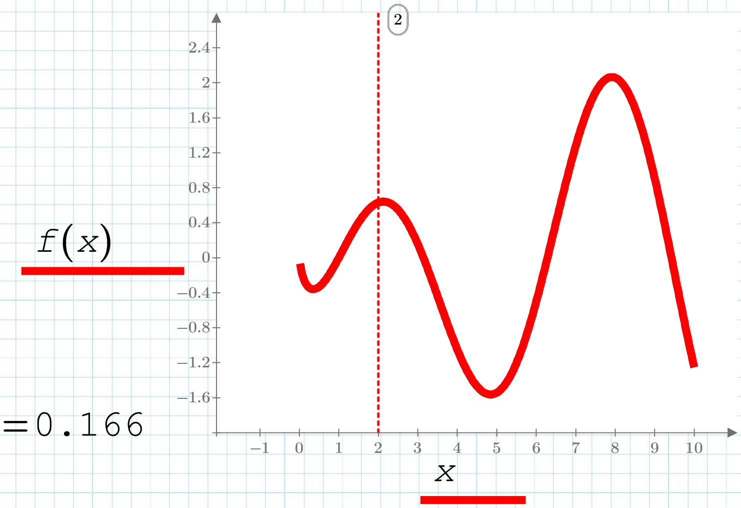
Numerical Differentiation:

The simplest way to numerically find 1st Derivative function *f(x)*, e.g. $f(x) := \sin(x) \cdot \ln(x)$, at $x0 := 2$:

$\Delta := 0.5$

$$\frac{f\left(x0+\frac{\Delta}{2}\right)-f\left(x0-\frac{\Delta}{2}\right)}{\Delta}=0.161$$

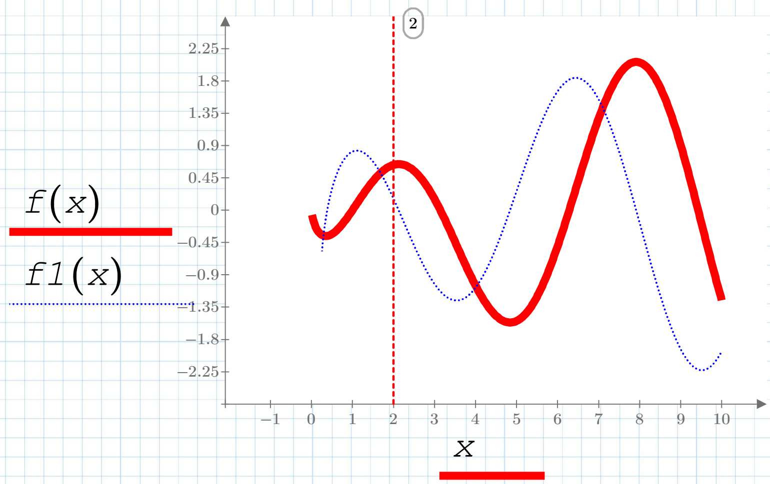
$$\frac{d}{dx0}f(x0) \rightarrow \frac{\sin(2)}{2}+\cos(2)\cdot\ln(2)=0.166$$



$$f1(x) := \frac{f\left(x+\frac{\Delta}{2}\right)-f\left(x-\frac{\Delta}{2}\right)}{\Delta}$$

$$\frac{f1\left(x0+\frac{\Delta}{2}\right)-f1\left(x0-\frac{\Delta}{2}\right)}{\Delta}=-1.231$$

$$\frac{d^2}{dx0^2}f(x0)=-1.274$$



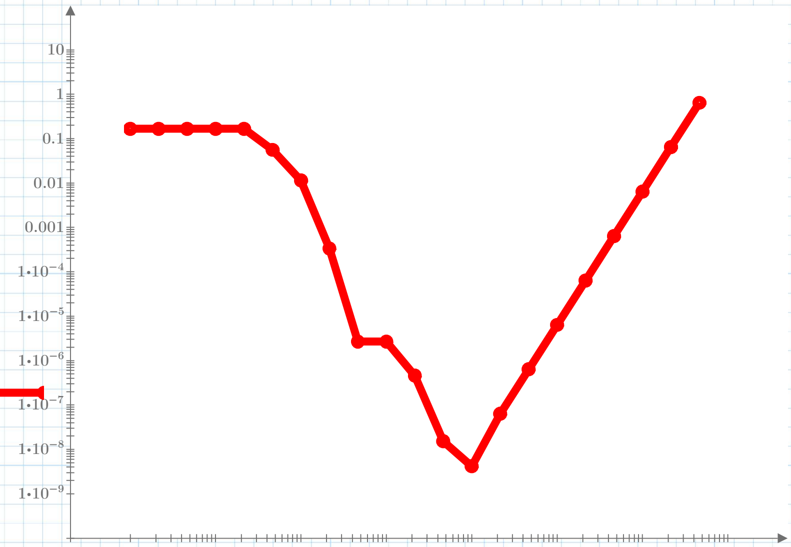
$$\frac{f1\left(x0+\frac{\Delta}{2}\right)-f1\left(x0-\frac{\Delta}{2}\right)}{\Delta}=-1.231$$

$$\frac{f(x0+\Delta)-2\cdot f(x0)+f(x0-\Delta)}{\Delta^2}=-1.231$$

$$\frac{d^2}{dx0^2}f(x0) \rightarrow \cos(2)-\frac{\sin(2)}{4}-\ln(2)\cdot\sin(2)=-1.274$$

$i := 0..20 \qquad d_i := 10^{-i}$

$$\left| \frac{d}{dx0} f(x0) - \frac{f(x0 + d_i) - f(x0)}{d_i} \right|$$

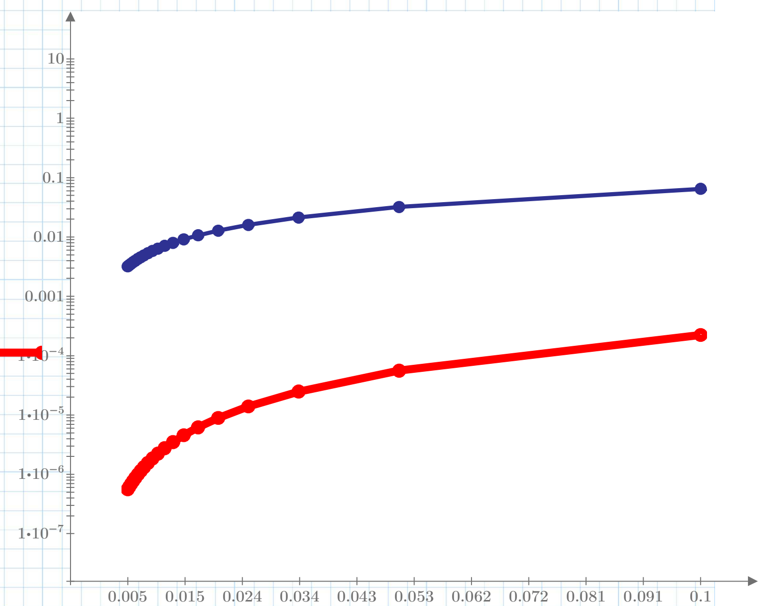


d_i

$i := 1..20 \qquad d_i := \frac{0.1}{i}$

$$\left| \frac{d}{dx0} f(x0) - \frac{f\left(x0 + \frac{d_i}{2}\right) - f\left(x0 - \frac{d_i}{2}\right)}{d_i} \right|$$

$$\left| \frac{d}{dx0} f(x0) - \frac{f(x0 + d_i) - f(x0)}{d_i} \right|$$



d_i

References:

1. **G.Simmons.** Calculus With Analitic Geometry (1996)
2. **MIT** lection 26.02.2013
3. **MIT** Note A.