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* $$\frac{df(x=x_0)}{dx} = f[x_0, x_1] + \sum_{j=2}^{N} f[x_0, \dots, x_j] \cdot (x_0 - x_1) \dots (x_0 - x_{j-1}).$$

$$P(x) = f[x_0] + f[x_0, x_1] \cdot (x - x_0) + f[x_0, x_1, x_2] \cdot (x - x_0)(x - x_1) \dots \dots f[x_0, \dots x_N] \cdot (x - x_0) \dots (x - x_{N-1}).$$

here; $P(x_0) = f[x_0], \dots \dots P(x_{N-1}) = f(x_{N-1})$.

Thus: $$\left.\frac{d}{dx} f(x)\right|_{x=x_0} = \left.\frac{d}{dx} P(x)\right|_{x=x_0}$$

So: $$\left.\frac{d f(x)}{dx}\right|_{x=x_0} = \frac{d}{dx}\Big[f[x_0] + f[x_0, x_1] \cdot (x - x_0) \dots \dots f[x_0 \dots x_N] \cdot (x - x_0) \dots \dots (x - x_{N-1}) \Big]_{x=x_0}$$

For any term:

$$\frac{d}{dx}\Big[f[x_0 \dots x_N] \cdot (x - x_0) \dots \dots (x - x_{N-1}) \Big]_{x=x_0}$$

$$= \underset{\text{constt.}}{f[x_0 \dots x_N]} \Big[1 \cdot (x - x_1) \dots (x - x_{N-1}) + (x - x_0) \cdot 1 \cdot (x - x_2) \dots (x - x_{N-1}) + \dots (x - x_0)(x - x_1) \dots (x - x_{N-2}) \cdot 1 \Big]_{x=x_0}$$

$$\Rightarrow f[x_0 \dots x_N] \Big[(x_0 - x_1)(x_0 - x_2) \dots (x_0 - x_{N-1}) + 0 + 0 \dots + 0 \Big] (x = x_0).$$

$$\Rightarrow 0 + f[x_0, x_1] + f[x_0, x_1, x_2](x_0 - x_1) \dots \dots f[x_0, x_1 \dots x_N](x_0 - x_1) \dots (x_0 - x_{N-1}).$$

$$\Rightarrow \frac{d}{dx} f(x)\bigg|_{x=x_0} = f[x_0, x_1] + \sum_{j=2}^{N} f[x_0 \ldots x_j] \cdot (x_0 - x_1) \ldots (x_0 - x_{j-1})$$