CPDES2023-2024: Basic Building Blocks/Topics Covered.

1. Introduction: How can we solve PDEs on a computer? Finite Difference Methods. Basic types and Classification of PDEs. Well-posedness and the importance of Boundary Conditions.
2. Parabolic equations: Explicit & Implicit Schemes. Maximum principal analysis.
3. Elliptic equations: Iterative methods: How can they be made faster? Jacobi, Gauss-Seidel, relaxation techniques. Multigrid methods and motivation and implementation.
4. Hyperbolic equations: characteristics, up-winding, Lex-Wendroff schemes. Non-reflecting boundary conditions, perfectly matched layers (PML).
5. Combinations, Extensions and Applications: e.g. advection/diffusion and Navier-Stokes equations. Magnetic Induction and heat transport equations. Domain decomposition, ADI, operator splitting, Grid-mappings, Coordinate Stretching, Nonlinearity.

6. Course-work designed to consolidate ideas.

Recommended Books:
1. LeVeque, Randall J., *Finite difference methods for ordinary and partial differential equations: steady-state and time-dependent problems.* (Core, online)
2. Tannehill, John C., *Computational fluid mechanics and heat transfer.*
3. Smith, G. D., *Numerical solution of partial differential equations : finite difference methods.*
4. Eleuterio F. Toro, *Riemann Solvers and Numerical Methods for Fluid Dynamics : A Practical Introduction (online).*

Further Reading: Google

Many resources available online (Oxford/Cambridge/Stanford/MIT/etc. Youtube, Wikipedia)
search computational PDES !

Programming Language Critique: *Python/Matlab ok for small code testing/ideas construction unless know that NumPy or underlying libraries-called are pre-compiled binary/C++/etc for fast computation and know precisely, limitations of usage of pre-written software.*
Python script :: Heavy computational resource then C++, C, Fortran etc. Parallel programming (MPI, OpenMP).

Alternative Numerical Discretisations: Spectral Methods, Finite Elements, Finite Volume.
Runge-Kutta Methods : (Explicit/Implicit), Method of Lines (MoL).

Compact Differences:
An Introduction to Compact Finite Differences (pptx) by Andrew Rees, University of Bath.
High-resolution high-order upwind compact scheme-based numerical computation of natural convection flows in a square cavity, by Zhao et al. (2016) International Journal of Heat and Mass Transfer 98 (2016) 313–328.
An optimized dispersion–relation-preserving combined compact difference scheme to solve advection equations, by Yu et al. Journal of Computational Physics 300 (2015) 92–115.

Numerical Methods in Finance: wwwf.imperial.ac.uk/~ajacquie/
https://jackantoinejacquie.wixsite.com/jacquier/numerical-methods
Option Pricing under a Heston Volatility model using ADI schemes (pptx)
Practical Problems in the Numerical Solution of PDE's in Finance, by Gianluca Fusai et al. (2002).
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2240864

Fluids: Navier-Stokes Eqns. Conservation Laws, Numerical Techniques (shock waves etc.)*: Riemann Solvers and Numerical Methods for Fluid Dynamics,* by Toro E. F.

Astrophysical Hydrodynamics : Yosuke Mizuno, Shanghai Jiao Tong University. Graduate lecture, SJTU, 2021. https://web.tdli.sjtu.edu.cn/mizuno/astrophysical-hydrodynamics/

Nektar++ : https://www.nektar.info/