An education in physics should prepare the student for a life-long career, and provide a background that will be important in her professional life. Since numerical computations and computational thinking have become important parts of almost any human activity, and particularly so for physics, numerical and algorithmic approaches should be an integrated part of the educational background of all students.

Ideally, numerical methods should be introduced and practiced along the same route as analytical methods: Introduced early in the studies, and then reused and developed in various contexts throughout the education, so that the methods become an integrated part of the students’ toolbox, and mastered on the same level as physics students currently are mastering analytical methods. The students should have an understanding of the underlying mathematics, but also an extended practical experience with applying the methods to subject specific problems. The students learn what they do every day throughout their education – numerical methods must therefore be integrated into the daily efforts of the students throughout the studies.

At the university of Oslo the physics students are introduced to programming and numerical methods from day one. The students start with courses in scientific programming, numerical methods, and calculus in their first semester. This combined background is reflected and built upon in later courses. This development depends on more than ten years of collaboration and coordination across the disciplines, with a tight integration of the basic courses in mathematics and computer sciences.

In this talk, I will demonstrate how numerical methods have been integrated into a beginning course in Newtonian mechanics by presenting examples of content, experiences of its application, and observations of student
behavior. I will present examples from the integrated introduction of numerical derivation and integration schemes for motions, air resistance, realistic contact forces, elastic pendulums, gravitational forces, nano-scale surface interactions, and energy partitioning.

The integration of numerical methods introduces two changes in the traditional curriculum in a mechanics course. First, more focus is given to the direct calculation of motion from quantitative force laws in two- and three dimensions. This depends on a more robust solution approach that separates the physics and mathematical/numerical components of a problem. In addition, we start from unconstrained motion and then address constrained motion later, such as the motion along a circular path for a stiff pendulum. An approach we have found pedagogically advantageous, since constrained problems often are conceptually difficult.

However, the main changes appear on a different level: The introduction of numerical methods allows us to solve more realistic systems and therefore demonstrate the power of physics. Numerical solutions also require different approaches to the analysis and discussion of results, which nicely complement and combines with analytical approaches, for example by comparison with simplified, analytically solvable models. And numerical problems open for exploration and discovery. In addition, formulating an algorithm for solving a physical problem also often elucidate the underlying physics, such as for static and dynamic friction, where a precise understanding of the physics is necessary for, and indeed may come about from, an algorithmic implementation of the problem.

The introduction of numerical problems does not make a course easier – indeed it often increases the level of abstraction and complexity. But an integrated approach, where courses gradually build on each other and the student over time develops an experience with numerical methods, seem to be a promising route. We also find that the early introduction of numerical methods, provides an opportunity to introduce research inspired and realistic problems at an early stage in a bachelor program, which both students and teachers find motivating.