Course Package

Fundamentals of Materials

Name module	Fundamentals of Materials
Educational programme	BSc Advanced Technology
Period	First quartile of the second semester (Quarter 2A)
Study load	15 ECTS
Coordinator	E.M. Marsman

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(9,5 EC)</td><td></td></tr>
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Required preliminary knowledge: High school Physics, Calculus of integrals

In this module matter and materials are the central themes: from fundamental quantum matter that which properties are ruled by the laws of quantum mechanics, to atoms, bonds between atoms, to larger microscopic and macroscopic structures with mechanical and electrical properties that are used everywhere in our society.

In Quantum Matter an introduction to quantum mechanics and elementary particles and systems is given. This is followed by Structure and Properties of Materials, in which the structure of materials is described and discussed, from individual atoms, to unit cells, to microstructures on larger mesoscopic and macroscopic length scales. The main mechanical and electrical properties that emerge from this microstructure is also discussed. Because of the importance of polymers and organic materials for many advanced technologies, their properties and synthesis are discussed in a separate block of lectures entitled Organic Chemistry for Molecular Materials. In the Project Materials for Energy all gained knowledge from the theoretical lecture series is applied in a literature survey on a materials-related topic in the field of energy harvesting, production, storage, or a closely related area. Analysing Technology in Societal Context aims to increase understanding of technology

as social phenomenon. The course will examine critically the social contexts in which technologies emerge and the social consequences of new technologies. Vector Calculus completes the module.

Materials

Quantum Matter

The basic elements of quantum mechanics will be introduced using a series of examples from modern physics. The following topics will be addressed: duality of particles, diffraction, photo-electric effect, uncertainty relation of Heisenberg, Schrödinger equation, quantum mechanical particle in a box, atoms and molecules, free electron model, band theory of solids, semiconductors and superconductors.

Structure and properties of materials

The 3 main classes of materials are discussed in this part of the module: metals, polymers, and inorganic materials such as ceramics and glass. The structure of these classes of materials are described on various length scales, going from atoms and atomic bonds, via microscopic, to macroscopic objects. The mechanical and electrical properties of materials are described and explained from the underlying structure on different length scales. This block ends with a discussion of metals and semiconductors.

Organic Chemistry for Molecular Materials

In this part of the module we will try to understand and rationalize the properties and the reactivity of organic materials and molecules, i.e. compounds that contain carbon atoms. Although organic chemistry is literally defined as the study of compounds that contain carbon atoms, its true essence is actually the study of electrons. Throughout this course, we will study the behavioural pattern of electrons, enabling us to predict, and even control, the outcome of chemical reactions. The structure and synthesis of some polymers will be discussed also.

Project Materials for Energy

The students carry out a literature survey on a given material science topic in the area of energy applications. They receive instruction on literature analysis using databases and search strategy, and get feedback by an information specialist in their search strategy. The essay is written in small groups of students, and each group has a contact person (staff member) who is familiar with the subject. The final essay is assessed based on contents and search strategy used. Secondly, all groups make a poster on which the topic of the essay is presented. The posters are presented at a poster session.

Vector Calculus

Vectors are used to describe phenomena in more than one dimension, not only the value but also the direction of a force or a flow is important. Vector calculus shows how to work mathematically in a world with more than one dimension. This includes integration in 2 and 3 dimensions, vector fields, integration along a curve, surface integrals, the definition of gradient, divergence and curl and the theorems of Gauss and Stokes and its use in describing flow systems and electromagnetism.

Analyzing Technology in Society

In this course, students will learn various concepts to analyze techno-social innovations. Examples of current debates and controversies on technologies will show how the use of specific theoretical approaches and models enables them to recognize and develop possibilities for management of innovation processes.

The course aims to increase understanding of technology as social phenomenon. The course will

examine critically the social contexts in which technologies emerge and the social consequences of new technologies. Students will gain knowledge of concepts and approaches introduced to analyze technologies in social contexts, including technological regimes and transitions, risks and responsibility issues, and technology assessment.