



Faculty of Health, Science and Technology
Mathematics

Syllabus

Particles and Partial Differential Equations

Course code: 7MAT010
Course Title: Particles and Partial Differential Equations
Partiklar och partiella differentialekvationer
Subject: Mathematics
Credits: 7.5 ECTS
Degree Level: Doctoral

Course approval

The syllabus was approved by the Faculty of Health, Science and Technology, 20 March 2024 and is valid from the spring semester 2024 at Karlstad University.

Language of instruction

Teaching is in English.

Prerequisites and selection

Admitted to research education in Mathematics. The course is primarily for research education students admitted at Karlstad University, and secondarily for research education students admitted at other universities.

Learning outcomes

After completed course the research education student should be able to:

- demonstrate familiarity with what interacting particle systems are and how can they be linked with partial differential equations via modelling perspectives as well as in terms of mathematical proofs for mean-field limits,
- demonstrate understanding of the discrete-to-continuum passage to the limit for transport equations (the case of the aggregation equation),

- demonstrate familiarity with the mathematical analysis techniques involved in proving the well-posedness of interacting particle systems and of the needed tightness properties to reach macroscopic scales (particularly, what concerns the handling of reaction-diffusion equations, transport equations, and of combinations thereof),
- demonstrate familiarity with applied measure theory and optimal transportation techniques,
- demonstrate familiarity with derivations of smooth particle hydrodynamics (SPH) discretizations of partial differential equations and provide implementations (in Python, Julia, or in other open-source computational platform) for selected tests, and
- demonstrate familiarity with constructing numerical approximations of hybrid systems.

Course content

The course is based on an individual study of the course literature on interacting particles systems, partial differential equations and their mesh free approximations, and related materials. The course includes scientific discussions with the supervisor(s) and with other colleagues.

Reading list

See separate document.

Examination

For a Pass grade, doctoral students are required to actively participate in the seminars, and have one submission task accepted.

Grades

One of the grades Fail (U) or Pass (G) is awarded in the examination of the course.

Quality assurance

A written evaluation is carried out at the conclusion of the course. The result of the evaluation is collated in accordance with *The Higher Education Ordinance*, Chapter 1, § 14.

Course Certificate

Course certificate is issued on request.

Goal matrix

Goals that, after completing the course, are fulfilled for the doctoral or licentiate degree are marked with an X.

| | Doctoral | | | Licentiate | |
|----|--|---|--|--|---|
| | Knowledge and understanding | | | Knowledge and understanding | |
| 1a | - demonstrate broad knowledge and systematic understanding of the research field and | x | | 1a demonstrate knowledge and understanding in the field of research including | x |
| 1b | advanced and up-to-date specialised knowledge in a limited area of this field, and | x | | 1b current specialist knowledge in a limited area of this field as well as | x |
| 1c | familiarity with research methodology in general and the methods of the specific field of research in particular. | | | 1c specialised knowledge of research methodology in general and the methods of the specific field of research in particular | |
| | Competence and skills | | | Competence and skills | |
| 2a | - demonstrate capacity for scholarly analysis and synthesis as well as | | | 2a demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively and to | |
| 2b | to review and assess new and complex phenomena, issues and situations autonomously and critically | | | 2b plan and use appropriate methods to undertake a limited piece of research and other qualified tasks within predetermined time frames in order to contribute to the formation of knowledge | x |
| 3a | - demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to | x | | 2c as well as to evaluate this work | |
| 3b | plan and use appropriate methods to undertake research and other qualified tasks within predetermined time frames and to review and evaluate such work | | | 3a demonstrate the ability in both national and international contexts to present and discuss research and research findings in speech and writing and in dialogue with the academic community and | |
| 4 | - demonstrate through a dissertation the ability to make a significant contribution to the formation of knowledge through his or her own research | | | 3b society in general | |

| | | | | | |
|-------------------------------|---|---|---|---|--|
| 5a | - demonstrate the ability in both national and international contexts to present and discuss research and research findings authoritatively in speech and writing and in dialogue with the academic community and | | 4 | demonstrate the skills required to participate autonomously in research and development work and to work autonomously in some other qualified capacity. | |
| 5b | society in general | | | | |
| 6 | - demonstrate the ability to identify the need for further knowledge and | x | | | |
| 7 | - demonstrate the capacity to contribute to social development and support the learning of others both through research and education and in some other qualified professional capacity. | | | | |
| Judgement and approach | | | | Judgement and approach | |
| 8a | - demonstrate intellectual autonomy and disciplinary rectitude as well as | | 5 | demonstrate the ability to make assessments of ethical aspects of his or her own research | |
| 8b | the ability to make assessments of research ethics, and | | 6 | demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used | |
| 9 | - demonstrate specialised insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used. | | 7 | demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning. | |