Numerical Integration of Dynamical Systems

Organisation 2025

Content overview

1. **Introduction to Runge-Kutta methods**
   - 1.1 Examples and first definitions
   - 1.2 Runge-Kutta methods
   - 1.3 Collocation methods
   - 1.4 Partitioned Runge-Kutta methods
2. **Geometric numerical integration of dynamical systems**
   - 2.1 Numerical conservation of invariants
   - 2.2 Symmetric integration
   - 2.3 Symplectic integration
   - 2.4 Symplectic numerical methods: long-time approximation
3. **Numerical integration of stiff problems**
   - 3.1 Examples
   - 3.2 Linear stability, motivation, limitation
   - 3.3 Stability of Runge-Kutta methods (A- and L-stability)
   - 3.4 Rational functions related to collocation methods
   - 3.5 Implementation of implicit Runge-Kutta methods
   - 3.6 Runge-Kutta-Chebyshev and ROCK methods

Organisation of the lectures and the exercises

Week 1	Lecture 1 No Tutorial Session on the 18th of February 2025 (start of the course)
Week 2	Lecture 2 Serie 1
Week 3	Lecture 3 Lecture 4
Week 4	Lecture 5 Serie 2

Week 5	Lecture 6 Serie 3
Week 6	Serie 4 Serie 5
Week 7	Lecture 7 Serie 6
Week 8	Lecture 8 Serie 7
Week 9	Lecture 9 Serie 8
Week 10	Lecture 10 Serie 9
Week 11	Lecture 11 Serie 10
Week 12	Lecture 12 Serie 11
Week 13	Lecture 13 Serie 12
Week 14	No Lecture on the 29th of May 2025 (bank holiday) Serie 13

Examination

Exam form: written (subject to modifications)

For the exam everything that has been covered in the lectures and the tutorial sessions is relevant. The proofs are an integral part of the exam. Precise implementation of numerical algorithms is not required, though pseudocode might be tested.

Workflow

- **Lectures**
  Lectures will take place on Thursday from 4.15 pm to 6.00 pm at room MAA112.

- **Tutorials**
  Tutorial sheets will be uploaded on Moodle by Tuesday evening (for the upcoming week). During exercise sessions (Tuesday, 10.15am to 12am, GRC001), students should present their solutions to the class. No "official" solution to the exercises will be given. The assistant will be present during the exercise sessions to make sure that what is presented by the students is indeed correct. Booking of an exercise can be done by entering the student's name on the Google docs spreadsheet (see Moodle). This approach should also contribute to an active exchange and help in the learning process.

- **Forums & announcements**
  There are two forums on Moodle (Q&A – Class and Q&A – Exercises), where students can ask questions and discuss difficulties. Feel free to post your questions and we will reply as soon as possible. Announcements will be made through Moodle.

- **Face-to-face meetings**
  Students can arrange face-to-face meetings (Zoom) with either the teacher (adrian.blumenthal@epfl.ch) or the assistant (yannis.voet@epfl.ch) if you feel the questions you have are not adapted to the forums. Of course students can also ask their questions or discuss problems before or after the lectures.

- **E-mail**
  As usual you can also share your questions with us by e-mail (addresses see above).

Course bibliography

- E. Hairer, C. Lubich and G. Wanner, "Geometric numerical integration: structure-preserving algorithms for ordinary differential equations", Springer-Verlag, Berlin and New York, 2002.
- E. Hairer, S.P. Norsett and G. Wanner, "Solving ordinary differential equations I", vol. 8 of Springer Series in Computational Mathematics, Springer-Verlag, Berlin, 2008.
- E. Hairer and G. Wanner, "Solving ordinary differential equations II", vol 14 of Springer Series in Computational Mathematics, Springer-Verlag, Berlin, 2002.

Should you have any questions or should you require further information, please let us know.

We are wishing you a successful and interesting spring term 2025!