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Complex numbers summary

- *Basic algebraic operations*
- *Complex trigonometric functions*
- *Inverse of trigonometric and hyperbolic*
- *Trigonometric relations*
- *Imaginary powers*
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Complex basic operations

Operation	*Regular form*	*Polar to Cartesian form*	
z	$a+ib$	$r(\cos\theta + i\sin\theta)$	
z_1+z_2	$(a+c)+\mathrm{i}(b+d)$	$\sqrt{(a+c)^2+(b+d)^2}\angle\tan^{-1}\left(\frac{b+d}{a+c}\right)$	
z_1-z_2	$(a-c)+i(b-d)$	$\sqrt{(a-c)^2+(b-d)^2}\angle\tan^{-1}\left(\frac{b-d}{a-c}\right)$	
z_1z_2	$(ac-bd)+i(ad+bc)$	$r_1r_2[\cos(\theta_1+\theta_2)+i\sin(\theta_1+\theta_2)]$	
$\frac{z_1}{z_2}$	$\frac{(ac+bd)+i(bc-ad)}{c^2+d^2}$	$\frac{r_1}{r_2}[cos(\theta_1-\theta_2)+i\,sin(\theta_1-\theta_2)]$	
$\frac{1}{z}$	$\frac{a}{a^2+b^2}-i\frac{b}{a^2+b^2}$	$\frac{1}{r}(\cos\theta - i\sin\theta)$	
z^2	$(a^2-b^2)+i2ab$	$r^2(\cos 2\theta + i\sin 2\theta)$	
$\sqrt{z}$	$\frac{1}{\sqrt{2}}\left(\sqrt{r+a}+i\sqrt{r-a}\right)$	$\sqrt{r}\left(\cos\frac{\theta}{2}+i\sin\frac{\theta}{2}\right)$	
Z^n	$(a+ib)^n$	$r^n(\cos n\theta + i\sin n\theta)$	
$\sqrt[n]{z}$	$\sqrt[n]{(a+ib)}$	$\sqrt[n]{r}\left(\cos\frac{\theta+2k\pi}{n}+i\sin\frac{\theta+2k\pi}{n}\right)$	
$z_1^{z_2}$	$(a+ib)^{(c+id)}=(a^2+b^2)^{\frac{(c+id)}{2}}e^{i(c+id)\theta}$ $r^ce^{-d\theta}[\cos(d\ln r+c\theta+2ck\pi)+i\sin(d\ln r+c\theta+2ck\pi)]$		e^{z_2l}
$\ln z$	$\ln\left(re^{i\theta}\right)=\ln\left[re^{i(\theta+2n\pi)}\right]=\ln r+i(\theta+2n\pi)$		$z\neq 0$
$\log_{z_2}z_1$	$\frac{\ln z_1}{\ln z_2}=\frac{\ln(a+ib)}{\ln(c+id)}$		
x^z	$x^a[\cos(b\ln x)+i\sin(b\ln x)]$		$e^{z\ln x}=$
e^z	$e^a(\cos b+i\sin b)$	$e^{z+i2\pi n}$	e^a
$\overline{z}$ conjugate	$a-ib$	$r(\cos\theta - i\sin\theta)$	re

$z_1=a+ib \quad z_2=c+id \quad \arg(z)=\theta=\tan^{-1}\left(\frac{b}{a}\right)+2n\pi \quad r=\sqrt{a^2+b^2} \quad k=0,1.$

$m,n=0,1,2\ldots any\ integer$

Complex trigonometric and hyperbolic functions

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$\cos z$	$\cos(a)\cosh(b) - i\sin(a)\sinh(b)$	$\frac{}{2}$	$\cosh($
$\tan z$	$\frac{\sin z}{\cos z}$	$\frac{(e^{iz}-e^{-iz})}{i(e^{iz}+e^{-iz})}$	$-i\tanh$
$\cot z$	$\frac{\cos z}{\sin z} = \frac{1}{\tan z}$	$\frac{i(e^{iz}+e^{-iz})}{e^{iz}-e^{-iz}}$	$i\coth($
$\sec z$	$\frac{1}{\cos z}$	$\frac{2}{e^{iz}+e^{-iz}}$	$\operatorname{sech}($
$\csc z$	$\frac{1}{\sin z}$	$\frac{i2}{e^{iz}-e^{-iz}}$	$i\operatorname{csch}($

$\sinh z$	$\sinh(a)\cos(b) + i\cosh(a)\sin(b)$	$\frac{e^z - e^{-z}}{2}$	$-i\sin($
$\cosh z$	$\cosh(a)\cos(b) + i\sinh(a)\sin(b)$	$\frac{e^z + e^{-z}}{2}$	$\cos(i$
$\tanh z$	$\frac{\sinh z}{\cosh z}$	$\frac{e^z - e^{-z}}{e^z + e^{-z}}$	$-i\tan($
$\coth z$	$\frac{\cosh z}{\sinh z} = \frac{1}{\tanh z}$	$\frac{e^z + e^{-z}}{e^z - e^{-z}}$	$i\cot($
$\operatorname{sech} z$	$\frac{1}{\cosh z}$	$\frac{2}{e^z + e^{-z}}$	$\sec(i$
$\operatorname{csch} z$	$\frac{1}{\sinh z}$	$\frac{2}{e^z - e^{-z}}$	$i\csc($

Complex inverse of trigonometric and hyperbolic functions

$\arcsin z$	$-i\ln\left(iz \pm \sqrt{1-z^2}\right)$	$\frac{\pi}{2} - \cos^{-1} z$	$\csc^{-1}\left(\frac{1}{z}\right)$	$-i\sinh^{-1}$
$\arccos z$	$-i\ln\left(z \pm i\sqrt{1-z^2}\right)$	$\frac{\pi}{2} - \sin^{-1} z$	$\sec^{-1}\left(\frac{1}{z}\right)$	$\pm i\cosh^{-1}$
$\arctan z$	$\frac{i}{2}\ln\left(\frac{i+z}{i-z}\right) = \frac{i}{2}\ln\left(\frac{1-iz}{1+iz}\right)$	$\frac{\pi}{2} - \cot^{-1} z$	$\cot^{-1}\left(\frac{1}{z}\right)$	$-i\tanh^{-1}$
$\operatorname{arccot} z$	$\frac{1}{2i}\ln\left(\frac{z+i}{z-i}\right)$	$\frac{\pi}{2} - \tan^{-1} z$	$\tan^{-1}\left(\frac{1}{z}\right)$	$i\coth^{-1}$
$\operatorname{arcsec} z$	$\frac{1}{i}\ln\left(\frac{1+\sqrt{1-z^2}}{z}\right)$	$\frac{\pi}{2} - \csc^{-1} z$	$\cos^{-1}\left(\frac{1}{z}\right)$	$\pm i\operatorname{sech}^{-1}$
$\operatorname{arccsc} z$	$\frac{1}{i}\ln\left(\frac{i+\sqrt{z^2-1}}{z}\right)$	$\frac{\pi}{2} - \sec^{-1} z$	$\sin^{-1}\left(\frac{1}{z}\right)$	$i\operatorname{csch}^{-1}$

$\operatorname{arcsinh} z$	$\ln\left(z \pm \sqrt{z^2+1}\right)$	$\operatorname{csch}^{-1}\left(\frac{1}{z}\right)$	$-i\sin^{-1}$
$\operatorname{arccosh} z$	$\ln\left(z \pm \sqrt{z^2-1}\right) = \ln\left(z + \sqrt{z+1}\sqrt{z-1}\right)$	$\operatorname{sech}^{-1}\left(\frac{1}{z}\right)$	$\pm i\cos$
$\operatorname{arctanh} z$	$\frac{1}{2}\ln\left(\frac{1+z}{1-z}\right) = \frac{1}{2}[\ln(1+z) - \ln(1-z)]$	$\coth^{-1}\left(\frac{1}{z}\right)$	$-i\tan^{-1}$
$\operatorname{arccoth} z$	$\frac{1}{2}\ln\left(\frac{z+1}{z-1}\right) = \frac{1}{2}\left[\ln\left(1+\frac{1}{z}\right) - \ln\left(1-\frac{1}{z}\right)\right]$	$\tanh^{-1}\left(\frac{1}{z}\right)$	$i\cot^{-1}$
$\operatorname{arcsech} z$	$\ln\left(\frac{1 \pm \sqrt{1-z^2}}{z}\right)$	$\cosh^{-1}\left(\frac{1}{z}\right)$	$\pm i\sec^{-1}$
$\operatorname{arccsch} z$	$\ln\left(\frac{1 \pm \sqrt{1+z^2}}{z}\right)$	$\sinh^{-1}\left(\frac{1}{z}\right)$	$i\csc^{-1}$

Complex trigonometric relations

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$\tan(z_1 \pm z_2)$	$\frac{\tan z_1 \pm \tan z_2}{1 \mp \tan z_1 \tan z_2}$
$\cot(z_1 + z_2)$	$\frac{\cot z_1 \cot z_2 - 1}{\cot z_2 + \cot z_1}$

$\sin z$	$\sin(z + 2\pi n)$	$-\sin(-z)$	$\cos\left(\frac{\pi}{2} - z\right) = -\cos\left(\frac{\pi}{2} + z\right)$
$\cos z$	$\cos(z + 2\pi n)$	$\cos(-z)$	$\sin\left(\frac{\pi}{2} + z\right) = \sin\left(\frac{\pi}{2} - z\right)$
$\tan z$	$\tan(z + \pi n)$	$-\tan(-z)$	$\cot\left(\frac{\pi}{2} - z\right) = -\cot\left(\frac{\pi}{2} + z\right)$
$\cot z$	$\cot(z + \pi n)$	$-\cot(-z)$	$\tan\left(\frac{\pi}{2} - z\right) = -\tan\left(\frac{\pi}{2} + z\right)$
$\csc z$	$\csc(z + 2\pi n)$	$-\csc(-z)$	$\sec\left(\frac{\pi}{2} - z\right) = -\sec\left(\frac{\pi}{2} + z\right)$
$\sec z$	$\sec(z + 2\pi n)$	$\sec(-z)$	$\csc\left(\frac{\pi}{2} - z\right) = \csc\left(\frac{\pi}{2} + z\right)$

$\sinh(-z) = -\sinh z$	$\sin iz = i \sinh z$	$\sinh iz = i \sin$
$\cosh(-z) = \cosh z$	$\cos iz = \cosh z$	$\cosh iz = \cos$
$\tanh(-z) = -\tanh z$	$\tan iz = i \tanh z$	$\tanh iz = i \tan$

$\sin^2 z + \cos^2 z = 1$	$cosh^2 z - sinh^2 z = 1$	$\sin 2z = 2 \sin z \cos$
$1 + \tan^2 z = \sec^2 z$	$1 - tanh^2 z = sech^2 z$	$\cos 2z = \cos^2 z -$
$1 + \cot^2 z = \csc^2 z$	$\coth^2 z - 1 = \operatorname{csch}^2 z$	$\tan 2z = \frac{2 \tan}{1 - \tan}$

$\sin\left(\frac{z}{2}\right) = \sqrt{\frac{1 - \cos z}{2}}$	$\sinh\left(\frac{z}{2}\right) = \sqrt{\frac{\cosh(z) - 1}{2}}$
$\cos\left(\frac{z}{2}\right) = \sqrt{\frac{1 + \cos z}{2}}$	$\cosh\left(\frac{z}{2}\right) = \sqrt{\frac{1 + \cosh z}{2}}$
$\tan\left(\frac{z}{2}\right) = \frac{1 - \cos z}{\sin z} = \frac{\sin z}{1 + \cos z}$	$\tanh\left(\frac{z}{2}\right) = \frac{1 - \cosh z}{\sinh z}$

$$\cos(2z) + i \sin(2z) = (\cos^2 z - \sin^2 z) + i(2 \sin z \cos z) = e^{i2z}$$

Complex logarithms and imaginary powers

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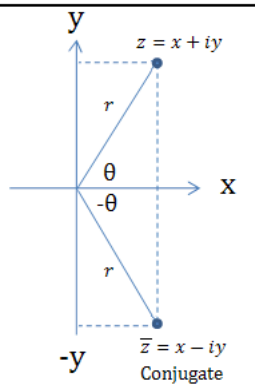
$\ln\left(\frac{1}{z}\right) = -\ln z$	$y^x = e^{x \ln y}$
$\ln(z_1 z_2) = \ln z_1 + \ln z_2$	$z^a = e^{a \ln z}$
$\ln\left(\frac{z_1}{z_2}\right) = \ln z_1 - \ln z_2$	$e^{-z} = \frac{1}{e^z}$
$\log_n z = \frac{\log z}{\log n}$	$e^{i\pi} = -1$
$\log_i x = \frac{-i2\ln x}{\pi}$	$\lvert e^z \rvert = e^x$
$\overline{\log z} = \log(\bar{z})$	$i^i = e^{i \ln i} = e^{-\frac{\pi}{2}+2\pi n}$
$\ln(e^z) = z + i2n\pi$	$e = 2.71828183 \ldots$
$\ln(1) = 0$	$e^{i\theta} = \cos\theta + i\sin\theta$
$\ln(-1) = \ln(e^{i\pi}) = i\pi$	$e^{iz} = \cos z + i\sin z$
$\ln(0) = -infinity$	$e^{-iz} = \cos z - i\sin z$
$\ln(i) = i\left(\frac{\pi}{2} + 2k\pi\right)$	$e^z = \cosh z + \sinh z$
$\ln(-i) = -i\left(\frac{\pi}{2} + 2k\pi\right)$	
$\ln(\infty) = infinity$	$\ln(-a) = \ln a + i\pi$

$i^3 = -i$	i^{-3}
$i^4 = 1$	i^{-4}
$i^5 = i$	i^{-5}
$i^6 = -1$	i^{-6}
$i^7 = -i$	i^{-7}
$i^8 = 1$	i^{-8}
$i^9 = i$	i^{-9}
$i^{10} = -1$	i^{-1}
General	
$i^{4n} = e^{i(2n)\pi} = 1$	i^{-4}
$i^{4n+1} = e^{i\left(2n+\frac{1}{2}\right)\pi} = i$	$i^{-(}$
$i^{4n+2} = e^{i(2n+1)\pi} = -1$	$i^{-(}$
$i^{4n+3} = e^{i\left(2n+\frac{3}{2}\right)\pi} = -i$	$i^{-(}$

n=0, 1, 2 ... (integer number)

Complex conjugate function

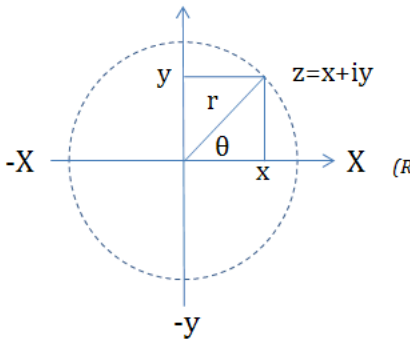
$\overline{z_1 \pm z_2} = \bar{z}_1 \pm \bar{z}_2$	$z + \bar{z} = 2a$
$\overline{z_1 z_2} = \bar{z}_1 \bar{z}_2$	$z - \bar{z} = i2b$
$\overline{\left(\frac{z_1}{z_2}\right)} = \frac{\bar{z}_1}{\bar{z}_2}$ *if* $z_2 \neq 0$	$z\bar{z} = x^2 + y^2 = \lvert z \rvert^2$
$\overline{(\bar{z})} = z$	$\frac{z}{\bar{z}} = e^{i2\theta}$
$\lvert z \rvert = \lvert \bar{z} \rvert = \sqrt{x^2 + y^2}$	$z = \bar{z}$ *only if z is real*
$\left\lvert \frac{z}{\bar{z}} \right\rvert = 1$	$\bar{z} = -z$ *if z is imaginary*
$\lvert z \rvert^2 = z\bar{z} = \bar{z}z$	$\bar{i} = -i$
$z^{-1} = \bar{z}\lvert z \rvert^{-2} \quad z \neq 0$	$\lvert i \rvert = 1$
$\lvert z_1 + z_2 \rvert \leq \lvert z_1 \rvert + \lvert z_2 \rvert$	$\lvert z \rvert$ *modulus of* z
$\lvert z_1 \rvert - \lvert z_2 \rvert \leq \lvert z_1 - z_2 \rvert$	$\lvert z \rvert = \sqrt{z\bar{z}}$
$\lvert z_1 z_2 \rvert = \lvert z_1 \rvert \lvert z_2 \rvert$	$arg(z) = \tan^{-1}\frac{z - \bar{z}}{z + \bar{z}}$



Conjugate – Polar Form
$\bar{z} = re^{-i\theta}$
Conjugate – Polar to Cartesian
$\bar{z} = r(\cos\theta - i\sin\theta)$

Complex functions

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Cartesian coordinate system, called the complex plane or Argand diagram. $z = x + iy$ **Polar Coordinate** The polar coordinate system uses angle and vector length r of a point from the origin of the axe. $z = re^{i\theta}$ r - modulus (absolute value of z) $r = \sqrt{x^2 + y^2}$ θ - phase or the argument of z $z = \arg(z) = \tan^{-1}\frac{y}{x}$ **Polar to Cartesian** $z = r(\cos\theta + i\sin\theta)$	
Complex Derivative Derivative of a complex function *f(z)* at a point z_0	$\frac{df}{dz} = f'(z_0) = \lim_{\Delta z \to 0}\frac{f(z_0 + \Delta z) - f(z_0)}{\Delta z}$ Δz *approch zero in any way possible*
Cauchy Riemann Equations A necessary condition for a function $f(z) = u(x,y) + iv(x,y)$ To be analytic at a point $z=x+iy$ is that the Cauchy Riemann equations are satisfied at that point.	$\frac{\partial u}{\partial x} = \frac{\partial v}{\partial y}$ $\frac{\partial u}{\partial y} = -\frac{\partial v}{\partial x}$ $(u_x = v_y)$ $(u_y = -v_x)$
Cauchy Equation in Polar Form	$\frac{\partial u}{\partial r} = \frac{1}{r}\frac{\partial v}{\partial \theta}$ $\frac{1}{r}\frac{\partial u}{\partial \theta} = -\frac{\partial v}{\partial r}$
Harmonic Function Function f(x,y) is harmonic if the first and second partial derivatives are continuous in a given domain and the Laplace's equation is satisfied.	$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} = 0$ $(f_{xx} + f_{yy} = 0)$
Harmonic Complex Function The real and the imaginary parts of a complex function is satisfying the Laplace equation	$\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial y^2} = 0$ $\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} =$
Cauchy Integral If *f(z)* is analytic in a closed domain *C* and z_0 is a point interior to C then:	$f(z_0) = \frac{1}{2\pi i}\int_C \frac{f(z)}{z - z_0}dz$
Taylor Series If *f(z)* is infinitely differentiable at a point z_0 then it can be expressed as a power series.	$f(z_0) = \frac{f'(z_0)}{1!}(z - z_0) + \frac{f''(z_0)}{2!}(z - z_0)^2$ $f(z_0) = \sum_{n=0}^{\infty}\frac{f^{(n)}(z_0)}{n!}(z - z_0)^n$
Oscillation Complex number describing oscillation. ω – *angular velocity* t – *time* φ – *initial phase of starting point*	$e^{j(\omega t + \varphi)} = \cos(\omega t + \varphi) + j\sin(\omega t + \varphi)$

Series expansion of complex functions

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$e^{-z} = 1 - z + \frac{z^2}{2!} - \frac{z^3}{3!} + \ ... = \sum_{n=1}^{\infty} (-1)^n \frac{z^n}{n!}$	*for all z*
$e^{\frac{1}{z}} = 1 + \frac{1}{z} + \frac{1}{2!\,z^2} + \frac{1}{3!\,z^2} + \ ... = \sum_{n=0}^{\infty} \frac{1}{n!\,z^n}$	$z \neq 0$
$e^{i\theta} = 1 + i\theta - \frac{\theta^2}{2!} - i\frac{\theta^3}{3!} + \ ... = 1 + \sum_{n=1}^{\infty} \frac{(i\theta)^n}{n!}$	
$\ln z = (z-1) - \frac{(z-1)^2}{2} + \frac{(z-1)^3}{3} - \frac{(z-1)^4}{4} + \ ... = \sum_{n=1}^{\infty} (-1)^{n-1} \frac{(z-1)^n}{n}$	
$\ln(1-z) = -z - \frac{z^2}{2} - \frac{z^3}{3} - \frac{z^4}{4} - \ ... = -\sum_{n=1}^{\infty} \frac{z^n}{n}$	*for* $\lvert z\rvert < 1$
$\ln(1+z) = z - \frac{z^2}{2} + \frac{z^3}{3} - \frac{z^4}{4} + \ ... = \sum_{n=1}^{\infty} (-1)^{n+1} \frac{z^n}{n}$	*for* $\lvert z\rvert \leq 1$ $z \neq -1$
$\ln \frac{1}{1-z} = z + \frac{z^2}{2} + \frac{z^3}{3} + \frac{z^4}{4} + \ ... = \sum_{n=1}^{\infty} \frac{z^n}{n}$	$\lvert z\rvert \leq 1$
$\ln \frac{z}{z-1} = \frac{1}{z} + \frac{1}{2z^2} + \frac{1}{3z^3} + \ ... = \sum_{n=1}^{\infty} \frac{1}{nz^n}$	$\lvert z\rvert > 1$
$\frac{1}{1-z} = 1 + z + z^2 + z^3 + \ ... = \sum_{n=0}^{\infty} z^n$	*for* $\lvert z\rvert < 1$
$\frac{1}{1+z} = 1 - z + z^2 - z^3 + \cdots = \sum_{n=0}^{\infty} (-1)^n z^n$	$\lvert z\rvert < 1$
$\frac{z}{(1-z)^2} = z + 2z^2 + 3z^3 + 4z^4 + \ ... = \sum_{n=1}^{\infty} nz^n$	*for* $\lvert z\rvert < 1$

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$$\sin^{-1} z = z + \left(\frac{1}{2}\right)\frac{z^3}{3} + \left(\frac{1\cdot 3}{2\cdot 4}\right)\frac{z^5}{5} + \left(\left(\frac{1\cdot 3\cdot 5}{2\cdot 4\cdot 6}\right)\frac{z^7}{7}\right) + \ldots\ldots = \sum_{n=0}^{\infty}\frac{(2n)!}{2^{2n}(n!)^2}\frac{z^{2n+1}}{(2n+1)} \quad for$$

$$\sinh z = z + \frac{z^3}{3!} + \frac{z^5}{5!} + \frac{z^7}{7!} + \ldots = \sum_{n=0}^{\infty}\frac{z^{2n+1}}{(2n+1)!} \quad for\ all\ z$$

$$\sinh^{-1} z = z - \frac{1}{6}z^3 + \frac{3}{40}z^5 - \frac{5}{112}z^7 + \ldots = \sum_{n=0}^{\infty}(-1)^n\frac{(2n)!}{4^n(n!)^2(2n+1)}z^{2n+1} \quad for\ |z| < 1$$

$$\cos z = 1 - \frac{z^2}{2!} + \frac{z^4}{4!} - \frac{z^6}{6!} + \ldots = \sum_{n=0}^{\infty}(-1)^n\frac{z^{2n}}{(2n)!} \quad -\infty < z < \infty$$

$$\cos^{-1} z = \frac{\pi}{2} - z - \frac{1}{6}z^3 - \frac{3}{40}z^5 - \frac{5}{112}z^7 - \ldots = \frac{\pi}{2} - \sum_{n=0}^{\infty}\frac{(2n)!}{2^{2n}(n!)^2}\frac{z^{2n+1}}{(2n+1)} \quad for\ |z|$$

$$\cosh z = 1 + \frac{z^2}{2!} + \frac{z^4}{4!} + \frac{z^6}{6!} + \ldots = 1 + \sum_{n=1}^{\infty}\frac{z^{2n}}{(2n)!} \quad for\ all\ z$$

$$\cosh^{-1} z = \ln(2z) - \frac{1}{4z^2} - \frac{3}{32z^4} - \frac{15}{288z^6} - \ldots \quad for\ |z| > 1$$

$$\tan z = z + \frac{1}{3}z^3 + \frac{2}{15}z^5 + \frac{17}{315}z^7 + \frac{62}{2835}z^9 \ldots = \sum_{n=1}^{\infty}\frac{B_{2n}(1-4^n)}{(2n)!}z^{2n-1} \quad |z| <$$

$$\tan^{-1} z = z - \frac{z^3}{3} + \frac{z^5}{5} - \frac{z^7}{7} + \ldots = \sum_{n=0}^{\infty}\frac{(-1)^n z^{2n+1}}{2n+1} \quad |z| \le 1 \quad z \ne i, \quad z \ne$$

$$\tanh z = z - \frac{1}{3}z^3 + \frac{2}{15}z^5 - \frac{17}{315}z^7 + \ldots = \sum_{n=1}^{\infty}\frac{B_{2n}4^n(4^n-1)}{(2n)!}z^{2n-1} \quad for\ |z| < \frac{\pi}{2}$$

$$\tanh^{-1} z = z + \frac{z^3}{3} + \frac{z^5}{5} + \frac{z^7}{7} + \ldots = \sum_{n=0}^{\infty}\frac{z^{2n+1}}{2n+1} \quad for\ |z| < 1$$

$$\cot z = \frac{1}{z} - \frac{1}{3}z - \frac{1}{45}z^3 - \frac{2}{945}z^5 - \frac{1}{4725}z^7 - \ldots = \sum_{n=0}^{\infty}\frac{(-1)^n 2^{2n}B_{2n}z^{2n-1}}{(2n)!} \quad for\ 0 <$$

$$\cot^{-1} z = \frac{\pi}{2} - \tan^{-1} z = \frac{\pi}{2} - \left(z - \frac{z^3}{3} + \frac{z^5}{5} - \frac{z^7}{7} + \ldots.\right) = \frac{\pi}{2} - \sum_{n=0}^{\infty}\frac{(-1)^n z^{2n+1}}{2n+1} \quad |z| \le 1$$

$$\coth z = \frac{1}{z} + \frac{1}{3}z - \frac{1}{45}z^3 + \frac{2}{945}z^5 - \frac{1}{4725}z^7 + \ldots = \frac{1}{z} + \sum_{n=1}^{\infty}\frac{2^{2n}B_{2n}z^{2n-1}}{(2n)!} \quad 0 < |$$

$$\coth^{-1} z = \tanh^{-1}\left(\frac{1}{z}\right)$$

$$\csc z = \frac{1}{z} + \frac{1}{6}z + \frac{7}{360}z^3 + \frac{31}{15120}z^5 + \ldots = \sum_{n=0}^{\infty}\frac{(-1)^{n+1}2(2^{2n-1}-1)B_{2n}z^{2n-1}}{(2n)!} \quad for\ 0 <$$

$$\csc^{-1} z = \sin^{-1}\left(\frac{1}{z}\right) = \frac{1}{z} + \left(\frac{1}{2}\right)\frac{1}{3z^3} + \left(\frac{1\cdot 3}{2\cdot 4}\right)\frac{1}{5z^5} + \ldots = \sum_{n=0}^{\infty}\frac{(2n)!}{2^{2n}(n!)^2}\frac{1}{(2n+1)z^{(2n+1)}}$$

$$\operatorname{csch} z = \frac{1}{z} - \frac{1}{6}z + \frac{7}{360}z^3 - \frac{31}{15120}z^5 + \ldots = \frac{1}{z} + \sum_{n=1}^{\infty}\frac{2\left(1-2^{(2n-1)}\right)}{(2n)!}B_{2n}z^{(2n-1)} \quad 0 <$$

$$\operatorname{csch}^{-1} z = \ln 2 - \ln z + \frac{1}{4}z^2 - \frac{3}{32}z^4 + \frac{5}{96}z^6 - \ldots$$

$$\sec z = 1 + \frac{1}{2}z^2 + \frac{5}{24}z^4 + \frac{61}{720}z^6 + \frac{277}{8064}z^8 + \ldots = \sum_{n=0}^{\infty}(-1)^n\frac{E_{2n}}{(2n)!}z^{2n} \quad for\ |z| <$$

$$\sec^{-1} z = \frac{\pi}{2} - \left(\frac{1}{z} + \left(\frac{1}{2}\right)\frac{1}{3z^3} + \left(\frac{1\cdot 3}{2\cdot 4}\right)\frac{1}{5z^5} + \cdots\right) = \frac{\pi}{2} - \sum_{n=0}^{\infty}\frac{(2n)!}{2^{2n}(n!)^2}\frac{1}{(2n+1)z^{(2n+1)}}$$

$$\operatorname{sech} z = 1 - \frac{1}{2}z^2 + \frac{5}{24}z^4 - \frac{61}{720}z^6 + \frac{277}{8064}z^8 + \ldots = \sum_{n=0}^{\infty}\frac{E_{2n}z^{2n}}{(2n)!} \quad |z| < \frac{\pi}{2}$$

$$\operatorname{sech}^{-1} z = \ln 2 - \ln z - \frac{1}{4}z^2 - \frac{3}{32}z^4 \ldots..$$

B_n *nth Bernoulli number:* $B_0 = 1$ $B_1 = -\frac{1}{2}$ $B_2 = \frac{1}{6}$ $B_4 = -\frac{1}{30}$ $B_6 = \frac{1}{42}$ $B_8 =$

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Derivatives of complex functions

$\frac{d}{dz}z^a = az^{a-1}$	$\frac{d}{dz}z^z = z^z(1+\ln z)$
$\frac{d}{dz}a^z = a^z\ln(a)$	$\frac{d}{dz}\ln z = \frac{1}{z}$
$\frac{d}{dz}e^z = e^z$	$\frac{d}{dz}\log_a z = \frac{1}{z\ln a}$

$\frac{d}{dz}\sin(z) = \cos(z)$	$\frac{d}{dz}\sinh(z) = \cosh(z)$
$\frac{d}{dz}\cos(z) = -\sin(z)$	$\frac{d}{dz}\cosh(z) = \sinh(z)$
$\frac{d}{dz}\tan(z) = \sec^2(z)$	$\frac{d}{dz}\tanh(z) = 1-\tanh^2(z) = \operatorname{sech}^2(z)$
$\frac{d}{dz}\cot(z) = -\csc^2(z)$	$\frac{d}{dz}\coth(z) = -\operatorname{csch}^2(z)$
$\frac{d}{dz}\csc(z) = -\csc(z)\cot(z)$	$\frac{d}{dz}\operatorname{csch}(z) = -\operatorname{csch}(z)\coth(z)$
$\frac{d}{dz}\sec(z) = \sec(z)\tan(z)$	$\frac{d}{dz}\operatorname{sech}(z) = -\operatorname{sech}(z)\tanh(z)$

$\frac{d}{dz}\sin^{-1}(z) = \frac{1}{\sqrt{1-z^2}}$	$\frac{d}{dz}\sinh^{-1}(z) = \frac{1}{\sqrt{1+z^2}}$
$\frac{d}{dz}\cos^{-1}(z) = -\frac{1}{\sqrt{1-z^2}}$	$\frac{d}{dz}\cosh^{-1}(z) = \frac{1}{\sqrt{z+1}\sqrt{z-1}}$
$\frac{d}{dz}\tan^{-1}(z) = \frac{1}{1+z^2}$	$\frac{d}{dz}\tanh^{-1}(z) = \frac{1}{1-z^2}$
$\frac{d}{dz}\cot^{-1}(z) = -\frac{1}{1+z^2}$	$\frac{d}{dz}\coth^{-1}(z) = \frac{1}{1-z^2}$
$\frac{d}{dz}\csc^{-1}(z) = -\frac{1}{z\sqrt{z^2-1}}$	$\frac{d}{dz}\operatorname{csch}^{-1}(z) = -\frac{1}{z^2\sqrt{1+\frac{1}{z^2}}}$
$\frac{d}{dz}\sec^{-1}(z) = \frac{1}{z\sqrt{z^2-1}}$	$\frac{d}{dz}\operatorname{sech}^{-1}(z) = -\frac{1}{z(z+1)\sqrt{\frac{1-z}{1+z}}}$

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