Review of Some Basic Signals

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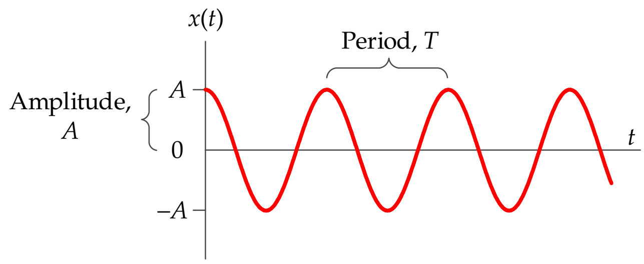
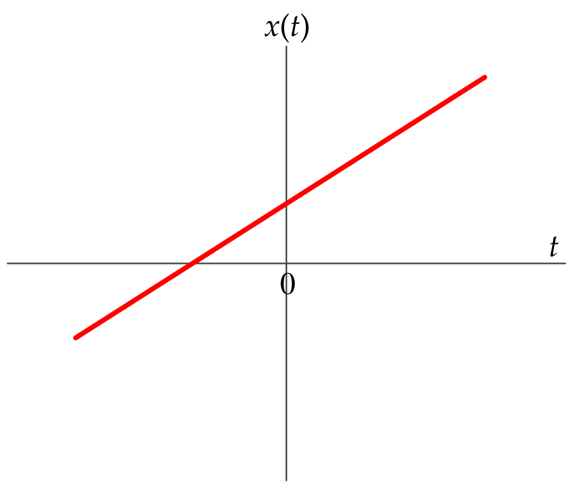


Please remember the following signals and know them well.

- **Linear function**: linear line *or* line *or* straight line:

$$x(t) = m\,t + b$$

- **Parameters**: The **slope** (*or* **gradient**) "m" and the **y-intercept** (vertical-axis intercept or in this case **x-intercept**) "b".

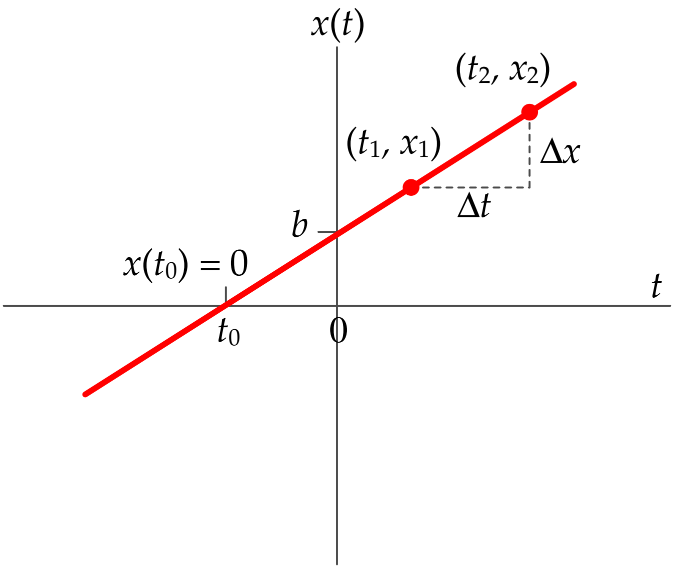


Linear line:

$$x(t) = m\,t + b$$

- The **slope** *or* **gradient**:

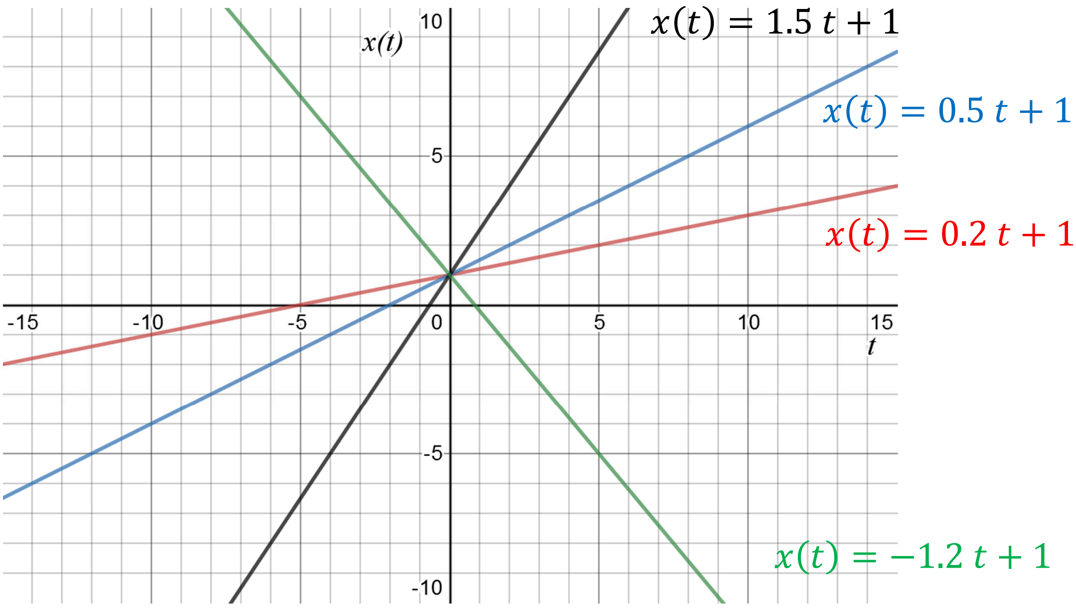
$$m = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$



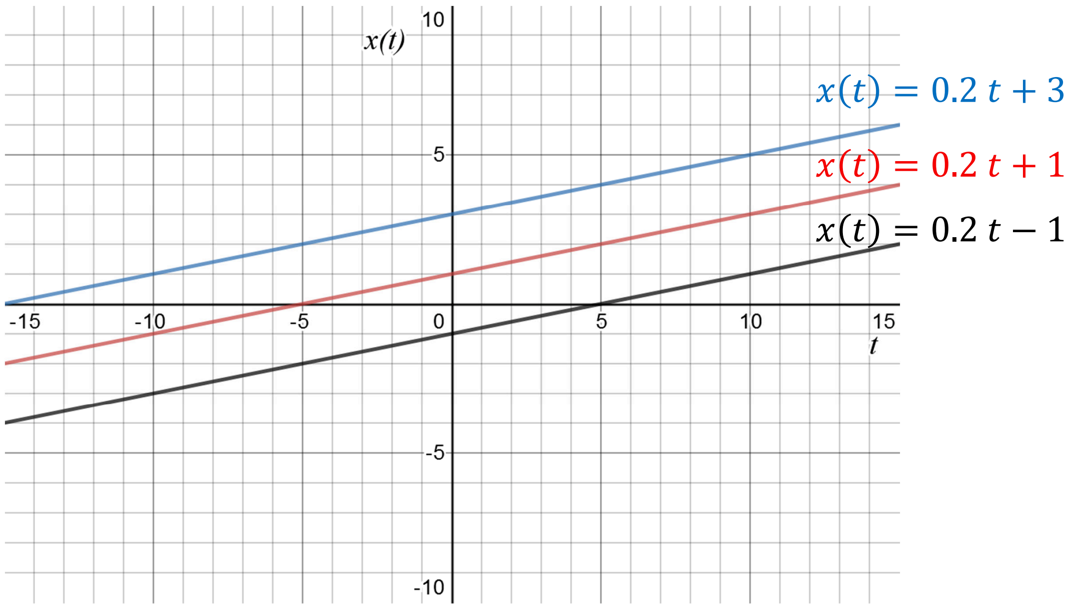
- The **y-intercept**:

$$b = x(t)|_{t=0} = x(t=0) = [m\,t + b]_{t=0} = b$$

Changing slope (also **positive** versus **negative** slope)

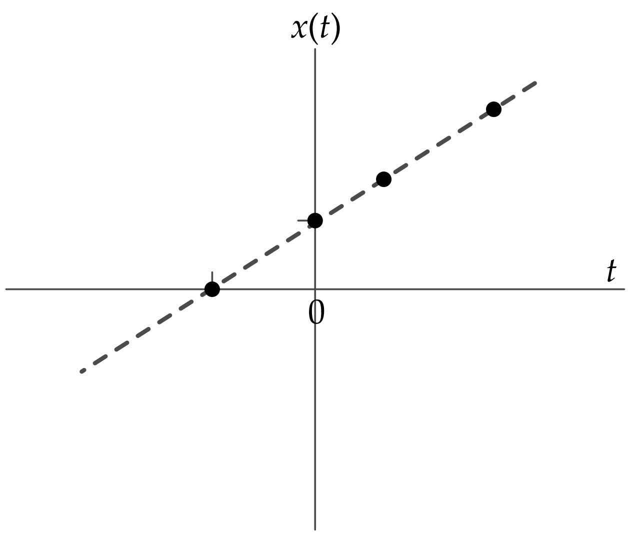


Changing y-intercept



To remember these signals draw them yourself (do this for *all* signals).

t	$x(t) = 0.7\,t + 1$
$t = -1$	$x(t) = 0.7\,t + 1$ $= (0.7 \times -1) + 1$ $= 0.3$
$t = 0$	$x(t) = 0.7\,t + 1$ $= (0.7 \times 0) + 1$ $= 1$
$t = 1$	…
$t = 2$	…

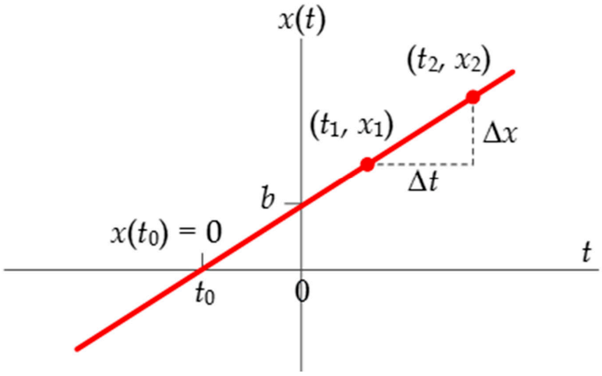


- **Zero of this signal** occurs at:

$$x(t_0) = 0$$

$$x(t_0) = m\,t_0 + b = 0$$

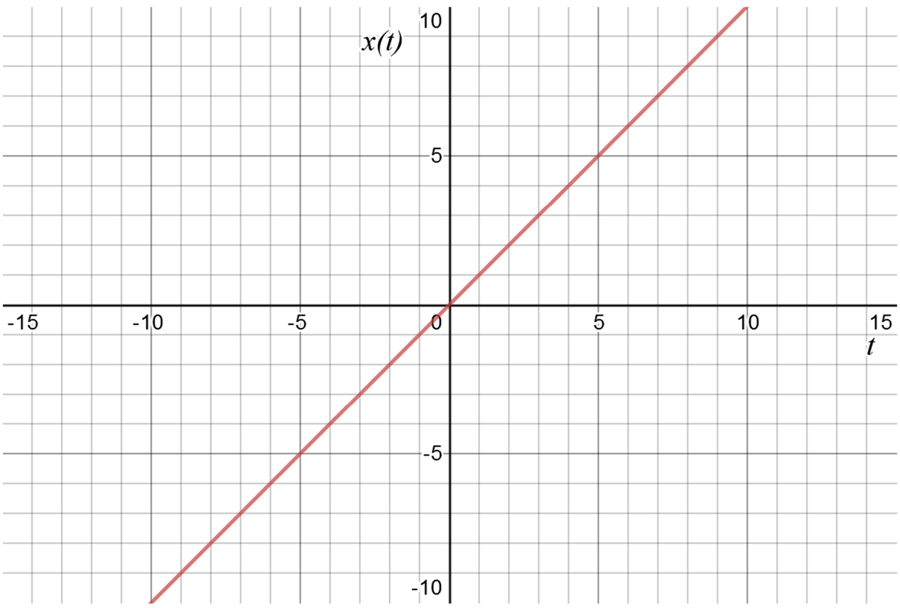
$$@\ t_0 = \frac{-b}{m}$$



Q1. Given the slope $m = 5.5$ and the y-intercept $b = -2.5$ draw the corresponding linear line. Where is the zero of this signal?

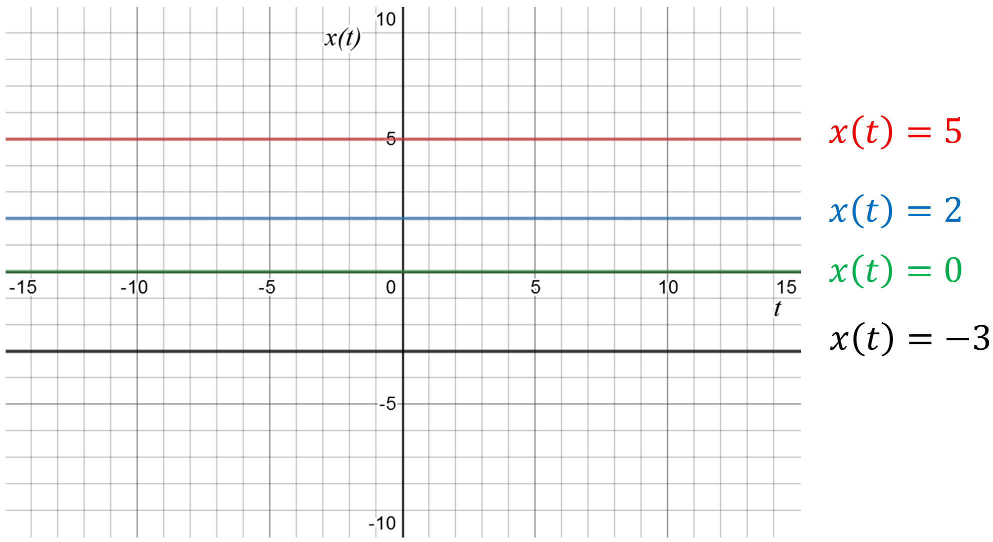
Q2. Given two points $(t_1, x_1) = (2, 1)$ and $(t_2, x_2) = (5, 7)$ on the linear line, write the equation of the line, determine the slope and y-intercept, and draw the line.

Special case of linear line ($m = 1$ and $b = 0$) gives $x(t) = t$:



Another special case of the linear line ($m = 0$ and $b =$ constant):

Constant signal *or* constant value *or* **DC value**: $x(t) = b$



Parabolic function

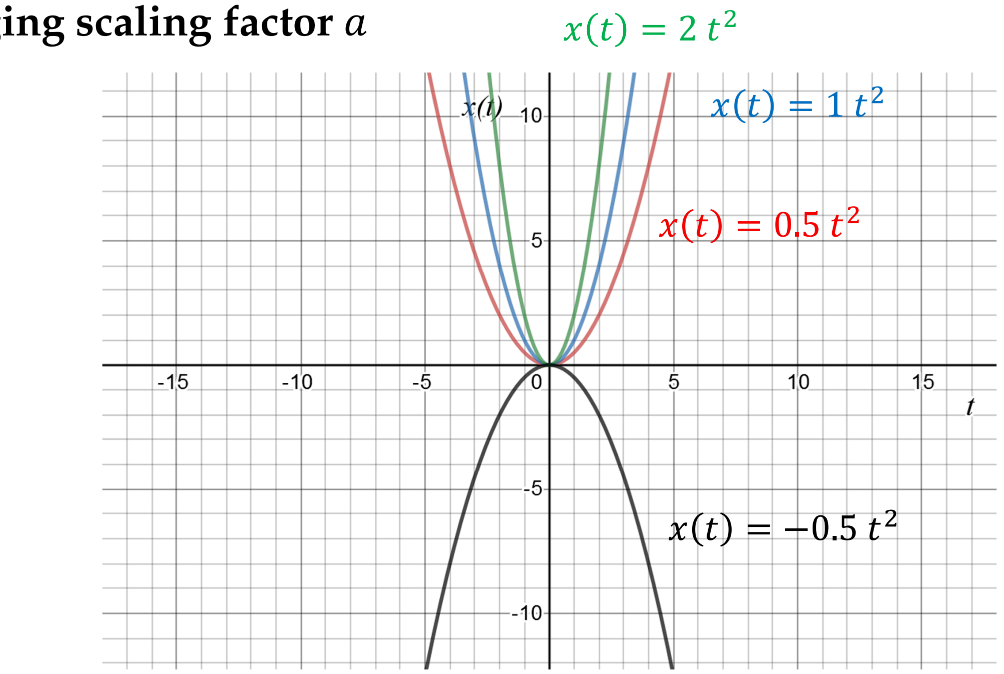
$$x(t) = a(t - c)^2 + b$$

Unit parabolic function,

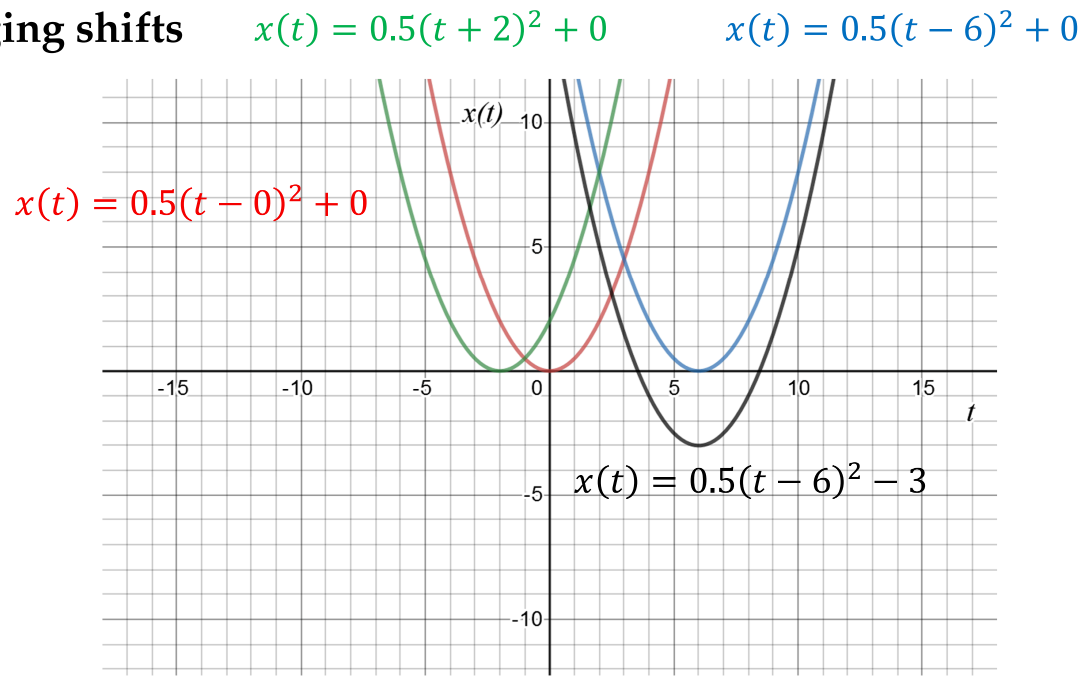
$$x(t) = 0.5(t - 0)^2 + 0 = \frac{t^2}{2}$$

Q. When is a parabolic function concave up or concave down?

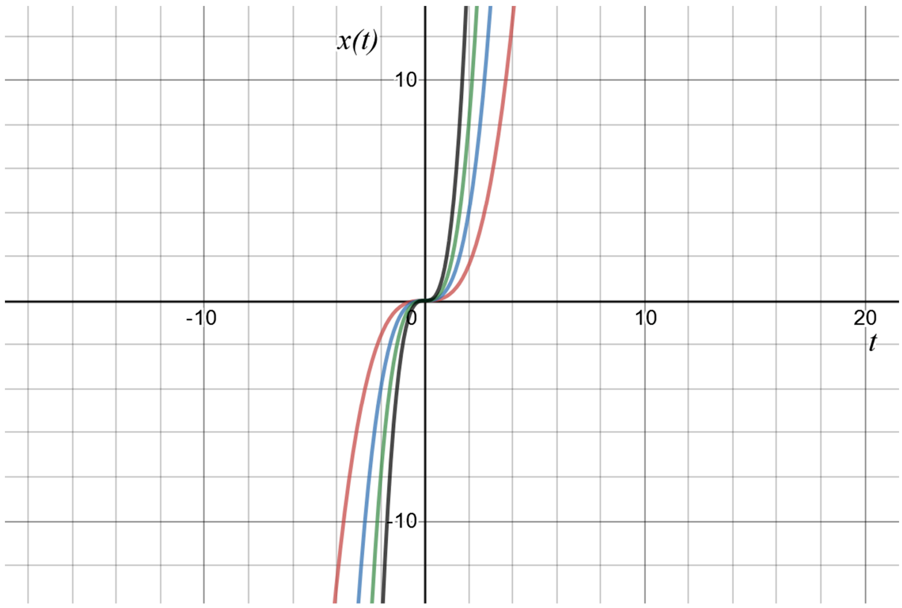
Changing scaling factor a



Changing shifts



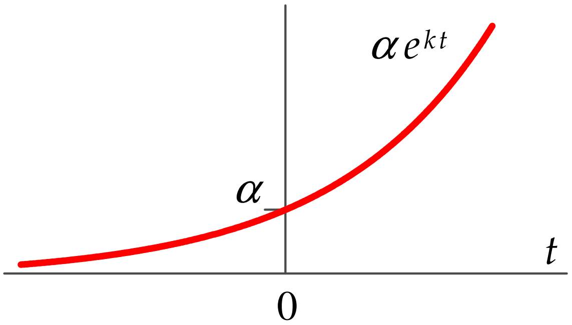
Q. Do you recognize these functions?



Real exponential function

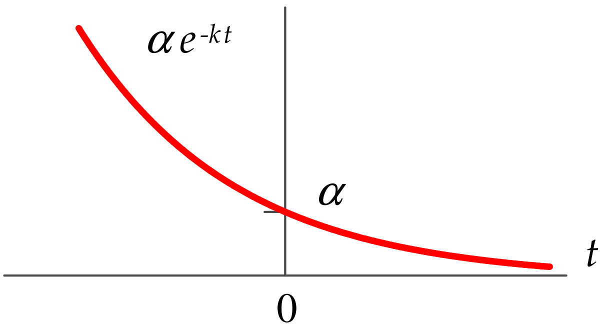
Increasing (growing) exponential:

$$x(t) = \alpha e^{kt}$$



Decreasing (decaying) exponential:

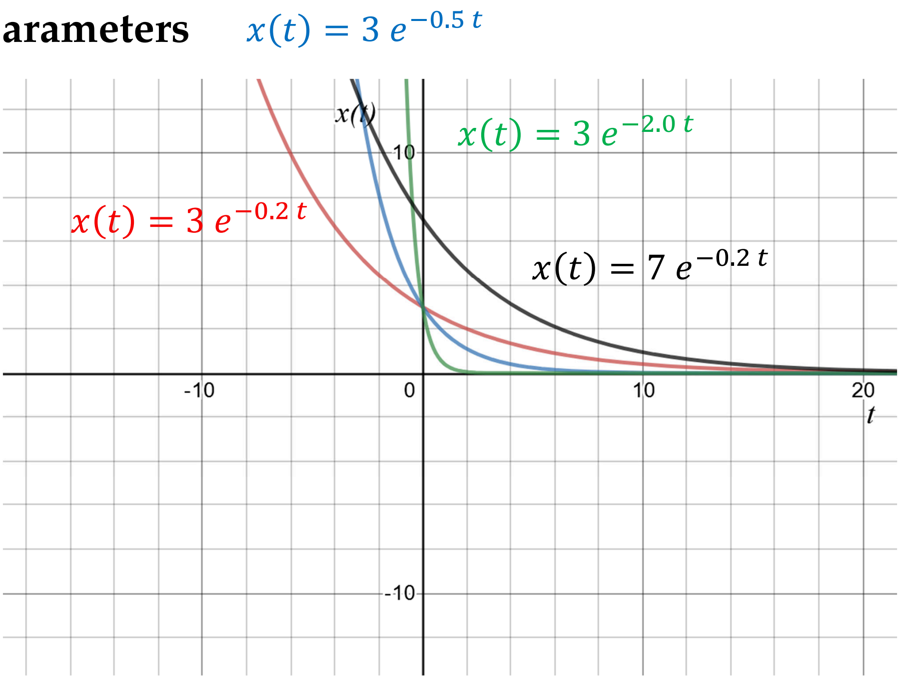
$$x(t) = \alpha e^{-kt}$$



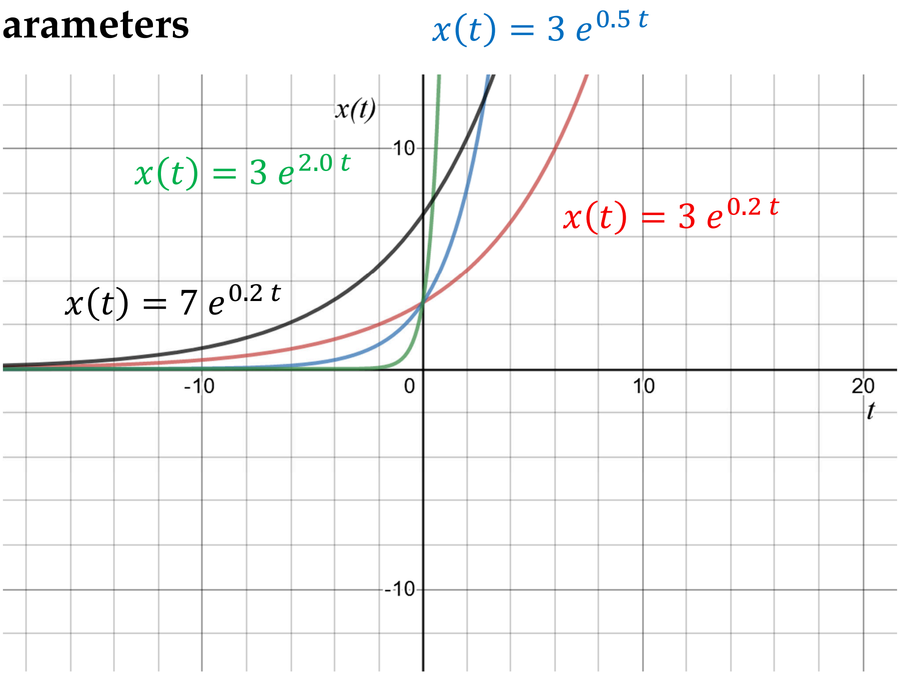
$$\alpha > 0$$

$$k > 0$$

Changing parameters



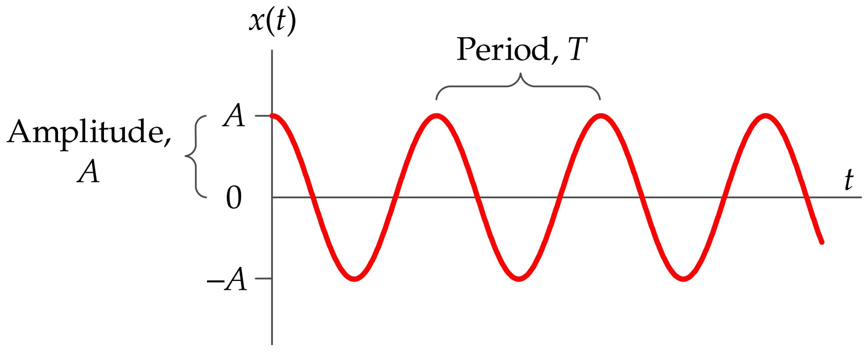
Changing parameters



Sinusoidal signals

Cosine function is periodic function (repeats itself):

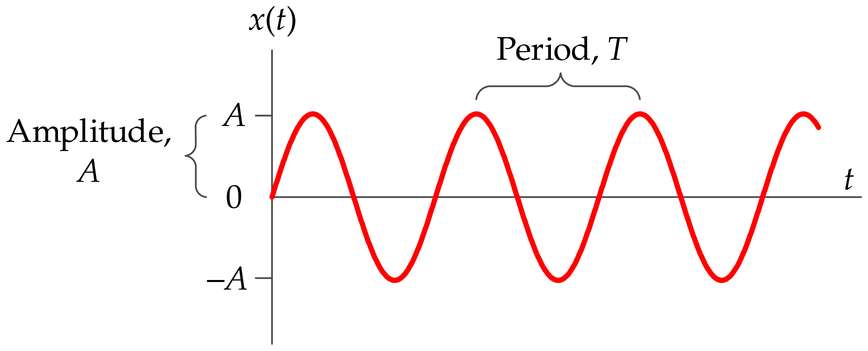
$$x(t) = A\cos(2\pi f t + \varphi) = A\cos(\omega t + \varphi)$$



Sinusoidal signals

Sine function is periodic function (repeats itself):

$$x(t) = A\sin(2\pi f t + \varphi) = A\sin(\omega t + \varphi)$$



Parameters:

The signal repeats itself every **period** of time, T (seconds).

The **frequency** f (ordinary frequency, or the number of oscillations per second, or the number of cycles per second):

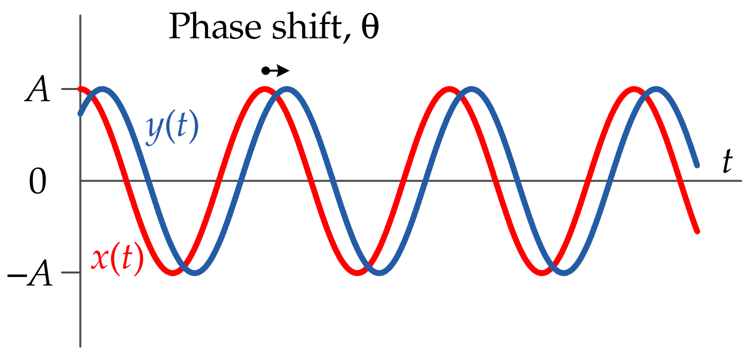
$$f = \frac{1}{T} \quad [Hz]$$

The **angular frequency** (rate of change of the function argument):

$$\omega = 2\pi f \quad [rad/s]$$

The **amplitude** A is the peak deviation of the function from zero (the peak-to-peak value is $2A$).

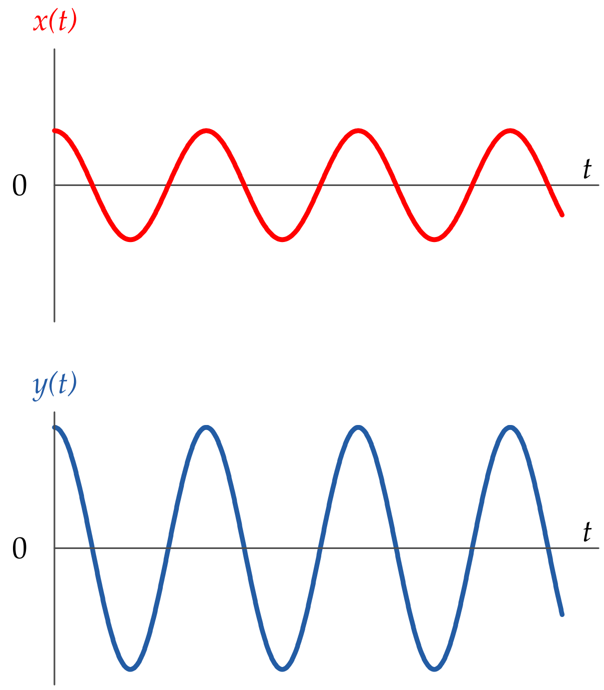
The **phase shift** φ (in radians) is the shift from the reference signal to the **left** (φ positive) or to the **right** (φ negative).



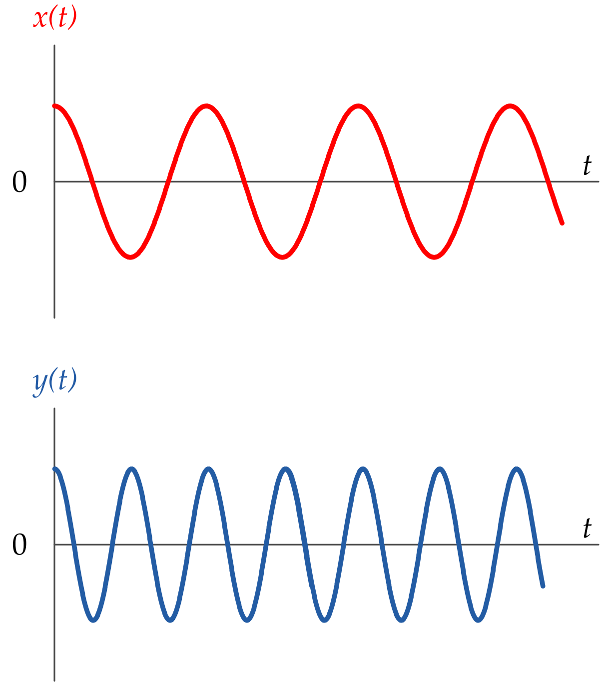
$$x(t) = A\cos(2\pi f t + 0) = A\cos(\omega t + 0)$$

$$y(t) = A\cos(2\pi f t - \theta) = A\cos(\omega t - \theta)$$

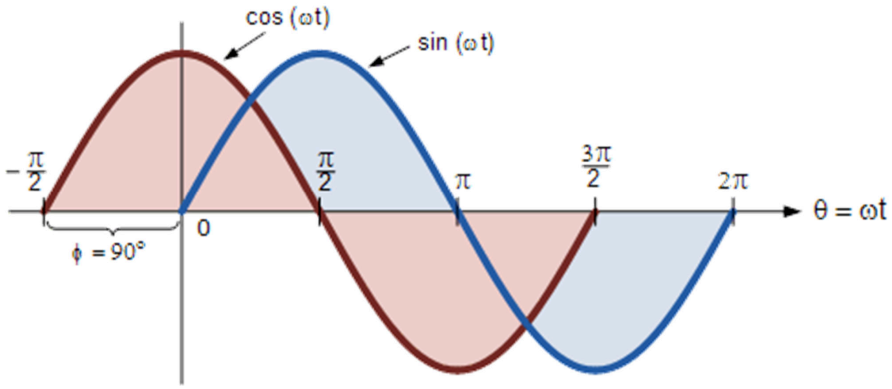
Q. What changed?



Q. What changed?



Phase shift φ (in radians) is the shift from the reference signal to the **left** (φ positive) or to the **right** (φ negative).



$$A\sin(\omega t) = A\cos(\omega t - \pi/2) = A\cos(\omega t - 90°)$$

$$A\cos(\omega t) = A\sin(\omega t + \pi/2) = A\sin(\omega t + 90°)$$

Q. Determine the result of the following phase shifts

$$A\cos(\omega t - 180°) = ?$$

$$A\cos(\omega t + 180°) = ?$$

$$A\sin(\omega t - 180°) = ?$$

$$A\sin(\omega t + 180°) = ?$$

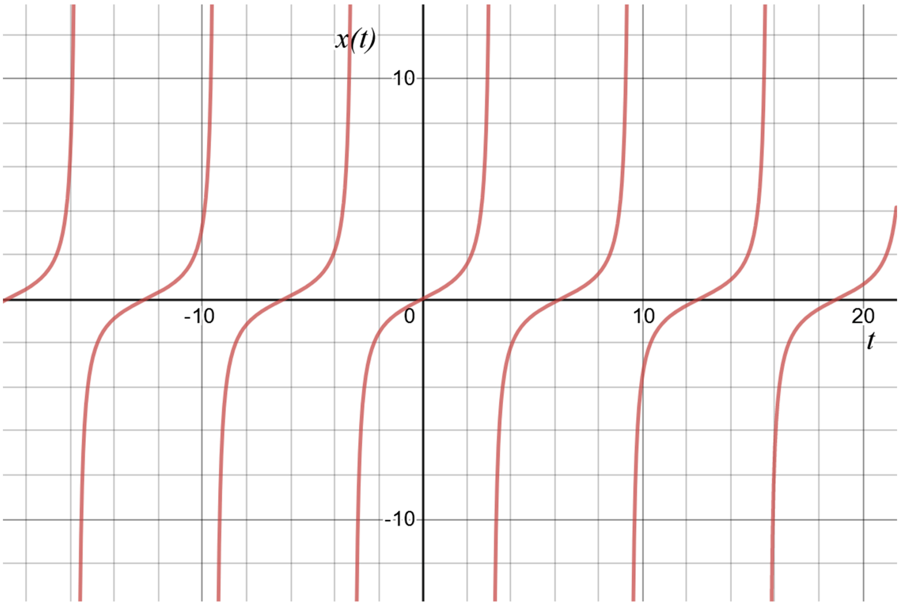
$$A\cos(\omega t - 270°) = ?$$

$$A\cos(\omega t + 270°) = ?$$

$$A\sin(\omega t - 270°) = ?$$

$$A\sin(\omega t + 270°) = ?$$

Q. What is this function?



Q. What is the difference between these two signals?