HPC and Data in Computational Fluid Dynamics

Syllabus

Week	Lecture	Topic	Lecturer
W1	**Introduction**		
29 Aug Tuesday 1-2:10pm AEST	Lecture 1	**Introduction** ● Purpose of course ● Brief introduction to CFD ● The role of HPC in CFD ● Overview of speakers and topics that will be covered	**Prof Richard Sandberg** (UniMelb)
31 Aug Thursday 1-2:15pm AEST	Lecture 2	**National and International HPC Landscape** ❖ National and International HPC Landscape ● Australia's capabilities in HPCD research ● How we are positioned in the larger international environment ❖ Introduction to Gadi and Setonix Introduction to HPC for CFD ● Hardware components and important aspects ● Software stack ● Metrics for parallel performance	*Overview* - **Prof Sean Smith** (NCI) - 30 min *Gadi* – 15 min **Dr Matthew Downton** (NCI) *Setonix* - 15 min **Dr Alexis Espinosa Gayosso** (Pawsey) *Panel Discussion* – 10 min

W2		Mathematical Models and Discretization Basics I	
5 Sep Tuesday 5-6:10pm AEST / 8-9:10am BST	Lecture 3	**Governing Equations** • The Navier Stokes equations • Simplifications (Euler, Stokes, Boussinesq etc.) • Implications for modeling and simulation	**A/Prof Fatemeh Salehi** (Macquarie Uni)
7 Sep Thursday 1-2:10pm AEST	Lecture 4	**Temporal Discretization** • Time-accurate schemes for unsteady flows • Convergence acceleration techniques for steady flows Distributed solution of sparse linear systems	**Dr Rowan Gollan** (UQ)
W3		Mathematical Models and Discretization Basics II	
12 Sep Tuesday 1-2:10pm AEST	Lecture 5	**Spatial Discretization/Analysis** • Finite difference methods • Finite volume methods • Assembly of systems of equations	**Prof Emile Sauret** (QUT)
14 Sep Thursday 1-2:30pm AEST	Tutorial 1	**Discretization of Test Problems** • Stability of schemes • Numerical diffusion • Grid convergence • Wave propagation example (e.g. upwinding vs central, Euler explicit vs implicit)	**Dr Zhongzheng Wang** (QUT)
W4		Mapping of CFD to HPC	
19 Sep Tuesday 1-2:10pm AEST	Lecture 6	**Parallelization Concepts** • MPI, OpenMP, Open ACC, hip/cuda • Profiling, scaling, performance • Debugging	**Dr Callum Atkinson** (Monash)
20 Sep Wednesday 1-2:30pm AEST	HPC Training Session for Beginners (Optional)	**Interacting with HPC** • Working from a command-line interface • Scripting for queueing and batch execution	**Fred Fung** (NCI)

		• Running your first HPC job	
21 Sep Thursday 1-2:30pm AEST	Tutorial 2	**Hands-on Parallelization**	**Atkinson** Team + NCI Staff

One Week Break

W5		Handling and Postprocessing Data	
3 Oct Tuesday 1-2:10pm AEST	Lecture 7	**Postprocessing Large Data Sets** • File systems (HDF5, netcdf etc.) • POD, DMD, EOF • In-situ and data driven post-processing	Dr Andrew Kiss (ANU)
5 Oct Sept Thursday 1-2:30pm AEST	Tutorial 3	**Data Processing Examples** • Scripted interrogation • In situ data extraction/manipulation • Approaches to visualisation • Verification and validation	**Kiss** team + NCI Staff

W6		Advanced Methods	
10 Oct Tuesday 4-5:10pm AEST / 8-9:10am CEST	Lecture 8	**High-Order Discontinuous Galerkin Schemes on Unstructured Grids** • Overview • Discontinuous Galerkin Spectral Element Method • Treatment of curved boundaries • Stabilization techniques for turbulent flows	Michael Bergmann (DLR Germany)
12 Oct Thursday 1-2:10pm AEST	Lecture 9	**Turbulence Modeling** • DNS • LES • (u)RANS • Data-driven turbulence modelling	**Prof Richard Sandberg** (UniMelb)

W7		Advanced Topics	

17 Oct Tuesday 1-2:10pm AEST	Lecture 10	**Multiphase Flows** ● Discrete phase modelling ● Euler-Euler modelling ● Volume of Fluid modelling	Prof Matthew Cleary (USyd)
19 Oct Thursday 1-2:10pm AEST	Lecture 11	**Fluent Capabilities**	Dr Lewis Clark (LEAP Australia)
W8		**Ansys Fluent on HPC - Industry Showcase**	
24 Oct Tuesday 1-2:30pm AEST	Tutorial 4	**Hands-on Fluent on HPC**	**Dr Lewis Clark** (LEAP Australia) + NCI Training
26 Oct Thursday 1-2:30pm AEST	Tutorial 5	**Hands-on Fluent on HPC**	**Dr Lewis Clark** + NCI Training (LEAP Australia)
W9		**OpenFOAM on HPC - Industry Showcase**	
31 Oct Tuesday 1-2:10pm AEST	Lecture 12	**The Flavors of OpenFOAM** ● OpenFOAM - what it is and is not ● History of OpenFOAM ● The three major flavours of OpenFOAM with a comparison of capability ● Why use OpenFOAM ● OpenFOAM architecture ● OpenFOAM implemented capabilities – ESI version ● Some examples ● Conclusions	**Dr Darrin Stephens** (Laminar 2 Turbulent)
2 Nov Thursday 1-2:30pm AEST	Tutorial 6	**Hands-on OpenFOAM on HPC**	**Dr Darrin Stephens** (Laminar 2 Turbulent) + NCI Training
W10		**Advanced Topics**	
7 Nov Tuesday	Lecture 13	**Discrete Methods for CFD**	**A/Prof Christopher Leonardi** (UQ)

1-2:10pm AEST		- Smoothed particle hydrodynamics - The Boltzmann equation - Lattice Boltzmann methods	
9 Nov Thursday 1-2:10pm AEST	Lecture 14	**CFD for Hypersonics** - Challenges at high-speed - Combustion	**Dr Rowan Gollan** (UQ)
W11		**Advanced Topics**	
14 Nov Tuesday 1-2:10pm AEST	Lecture 15	**CFD (DNS/LES) of Oceanic Flows** - Small scales - Internal waves, - Ice-ocean interaction - Upper ocean mixing - Ocean heat transport - Coastal ocean	**A/Prof Bishakhdatta Gayen** (UniMelb)
16 Nov Thursday 1-2:10pm AEST	Lecture 16	**Large-Scale Ocean Modelling** - Southern Ocean - Global heat transport - Circulation Antarctic margin - Climate change scenario	**A/Prof Bishakhdatta Gayen** (UniMelb)
W12		**Advanced Topics**	
21 Nov Tuesday 1-2:10pm AEST	Lecture 17	**CFD for Turbomachinery** - The challenges with deterministic unsteadiness - Moving towards more realistic setups	**Prof Richard Sandberg** (UniMelb)
23 Nov Thursday 1-2:10pm AEST	Lecture 18	**Suspension Transport** small-scale, fully resolved simulations **Closing Remarks**	**A/Prof Christopher Leonardi** (UQ)

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