Course Package

Fundamentals of Materials – Q3

Name module	Fundamentals of Materials – Q3
Course Code	202000618
Educational programme	BSc Advanced Technology
Period	First quartile of the second semester – Q3
Study load	15 ECTS
Coordinator	A.W. Schouwstra

Fundamentals of Materials			
Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
		Structure and Properties of Materials **202400642** (3 EC)	
		Vector Calculus **202200189** (2 EC)	
		Quantum Matter **202000620** (3 EC)	
		Organic Chemistry **202000621** (3 EC)	
		Materials Project **202400643** (4 EC)	

Required preliminary knowledge: High school Physics; Calculus of Integrals; Integrals in Multiple Dimensions: including double and triple integrals; high school Math; Programming Skills, i.e. Matlab or Python.

202200188 - Structures 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.

202200189 - Vector Calculus

This course focuses on the calculation of vector fields. The concepts of rotation, divergence and gradient are introduced, and special attention is given to conservative vector fields. In addition, integrals of vector fields along a line, a surface and 3D volume are treated, using the theorems of Green, Stokes and Gauss (Divergence) to establish relationships between these different types of integrals. This provides more insight into the meaning of integrals of vector fields and important theoretical relationships, but can also often be used to calculate these integrals more easily. The three big theorems of Vector Calculus extend the Fundamental Theorem of Calculus into higher dimensional spaces.

The modules are tentative and subject to change. Please check the website regularly.
Be aware that resits may occur outside of the block. This may mean you cannot partake in these without making additional travel arrangements.

202000620 - 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.

202000621 - Organic Chemistry

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.

202200193 - Materials Project

This course consists of a project assignment and a lab assignment (practicum). To complete this course, you need to complete both assignments, and the same groups are used for both assignments. Students work in groups of 3, and you form these groups yourselves. This means that any student who is not a first-year AT student needs to report to the coordinator (Arnoud Onnink) 2 weeks in advance, so that we can help you join a group.

The lab assignment involves a puzzle: you get an unknown powder from the teachers (different groups get different powders) and measure the X-ray diffractogram. You analyse the data and conclude, on the basis of your data analysis which should meet scientific standards, which powder it is. You write a scientific report (research format) about this analysis. The lab assignment + report form 30% of the course grade.

For the project assignment (70% of the course grade), students run a fictional consultancy agency. The agency is asked to formulate an advice, based on the latest scientific literature, to a technology company (usually but not always fictional) about improving a material that is used in a device. The technology company is represented by a chief technology officer (CTO), usually in fact a staff member from the university who performs research on your topic.

The exact assignment (material, device, questions) is specific for your group and formulated by the CTO. Some examples are: perovskite solar cells, quantum dots for quantum bits, lithium ion batteries with solid electrolytes, photonic crystals used in EUV optics or as solar cell back reflectors. The topic is always related to materials science and as such connected to at least one of the other courses in module 3 AT, but you will dive deeper into your specific topic than what is covered at the course lectures.

A key point of the project is that you learn how to master a topic by finding and studying literature, instead of getting ready-made lectures from teachers who have already done that for you.

The project has 2 phases. In both, you search and study the literature, and report your findings in multiple ways. Phase 1: study the basic principles of the device and materials. Formulate questions to research in phase 2. Culminates in an initial report and an interview with the CTO, which are not graded, but are essential to choosing a good path for phase 2. Phase 2: study state-of-the-art materials' research for the device. Formulate an advice to your customer. Culminates in the final report and pitch, which are assessed. The report provides the project assignment grade (70% of course grade), and the pitch is a pass/fail assignment that must be passed to complete the course.

You will get lectures about Searching for Information, and Working with Information by Hanneke Becht, who will also provide feedback in your search activities and intermediate reports. Arnoud Onnink organizes the course and gives 2 workshops: (1) Academic Writing, and (2) Pitching.

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