Numerical formulas

- Let $p(x)$ be the polynomial of degree $\leq n$ which coincides with $f(x)$ at points $x_i, i = 0, 1, \ldots, n$. Under the assumption that x and all the nodes x_j lie in the interval $[a, b]$, we have

$$f(x) - p(x) = \frac{1}{(n+1)!} f^{(n+1)}(\xi) \prod_{i=0}^{n} (x - x_i), \quad \xi \in (a, b).$$

- Newton's divided difference interpolation formula $p(x)$ of degree $\leq n$:

$$\begin{aligned} p(x) = f[x_0] &+ (x - x_0) f[x_0, x_1] + (x - x_0)(x - x_1) f[x_0, x_1, x_2] \\ &+ \cdots + (x - x_0)(x - x_1) \ldots (x - x_{n-1}) f[x_0, \ldots, x_n] \end{aligned}$$

- Numerical differentiation:

$$\begin{aligned} f'(x) &= \frac{1}{h}\big[f(x+h) - f(x)\big] + \frac{1}{2} h f''(\xi) \\ f'(x) &= \frac{1}{2h}\big[f(x+h) - f(x-h)\big] - \frac{1}{6} h^2 f'''(\xi) \\ f''(x) &= \frac{1}{h^2}\big[f(x+h) - 2f(x) + f(x-h)\big] - \frac{1}{12} h^2 f^{(4)}(\xi) \end{aligned}$$

- Simpson's rule of integration:

$$\int_{x_0}^{x_2} f(x)\ \mathrm{d}x \approx \frac{h}{3}(f_0 + 4f_1 + f_2)$$

- Newton's method for solving system of nonlinear equations $\mathbf{f}(\mathbf{x}) = \mathbf{0}$ is given by the scheme

$$\begin{aligned} J^{(k)} \cdot \Delta\mathbf{x}^{(k)} &= -\mathbf{f}\big(\mathbf{x}^{(k)}\big) \\ \mathbf{x}^{(k+1)} &= \mathbf{x}^{(k)} + \Delta\mathbf{x}^{(k)}. \end{aligned}$$

- Iteration methods for solving systems of linear equations

$$\sum_{j=1}^{n} a_{ij} x_j = b_i, \qquad i = 1, 2, \ldots, n$$

$$\begin{aligned} \text{Jacobi:} \quad x_i^{(k+1)} &= \frac{1}{a_{ii}} \left(b_i - \sum_{j=1}^{i-1} a_{ij} x_j^{(k)} - \sum_{j=i+1}^{n} a_{ij} x_j^{(k)} \right) \\ \text{Gauss–Seidel:} \quad x_i^{(k+1)} &= \frac{1}{a_{ii}} \left(b_i - \sum_{j=1}^{i-1} a_{ij} x_j^{(k+1)} - \sum_{j=i+1}^{n} a_{ij} x_j^{(k)} \right) \end{aligned}$$

- Heun's method for solving $\mathbf{y}' = \mathbf{f}(x, \mathbf{y})$:

$$\begin{aligned} \mathbf{k_1} &= h\mathbf{f}(x_n, \mathbf{y}_n) \\ \mathbf{k_2} &= h\mathbf{f}(x_n + h, \mathbf{y}_n + \mathbf{k_1}) \\ \mathbf{y}_{n+1} &= \mathbf{y}_n + \frac{1}{2}(\mathbf{k_1} + \mathbf{k_2}) \end{aligned}$$

Table of some Laplace transforms

$f(t)$	$F(s) = \mathscr{L}\{f(t)\} = \int_0^\infty e^{-st} f(t)\ \mathrm{d}t$
1	$\frac{1}{s}$
t	$\frac{1}{s^2}$
$t^n\ (n = 0, 1, 2, \ldots)$	$\frac{n!}{s^{n+1}}$
e^{at}	$\frac{1}{s-a}$
$\cos\omega t$	$\frac{s}{s^2+\omega^2}$
$\sin\omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cosh at$	$\frac{s}{s^2-a^2}$
$\sinh at$	$\frac{a}{s^2-a^2}$
$e^{at}\cos\omega t$	$\frac{s-a}{(s-a)^2+\omega^2}$
$e^{at}\sin\omega t$	$\frac{\omega}{(s-a)^2+\omega^2}$
$\delta(t-a)$	e^{-as}

Table of some Fourier transforms

$f(x)$	$\hat{f}(w) = \mathcal{F}(f) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} f(x) e^{-iwx}\ \mathrm{d}x$
$g(x) = f(ax)$	$\hat{g}(w) = \frac{1}{a}\hat{f}\left(\frac{w}{a}\right)$
$u(x) - u(x-a)$	$\frac{1}{\sqrt{2\pi}}\left(\frac{\sin aw}{w} - i\frac{1-\cos aw}{w}\right)$
$u(x)e^{-x}$	$\frac{1}{\sqrt{2\pi}}\left(\frac{1}{1+w^2} - i\frac{w}{1+w^2}\right)$
e^{-ax^2}	$\frac{1}{\sqrt{2a}} e^{-\frac{w^2}{4a}}$
$e^{-a\lvert x\rvert}$	$\sqrt{\frac{2}{\pi}}\frac{a}{w^2+a^2}$