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Calculus and Analysis > Integral Transforms > Convolution

## Cross-Correlation



The cross-correlation of two **complex functions**  $f(t)$  and  $g(t)$  of a real variable  $t$ , denoted  $f \star g$  is defined by

$$f \star g \equiv \overline{f}(-t) * g(t), \quad (1)$$

where  $*$  denotes **convolution** and  $\overline{f}(t)$  is the **complex conjugate** of  $f(t)$ . Since **convolution** is defined by

$$f(t) * g(t) = \int_{-\infty}^{\infty} f(\tau) g(t - \tau) d\tau, \quad (2)$$

it follows that

$$f \star g \equiv \int_{-\infty}^{\infty} \overline{f}(-\tau) g(t - \tau) d\tau. \quad (3)$$

Letting  $\tau' \equiv -\tau$ ,  $d\tau' = -d\tau$  so (3) is equivalent to

$$f \star g = \int_{\infty}^{-\infty} \overline{f}(\tau') g(t + \tau') (-d\tau') \quad (4)$$

$$= \int_{-\infty}^{\infty} \overline{f}(\tau) g(t + \tau) d\tau. \quad (5)$$

The cross-correlation satisfies the identity

$$(g \star h) \star (g \star h) = (g \star g) \star (h \star h). \quad (6)$$

If  $f$  or  $g$  is **even**, then

$$f \star g = f * g, \quad (7)$$

where  $*$  again denotes **convolution**.

**SEE ALSO:** [Autocorrelation](#), [Convolution](#), [Cross-Correlation Theorem](#), [Fourier Transform](#).  
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### REFERENCES:

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Papoulis, A. *The Fourier Integral and Its Applications*. New York: McGraw-Hill, pp. 244-245 and 252-253, 1962.

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