(t) &= 0 & 0 \leq t < T/2 \\ &= A & T/2 \leq t < T \end{aligned} \right\} \text{Repeats with period, } T.$$

What is the frequency of the signal?

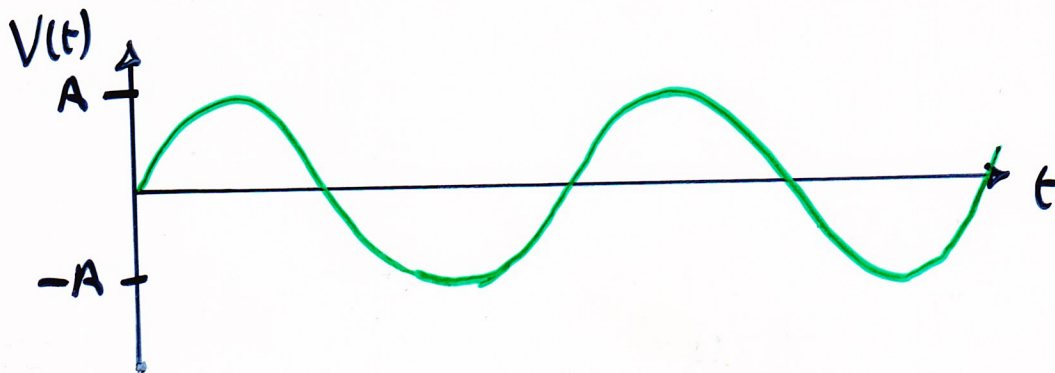
$$f = \frac{1}{T}$$

Units are Hertz, Hz, if T is in seconds.

What about a non-periodic signal?

Some other periodic signals

Sine
Wave



$$V(t) = A \sin \omega t$$

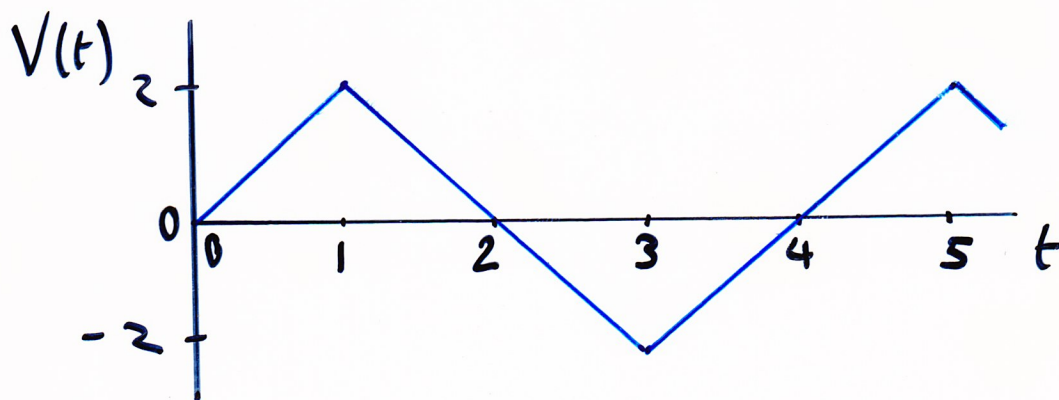
ω is angular frequency (rad/s)

$$\omega = 2\pi f$$

$$\therefore V(t) = A \sin 2\pi f t = A \sin \frac{2\pi t}{T}$$

Sine (cosine) wave is the simplest form of wave. All other periodic waves can be constructed from the addition of a series of sine (cosine) waves of different amplitudes, frequency and relative phase difference - see Fourier Series later in the course

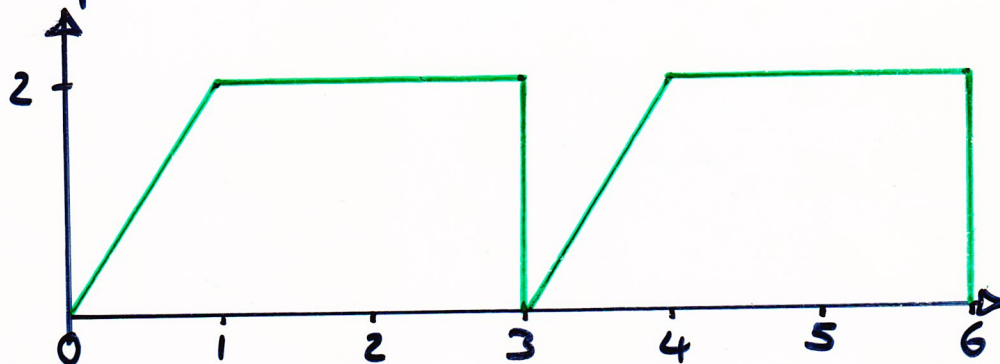
$$\left| A \sin \omega t + \frac{A}{3} \sin 3\omega t + \frac{A}{5} \sin 5\omega t + \frac{A}{7} \sin 7\omega t + \dots \right|$$



$$\begin{aligned}
 V(t) &= 2t & 0 \leq t < 1 \\
 &= -2t + 4 & 1 \leq t < 3 \\
 &= 2t - 8 & 3 \leq t < 5
 \end{aligned}$$

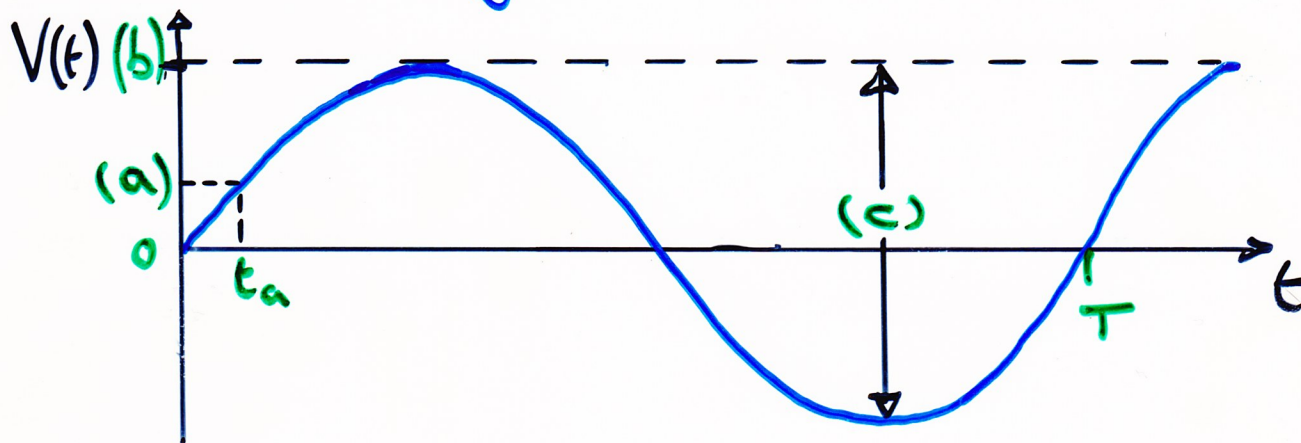
Period ?

Example



$$\begin{aligned}
 V(t) &= 2t & 0 \leq t < 1 \\
 &= 2 & 1 \leq t < 3
 \end{aligned}$$

Signal Properties



- (a) Instantaneous value - value at any given instant.
- (b) Peak value - highest value.
- (c) Peak to Peak value - difference between max. & min. values.

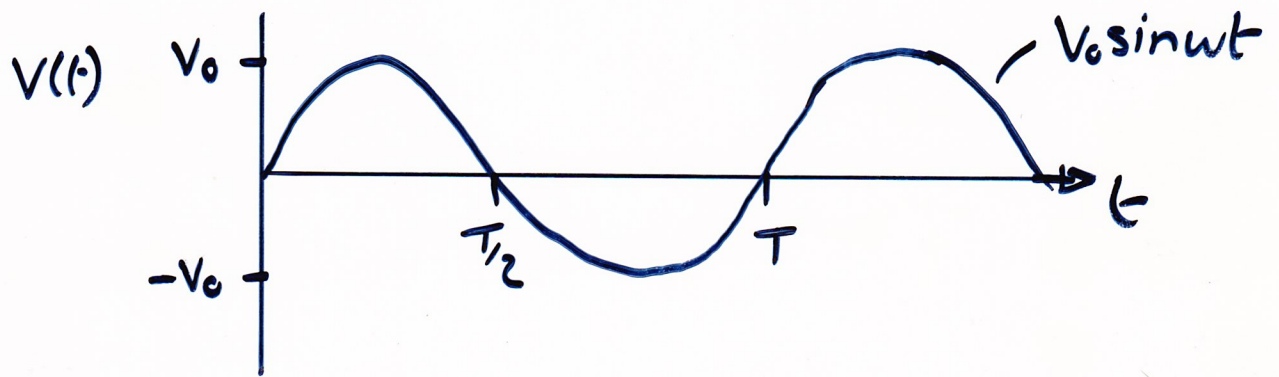
Average value

$$V_{avg} = \frac{1}{T} \int_0^T V(t) dt$$

Root Mean Square (RMS)

$$V_{rms} = \sqrt{\frac{1}{T} \int_0^T V^2(t) dt}$$

Examples.



$$V_{avg} = 0$$

Proof.

$$V_{avg} = \frac{1}{T} \int_0^T V_0 \sin \omega t \, dt$$

$$= \frac{V_0}{T} \int_0^T \sin \omega t \, dt$$

$$= \frac{V_0}{\omega T} \left[-\cos \omega t \right]_0^T$$

$$= \frac{V_0}{\omega T} \left(-\cos \frac{2\pi T}{T} - (-\cos 0) \right)$$

$$= \frac{V_0}{\omega T} (-1 - (-1))$$

$$= 0$$

$$V_{RMS} = \sqrt{\frac{1}{T} \int_0^T v^2(t) dt}$$

$$\frac{1}{T} \int_0^T v^2(t) dt = \frac{V_0^2}{T} \int_0^T \sin^2 \omega t dt = \frac{V_0^2}{T} \int_0^T \frac{1}{2} (1 - \cos 2\omega t) dt$$

$$= \frac{V_0^2}{2T} \left[t - \frac{\sin 2\omega t}{2\omega} \right]_0^T$$

$$= \frac{V_0^2}{2T} \left(T - \frac{\sin 4\pi}{2\omega} - \left(0 - \frac{\sin 0}{2\omega} \right) \right)$$

$$= V_0^2 / 2$$

$$V_{RMS} = \sqrt{V_0^2 / 2} = V_0 / \sqrt{2}$$

$$= 0.707 V_0$$

