# Calculus II Power series expansion of arctangent, part 1

**Todor Miley** 

2019

Find a power series for  $\arctan x$  and state its radius of convergence.

$$arctan(x) = \int d(arctan x)$$

up to const.

Find a power series for arctan x and state its radius of convergence.

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx$$

up to const.

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx$$
 up to const.  
= 
$$\int \left( ? \right) dx$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx$$
 up to const.  
$$= \int \left(\frac{1}{1+x^2}\right) dx$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(\mathbf{?}\right) dx \qquad \text{for } |x| < 1$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right)$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right)$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right)$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right)$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right) + C$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right) + C$$

$$= C + \sum_{n=0}^{\infty} ?$$

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right) + C$$

$$= C + \sum_{n=0}^{\infty} ?$$

$$\operatorname{arctan}(x) = \int d(\operatorname{arctan} x) = \int (\operatorname{arctan} x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right) + C$$

$$= C + \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{2n+1}$$

Find a power series for arctan x and state its radius of convergence.

$$\operatorname{arctan}(x) = \int d(\operatorname{arctan} x) = \int (\operatorname{arctan} x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right) + C$$

$$= C + \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{2n+1}$$

• To find C, plug in  $\overset{n=0}{x} = 0$ :  $\overset{n}{C} = ?$ 

Find a power series for arctan x and state its radius of convergence.

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right) + C$$

$$= C + \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{2n+1}$$

• To find C, plug in  $\frac{n=0}{x} = 0$ : C = 0.

$$\arctan(x) = \int d(\arctan x) = \int (\arctan x)' dx \qquad \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right) + C$$

$$= C + \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{2n+1}$$

- To find C, plug  $\lim_{x \to 0}^{n=0} x = 0$ : C = 0.
- Therefore the theorem on integrating power series implies that  $\arctan x = \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{2n+1}$ , for |x| < 1.

$$\operatorname{arctan}(x) = \int d(\operatorname{arctan} x) = \int (\operatorname{arctan} x)' dx \qquad | \text{up to const.}$$

$$= \int \left(\frac{1}{1+x^2}\right) dx = \int \left(\frac{1}{1-(-x^2)}\right) dx$$

$$= \int \left(1-x^2+x^4-x^6+\cdots\right) dx \qquad | \text{for } |x| < 1$$

$$= \left(x-\frac{x^3}{3}+\frac{x^5}{5}-\frac{x^7}{7}+\cdots\right) + C$$

$$= C + \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{2n+1}$$

- To find C, plug in x = 0: C = 0.
- Therefore the theorem on integrating power series implies that  $\arctan x = \sum_{n=0}^{\infty} (-1)^n \frac{x^{2n+1}}{2n+1}$ , for |x| < 1.
- By the same theorem, the radius of convergence remains R = 1.