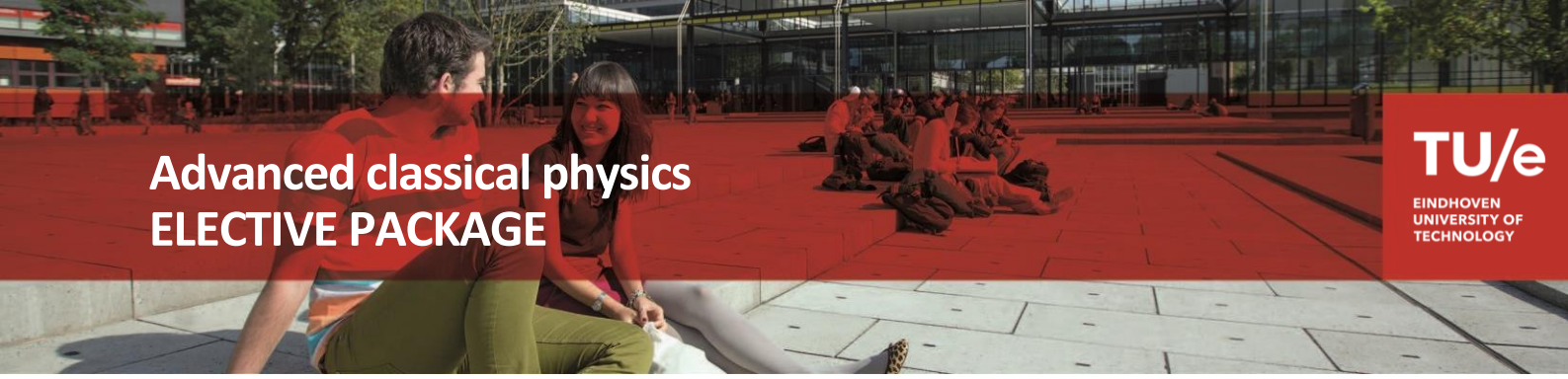


Advanced classical physics
ELECTIVE PACKAGE

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Advanced classical physics	
Offered by	Department of Applied Physics and Science Education
Language	English
Primarily interesting for	All students, but most relevant for students with background in Applied Physics and Science Education, Applied Mathematics and Mechanical Engineering majors
Prerequisites	3EMX0: required: 2WCB0, 2DBN00, 2DBN10; recomm.: 3AMX0,3BMX0 3EEX0: required: 2DBN10, 3BMX0, 3AEX0 3FFX0: required: Thermal physics (3BTX0) 3FTX0: recommended: Physics of transport phenomena (3CTX0)
Contact person	Prof. Dr. A. A. Darhuber (E-mail: a.a.darhuber@tue.nl)

Content and composition

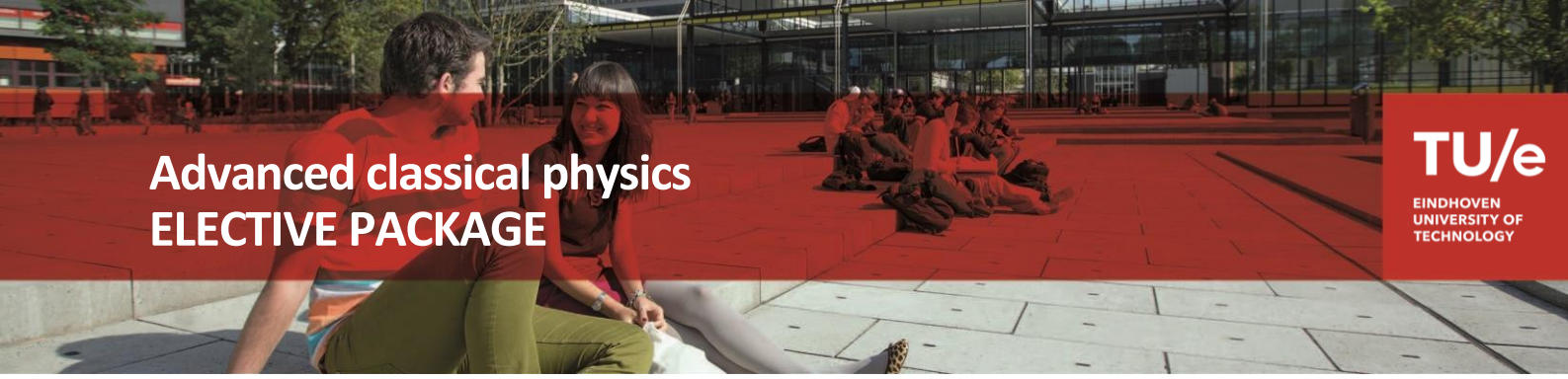
This set of electives will take the students on a rewarding journey through some of the core foundations of physics. The course “Theoretical classical mechanics” deals with Newtonian, Lagrangian and Hamiltonian mechanics, and provides a glimpse into the special theory of relativity and the structure of space and time. The course “Statistical Physics” will elucidate the connection between the nanoscale behavior of individual atoms and molecules and the macroscopic properties of systems that comprise a huge number (~10^{23}) of microscopic degrees of freedom. The course “Electrodynamics” extends and deepens insight into static and dynamic electromagnetic fields and their interaction with matter. The course “Turbulence, Waves & Instability” provides an introduction into turbulence, which is one of the remaining grand challenges of the mechanics of continua.

Course code	Course name	Level classification
3EMX0	Theoretical classical mechanics	Advanced
3EEX0	Electrodynamics	Advanced
3FFX0	Statistical Physics	Advanced
3FTX0	Turbulence, Waves & Instabilities	Advanced

Students are required to take “Theoretical classical mechanics” (3EMX0) and are invited to select 2 out of the remaining 3 courses. All 4 courses can be selected as well, one then counts as a free elective.

Precedence relationships within the package

We recommend students to take Theoretical classical mechanics (3EMX0) before Statistical Physics (3FFX0) and Turbulence, Waves & Instabilities (3FTX0). There are no further recommendations or requirements regarding the order of the courses.



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Course descriptions

3EMX0, Theoretical classical mechanics
The concepts and methods of classical mechanics form the basis for a large fraction of modern physics. This first course in theoretical physics will provide an introduction into the concepts of space and time, and Einstein's special theory of relativity. We will learn how the symmetry properties of systems can be used to simplify the solution of the equations of motion of mechanical systems. Moreover, we will discuss the symmetry properties of the governing physical laws themselves. We will become acquainted with the concept of phase space, which is the basis of statistical mechanics. We will intensively study the powerful and elegant frameworks of Lagrangian and Hamiltonian mechanics, which have been extended to other areas of physics, most notably quantum mechanics.

3FFX0, Statistical Physics
Often very simple physical laws can be used to describe the behavior of matter. Typical examples are the ideal gas law, Curie's law for magnetization and Fick's law for diffusive fluxes. This is amazing since the number of degrees of freedom of matter from a microscopic viewpoint is huge (~10^{23}). Statistical physics explains how the behavior of atoms and molecules translates into macroscopic phenomena. In the course students will become familiar with tools for coupling particle- based theories with macroscopic observables.

3EEX0, Electrodynamics
Electrodynamics is at the heart of classical and modern physics. This class will expand and complement previously treated topics. Static and dynamic electromagnetic fields will be described by Maxwell's equations. The emphasis is on a physically transparent picture and on aspects that are of relevance to engineering, like the interaction of EM fields with matter.

3FTX0, Turbulence, Waves & Instabilities
Many flows in nature and in industrial situations are turbulent. This course serves as an introduction in the theory of such turbulent flow phenomena. Turbulent flows emerge as a result of instability processes of laminar flows, initially often taking the appearance of waves with growing amplitudes. For this reason, the course starts with a description of the general characteristics of wave phenomena in fluids, like gravity waves and acoustic waves, followed by an introduction into stability analysis. Subsequently, the following subjects are considered: general features of turbulence including statistical properties and spectra, the structure of turbulent flows near walls, some aspects of vorticity and the energy budget, closure models, introduction to numerical techniques, and turbulent diffusion.
In addition to the lectures, which focus on theoretical concepts, the students will also be actively involved in numerical simulations of certain aspects of waves and flow instability; for this purpose a number of numerical sessions are scheduled.