(Virtual) Joint ICTP/IAEA Course on Theoretical Foundations and Applications of Computational Fluid Dynamics in Nuclear Engineering

13 – 17 September 2021

Directors:

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Local Organizer:

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Nuclear Power Technology Development Section

Department of Nuclear Energy

Introduction and Course Objectives

The course will provide graduate students and professionals with theoretical foundations and examples for application of computational fluid dynamics (CFD) modelling in nuclear engineering. The need for high fidelity nuclear reactor thermal hydraulic simulations has led to increased application of the CFD codes that are prevailing substitute of currently established one dimensional system thermal hydraulics codes and coarse mesh sub-channel analyses codes. Therefore, CFD constitutes the "third approach" in the philosophical study and development of the whole discipline of fluid dynamics. Combining the power of experimentation and theory, this approach has made possible the accounting of flow fields in complex geometries. This course will outline these aspects and provide the participants with hands-on examples.

The course will build a theoretical understanding on the science of CFD and its applications in nuclear engineering supported by various hands-on practical examples. Knowledge transfer will be facilitated between the international experts as lecturers, and students, professionals, and engineering analysists, as participants. Given that the CFD codes, which have empirical models for simulating heat transfer, turbulence, single-phase and multi-phase flow, are currently available along with general application-oriented training in their use, the focus of this course is on providing the required background about the embedded models with the goal to improve the participants' theoretical foundation for CFD applications in nuclear engineering.

Along with the theoretical lectures and hands-on learning examples, the course will include comprehensive overview of the history of CFD development and its applications in nuclear engineering, including development, status, and challenges.

DAY 1: Monday, 13 September 2021

WELCOMING VIDEO

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TOPIC	Vienna Time	Speaker / Presenter
Welcoming Remarks by ICTP and IAEA	**11:30 – 11:50**	**ICTP and IAEA**
Introduction to Course and the Expectations	**11:50 – 12:10**	**Ms Tatjana Jevremovic, IAEA**
Today's Speakers Intro		
Session 1. History and Theory of Computational Fluid Dynamics		
Basics of Vector Calculus and Conservation Equations (Governing Equations in Fluid Dynamics)	**12:30 – 13:30**	**Mr Kamran Rasheed, PIEAS, Pakistan**
Break & Virtual Tour of VIC Video (13:30 – 14:00)		
Solving the Equations	**14:00 – 15:00**	**Mr Giovanni Giustini, ICL, UK**
Session 2.A. Basics of Turbulence Modelling		
RANS and URANS Modelling for Turbulent Flows	**15:00 – 16:00**	**Mr Kamran Rasheed, PIEAS, Pakistan**
Q&A Session (16:00 – 16:45) **Ms Maria Avramova, NCSU, USA** **Mr Matthias Krause, Inmost Nuclear Energy Consulting, Canada** **Mr Bojan Niceno, Switzerland**		
Break & IAEA Activities on Part-Task Simulators Video (16:45 – 17:00)		
Hands-on Session –1		
Quarter Sub-channel Geometry and Meshing	**17:00 – 18:00**	**Mr Elia Merzari, PSU, USA** **Mr Haomin YUAN ANL, USA** **Moderator: Mr Bassam Khuwaileh, UoS, UAE**
Adjourn Day 1 (18:00 – 18:15)		

DAY 2: Tuesday, 14 September 2021

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TOPIC	Vienna Time	Speaker / Presenter
Today's Speakers Intro		
Session 2.B. Basics of Turbulence Modelling		
Turbulence Resolving Simulations: DNS, LES and Hybrid Methods	**11:30 – 12:30**	**Mr Elia Merzari, PSU, USA**
Session 3. Two Phase Computational Fluid Dynamics		
Various Modelling Approaches in Two-Phase Flow	**12:30 – 13:30**	**Mr Dominique Bestion, CEA, France**
Break & Video (13:30 – 14:00)		
Interface Resolving Techniques	**14:00 – 15:00**	**Mr Yohei Sato, PSI, Switzerland**
Eulerian – Eulerian Approach	**15:00 – 16:00**	**Mr Edo Frederix, NRG, Netherlands**
Q&A Session (16:00 – 16:45) **Ms Maria Avramova, NCSU, USA** **Mr Bojan Niceno, Switzerland** **Mr Matthias Krause, Inmost Nuclear Energy Consulting, Canada**		
Break & IAEA Activities Video (16:45 – 17:00)		
Hands-on Session –2		
Quarter Sub-channel Modelling Options	**17:00 – 18:00**	**Mr Elia Merzari, PSU, USA** **Mr Haomin YUAN ANL, USA** **Moderator: Mr Kamran Rasheed, PIEAS, Pakistan**
Adjourn Day 2 (18:00 – 18:15)		

DAY 3: Wednesday, 15 September 2021

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Today's Speakers Intro

TOPIC	Vienna Time	Speaker / Presenter
Session 4. Application of CFD Codes in Nuclear Reactor Design and Safety Analysis		
Water Cooled Reactor (DBAs and Operations)	**11:30 – 13:00**	**Ms Annalisa Manera, ETH, Switzerland**
IAEA Relevant Activities	**13:00 – 13:30**	**Ms Tatjana Jevremovic, Mr Chirayu Batra, Mr Haseeb ur Rehman, IAEA**
Break & Video (13:30 – 14:00)		
CFD Analysis of Water Cooled Reactors Severe Accident Phenomena	**14:00 – 15:00**	**Mr Stephan Kelm, FZJ, Germany**
Innovative (Gen-IV) Reactors	**15:00 – 16:00**	**Mr Ferry Roelofs, NRG, Netherlands**
Q&A Session (16:00 – 16:45) **Mr Bojan Niceno, Switzerland** **Ms Maria Avramova, NCSU, USA** **Mr Matthias Krause, Inmost Nuclear Energy Consulting, Canada**		
Break & IAEA Activities Video (16:45 – 17:00)		
Hands-on Session – 3		
Quarter Sub-channel Simulation and Post Processing	**17:00 – 18:00**	**Mr Elia Merzari, PSU, USA** **Mr Haomin YUAN ANL, USA** **Moderator: Mr Stephan Kelm, FZJ, Germany**
Adjourn Day 3 (18:00 – 18:15)		

DAY 4: Thursday, 16 September 2021

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Today's Speakers Intro

TOPIC	Vienna Time	Speaker / Presenter
Session 5. Application of CFD Codes in Nuclear Reactor Design and Safety Analysis		
Introduction to Multi-scale Approach	**11:30 – 12:30**	**Mr Antoine Gerschenfeld, CEA, France**
Session 6. Uncertainty Quantification and Error Analysis		
Sources of uncertainty in CFD Modelling	**12:30 – 13:30**	**Mr Bassam Khuwaileh, UoS, UAE**
Break & Video (13:30 – 14:00)		
Uncertainty Quantification Methodology	**14:00 – 15:00**	**Mr Bassam Khuwaileh, UoS, UAE**
Review of UQ Applications	**15:00 – 16:00**	**Mr Dominique Bestion, CEA, France**
Q&A Session (16:00 – 16:45) **Ms Maria Avramova, NCSU, USA** **Mr Matthias Krause, Inmost Nuclear Energy Consulting, Canada** **Mr Bojan Niceno, Switzerland**		
Break & IAEA Activities Video (16:45 – 17:00)		
Hands-on Session –4		
CFD Modelling Challenges for Problems Related to Nuclear Reactors	**17:00 – 18:00**	**Mr Victor Petrov, PSI, Switzerland** **Moderator: Mr Elia Merzari, PSU, USA**
Adjourn Day 4 (18:00 – 18:15)		

DAY 5: Friday, 17 September 2021

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Today's Speakers Intro

TOPIC	Vienna Time	Speaker / Presenter
General Discussion Session	**11:30 – 12:30**	**Moderators: Ms Maria Avramova, NCSU, USA, Mr Bojan Niceno, Switzerland and Mr Matthias Krause, Inmost Nuclear Energy Consulting, Canada** **Ms Chirayu Batra, IAEA**
CFD Applications (I)	**12:30 – 13:30**	**Mr Yassin Hassan, TAMU, USA**
Break & Video (13:30 – 14:00)		
CFD Applications (II)	**14:00 – 14:30**	**Mr Yassin Hassan, TAMU, USA**
Selected Presentations from the Participants	**14:30 – 16:00**	**Ms Tatjana Jevremovic, IAEA Ms Haseeb ur Rehman, IAEA Mr Bojan Niceno, Switzerland Ms Maria Avramova, USA Mr Matthias Krause, Canada**
Closing (16:00 – 16:15) **Ms Tatjana Jevremovic, IAEA** **All**		
***Good Bye* Video (16:15 – 16:30)**		