Faculty common course 2021

English course title: Introduction to Mathematica

Swedish course title: Introduktion till Mathematica

Extent (credits): 5

Language of instruction: English

Recommended prerequisites: Students should be familiar with linear algebra, calculus and basic programming. No previous knowledge of Mathematica is assumed

Learning outcomes of the course:

By the end of the course, students will be able to:
1. Account for the basic structure of computer algebra systems
2. Implement various algorithms in the Mathematica language
3. Compare and contrast different programming styles
4. Use efficiently functional and rule-based programming
5. Understand how the Mathematica kernel evaluates expressions
6. Test and optimize Mathematica code
7. Design and set up their own Mathematica packages
8. Install simple functions written in C/C++ into Mathematica with MathLink
9. Apply symbolic programming to their research

Specify which learning outcomes of the doctoral degree that are address/covered (see appendix 1 of the call or the template of ISP). Describe how:

According to the learning outcomes for a doctoral degree, a doctoral candidate should ”demonstrate broad knowledge and systematic understanding of the research field”. Computer algebra systems and symbolic computation are a field that lies at the intersection of Mathematics and Computer Science. As such, the course allows students in certain fields (mainly Mathematics, Information Technology and Theoretical/High Energy Physics) to gain deeper knowledge of an important (and growing) part of their field.

Additionally, a doctoral student should, ”demonstrate familiarity with research methodology in general and the methods of the specific field of research in particular”, as well as ”demonstrate the ability to [...] plan and use appropriate methods to undertake research”. Scientific programming in general and symbolic calculation with Mathematica in particular are necessary tools/methods for undertaking research in many fields in TekNat. These include, aside from Mathematics, Physics and Information Technology, also Chemistry, Biology, Engineering. In this respect, the course is designed to directly help students apply what they have learned to their research (e.g. the final project needs to be related to a student’s research).

Course contents:

1. An introduction to computer algebra systems and symbolic programming
2. The basics of Mathematica as a programming language (symbolic expressions, vectors and matrices, conditional expressions, loops)

3. Substitutions and patterns
4. Linear algebra and calculus with Mathematica
5. Different programming styles in Mathematica: procedural, functional and rule-based programming
6. Kernel evaluation.
7. MathLink interface (how to install C/C++ functions into Mathematica)
8. Elements of optimization, parallel programming
9. Writing your own Mathematica package
10. Applications in Mathematics, Physics, Chemistry
11. Data analysis with Mathematica
12. Open-source alternatives to Mathematica

Instruction (course structure):

– 12 lectures (24 h total)
– 3 problem-solving sessions in which students work in groups
– 2 additional overview sessions may be held at the beginning of the course to support students who need some extra help with the material.

If needed and in accordance with University policies, all instruction could be conducted via Zoom.

– Textbooks: Andrey Grozin, ”Introduction to Mathematica for Physicists”, Springer, 2014; P. Wellin, ”Programming with Mathematica: An Introduction”, Cambridge University Press, 2013
– Useful reference: Wagner, ”Power Programming with Mathematica: the Kernel, McGraw-Hill, 1996
– Lecture notes will be handed out during the course

The course exists also as a master course with code 1FA164; this application asks for funds to support participation of doctoral students, which typically constitute approximately half of the total enrolled students.

In the second iteration of the course (2020), a stronger group-work component was introduced by asking students to work in teams for the problem-solving sessions. In this way, my course provides an opportunity to develop teamwork skills in the context of interdisciplinary collaborative work (groups contain students from different departments). At the same time, I find that group work augments possibilities for student-student interaction, overcoming some of the difficulties of distance-learning in the context of the current pandemic.

My plan for the 2021 iteration of the course is to add 2 lectures specifically designed for doctoral students, covering more advanced topics such as open-source alternatives (SageMath) and data analysis with Mathematica. I also intend to add a guest lecture discussing more in depth the interface between Mathematica and C or C++.

Assessment (form of examination):
hand-in problems during problem-solving sessions (50%, the students work in groups), final project (50%).

Course examiner (name, e-mail):

Marco Chiodaroli, marco.chiodaroli@physics.uu.se

Department with main responsibility: Physics and Astronomy

Contact person/s (course responsible teacher) (name, e-mail): Marco Chiodaroli, marco.chiodaroli@physics.uu.se

Course dates/period: Fall Semester 2021, Period 1

Maximum number of participants: 30

Submit the application for admission to: Marco Chiodaroli

Submit the application not later than: April 15