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Mathematics for engineers V (Partial differential equations)

1 integration in $\mathbb{R}^d$ and integral theorems

differentiation in $\mathbb{R}^d$, partial derivative, directional derivative, gradient, divergence, curl, Laplacian, Taylor expansion (rep.)

integration in $\mathbb{R}^d$, volume and surface integrals, curve integrals (rep.)

transformation rule, integration by parts in $\mathbb{R}^d$, Gauss' divergence theorem, sinks and sources, Green's formulae, Stokes' theorem

2 partial differential equations

diffusion and heat conduction: modeling, consitutive equations, continuity equation, Dirichlet and Neumann boundary conditions, energy balance, steady state

oscillation of a string, waves, membrane, energy balance

transport equation, deformation of a plate, electric field, Navier stokes equation

classification of PDEs, maximum principle, admissible initial and boundary conditions

3 analytical solution procedures

homogeneous parabolic PDE, separation of variables, Fourier approach, spectral decomposition

Laplace's equation in cartesian and polar coordinates

wave equation, speed of sound, decomposition into waves

transport equation and characteristics, traffic dynamics, conservation form, method of characterics, Burgers' equation, shock wave, position depending transport equation

4 fundamental solution and Green function

fundamental solutions of Laplace's equation and heat equation, Green functions of elliptic PDEs, Poisson's formula, idea of BEM

5 variational formulation

energy functional of elliptic PDEs, membrane displacement

weak formulation, test functions, weak solution, solvability conditions of pure Neumann BVP

6 finite elements

stationary problems, idea of Ritz-Galerkin method, stiffness and mass matrix

time-dependent problems