AMIS: Master’s programme in Advanced Materials for Innovation and Sustainability

SD2: Detailed curriculum and courses description

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AMIS: Advanced Materials for Innovation and Sustainability

SUMMARY OF INNOVATION AND ENTREPRENEURSHIP COURSES

Name of the course	**ECTS**	**YEAR OF STUDY**	**REMARKS**
Local Innovation, Entrepreneurship and Business courses	5/5/6	M1 (first year of master-programme)	Aalto/GINP/TUD curriculum
Local Innovation & Entrepreneurship integrated courses	10/6/3	M1	Aalto/GINP/TUD curriculum
Joint collaborative course: **INNO-Project I and II**	I: 6 II: 3	M1 M2	M1: Aalto/GINP/TUD M2: Aalto/GINP/TUD/UB/UL curriculum
Joint collaborative course: **Summer Camp** Camp: Aalto Camp	3	Between M1 and M2	Compulsory for all programme students, 7 days
Inno-Mission Internship	7-9	End of M1	Compulsory for all programme students, min 3 months
TOTAL minimum of I &ENT courses	30		

SD 3A: SUMMARY OF ALL INNOVATION AND ENTREPRENEURSHIP COURSES

SD 3B: EIT OVERARCHING LEARNING OUTCOME COVERAGE ON EIT-AMIS PROGRAMME COURSES

FOCUS OF AMIS CURRICULUM AND LEARNING OUTCOMES

GRENOBLE INSTITUT POLYTECNIQUE (GINP) – M1/M2	
Focus of courses and learning outcomes	
FIRST YEAR (M1) FOCUS	Advanced courses in functional and applied materials, materials characterisation and modelling tools for materials. Courses in innovation and entrepreneurship to achieve basic business knowledge. Functional materials and their sustainability course integrated with innovation and entrepreneurship contents. Joint collaboration courses with AMIS partners (Inno-project I and summer camp). Internship in a company or research organization.
LEARNING OUTCOME	In the first year, students build a body of skills and knowledge that puts them on fast track to becoming specialists in materials science and entrepreneurship. They will receive a state-of-the art knowledge in functional and applied materials science (e.g. their elaboration, phase transformation, structure, microstructure and properties) together will fundamental principles and concepts of businesses and entrepreneurship strategy. They will apply this knowledge in hand-on exercises and group work. Through tailored methodology and English language courses, the student will get introduced into project management, group dynamics, entrepreneurship and oral communications, in a setting that mimics a professional environment. Such integrated training of soft and hard skills is needed for the rest of the Master's studies. The year is completed by summer camp, jointly with all the other AMIS students, and internship in the field.
SECOND AUTUMN (M 2): FOCUS: Materials interfaces: surfaces, films & coatings	A learning by boing approach through various industrial connected projects in combination with advanced lectures and seminars in functional materials and process selection and from material to device courses, practical and projects integrated with innovation and entrepreneurship contents. Joint collaboration course with AMIS partners (Inno-project II). Research project in materials science (entrepreneurship & innovation integration).
LEARNING OUTCOME	Building on the foundations laid in the 1st year, the students learn advanced topics in areas of their choice and continue to improve their research and hands-on skills. They will have in-depth understanding of some specialist topics in functional materials and from materials to device approach. Through tailored methodology and English language courses, the student will get introduced into project management, group dynamics, entrepreneurship and oral communications, in a setting that mimics a professional environment. The students are able to apply their knowledge and present technical information in written and spoken form.

AALTO UNIVERSITY (AALTO) M1/M2	
Focus of courses and learning outcomes	
FIRST YEAR (M1) FOCUS	Advanced courses in Nanophysics and Functional materials, microscopy of nanomaterials and computational physics. Courses in innovation, business and entrepreneurship to achieve basic business knowledge. Functional materials course integrated with innovation and entrepreneurship contents. Joint collaboration courses with AMIS partners (Inno-project x 1 and summer camp). Internship in a company or research organization.
LEARNING OUTCOME:	In the first year, students build a body of skills and knowledge that puts them on fast track to becoming specialists in entrepreneurship and materials science. They will know the fundamental principles and concepts of businesses and entrepreneurship, and have an up-to-date picture of nanophysics, nanomaterials and functional materials. They will apply this knowledge in hand-on exercises and group work. Through tailored methodology and English language courses, the student will get introduced into project management, group dynamics, entrepreneurship and oral communications, in a setting that mimics a professional environment. Such integrated training of soft and hard skills is needed for the rest of the Master's studies. The year is completed by summer camp, jointly with all the other AMIS students, and internship in the field.
SECOND AUTUMN (M 2): FOCUS: Nanomaterials and interfaces: advanced characterization and modelling	Advanced course in Nanophysics and Functional materials course integrated with innovation and entrepreneurship contents. Joint collaboration course with AMIS partners (Inno-project II). Research project in materials science (entrepreneurship & innovation integration).
LEARNING OUTCOME	Building on the foundations laid in the 1st year, the students learn advanced topics in areas of their choice and continue to improve their research and hands-on skills. They will have in-depth understanding of some specialist topics in nanophysics, nanomaterials and functional materials. Through tailored methodology and English language courses, the student will get introduced into project management, group dynamics, entrepreneurship and oral communications, in a setting that mimics a professional environment. The students are able to apply their knowledge and present technical information in written and spoken form.

TECHNISCHE UNIVERSITÄT DARMSTADT (TUD) M1/M2	
FIRST YEAR (M1) FOCUS	Advanced courses on functional materials, surfaces and interfaces as well as lectures on micromechanics and characterisation techniques in combination with lab courses on characterization techniques. Courses in Entrepreneurship and Entrepreneurial Finance to achieve basic business knowledge. Functional materials course integrated with innovation and entrepreneurship contents. Joint collaboration courses with AMIS partners (Inno-project x 1 and summer camp). Internship in a company or research organization.
LEARNING OUTCOME	In the first year, students build a body of skills and knowledge that puts them on fast track to becoming specialists in materials science and entrepreneurship. They will receive a state-of-the art knowledge in functional materials and specific devices (e.g. their elaboration, structure, microstructure and properties) together with fundamental principles and concepts of businesses and entrepreneurship strategy. They will apply this knowledge in hand-on exercises and group work. Through tailored methodology and English language courses, the student will get introduced into project management, group dynamics, entrepreneurship and oral communications, in a setting that mimics a professional environment. Such integrated training of soft and hard skills is needed for the rest of the Master's studies. The year is completed by summer camp, jointly with all the other AMIS students, and internship in the field.
SECOND AUTUMN (M 2): FOCUS: Functional Ceramics: Processing, Characterization and Properties	Advanced courses on the processing and characterisation of functional ceramic materials and their applications. Practical and projects integrated with innovation and entrepreneurship contents. Joint collaboration course with AMIS partners (Inno-project II). Research project in materials science (entrepreneurship & innovation integration).
LEARNING OUTCOME	Building on the foundations laid in the 1st year, the students learn advanced topics in areas of their choice and continue to improve their research and hands-on skills. They will have in-depth understanding of some specialist topics in functional materials and from materials to device approach. Through tailored methodology and English language courses, the student will get introduced into project management, group dynamics, entrepreneurship and oral communications, in a setting that mimics a professional environment. The students are able to apply their knowledge and present technical information in written and spoken form.

UNIVERSITY OF BORDEAUX (UB) – M2	
SECOND AUTUMN (M 2): FOCUS: Advanced Hybrid Materials Composites and Ceramics by Design	The proposed curriculum offers a balanced combination of chemistry and physics colored lectures: hybrids and nanomaterials, magnetic, dielectric and optical properties (...). It will allow the students to strengthen their knowledge and culture in the field of materials in various ways thanks to diversified elective courses. They will thus be able to tackle many of the challenges related to EIT Raw Materials. They will entertain a continued development of their innovation and entrepreneurship skills. The students will validate 120 ECTS and will graduate a double-diploma delivered by two of the five partner institutions where they will have studied. They will then be able to develop their own activities, join the industry or eventually start a PhD focused on EIT Raw Materials challenges.
LEARNING OUTCOME	Building on the foundations laid in the 1st year, the students learn advanced topics in areas of their choice and continue to improve their research and hands-on skills. They will have a strong background in the synthesis, shaping and characterization of functional materials, and will be aware of the main associated challenges, either scientific, societal, environmental or strategic. The students will be able to apply their knowledge and present technical information in written and spoken form.

UNIVERSITY OF LIEGE – M2	
SECOND AUTUMN FOCUS: Nanomaterials and Modelling	At the University of Liege, special focus will be dedicated to the tailoring of materials at the nanoscale to fulfill specific, user-defined, functionalities in a broad range of modern applications. The methodology of this Master-level program combines theoretical foundations through numerical modelling by means of quantum simulation tools, as well as hands on experiments of material synthesis and device fabrication with advanced techniques in the fields of biology, chemistry, biochemistry and physics. It is the goal of this curriculum to lead the students to a mastering level of a range of advanced techniques in materials physics and (bio-) chemistry in order to allow them to tackle innovative solutions or applications in the domain of information technologies, energy and health.
LEARNING OUTCOME	Upon the completion of this curriculum, the students will acquire a better, deeper, understanding of the properties of matter from the atomic scale to the molecular and the mesoscopic length scales, in order to develop new, useful, and smart materials and to bring them to the upper level of industrial valorisation. The graduates will be able to carry out cutting edge research in the field of nanostructured materials which play an essential role in technological devices such as memories, sensors, actuators and transductors where finite size effects in nanostructures are harnessed. The combination of these expertise with the learnings in entrepreneurship will allow them to design, fabricate and apply innovative solutions in the domain of functional materials.

LEARNING OUTCOMES FOR COLLABORATIVE COURSES, INTERNSHIP AND THESIS

INNO-PROJECT I & II: INNO-projects will reinforce EIT Overarching Learning Outcomes such as leadership competences, entrepreneurship skills, creativity, innovation and research skills, development of business models from the commercialization process of new technologies. The students, in the framework of the Inno-Project, will also benefit from improved communication and organisational skills which will reinforce their chances of success as professionals, innovators and entrepreneurs. The understanding of legal requirements in patenting intellectual property will also be one of the objectives.

INNO-MISSION INTERNSHIP: The internship in a company or research organisation prepares students to plan and prepare for their professional career in the commercialization, R&D, Innovation, or New Business Development functions of companies. Inno-Mission internships will develop the ability of students to work on developing a solution-focused approach in translating the innovations into feasible business solutions. Also it will develop their knowledge and expertise in methods and processes employed in leading companies in the raw materials sector in commercializing new technologies and developing new business solutions or activities.

SUMMER CAMP: The summer camp supports the development of entrepreneurial skills and competences, the creativity, production of new ideas and innovation skills. Specific attention is paid to commercialization of technologies and products. As learning objective is to support the ability of students to use knowledge, ideas and technology to create new or significantly improved products, services, processes, policies, new business models or jobs. One week intensive course is strongly built on team-work.

THESIS: For the last semester of the second year, the most research oriented component of the programme, the student will be given the opportunity to harness his newly-acquired skills and competencies into the realization of an original research work. Moreover, independent thesis writing will naturally increase the students' scientific methods skills and capacity to critical thinking. The thesis is jointly supervised by home and host university professors. With jointly supervised thesis, the student is expected to acquire following skills on the top of the Overarching Learning Outcome Coverage as defined by EIT:

- *To analyze and define the scope of a given problem in the area of advanced materials:*
- *To identify and evaluate the applicable tools and approaches, and to perform a qualified selection of suitable tools and approaches;*
- *To identify shortcomings of the tools and approaches chosen, and if necessary develop them further;*
- *To plan as accurately as possible the different process steps required to achieve the goals;*
- *To apply the dedicated tools within the previously-identified approach and to carry out all steps of the research plan in a timely manner;*
- *To evaluate the achieved solution, and to compare it with the original goal and other approaches;*
- *To reflect on, evaluate, and critically assess one's own and others' scientific results;*
- *Report on the problem, the problem's background, the work performed, the achieved solution and its evaluation, arguing for the decisions taken, in a coherent way following academic and scientific standards.*

M1 GINP HOME UNIVERSITY (first year students)

AUTUMN SEMESTER			
Code	Name	ECTS credits	Comments
Compulsory courses			
4PMCBMAX-XX	Business Marketing	3	I&ENT
XXX	Inno-Project I	3	Collaborative new course with partners, I&ENT
4PMMEL34X-XX	Elaboration I	4	Fundamentals of materials science
4PMMTP34X-XX	Phase Transformation	2	Fundamentals of materials science
4PMMMIC9X-XX	Microstructure and Properties	2	Fundamentals of materials science
4PMXPHS4X-XX	Semiconductor physics	2	Fundamentals of materials science
VPMFCRI4X-XX	Crystallography	2	Fundamentals of materials science
4PMFCHS4X-XX	Solid state chemistry	2	Applied materials
4PMFIPF2X-XX	Intro. to functional polymers	2	Applied materials
4PMFPMF4X-XX	Functional materials physics	2	Applied materials
4PMFNUM4X-XX	Numerical Methods	4	Modelling tools and materials
4PMXGCM4X-XX	Materials families	2	Modelling tools and materials
	TOTAL	**30**	
SPRING SEMESTER			
Code	Name	ECTS credits	
Compulsory course			
4PMCSTRX-XX	Strategy	2	I&ENT
XXX	Inno-Project I	3	Collaborative new course with partners, I&ENT
XXX	Integrated entrepreneurship & innovation course in Sustainability in Industrial Engineering	6	New course, I&ENT
4PMMCAR9X-XX	Materials Characterisation	4	New method: Live Classroom response System
4PMFTPC5X-XX	Practical Lab Work	2	Materials characterisation
4PMMEL44X-XX	Elaboration II	2	Fundamentals of materials science
4PMMTP44X-XX	Phase Transformation II	2	Fundamentals of materials science
VPMFSTA4	Inno-Mission Internship	6	I&ENT
xxx	Summer Camp	3	Collaborative summer camp with all partners, I&ENT
	TOTAL	**30**	

M2 GINP HOST UNIVERSITY (second year students)

AUTUMN SEMESTER			
Code	Name	ECTS credits	
Compulsory			
5PMXSEL0X-XX	Material and process selection	6	Functional materials-Applied projects
5PMMMOD0X-XX	Modelling multi scale	6	Functional materials-Applied projects
5PMFCCM2X-XX	Thin films, surfaces and interfaces	2	Functional materials
5PMFPWO3X-XX	Clean room Practical works	2	From materials to device
5PMFFFM6X-XX	Process flow for micro-technologies	2	From materials to device
5PMXPAC5X-XX	Packaging	1	From materials to device
5PMFLPR3X-XX	Multidisciplinary project	5	I&ENT & From materials to device
XXXX	Inno-project	3	Collaborative new course with all partners, I&ENT
XXXXX	Global Industrial Engineering Project	3	New course, I&ENT
	TOTAL	**30**	
SPRING SEMESTER	THESIS	**30**	
Code	Name	ECTS credits	
	THESIS	30	
	TOTAL	**30**	

GINP COURSE DESCRIPTIONS

4PMCBMAX-XX **Business Marketing (3ECTS)**

Responsible teacher: Damperat Maud
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 30
Learning Outcomes: This course focuses on business marketing, e.g. industrial products and services. Different industries will also be studied (i.e. raw materials, industrial equipments, professional services, etc.) to provide a vision as large as possible. Therefore, our learning objectives are: (i) Understanding the fundamental principles of business marketing (ii) Developing analytical and decision-making capacities in term of business marketing and strategy (iii) Providing an universal, multi-sectors, and international approach (iv) Using case studies and highlighting business practices based on experience.
Content: This course explores decision-making and activities involving business-to-business (i.e., industrial, organizational, institutional, or governmental) transactions and provides fresh ideas for innovative business marketing. Business-to-business transactions occur when organizations acquire goods and services from (or sell them to) other businesses. Business-to-business activities pertaining to buying, market segmentation, positioning, pricing, communication, physical distribution and customer service, sales management, and other activities are examined within the context of a framework that views business market management as the process of understanding, creating, and delivering value to customers. Best practices and new concepts from the business-to-business sector will be examined. A global perspective is deliberately chosen to provide the most compelling examples from America, Europe, or Asia.
Assessment Methods and Criteria: 50% Presentation of a case study (group) and 50% Report on a case study (individual).
Evaluation: 0-20
Language of Instruction: English

XXXX-XX **Inno Project (3ECTS): See SD 3A: "Innovation and entrepreneurship education courses" document**

4PMMEL34X-XX **Elaboration I (4ECTS)**

Responsible teacher: Tassin-Arques Catherine
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 40
Learning Outcomes: Develop the basic concepts in physical chemistry useful for controlling the microstructure of materials during various fabrication processes. At the end the student should be able to: (i) choose an appropriate single crystal growth technique for a given material (ii) design and optimize a crystal growth set-up and (iii) analyse and control the defect generation during the growth of a crystal.
Content: • Phases equilibria, phase diagrams (binary and ternary systems), predominance area diagrams
• Basics of phase transformations: driving forces, nucleation, growth, various classes of solid state transformations
• Sintering microstructures: powders, sintering process (mechanisms, kinetics, evolution of microstructures)
• Solidification microstructures: metallic alloys: process parameters, solidification paths (kinetics), microstructures (cells, dendrites, eutectics, peritectics) / crystallisation of polymers : Introduction on polymer synthesis, crystallite morphologies, crystallisation kinetics
Assessment Methods and Criteria: 3h written exam
Evaluation: 0-20
Language of Instruction: English

4PMMTP34X-XX **Phase Transformation I (2ECTS)**

Responsible teacher: Deschamps Alexis
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 20
Learning Outcomes: To introduce the different types of plastic deformations depending on the temperature and the materials family.
Content: <u>Plastic deformation of polymers</u>**:** Plastic deformation and damage mechanisms of amorphous and semi-cristalline polymers, Theory of Ree-Eyring of Robertson and of Argon, Numerical modelling Thermomechanical treatments. <u>Plastic deformation at low temperatures</u>: Dislocations: nature, elastic field, interactions, quantitative description of yield stress, thermal activation of plastic deformation, physically based constitutive laws, relationship with mechanics & ductility. <u>Plastic deformation at high temperature</u>:
recovery, recrystallization, dynamic recovery & recrystallization, Grain boundary sliding. <u>Thermomechanical treatments:</u> Equilibrium microstructures, TTT, CCT diagram, Non equilibrium transformations.
Assessment Methods and Criteria: 2h written exam
Evaluation: 0-20
Language of Instruction: English

4PMMMIC9X-XX **Microstructure and Properties (2ECTS)**

Responsible teacher: Blandin Jean Jacques
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 24
Learning Outcomes: To give information about the links between microstructural parameters (defects, grain size…) and both mechanical properties (hardening, brittleness, plastic deformation) and functional properties (electric, magnetic…) of metals, ceramics and polymers.
Content: 1. Effects of atomic bonds on properties
2. Microstructural parameters of metals and ceramics (vacancy, dislocation, grain size, precipitates, non-stoichiometry, pores and cracks, amorphous and crystallized structures, texture…)
3. Effects on mechanical properties of metals and ceramics (hardening, plastic deformation, ductility and brittleness, property scattering…)
4. Effect on functional properties of metals and ceramics (piezoelectricity, di-electric properties, electrical conductivity, superconductivity, ionic conductivity, magnetic properties, optical properties…)
5. Relation between molecular architecture of polymers and their properties (molecular architecture and organization, polar functions, crystallinity, nodal density, effect on elastic properties, plastic deformation, effect on electrical and optical properties, ionic and electronic conductivities…).
Assessment Methods and Criteria: 2h written exam
Evaluation: 0-20
Language of Instruction: English

4PMXPHS4X-XX **Semiconductor Physics (2ECTS)**

Responsible teacher: Ionica Irina
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 20
Learning Outcomes: This course presents the physics of solids and physics of semiconductors which are necessary to nderstand the basic operation of semiconductor devices.
Content: 1. Semiconductor crystallography, energy bands, Fermi-Dirac distribution, intrinsic and extrinsic

semiconductors. 2. Semiconductors at equilibrium (mass action law, electroneutrality, Fermi level,…). 3. Transport (diffusion, conduction, mobility, conservation equation,…). 4. Semiconductors out of equilibrium (carriers injection, depletion regions,…). 5. Schottky contact.
Assessment Methods and Criteria: 2h written exam
Evaluation: 0-20
Language of Instruction: English

VPMFCRI4X-XX **Crystallography (2ECTS)**

Responsible teacher: Hippert Francoise
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 20
Learning Outcomes: Understanding of crystal structures, with an emphasis on the role of symmetry. X-ray diffraction by perfect crystals. This course should provide the tools required to describe any crystalline structure and determine a crystal structure from the analysis of a X-ray diffraction pattern.
Content: 1. Introduction 2. Lattice 3. Crystal symmetries 4. Interactions of X-rays with matter 5. Theory of the X-Ray diffraction 6. Experimental methods & examples of applications.
Assessment Methods and Criteria: 2h written exam
Evaluation: 0-20
Language of Instruction: English

4PMFCHS4X-XX **Solid State Chemistry (2ECTS)**

Responsible teacher: Djurado Elisabeth
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 28
Learning Outcomes: Put into evidence the relations in between the structure of the ionic, covalent and iono-covalent solids with their microscopic and macroscopic physical properties
Content: 1.Introduction: physical properties & structural characterizations of 4 types of crystals. 2. Factors influencing crystal structure (lattice energy, Born-Haber cycle, valences, coordination numbers, ...). 3. Descriptive crystal chemistry (close packed structures, radius ratio rule, solid solutions). 4.Crystal defects and non-stoichiometry (thermodynamic, Schottky, Frenkel, Brower's diagrams, on-stoichiometry). 5.Ionic conductivity and solid electrolytes (SOFC). Exercises: Ionic solid (Born-Haber cycle, lattice energy, cristobalite) Structure-properties relations (Graphite, diamond, nickeline) Crystalline sites - Crystal defects and conductivity - Phase transitions
Assessment Methods and Criteria: 2h written exam
Evaluation: 0-20
Language of Instruction: English

4PMFIPF2X-XX **Introduction to functional polymers (2ECTS)**

Responsible teacher: Iojoiu Cristina
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 20
Learning Outcomes: The scientific and technologic field related to functional polymers is very broad. Therefore a selection of applications allowing the multifunctional aspects i.e. chemical, physicochemical, mechanical to be emphasized has been done. In addition the scientific domains have been selected in view of their societal and industrial impacts. They are related to renewable energy sources i.e. advanced batteries and Fuel Cells and to environmental aspects dealing with water purification through membrane separation processes.

Content: 1. General Introduction. 2. Comparison Between Electrochemical Storage & Conversion 3. Lithium Batteries (Lithium-Ion Batteries (Anodes & Cathodes, Solvents & Salts, Macroporous Polymeric Separators, Gelled Polymer Electrolytes) and Lithium Polymer Batteries (History, Polymer-Salt Complexes: Solvating Polymers, Ionomers & Salts, and their interaction with polymers, Reinforcement: Through Polymer Cross-Linking & via Nanocomposites. 4. PEMFC Overview On Fuel Cells And Bottlenecks and Ionomers (State Of The Art, Progress Beyond The State Of The Art, Electrochemical & Physico-Chemical Aspects, Thermomechanical Aspects, Elaboration Processes (Film Casting & Extrusion), Polymers For Pemfc Dedicated To Ev Implementation. 5. Separation Processes Involving Polymeric Membranes (Environmental & Health Aspects, Filtration Processes and Pervaporation)
Assessment Methods and Criteria: 2h written exam
Evaluation: 0-20
Language of Instruction: English

4PMFPMF4X-XX **Functional materials physics (2ECTS)**

Responsible teacher: Gottlieb Ulrich
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 24
Learning Outcomes: Basics of functional materials (magnetic, superconductors & biomaterials). Provide a basic knowledge of functional materials in view their use in various applications
Content: Magnetic Materials: Introduction of magnetism: magnetic materials (paramagnetic, ferromagnetic) and spintronics. By using the magnetic material properties, the basics of permanent magnets, field sensors and magnetic recording are presented.
Superconductors: History, Experimental results, Theoretical aspects, BCS theory, Josephson effects, High temperature Superconductors. The aim is to get a basic knowledge of extraordinary properties of superconductors, in view of their possible applications and their fundamental physical properties.
Biomaterials: This course will introduce the broad topic of biomaterials. It will touch on the impact of biomaterials in our society. It will introduce the concept of cell-material interaction, and the cascade of events associated with it. We will discuss important parameters for the engineering of biomaterials. Finally it will give specific examples of applications of biomaterials in orthopedics, cardiology, and--time permitting--tissue engineering.
Assessment Methods and Criteria: 2h written exam
Evaluation: 0-20
Language of Instruction: English

4PMFNUM4X-XX **Numerical Methods (4ECTS)**

Responsible teacher: Fournier Annie
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 64
Learning Outcomes: 1. Solving numerically different problems associated to the modeling in physics (ordinary differential equations, partial differential equations, optimization,…). 2. Present different Numerical Tools (integration, interpolation, solving systems of equations) as well as methods (Finite Difference method, Finite Element Method,…). 3. Introduce discrete modeling techniques (Monte Carlo, Cellular Automata, genetic algorithms …).
Content: Introduction to the art modelling, introduction to the software Matlab. Ordinary Differential Equations. Integration / Interpolation. Finite Difference Method. Finite Element Method. Solving systems of equations. Cellular Automata. Monte Carlo method. Optimization. Genetic Algorithms
Assessment Methods and Criteria: 3h written exam in computer room.
Evaluation: 0-20
Language of Instruction: English

4PMXGCM4X-XX **Materials families (2ECTS)**

Responsible teacher: Salvo Luc
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I (Autumn)
Workload: 20
Learning Outcomes: Give an outline of the main material classes (properties, sectors of use). Use the software CES which makes possible to compare materials between them. Sensitize the students with the concept of approach produced through a mini project.
Content: During this lecture the main materials classes will be seen (metals, polymers, composites, ceramics) with a focus on their physical, mechanical properties as well as their processing. Concerning metals specific attention will be paid on the most used ones (aluminum, magnesium, copper, titanium and steels). Each times some case studies will be given in the field of structural materials, functional materials and nuclear materials.
Assessment Methods and Criteria: 2h written exam + report project (group).
Evaluation: 0-20
Language of Instruction: English

4PMCSTRX-XX **Strategy (2ECTS)**

Responsible teacher: Samuel Karine
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: II (String)
Workload: 20
Learning Outcomes: Our learning objectives are to cover topics of mission, goal, strategy formulation, strategy implementation and strategy evaluation.
Content: Part 1: Understanding Strategy. Part 2 : Strategy into action. Key Takeaways: • Develop a long range planning approach balancing short term and long term goals. • Learn how to develop and improve your firm's competitive advantage. • Improve your ability to integrate key functional areas into a unified strategic plan. • Enhance your understanding of the impact of changes in the external environments on executive decisions. • Learn the importance of changes in economic, technological, government, political and social forces on the formulation of a firm's strategy. • Develop your skills in identifying key business issues and problems. • Sharpen your ability to make quality, reasoned business decisions.
Assessment Methods and Criteria: o Case studies (70% of the final mark): individual mark (50%) + group work (50%). Any unjustified absence will be penalized by a mark of 0/20. Any work that will be late delivered will also be penalized. O Final exam (30% of the final mark) : multiple choice exercise that will help to measure concepts' acquisition (individual).
Evaluation: 0-20
Language of Instruction: English

XXXX-XX **Inno Project (3ECTS): See SD 3A: "Innovation and entrepreneurship education courses" document**

XXXX-XX **Sustainability in Industrial Engineering (6ECTS)**

Responsible teacher: Zwolinski Peggy
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: II (String)
Workload: 48
Learning Outcomes: This technical training is oriented to increase competences in Leading Sustainability within organisation. The training will drive leadership understanding, strategic business approaches, enthusiasm and innovation and consideration of environment and social aspects as a key issues toward sustainable development.
Content: 1. Foundation - Understanding Sustainability

1.1. Dimensions of Sustainability (economic, ecologic and social)
1.2. Relevant/Actual Standards and Norms (relevant sustainability ISO and other norms)
2. Technical concepts - Resource Management
RECP Methodology (Resource Efficiency and Cleaner Production)
3. Social Responsibility
3.1. Definition/Approach of Social Responsibility
3.2. Social impact assessment
3.3. Stakeholder management
4. Product/Service Sustainability
4.1. Understanding of the Life Cycle
4.2. Life Cycle Assessment
4.3. Life Cycle Costing
Assessment Methods and Criteria: Oral presentation (20%-group) + LCA report (40%-group) + final exam (40%-individual)
Evaluation: 0-20
Language of Instruction: English

4PMMCAR9X-XX **Materials Characterisation (4ECTS)**

Responsible teacher: Missiaen Jean-Michel
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: II (String)
Workload: 44
Learning Outcomes: The aim of this course is to give an overview of analytical and microstructural characterization techniques in materials science. The specificity of each technique will be emphasized, in terms of kind of information which is supplied, scale of analysis, resolution and sensitivity. Courses will be illustrated by examples for the different materials classes.
Content: Introduction: overview of characterisation techniques; material-radiation interactions. Global characterization: composition (X-Ray Fluorescence; atomic spectroscopy), chemical binding (IR/Raman spectroscopy, NMR) ; structure (X-Ray and neutrons diffraction). Characterization of microstructure: imaging by scanning electron microscopy (SEM) and transmission electron microscopy (TEM); image analysis ; structure, texture and defects (EBSD, electronic diffraction) ; local composition (X-Ray µAnalysis ; electron energy loss spectroscopy). Characterization of surfaces and thin films: imaging by scanning probe microscopy ; composition (Auger and photoelectrons spectroscopy, ion beam analyses) ; structure (grazing incidence X-Ray diffraction ; low energy electron diffraction)
Lab. sessions: Global analysis by ICP ; X-Ray diffraction ; scanning electron microscopy and X-Ray microanalysis ; transmission electron microscopy ; image analysis ; Auger/XPS spectroscopy ; atomic force microscopy ; DSC (polymers).
Assessment Methods and Criteria: 2h written examination (70% of the final mark-individual) + Report on practical work (30%-group)
Evaluation: 0-20
Language of Instruction: English

4PMFTPC5X-XX **Practical Lab Work (2ECTS)**

Responsible teacher: Sarigiannidou Eirini
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: II (String)
Workload: 36
Learning Outcomes: The aim of this labs is to give to opportunity to the students to manipulate and put in practice the notions that they have studied in the first semester.
Content: Clean Room (Diode/ Capacitors) / Electrical Measurements / Hall Effect / Superconductors / Nuclear

Magnetic Resonance / Vacuum techniques
Assessment Methods and Criteria: Report (30%-group) + Oral examination(70%-individual)
Evaluation: 0-20
Language of Instruction: English

4PMMEL44X-XX **Elaboration II (2ECTS)**

Responsible teacher: Duffar Thierry
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: II (String)
Workload: 30
Learning Outcomes: This course presents the wide panel of techniques used for the elaboration of thin films. Physical and physico-chemical aspects of the techniques are presented. Further, knowledge of the various types of single crystals used in advanced technologies together with all the industrial and laboratory crystal growth processe are presented.
Content: Elaboration techniques for thin films : CVD, PVD, MBE, ALD, plasma processes, spin-coating,…
Vacuum techniques: Basic notions on thin film elaborations:
- Introduction to relation between processes / microstructures / properties
- Impact of physical, chemical or thermodynamic parameters on elaboration mechanisms
- Link between experimental parameters and the elaborated film
- Mechanics of thin films

Bulk crystal growth techniques: Czochralski, floating zone, Verneuil, shaping, Bridgman, PVT …
Assessment Methods and Criteria: 2h written exam
Evaluation: 0-20
Language of Instruction: English

4PMMTP44X-XX **Phase Transformation II (2ECTS)**

Responsible teacher: Tassin-Arques Catherine
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: II (String)
Workload: 30
Learning Outcomes: This course presents the relations between processes, microstructures and properties of these thin films.
Content: Basic notions on thin film elaborations:
-Introduction to relation between processes / microstructures / properties
-Impact of physical, chemical or thermodynamic parameters on elaboration mechanisms
-Link between experimental parameters and the elaborated film
-Mechanics of thin films
Microstructural evolution of thin films (voids, hillocks, wiskers,…)
Stress and semiconductor processing
Assessment Methods and Criteria: 2h written exam
Evaluation: 0-20
Language of Instruction: English

XXXX-XX **Inno Mission Internship (6ECTS): See SD 3A: "Innovation and entrepreneurship education courses" document**

XXXX-XX **Summer Camp (3ECTS): See SD 3A: "Innovation and entrepreneurship education courses" document**

5PMXSEL0X-XX **Material and process selection (6ECTS)**

Responsible teacher: Salvo Luc
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their first year of Master
Teaching period: I (autumn)
Workload: 68
Learning Outcomes: Know how to select a material and process. Know the challenges in new materials, recycling and eco-design.
Content: Background on materials properties / new materials and application domains / Introduction to material and process selection (performance indices) / Recycling and eco-design / Case studies using CES software. Project given by an industrial partner.
Assessment Methods and Criteria: Report (50%)+ oral presentation on the long project (50%)
Evaluation: 0-20
Language of Instruction: English

5PMMMOD0X-XX **Modelling multi scale (6ECTS)**

Responsible teacher: Jakse Noel
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their first year of Master
Teaching period: I (autumn)
Workload: 66
Learning Outcomes: Provide the concepts of simulations at the atomistic and mesoscopic level in relation to the physical properties of materials. Standard numerical techniques for Engineers are a prerequisite. The setup of simulation projects supervised by researchers in the laboratories is preferred to favours the practice of the methods given during the lectures and offer the students an opportunity to be in contact with research.
Content: Introduction: relationships between scale of description and simulation methods.
Algorithms : Molecular dynamics / Particle dynamics / Monte-Carlo
Interaction potentialsand properties: Pair potentials / Many-body potentials /EAM potentials
Advanced techniques: Statistical ensembles / Rare events / Diffusion and kinetics / Constraints
Practice: Simulation of physical phenomena at various scales using appropriate methods (Molecular dynamics, particle dynamics, Monte-Carlo, cellular automata) in order to illustrate and practice the methods given during the lectures.
Assessment Methods and Criteria: Project Report (group).
Evaluation: 0-20
Language of Instruction: English

5PMFCCM2X-XX **Thin films surfaces and interfaces (2ECTS)**
Responsible teacher: Riassetto David
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their first year of Master
Teaching period: I (autumn)
Workload: 24
Learning Outcomes: This course offers an overview of the physical chemistry of surfaces in a broad sense. All the possible interfaces between the three states of matter -solid, liquid and gas- are addressed to various degrees of details.
Content: Liquids and their interfaces: i) A Quiescent Interface? ii) Thermodynamics of Liquid Interfaces iii) Orientation at Interfaces iv) The spreading of one liquid on another. Surfaces of solids: i) A Quiescent Surface! ii) Description of surfaces iii) Thermodynamics of Crystals iv) Surface crystallography. Surface tension measurement methods : i) Wilhelmy plate ii) Du Nouy ring iii) Bubble pressure. The solid-gas interface: i) Types of adsorption process ii)The Adsorption Time iii) The Langmuir Adsorption Isotherm iv)The BET and Related Isotherms. The solid-liquid interface

Assessment Methods and Criteria: 2h written exam.
Evaluation: 0-20
Language of Instruction: English

5PMFPWO3X-XX **Clean room Practical works (2ECTS)**

Responsible teacher: Volpi Fabien
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their first year of Master
Teaching period: I (autumn)
Workload: 24
Learning Outcomes: Technical assessment of theoretical knowledge.
Content: Practical Works in Clean-Room (class 100). Photovoltaic cell elaboration or MOS-technology cells elaboration. Electrical characterization
Assessment Methods and Criteria: Report (group).
Evaluation: 0-20
Language of Instruction: English

5PMFFFM6X-XX **Process flow for micro technologies (2ECTS)**

Responsible teacher: Volpi Fabien
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their first year of Master
Teaching period: I (autumn)
Workload: 24
Learning Outcomes: Know the complete process flow used in microelectronic industry.
Content: Review of the complete process flow.
Assessment Methods and Criteria: 2h written exam.
Evaluation: 0-20
Language of Instruction: English

5PMXPAC5X-XX **Packaging (1ECTS)**

Responsible teacher: Hodaj Fiqiri
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their first year of Master
Teaching period: I (autumn)
Workload: 20
Learning Outcomes: Provide notions about interfaces and durability in systems concerning microelectronic and electrochemical generators.
Content: The role of packaging in microelectronics: IC packaging, technologies (WB - wire-bonding, FC - flip chip, TAB - Tape Automated Bonding). / Packaging families (SMP, THP,..), types (BGA, PQA, SIP, PGA,...) and packages (plastic, ceramic). / Materials used in packaging (advantages and limits). / Microsystem packaging. / Description and study of physico-chemical and mechanical phenomena intervening in packaging process (thermodynamics, reaction kinetics, wetting,...). / Study of particular cases of packaging.
Electrochemical generators: I - How electrochemical interfaces do influence the initial performances. Optimized electrode structure (PEMFC), dilatation, adhesion, stability (SOFC), metal-base electrodes (batteries). II - Systems durability. Intrinsic properties of the materials and their assembly. Effect of the operating conditions (temperature, load, etc.) on the durability.
Assessment Methods and Criteria: 1,5h written exam.
Evaluation: 0-20
Language of Instruction: English

5PMFLPR3X-XX **Multidisciplinary project (5ECTS)**

Responsible teacher: Volpi Fabien
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their first year of Master
Teaching period: I (autumn)
Workload: 68
Learning Outcomes: Performing practical R&D projects. Dealing with scientific, technical and management tasks associated to research projects.
Content: Students deal with projects within associated labs and industrial partners supporting already running long-term research projects (e.g. R&D projects ,PhDs, internships,...)
Assessment Methods and Criteria: 1,5h written exam.
Evaluation: 0-20
Language of Instruction: English

XXX-XX **Global Industrial Engineering Project (3ECTS)**

Responsible teacher: Vignat Frederic
Status of the Course: Compulsory course
Level of the Course: The course is only for students who have completed their first year of Master
Teaching period: I (autumn)
Workload: 120
Learning Outcomes: At the end of this course, the student will be able to: Run well-considered and coordinated design tasks to carry out a product which meets specific needs provided by an industry / Study on the Product environment: market, production chain, cost / Functional Analysis / Choice of technological solutions / Simulation: kinematics, dynamics, structure, multi physical, manufacturing, ergonomics / Manufacturing, assembly / Rests, instrumentation, measurement / Study costs / Use methods and tools for structuring a design within a group / Functional specification / Project scheduling
Content: The global industrial engineering project is a design activity conducted in a group with the following objectives: Collaborate and work inside a team to design and (or) manufacture a product that meets the (x) need (s) of a customer / Implement a structured approach by using design and project management methods and tools (functional specifications, projected schedule,...)
Within the framework of this activity students will: Apply scientific and technological knowledge and tools taught / Manage group work / communicate within the group and with the various stakeholders of the global industrial engineering project
The aim of the Project is to offer innovation that takes into account social and environmental issues. Our main focuses are on: User centered design / Sustainable design / Inclusive design / Ethics & responsibility / Eco-efficient innovation and design /
The project is organised in group of 5 or more students
• Each group will include a Project Manager and a librarian
• Each group will have a customer with whom he will have to define and negotiate the need to satisfy.
• Each group will have an advisor that will help the implementation of a structured approach. The advisor may be present at meetings customer - group.
• Each group will address the training team (teachers and technicians) presents for the resolution of its scientific and technical problems
Assessment Methods and Criteria: The assessment is based on the following deliverables:
• Functional specifications (product and project)
• project scheduling
• mid-term report and defense
• final report and defense
Evaluation: 0-20
Language of Instruction: English

XXXX-XX **Inno Project (3ECTS): See SD 3A: "Innovation and entrepreneurship education courses" document**

M1 AALTO HOME UNIVERSITY (first year students):

AUTUMN SEMESTER			
Code	Name	ECTS	Comments
Compulsory courses			
Kie-xxx	Academic Communication	3	Compulsory degree requirement, both oral and written requirements
CSE-E4751+ TU-E4040 TU E5020	**Basic Entrepreneurship, business, innovation courses:** Introduction to Technology based Business and Venturing (2 ECTS) + Opportunity Prototyping (3 ECTS) OR Collaborative Innovation Management (5 ECTS)	5	I&ENT
PHYS-E0424	Nanophysics	5	
PHYS-xxx	**Integrated Entrepreneurship & Innovation course in Functional Materials**	10	New course, I&ENT
PHYS-xxx	Inno-Project I	6	Collaborative new course with partners, I&ENT
PHYS- xxx	Special assignment in advanced materials	1	Individual assignment
	TOTAL	**30**	
SPRING SEMESTER			
Code	Name	ECTS	
Compulsory courses			
PHYS-E0525	Microscopy of Nanomaterials	5	
PHYS-E0412	Computational Physics	5	
PHYS-xxx	Inno-Mission Internship	7	I&ENT
PHYS-xxx	Summer Camp	3	Collaborative summer camp with all partners, I&ENT
Optional, choose two courses, 10 ECTS total			
PHYS-E0422	Soft Condensed Matter Physics	5	
PHYS-E0526	Microscopy of Nanomaterials, laboratory course	5	
PHYS-C0240 or PHYS-E0421	Materials Physics or Solid-State Physics	5	
CHEM-E5115	Microfabrication	5	
CHEM-E5145	Materials for Renewable Energy P	5	
	TOTAL	**30**	

M2 AALTO HOST UNIVERSITY (second year students)

Autumn

AUTUMN SEMESTER			
Code	Name	ECTS	
Compulsory			
KIE-xxx	Academic Communication	3	Compulsory degree requirement, both oral and written requirements 3 ECTS
PHYS-E0424	Nanophysics	5	
PHYS-xxx	Integrated Entrepreneurship & Innovation course in Functional Materials	10	New course, I&ENT
PHYS-xxx	Inno-project II	3	Collaborative new course with all partners, I&ENT
PHYS-xxx	Research project in materials science	9	New course, I&ENT
	TOTAL	**30**	
SPRING SEMESTER	THESIS	**30**	

AALTO COURSE DESCRIPTIONS

LC-1310 Academic Communication for MSc Students (o,w) (3 ECTS)

Responsible teacher: Anya Siddiqi
Level of the Course: Master's
Teaching Period: I-II, III-IV, IV
Workload: 81 h (Small-group instruction 24-36 h + independent work 45-57 h)
Learning Outcomes:
Upon completion of this course, students will be able to:
- Recognise the strategies and elements that enhance clarity and audience-friendliness in both oral and written academic communication
- Apply these strategies and elements in oral presentations and writing related to their field of study
- Distinguish between formal and informal styles of communication
- Apply a process approach to the development of oral and written work
- Document sources properly and select strategies to avoid plagiarism

Content: The course is intended for students in master's programs who are not yet in the process of writing their master's theses. It introduces written and oral communication principles and strategies that are applicable to academic and research purposes. Students begin by writing on a topic from their own field of study based on previous (BSc) or ongoing (MSc) research. To enhance readability of the texts, students apply organisational patterns, such as problem-solution, as well as other writing principles. Based on their written work, students deliver an oral presentation videoed for self- and teacher-evaluation. As part of the learning process, students analyse presentations to identify their strengths and areas for improvement, as well as practise organizing and presenting information clearly to a non-expert, but academic audience. Throughout this course, students work individually, in pairs and in small groups to develop their presentation and writing skills. Moreover, students give and receive constructive feedback on their work and revise it accordingly.
Assessment Methods and Criteria:
- Course work 20%
- Exam/project 20%

- Writing assignment 30%
- Oral presentation 30% (Videoed)

Study Material: Provided by the teacher and students.
Substitutes for Courses: Kie-98.1700 Integrated English course (1-2 cr)
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=LC-1310
CEFR level: B2 or higher
Grading Scale: 0 - 5
Registration for Courses: WebOodi Students are considered for admission in order of highest number of credits
Language of Instruction: English
Further Information: Master's-level students can earn the undergraduate (i.e. Bachelor's) requisite foreign language credits through this course. Participants must attend 80% of the class sessions as part of continuous assessment

CSE-E4751 Introduction to Technology based Business and Venturing (2 ECTS)

Responsible teacher: Heikki Saikkonen; Olli Mutanen
Status of the Course: Optional course of the Software and Service Engineering major. Part of the Aalto Ventures Program and Master's Programme in ICT Innovation studies belonging to the 30 ECTS minor on Innovation and Entrepreneurship in ICT.
Level of the Course: Master's level
Teaching Period: I-II (Autumn)
Workload: This is a 2 ECTS course (1cr ≅ 27 work hours). The expected student work hours are as follows: Lectures: 4 x (2+2) h = 16 h, Group assignments and related individual work: 38 h. Student work hours for lectures are assessed to provide students time to prepare for lectures up to 2 hours and to discuss them afterwards. Assignments consist of working in groups of 4-7 students, with the organization of the groups' work managed by each group (course personnel provides support for organization as well as group work guidance). Individual work consists of preparing for lectures and parts of assignments.
Learning Outcomes: Students learn basic characteristics of information technology business and venturing, importance of new and growing businesses to national economies, process and roles involved in developing an idea and starting up a new technology-based venture, systematically exploring customers and markets, recognizing and classifying technology and service based business models and analyzing factors in them having effect on the success of a venture.
Content: The lectures and course materials present basic information on the local, European and global IT industry and the significance of growth ventures to national economies. Theory base for idea generation, technology-based entrepreneurship, markets, customer segments and firm level value creation logic is presented, and different business models based on technology or the related services are discussed. Assignments consist of business model analysis, development and design for real-life high technology startup businesses.
Assessment Methods and Criteria: The course is assessed based on business modeling assignments about real business cases that are presented to the class. Participation in lectures firmly supports completing the course.
Study Material: To be announced at the beginning of the course.
Substitutes for Courses: Replaces the former courses T-128.4101 Introduction to Software Business and T-128.1000 Introduction to Software Business and Venturing.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CSE-E4751
Prerequisites: It is recommended that students have obtained basic information about business and software engineering.
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: The number of participants will be limited. Registrations will be prioritized in the following order: The students that have the course as a mandatory part of their study program will be prioritized first. The students that are participating in the Aalto Ventures Program minor will be prioritized second. After this, all students are prioritized based on registration order.

TU-E4040 Opportunity Prototyping (3 ECTS)

Responsible teacher: Peter Kelly
Status of the Course: Aalto Ventures Program Minor, optional course. Master's Programme in Industrial Engineering and Management, optional course in major of Framtidends Industriföretag. Compulsory course in minor of Strategy and Venturing.
Level of the Course: Master's level.
Teaching Period: I (Autumn 2015)
Learning Outcomes: To gain an understanding of the process of identifying, exploring, and developing an entrepreneurial opportunity that best leverages your experience, interests, passions and networks. Working in teams, students are expected to develop a "prototype" of their prospective offering.
Content: Process overview through the lens of effectuation.
Assessment Methods and Criteria: Masterclasses, workshops, studio work
Study Material: Saras Sarasvathy "What Makes Entrepreneurs Entrepreneurial?", Chris Guillebeau The Art of Non-Conformity Turnaround Books (2010) and other resource materials available on the course website.
Substitutes for Courses: Replaces the courses TU-91.120, TU-91.2003 and TU-91.2103
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=TU-E4040
Evaluation: 1-5 · Courses
Language of Instruction: English
Further Information: The number of participants will be limited to 120 and the course is open to all students of Aalto. Students minoring in Strategy and Venturing are given priority.

TU-E5020 Collaborative Innovation Management (5 ECTS)

Responsible teacher: Pekka Berg
Status of the Course: Project course in Aalto Ventures Program (AVP)
Level of the Course: Master and Doctoral level
Teaching Period: IV (Spring)
Workload: Lectures 25%, assignments and independent work 75%
Learning Outcomes: Collaborative Innovation Management Course (COINNO) is a new type of course for corporate and university students to study innovation management together in mixed teams to foster collaborative learning. The course gives students expertise and know-how needed for effective innovation management through linking scientific theory with practical case projects and fostering the sharing of best practices across companies and with academia.
Content: Students learn the basic concepts and terms surrounding innovation management starting from the relations between invention, innovation and innovativeness. Different phases of the innovation process from front end to project portfolio management are examined. Participants also learn about idea management, foresight, creating scenarios and prototypes, conceptualizing and other tools and methods that are key to successful and efficient creative work.
Assessment Methods and Criteria: The main teaching methods are interactive lectures and group work. Grading: exam 75%, assignments 25%.
Study Material: Set of readings provided by the lecturer/lecture notes by lecturers.
Substitutes for Courses: TU-22.1530
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=TU-E5020
Evaluation: 1-5 · Courses
Language of Instruction: English
Further Information: The course is for all Aalto master and doctoral level students. Attendance is required.

PHYS-E0424 Nanophysics (5 ECTS)

Responsible teacher: Sebastiaan van Dijken
Status of the Course: Optional course of the Physics of Advanced Materials major.
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: I - II (Autumn)
Workload: 36 + 24 (3 + 2)
Learning Outcomes: This course focuses on new developments in nanophysics and will test the ability of students to review recent scientific results.
Content: The course reviews current topics in nanophysics including, nanostructure fabrication techniques (lithography/self-organization),the physics of fullerenes and nanotubes, low-dimensional semiconductorsystems, nanoelectronics, nanomagnetism, and spintronics.
Assessment Methods and Criteria: Topical essay and short presentation.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=PHYS-E0424
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English

PHYS-xxx Integrated Entrepreneurship & Innovation course in Functional Materials (10 ECTS)

Responsible teacher: Prof. Robin Ras, Prof. Mikko Alava, Prof. Sebastiaan van Dijken, Prof. Janne Ruokolainen, Dr. Ari Harju, Prof. Martti Puska,
Status of the Course: new course
Level of the Course: Master's level
Teaching Period: I – II (III)
Workload:
Contact hours:
Teaching session on Functional Materials 1x2 hours = 2 h, teaching sessions on Entrepreneurship 3x 2 hours = 6 h, Workshops and coaching sessions 7 * 3 h = 21 h (3 coaching sessions on designing thinking / creativity / business development side of the project), Presentations of group assignments 3h
Assessment hours:
Individual Reflective journals 30h, Individual reflective essay 3 h on the innovation /commercialization/ business development side of the group project, 4 interim progr§ess project reports and final report/presentation 205 h
Learning Outcomes:
This course sets out with generic content to examine creative thinking and the ability to evaluate new ideas for solving problems that could be resolved through the development and use of functional materials by large companies and for everyday use.

Following a short introduction to functional materials, students will work in a group project with the mandate to review the existing cutting-edge research on the physics and chemistry of nanomaterials, to evaluate the society's need for relevant material functionalies, and employ creativity techniques, design thinking, and effectuation thinking principles originating in the entrepreneurship discipline to design next-generation of functional materials, to develop novel fabrication processes for functional materials as well as to conceive new uses of functional materials in ways that solve actual, big problems for society or communities. Following the completion of the course the students will be able to develop the following knowledge and skills:

- Develop their knowledge on creativity and opportunity recognition techniques
- Develop their knowledge in processes through which they can involve market trends and end-user needs and wants in developing functional materials and designing their use
- Develop their creativity and opportunity recognition skills by working on a real problem
- Develop their ability to identify the consequences of decisions and plans regarding the development of functional materials in their commercial use and in their potential to resolve everyday problems
- Develop their ability to think beyond boundaries and challenge existing practices in developing and using functional materials and generate new ideas

- Develop their ability to use integrate technical knowledge and market trends in developing new insights in the use of functional materials
- Develop project management and team work skills in teams with heterogeneous background
- Develop their ability to use cutting-edge research method and techniques in creating new value by reconceptualizing the use of certain functional material to solve problems and by developing business models that can demonstrate how this value could be created.
- Develop market research skills
- Develop their skills in planning, executing and reporting laboratory work
- Develop their presentation skills in delivering presentations for research and commercial audiences

Content: The objective of the course is to enable students to provide a fundamental understanding of the use of functional materials and materials properties in creating value for solving an existing problem. By being involved in a group project that spans over several months the students will have the opportunity to link the project management process of working in the field of functional material with business and commercialization aspects. The course introduces basic background on the field of functional materials, and core frameworks on opportunity recognition and value creation in the entrepreneurship discipline (effectuation, business models, design thinking, creativity). Building on this knowledge content, students will be then asked to identify a real problem and explore how (exiting, modified, recombined or new) functional materials can resolve these problems. During this phase of the project the students will work in groups to integrate cutting-edge research in the field of functional materials with market trends, primary research with industry experts, end users, companies and third parties (governmental organizations, universities etc.) addressing the identified problem to inform its solution. In the next phase of the project, the students will work in the lab to incorporate the knowledge from the primary market research to advance/modify/combine or develop new functional materials to address the problem. In the third phase of the project the students will be coached on developing a business model that captures the value that their solution creates, as well as a plan on how their solution could be commercialized (i.e., licensed, spun out as a startup, sold as IP to existing company). More primary research and engagement with end users and industry experts will be required to validate the students' solutions.

During the course the students will attend: teaching sessions to be introduced to the core content of the course, workshops and coaching sessions through which the students will practice work life practices and basics of project work (planning, schedule, targets)

Assessment Methods and Criteria: the group project (final presentation, and 4 interim progress reports), and an individual reflective essay, summarizing the detailed reflection journal each student needs to keep during the project reflecting in new skills and the challenges in creating value.

Study Material: Lecture slides, scientific articles
Course Homepage: https://mycourses.aalto.fi/ (to be published spring 2017)
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: new integrated course with entrepreneurship and innovation teaching

XXXX-XX **Inno Project (3 ECTS): See SD 3A: "Innovation and entrepreneurship education courses" document**

PHYS-xxx Special Assignment in Advanced Materials (1-10 ECTS)

Responsible teacher: Martti Puska; Päivi Törmä; Matti Kaivola; Pertti Hakonen; Esko Kauppinen; Mika Sillanpää; Peter Liljeroth; Janne Ruokolainen; Robin Ras; Mathias Groth; Adam Foster; Christian Flindt; Mikko Alava; Sebastiaan van Dijken; Filip Tuomisto; Peter Lund; Olli Ikkala; Jukka Pekola; Tapio Ala-Nissilä; Patrick Rinke
Status of the Course: Engineering Physics major, Physics of Advanced Materials major
Level of the Course: The course is only for students who have completed their Bachelor's Degree
Teaching period: According to agreement
Workload: 0 + 200
Content: Special assignments are not connected to a specific lecture course, but the requirements and expectations of a special assignment are similar to the bachelor's thesis. The special assignments are usually small research projects or literature surveys. Their aim is to teach independent work on certain scientific topics and to increase the students' knowledge on selected fields of science and technology of advanced materials.
The special assignments offer excellent opportunities for the students to learn how to write technical or scientific reports before they start working on their master thesis. Students should therefore pay a special attention to writing the report of their special assignment.

Evaluation: 0-5
Language of Instruction: English
Further Information: http://physics.aalto.fi/en/studies/special_assignments/

PHYS-E0525 Microscopy of Nanomaterials (5 ECTS)

Responsible teacher: Hua Jiang; Janne Ruokolainen
Status of the Course: Optional course of the Physics of Advanced Materials major.
Level of the Course: Master's level
Teaching period: III - IV (Spring)
Workload: 24 + 24 (2 + 2)
Content: The course gives basic knowledge of the microscopy of materials nanoscale structures - including soft and hard materials. Lectures will concentrate on transmission electron microscopy (TEM), cryo-electron microscopy, high resolution imaging, electron diffraction and analytical microscopy by using elemental analyses (EDX, EELS). Additionally scanning electron microscopy (SEM), atomic force microscopy (AFM) and methods to prepare samples are lectures.
Study Material: to be announced
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=PHYS-E0525
Evaluation: 0 - 5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English

PHYS-E0412 Computational Physics (5 ECTS)
Responsible teacher: Ari Harju
Status of the Course: Engineering Physics major, Physics of Advanced Materials major Engineering Physics minor, alternative course
Level of the Course: The course is only for students who have completed their Bachelor's Degree.
Teaching period: III - V (Spring)
Workload: Contact teaching: 48 hrs (lectures 24 hrs, exercises 24 hrs)
Independent work: 82 hrs
Optional examination: 3 hrs
Learning Outcomes: The course provides computational tools for problem solving with main emphasis on physics-related cases. The course teaches both actual programming and the algorithms used.
Content: The course involves various ways to use computers to solve physical problems. The aim is to provide an

overview of the field and discuss various simulation techniques of both classical and quantum systems, ranging from Monte Carlo calculation of integrals to simulations of interacting many-body quantum systems.
Assessment Methods and Criteria: Assignments or exam.
Study Material: Lecture notes and additional supporting material
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=PHYS-E0412
Evaluation: 0-5
Registration for Courses: registration via WebOodi.
Language of Instruction: English

PHYS- **Inno Mission Internship (7 ECTS): See SD 3A: "Innovation and entrepreneurship education courses" document**

PHYS- **Summer Camp (3 ECTS): See SD 3A: "Innovation and entrepreneurship education courses" document**

PHYS-E0422 Soft Condensed Matter Physics (5 ECTS)

Responsible teacher: Robin Ras
Status of the Course: Optional course of the majors Engineering Physics and Physics of Advanced Materials. Optional course of the Engineering Physics minor.
Level of the Course: Master's level
Teaching period: III - IV (Spring)
Workload:
Contact teaching: 48 h
Independent work: 79 h
Exam: 3 h
Learning Outcomes:
After taking the course, the students will be able to
- Define soft condensed matter, explain how it differs from ordinary crystalline solids and isotropic liquids, give examples of typical soft matter systems and their characteristic physicochemical properties.
- Describe how physical properties of polymers are affected by molecular weight, crystallinity and temperature.
- Describe different experimental and theoretical methods for characterizing rheological properties of soft matter. More specifically, in the case of polymeric materials, the students will be able to explain how macroscopically observed viscoelastic behaviour is related to the molecular-scale structure and dynamics of the materials.
- Explain the basic thermodynamic concepts related to solutions, such as free energy of mixing, osmotic pressure, and chemical potential. Based on the underlying physical principles and with given experimental data on mixing substances, the student will be able to use simple theoretical models to predict the phase diagram of the mixture.
- Explain the physical basis of surface tension, capillarity and wetting phenomena, and determine equilibrium states for given simple systems.
- Explain the thermodynamic and molecular-scale basis of the hydrophobic effect and molecular self-assembly, and describe the molecular-scale structural features of various self-assembled surfactant aggregates. Based on given experimental data on simple surfactant molecules, the student will be able to deduce the types of aggregates formed, and evaluate the thermodynamics (i.e., changes in free energy, enthalpy, and entropy, as well as temperature dependence) of the aggregation processes.
Content:
- General features of soft condensed matter and basic soft matter systems
- Polymer physics: chain conformation and glass transition, polymer self-assembly
- Flow and deformation of soft condensed matter, viscoelastic behaviour
- Phase transitions in soft condensed matter, theoretical models of simple solutions
- Surface tension, wetting, capillarity, superhydrophobicity
- Hydrophobic effect and surfactant self-assembly

Assessment Methods and Criteria: Reading assignments, homework and lecture exercises, exam.
Study Material: Lecture notes and literature provided by the teachers.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=PHYS-E0422
Evaluation: 0 - 5
Language of Instruction: English

PHYS-E0526 Microscopy of Nanomaterials, laboratory course (5 ECTS)
Responsible teacher: Hua Jiang; Janne Ruokolainen
Status of the Course: Optional course of the Physics of Advanced Materials major.
Level of the Course: Master's level
Teaching period: IV - V (Spring)
Workload: 0 + 48 (0 + 4)
Content: As practical exercises nanostructured materials are studied with various microscopy methods. Course includes all the basic sample preparation methods for both hard and soft materials and practical microscopy exercises by using transmission electron microscopy (TEM), scanning electron microscopy (SEM) and atomic force microscopy (AFM).
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=PHYS-E0526
Evaluation: 0-5
Language of Instruction: English

PHYS-C0240 Materials Physics (5 ECTS)

Responsible teacher: Martti Puska
Status of the Course: Compulsory course of the Engineering Physics major. Optional course of the Engineering Physics minor.
Level of the Course: Bachelor's level
Teaching Period: IV- V
Workload: Lectures 6 x 4 h, exercises 6 x 2 h
Content:

- Ionic structures: bonds, crystal lattices, diffraction
- Electronic structures: free-electron model, electron band structure
- Response of solids on changes in the environment: Thermodynamics (ion vibrations, free electrons), electric current, (visco-)elastic properties.

Study Material: Steven H. Simon, The Oxford Solid State Basics (Oxford University Press. 2013).
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=PHYS-C0240
Prerequisites: 1st year physics and mathematics courses, and 2nd year physics and mathematics courses (periods I-III).
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: Finnish

PHYS-E0421 Solid-State Physics (5 ECTS)

Responsible teacher: Martti Puska
Status of the Course: Optional course of the majors Engineering Physics and Physics of Advanced Materials. Optional course of the Engineering Physics minor.
Level of the Course: Master's level
Teaching period: IV-V (Spring)
Workload: Contact teaching: 48 h
Independent work: 76 h
Exams: 6 h
Learning Outcomes: The student obtains the basic knowledge to follow scientific research on different fields of materials physics.
Content: Selected topics in materials physics: Electron dynamics in periodic solids, physics of semiconductors,

lattice defects, dielectric properties of solids, magnetism, superconductivity.
Assessment Methods and Criteria: Home exercises and two midterm exams or one final exam.
Study Material: S. Elliott: The Physics and Chemistry of Solids
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=PHYS-E0421
Evaluation: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English

CHEM-E5115 Microfabrication (5 cr)

Responsible teacher: Kirsi Yliniemi; Samuli Franssila
Status of the Course:
Elective course in the following majors:
Functional materials
Advanced materials and photonics
Micro- and nanosciences
Biosensing and -electronics
Level of the Course: Master-level
Teaching period: III-IV
Workload: 1 hour of lectures/week = 14 h
2 hours of exercises/week = 28 h
Homework for weekly exercises = 70 h
Preparation for exam = 20 h
Exam = 3 h
Learning Outcomes: The student is able to design fabrication processes for simple silicon microdevices, and able to analyze fabrication processes of complex silicon microdevices.
Content: Silicon and thin film materials. Unit processes in microfabrication: lithography, etching, deposition, oxidation, doping, polishing, bonding. Process integration of MOS and MEMS devices. Cleanrooms, process equipment, yield and reliability. Lab demo.
Assessment Methods and Criteria: Exercises and quizzes 60%; exam 60% (bonus possibility). The student must achieve at least 40% of maximum points both in exam and in exercises.
Study Material: Sami Franssila: Introduction to Microfabrication, 2nd edition, John Wiley & Sons, 2010. Available electronically via Aalto library. 1st edition can also be used.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5115
Prerequisites:
Useful previous studies:
Bachelors-level physics, chemistry, materials science, electronics.
Important concepts: crystal structure, unit cell, defects, doping, diffusion, Arrhenius, diffraction. Semiconductor technology a plus.
Evaluation: 0-5. 60% based on exercises and quizzes; 60% on exam (bonus possibility).
Registration for Courses: WebOodi
Language of Instruction: English

CHEM-E5145 Materials for Renewable Energy P (5 ECTS)

Responsible teacher: Mikhail Gasik
Status of the Course:
Elective for Functional Materials major students, offered also for Bachelor students
Level of the Course: Master-level
Teaching period: III-IV
Workload: 5 cr = 135 h; contact teaching; lectures + seminar 24 h, group work 50 h, independent work and reflection 48 h, exam 3 h
Learning Outcomes:
At the end of this course the students are able to:

• Recognize state-of-the-art materials currently used in renewable energy systems
• Identify common degradation and corrosion mechanisms in these applications
• Relate new material solutions
• Share the expertise of ones field in a heterogeneous team
• Justify material selection in front of an audience
Content: At this course the students learn how materials behave at circumstances relevant for the renewable energy systems (solar cells, wind power, electrolysers, hydrogen storage, fuel cells, batteries) and develop thinking to produce new material solutions for these applications.
Assessment Methods and Criteria: Contact sessions, group work and seminar.
Study Material: M. Gasik, Materials for fuel cells, Woodhead Publishing Limited, 2007. C.C. Sorrell, S. Sugihara, J. Nowothy, "Materials for energy conversion devices", Woodhead Publishing Limited, 2005. Material from the lectures.
Course Homepage: https://mycourses.aalto.fi/course/search.php?search=CHEM-E5115
Prerequisites: BSc
Evaluation: 0-5.
Registration for Courses: WebOodi
Language of Instruction: English

PHYS-xxx Research Project in Materials Science (9 ECTS)
Responsible teacher: Martti Puska; Päivi Törmä; Matti Kaivola; Pertti Hakonen; Esko Kauppinen; Mika Sillanpää; Peter Liljeroth; Janne Ruokolainen; Robin Ras; Mathias Groth; Adam Foster; Christian Flindt; Mikko Alava; Sebastiaan van Dijken; Filip Tuomisto; Peter Lund; Olli Ikkala; Jukka Pekola; Tapio Ala-Nissilä; Patrick Rinke
Status of the Course: new course
Level of the Course: Master's level
Teaching Period: According to agreement
Workload:
Content:
The research project will introduce the students to the topic of their master thesis. Students can choose from master thesis topics to be carried out in research labs at the company or at the university. The research project involves a short-term internship at the site of research, to familiarize the student with the topic, and to start first preparations for the master thesis. The student will carry out activities such as a thorough survey of literature (scientific publications, patents as well as market reports) and a short well-defined experimental project.
Course Homepage: https://mycourses.aalto.fi/ (to be published spring 2017)
Grading Scale: 0-5
Registration for Courses: Registration via WebOodi.
Language of Instruction: English
Further Information: new integrated course with entrepreneurship and innovation content

M1 TUD HOME UNIVERSITY (first year students):

AUTUMN SEMESTER			
Code	Name	ECTS credits	Comments
Compulsory courses			
01-27-1M01-vl	Entrepreneurial Finance	3	I&ENT
XXX	Inno-Project I	3	Collaborative new course with partners, I&ENT
11-01-4104	Functional Materials	6	Applied materials
11-01-4105	Surf aces and Interfaces	5	Fundamentals of materials science Applied materials
11-01-4109	Micromechanics for Materials Science	6	Fundamentals of materials science Applied materials
11-01-4101	Research Lab I	4	Lab work
11-01-7562	Ceramic Materials: Syntheses and Properties	3	Applied materials
	TOTAL	**30**	
SPRING SEMESTER			
Code	Name	ECTS credits	
Compulsory course			
11-01-4107	Advanced Characterization Methods of Materials Science	4	New method: Live Classroom response System
11-01-4106	Theoretical Methods in Materials Science	6	Fundamentals of materials science Applied materials
11-01-4102	Research Lab II	4	Lab work
01-62-0007-vl	Entrepreneurship	3	I&ENT
11-01-4002	Career Coaching	0	I&ENT
XXX	Inno-Project I	3	Collaborative new course with partners, I&ENT
Xxx	Summer Camp	3	Collaborative summer camp with all partners, I&ENT
xxx	Integrated entrepreneurship & innovation course	3	New course, I&ENT
Optional courses			
11-01-3029-vl	Advanced Microscopy	4	
11-01-8191-vl	Ceramic Materials: Syntheses and Properties. Part I	4	

11-01-9811-vl	Characterization Methods in Materials Science: Neutrons and Synchrotron	4	
11-01-8241-vl	Chemical Sensors: Basics and Applications	4	
11-01-8291-vl	Density Functional Theory: A Practical Introduction	4	
11-01-7301-vl	Electrochemistry in Energy Applications II: Storage Devices	4	
11-01-8401-vl	Fundamentals and Technology of Solar Cells	4	
11-01-2008-vl	Graphen and Carbon Nanotubes - from fundamentals to applications	4	
11-01-7602-vl	High Pressure Materials Synthesis	4	
11-01-2017-vl	In-situ Transmission Electron Microscopy	4	
11-01-2004-vl	Materials Science of Thin Films	4	
11-01-7070-vl	Micromechanics and Nanostructured Materials	4	
11-01-9090-vl	Modern steels for automotive applications	4	
11-01-3030-vl	Polymer Processing	4	
11-01-8411-vl	Properties of Ferroelectric Materials	4	
11-01-2019-vl	Quantum Materials: Theory, Numerics, and Applications	4	
11-01-7060-vl	Scanning probe microscopy in materials science	4	
11-01-2002-vl	Spintronics	4	
11-01-2016-vl	Surfaces and Interfaces - From wetting to friction	4	
	TOTAL	**30**	

M2 TUD HOST UNIVERSITY (second year students)

AUTUMN SEMESTER			
Code	Name	ECTS credits	
Compulsory			
11-01-4109	Micromechanics for Materials Science	6	
11-01-4101	Research Lab I	4	
01-27-1M01-vl	Entrepreneurial Finance	3	I&ENT
Optional			
11-01-7562-vl	Ceramic Materials: Syntheses and Properties. Part II	4	
11-01-2009-vl	Concepts in Materials Physics	4	

11-01-7300-vl	Electrochemistry in Energy Applications I: Converter Devices	4	
11-01-8131-vl	Engineering Microstructures - Processing, Characterization and Application	4	
11-01-8202-vl	Fundamentals and Techniques of Modern Surface Science	4	
11-01-2001-vl	Magnetism and Magnetic Materials	4	
11-01-9312-vl	Materials Engineering	4	
11-01-4404-vl	Materials Science for Renewable Energy Systems	4	
11-01-9332-vl	Mechanical Properties of Ceramic Materials	4	
11-01-9092-vl	Mechanical Properties of Metals	4	
11-01-3031-vl	Polymer Materials	4	
11-01-4004-vl	Quantum Mechanics for Materials Science	6	
11-01-8162-vl	Semiconductor Interfaces	4	
11-01-2014-vl	Solid State and Structural Chemistry of Materials	4	
11-01-2018-vl	Tunable properties in nanomaterials	4	
	TOTAL	**30**	
SPRING SEMESTER	THESIS	**30**	

TUD COURSE DESCRIPTIONS

Course name: Entrepreneurship and Entrepreneurial Finance
Module: 01-27-0M01 Entrepreneurship and Entrepreneurial Finance (6 ECTS)
Responsible teacher: Prof. Dr. Carolin Bock, Prof. Dr. V. Nitsch
Status of the Course: existing course
Level of the Course: Master's level
Language of Instruction: English
Teaching Period: I – II
Workload: 180h

Content:

Course A - Entrepreneurial Finance: In the course, special attention is put on sources of financing which are relevant in different development stages of start-ups. Students get an overview of different sources of funding available for young companies. This part also provides a broad overview of the private equity industry including both early stage venture capital funds and buyout funds. Further, the business model of private equity firms and the relationship between an equity investor and an entrepreneurial firm are analyzed in more detail. Based on a general understanding of the private equity industry, the refinancing and investment process of a private equity firm will be discussed intensively.

Course B - Entrepreneurship: This course covers a broad range of topics in the new (and recently rapidly growing) field on the economics of entrepreneurship and start-up activity. Topics covered include: the characteristics of entrepreneurs; the start-up process; financing entrepreneurship; success factors and failure causes of start-up activity.

Learning Outcomes:

Outcome course A: Students gain in-depth knowledge on theoretical concepts and methods important in the field of financing young companies. Within the course, both young ventures as well as established entrepreneurial firms are considered. Three main objectives of the course are:
• to understand challenges of financing entrepreneurial firms,
• to analyze the suitability of different sources of financing for entrepreneurial firms and to know their strengths and weaknesses,
• to analyze tools and techniques of finance for entrepreneurial firms in early and later development stages, thereby focussing on private capital markets with an emphasis on venture capital and private equity,
Outcome course B: The aim of this course is to make participants familiar with a number of relevant theoretical concepts and empirical research designs in entrepreneurship.

Course name: Research Lab I
Responsible teacher: Prof. Dr. rer. nat. Wolfgang Donner
Status of the Course: compulsory course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: In experiments with partly open results, the candidate gets used to modern state-of-the-art scientific equipm
science. The experiments are performed using the equipment of the involved research groups, making sure that every student is e
scientific research groups. The students are able to plan and realize materials synthesis and characterization experiments self-relia
able to analyze the data with complex data analysis programs. They can discuss and interpret the results in a complex material con
Assessment Methods and Criteria: Oral exam
Study Material:
**Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M
015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Research Lab II
Responsible teacher: Prof. Dr. rer. nat. Wolfgang Donner
Status of the Course: Compulsory course for Materials Science
Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: In experiments with partly open results, the candidate gets used to modern state-of-the-art scientific equipm
science. The experiments are performed using the equipment of the involved research groups, making sure that every student is e
scientific research groups.
Assessment Methods and Criteria: Oral exam
Study Material:
**Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M
015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Functional Materials
Responsible teacher: Prof. Dr.-Ing. Oliver Gutfleisch
Status of the Course: Compulsory course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: Gaining knowledge of the most important principles in the before mentioned material classes. Focusing not o
physical principles but also materials synthesis and application of the most important functional materials. Furthermore applicatio
material classes will be discussed. The students will be able to develop and characterise simple devices constructed from the abov
materials.

Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf
Evaluation: 1-5
Language of Instruction: English

Course name: Surfaces and Interfaces
Responsible teacher: Prof. Dr. Wolfram Jaegermann
Status of the Course: Compulsory course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: The student is able to understand and treat the specific effects of surfaces and interfaces in materials science, differentiates between thermodynamically and kinetically determined properties, he/she knows the important terms and definitio theoretical concepts used in surface/interface science and electrochemistry, he/she has reached a conceptual understanding how surfaces/interfaces affect the properties of presented devices, he/she will reach a materials science related understanding of elect processes, he/she will be able to transfer this knowledge to any future envisaged problems and materials, the student has reached to differentiate between bulk and surface effects in devices and to correlate them with material's properties, he/she is qualified to experimental and theoretical methods in his/her possible future research involving surface/interface effects and electrolyte interfa have the competence to follow advanced textbooks and scientific literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf
Evaluation: 1-5
Language of Instruction: English

Course name: Theoretical Methods in Materials Science
Responsible teacher: Prof. Dr. Karsten Albe
Status of the Course: Compulsory course for Materials Science
Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: The student gains fundamental insights into the key concepts of non-equilibrium thermodynamics, continuum (quantum) statistical mechanics relevant for materials science. He/she is able to identify and apply appropriate theoretical concept materials science problems related to properties and processing of materials. The students are acquainted to numerical methods a solve boundary value problems, ordinary differential equations and transport equations. His/her knowledge allows him/her to foll textbooks and scientific literature on theoretical methods in materials science.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf
Evaluation: 1-5
Language of Instruction: English

Course name: Advanced Characterization Methods of Materials Science
Responsible teacher: Prof. Dr. rer. nat. Wolfgang Donner
Status of the Course: Compulsory course for Materials Science
Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: The student knows the fundamentals of various methods of structural and elemental analysis, their advantag disadvantages. He/she is able to select an appropriate technique for a given analytical problem. The course prepares the students courses, where they perform analytical experiments on their own. The methods presented in the course represent the state of the and spectrometry; therefore the students will be able to critically judge the validity of experimental results in the scientific literatu

Assessment Methods and Criteria: Oral exam
Course Homepage: [http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M
015.pdf]
Evaluation: 1-5
Language of Instruction: English

Course name: Quantum Mechanics for Materials Science
Responsible teacher: Apl. Prof. Dr. rer. nat. Andreas Klein
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: The successful students are able to recognize basic quantum mechanical phenomena. The students are able t
calculate simple quantum mechanical problems and are able to use them in daily problems. The students will be able to understan
binding and the electronic structure of atoms, molecules and solids. The students are qualified to apply the theory to the evaluatio
electronic structure of atoms, molecules and solids and are able to describe charge transport in a quantum mechanical manner. Th
a first insight into modern research in quantum mechanics and their knowledge allows them to follow advanced textbooks and scie
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M
015.pdf
Evaluation: 1-5
Language of Instruction: English

Course name: Micromechanics for Materials Science
Responsible teacher: Prof. Ph. D. Baixiang Xu
Status of the Course: Compulsory course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: The successful students can interpret the elastic and plastic behavior of a material using the continuum theor
the stress situation around certain microstructure e.g. at crack tips and near defects. They can also apply the basic concept of hom
calculate the effective properties of heterogeneous material. They will have the competence to follow advanced textbooks and sci
on nonlinear continuum mechanics and composite mechanics.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M
015.pdf
Evaluation: 1-5
Language of Instruction: English

Course name: Concepts in Materials Physics
Responsible teacher: Prof. Dr. rer. nat. Robert Stark
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: The student is able to describe a crystal as a lattice with a pattern and can explain x-ray diffraction patterns us
of the reciprocal lattice. He/She has gained an understanding of diffraction of electromagnetic waves, electron waves or collective
lattice. In particular the students are able to explain fundamental material properties in the appropriate pictures of quasi-particles
excitations. He/She has gained an understanding for the relation between transport properties, crystal structure, and electronic st
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M
015.pdf

Evaluation: 1-5
Language of Instruction: English

Course name: Ceramic Materials: Syntheses and Properties. Part I
Responsible teacher: Prof. Dr. Ralf Riedel
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: The student has gained an overview on and remembers different synthesis techniques for ceramic materials.
he/she has gained the competence to evaluate the (micro)structureproperties relationship for ceramic materials. He/she is able to
different classes of ceramic materials with specific properties and applications. The student has the competence to evaluate exper
theoretical methods for goal-oriented research in the area of ceramics. The student has a first insight in modern preparative techn
materials and a beginner's competence to follow advanced textbooks and scientific literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: **http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Ceramic Materials: Syntheses and Properties. Part II
Responsible teacher: Dr. Emanuel Ionescu
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: The student has gained practical experience with and remembers different processing techniques for ceramic
Furthermore, he/she has gained the competence to correlate the relationship between (micro)structure/phase composition of cer
property profiles. The student gets acquainted with modern processing techniques for ceramic materials and is able to follow adva
and scientific literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: **http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Chemical Sensors: Basics and Applications
Responsible teacher: Prof. Dr. Ralf Riedel
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: The students have an overview of the different types of chemical sensors. They are able to describe the opera
for chemical sensors and give examples of their applications. They are able to decide which sensor is appropriate for a given proble
Assessment Methods and Criteria: Oral exam
Course Homepage: **http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Electrochemistry in Energy Applications I: Converter Devices
Responsible teacher: Prof. Dr. Wolfram Jaegermann
Status of the Course: Elective course for Materials Science

Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: The student will be introduced to the main concepts of heterogeneous electrochemistry (electrodics), basic el
methods and main materials science questions related to the use and application of electrochemical converter devices. She/He wil
evaluate experimental and theoretical results obtained with different electrochemical, surface science and theoretical techniques,
insight in modern electrodics applied for continuing experimental work in this field. Moreover, he/she obtains basic competence to
advanced textbooks and scientific literature.
Assessment Methods and Criteria: Oral exam
**Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M
015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Electrochemistry in Energy Applications II: Storage Devices
Responsible teacher: Prof. Dr. Wolfram Jaegermann
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: The student will be introduced to the main concepts of heterogeneous electrochemistry (electrodics), solid st
main materials science questions related to the use and application of electrochemical storage and converter devices. She/He will
electrochemical concepts and solid state concepts for dealing with energy devices and to evaluate experimental and theoretical re
with different electrochemical, surface science and theoretical techniques, and obtain a first insight in modern electrodics applied
experimental work in this field. Moreover, he/she obtains basic competence to follow advanced textbooks and scientific literature
Assessment Methods and Criteria: Oral exam
**Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M
015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Fundamentals and Techniques of Modern Surface Science
Responsible teacher: Prof. Dr. Wolfram Jaegermann
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: The student has been introduced to the main methods used in modern surface science, he/she is familiar wit
physical processes used for the different techniques, he/she has learned for which problems and how the techniques are applied i
she/he has been introduced to the main materials science questions related to the use and application of these techniques, the stu
competence to judge when the application of these techniques is of use in his/her future scientific life, he/she is qualified to evalu
and theoretical results obtained with these techniques, the student has obtained a first insight in modern surface science research
applied for continuing experimental work in this field, he/she has obtained basic competence to follow advanced textbooks and sc
Assessment Methods and Criteria: Oral exam
**Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M
015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Fundamentals and Technology of Solar Cells
Responsible teacher: Prof. Dr. Wolfram Jaegermann
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level

Teaching Period: Spring
Learning Outcomes: The student has gained the information to address and judge energy topics in their relevance for future techn he/she has gained a broad understanding of semiconductor physics as background of the working principles of solar cells, he/she h introduced to the materials science challenges given for the different cell technologies, he/she has learned which preparation and techniques are involved in the manufacturing and improvement of solar cells, he/she is qualified to evaluate experimental and the for possible future research in solar cell basic science and technology, he/she has obtained the competence to follow advanced tex scientific literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf
Evaluation: 1-5
Language of Instruction: English

Course name: Graphen and Carbon Nanotubes - from fundamentals to applications
Responsible teacher: Prof. Dr. Ralph Michael Krupke
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: The student has gained a basic knowledge in the fundamentals of graphene and carbon nanotubes. He/she is understand how the atomic structure of a carbon allotrope determines its properties. He/she is able to understand the electrical a properties of nanocarbons and its implications for future applications. He/she is qualified in characterisation techniques and devic techniques. The student has the competence to follow scientific literature and the knowledge that is required to conduct research
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf
Evaluation: 1-5
Language of Instruction: English

Course name: Magnetism and Magnetic Materials
Responsible teacher: Prof. Dr. rer. nat. Lambert Alff
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: The student is able to remember the basic notions of magnetism for a broad range of situations and materials the competence to differentiate different types of magnetism and their origin, and to correlate them with materials properties. He to evaluate experimental and theoretical methods for goal-oriented research in the area of magnetism and magnetic materials. Th remembers modern magnetic materials and their use in current applications. The student has a first insight in modern research in magnetic materials and a beginner's competence to follow advanced textbooks and scientific literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf
Evaluation: 1-5
Language of Instruction: English

Course name: Materials Science of Thin Films
Responsible teacher: Prof. Dr. rer. nat. Lambert Alff
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: The student has gained a broad overview on and remembers relevant thin film deposition methods. He/she is

the advantages and disadvantages of each deposition method for different applications and needs. The student has the competen
fundamental thin film science to novel materials. The student has the competence to differentiate different types of deposition me
to their physical and chemical principles. He/she is qualified to evaluate thin film methods for goal-oriented research in the diverse
film applications. The student has a first insight in modern research in thin films and a beginner's competence to follow advanced t
scientific literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: **http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Mechanical Properties of Ceramic Materials
Responsible teacher: Prof. Dr.-Ing. Jürgen Rödel
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Autumn
Learning Outcomes: The student has obtained a global and detailed view of the different mechanical properties of ceramic materi
and structures. This knowledge allows him/her to choose materials with adequate properties for a given application. The student u
phenomenon responsible for crack extension and brittle fracture under the combined effects of applied loading, temperature, tim
environment. He/she can choose appropriate measurement techniques to get reliable data. The student understands the influenc
microstructure on the mechanical properties of ceramic materials. He/she has the competence to devise mechanisms of optimizin
materials and to develop new materials with improved properties. The student has a first insight into modern research in the field
ceramics and is competent to follow advanced textbooks and scientific literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: **http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Micromechanics and Nanostructured Materials
Responsible teacher: Prof. Dr.-Ing. Karsten Durst
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: The student develops a basic understanding of the different testing methods and deformation mechanism for
mechanical properties. The student can discuss in detail the governing equations for Nanoindentation, bulge testing as well as star
testing approaches. Based on the knowledge of the deformation behavior at the macroscopic length scale, the student can describ
deformation resistance of materials at small length scales and for small scale microstructures using concepts like theoretical streng
break down. Finally the students gain a first insight into small scale mechanical testing methods as well as the deformation mechan
nanocrystalline materials to follow advanced textbooks and scientific literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: **http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf**
Evaluation: 1-5
Language of Instruction: English

Course name: Modern Steels for Automotive Applications
Responsible teacher: Apl. Prof. Dr.-Ing. Clemens Müller
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level

Teaching Period: Spring
Learning Outcomes: The student has gained an advanced knowledge of the processing (TMT) of modern steels, their microstructu deformation and strengthening modes as well as their mechanical properties. He/she is able to correlate the mechanical propertie microstructural features and has an advanced knowledge of the methods to produce the required microstructure. The student has the special requirements on steels/materials for automotive applications and a beginner's competence to follow advanced textboo literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf
Evaluation: 1-5
Language of Instruction: English

Course name: Properties of Ferroelectric Materials
Responsible teacher: Prof. Dr.-Ing. Jürgen Rödel
Status of the Course: Elective course for Materials Science
Level of the Course: Master-level
Teaching Period: Spring
Learning Outcomes: The student can identify different mechanisms of electrical polarization and is able to deduce possible polariz from information about the structure of a material. He/she can chose basic characterization techniques and adapt them to the req given problem. The student understands the influence of domain structures on the properties of a ferroelectric/ferroelastic and kn manipulate these structures to obtain optimum material response for a specific application. He/she has the competence to devise optimizing existing ferroelectric materials and to develop new materials with improved properties. The student has a first insight in research in ferroelectrics and is competent to follow advanced textbooks and scientific literature.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://www.mawi.tu-darmstadt.de/media/materialwissenschaften/studiengaenge/std_master_msc/pruefungsordnung_2015/dokumente_7/MHB_M 015.pdf
Evaluation: 1-5
Language of Instruction: English

M2 UB HOST UNIVERSITY (second year students)

Autumn

AUTUMN SEMESTER			
Code	Name	ECTS credits	
Compulsory			
	Large Scale Facilities	6	
	Hybrid and Nanomaterials	6	
Elective (3 of 6)			
	Innovative and composite materials	6	
	Energy, communication and information	6	
	Photonics, lasers and imaging	6	
	Computational Chemistry	6	
	Applied Nanosciences	6	
	Magnetic and dielectric properties	6	
	TOTAL	**30**	
SPRING SEMESTER			
	Bibliographic project (3) and Inno-project (3)*	6	
	Research project in materials science (entrepreneurship & innovation integration)	24	
	TOTAL	**30**	

*The structure of the local master in Bordeaux does not allow for accommodation of the INNO-project in the fall semester. However while contributing to the spring semester, it will be possible to organize INNO-project II in coordination with the other partners institutions (i.e. for operation during the fall semester).

UB COURSE DESCRIPTIONS

Course name: Large Scale Facilities
Responsible teacher: A. Desmedt
Status of the Course : compulsory (proposed in 3 different curricula at Bordeaux University)
Level of the Course: for students who have completed their M1
Teaching Period: I (Autumn)
Learning Outcomes:
Objectives

- This lecture aims at discovering the contribution of the large scale facilities (neutron source and synchrotron radiation), at fundamental as well as applied levels, in the understanding of structural and dynamical properties of matter ranging from materials to macromolecular science.
- Improved knowledge of the large scale facilities in the field of Materials Science and improved capacity to call upon large scale facilities in Europe.

Lecture course content

- Background. General considerations, matter/radiation interaction (linear response theory…), sources (neutron and synchrotron radiations), facilities (which information, where and how?), concerned fields of applied and fundamental research, complementarities with other techniques (NMR, light scattering, IR absorption…).
- Nuclear and Magnetic Structure. Specificities of neutron diffraction (ND) and X-ray diffraction (XRD). Nuclear diffraction: complementarities ND/XRD. Scattering and absorption lengths, isotopic effects: ND/XRD contrasts. Neutron Magnetic diffraction: access to magnetic structure. Examples and limits of ND and XRD.
- Large scale structure. Small angle scattering (SAS) techniques. Complementarities of Neutron and X-ray SAS. Structure and form factors. Modeling small angle scattering data. Application to macromolecular systems of interests for soft materials.
- X-ray imaging and spectroscopy. Techniques proper to synchrotron radiation: X-ray absorption techniques and Exafs (contribution of linear and circular polarized beam in the study of crystalline and magnetic anisotropy), scanning imaging techniques (X-ray micro-diffraction, micro-fluorescence and UV/IR microspectrometry) and full-field imaging techniques (soft X-ray spectroscopy, X-ray microtomography)
- Neutron spectroscopy. Elastic, quasi-elastic and inelastic neutron scattering, structure factors, van Hove formalism, molecular dynamics (from vibrations to Brownian motions). Complementarities with computing science (MD simulations…) and applications in solid-state chemistry, materials science and soft materials.

Practical course content.
In addition to the lectures, a practical training project is organized in the neutron facility near Paris (Nuclear reactor "Orphée" of the "Laboratoire Léon Brillouin", http://www-llb.cea.fr) during three days. Each group of 5 to 7 students select a training project among several options (e.g. nuclear and magnetic structure of relevant crystals, velocity of sound in materials, diffusion of macromolecules in solution, macromolecular arrangement of polymeric materials, etc…). This project gives the students the opportunity to experience the acquired concepts. It should be noted that such a project is subjected to obtaining the access authorizations.
Assessment Methods and Criteria: Experimental Report (practical) and Oral Examination**.**
Study Material:

- Free access to the EDP-SFN book collection via www.neutron-sciences.org
- All lecture materials available on http://www.hydrate.eu
- Quasielastic Neutron Scattering, M. Bée, Adam Hilger, Bristol and Philadelphia, 1988.
- Theory of the thermal neutron scattering. » W. Marshall, S.W. Lovesey, Clarendon Press, 1971.
- Neutrons et Matériaux, W. Paulus et J. Meinnel (Eds), Journal de Physique IV, 2003, vol. 103.
- Neutrons et Magnétisme, C. Fermon et F. Tasset (Eds), Journal de Physique IV, 2001, vol. 89.
- Elements of Modern X-Ray Physics, J. Als-Nielsen et D. Morrow, Wiley
- Neutron and Synchrotron radiation for condensed matter studies, HERCULES Edition de Physique et Springer Verlag (1993)

Course Homepage:
Evaluation: 0-20
Language of Instruction: English

Further Information: Other lecturers M. Josse, O. Toulemonde and a teacher for small angle scattering (TBD) + 1 tutor from LLB per practical group (5 to 7 students per group)

Course name: Nanomaterials and hybrids
Responsible teacher: M.Tréguer-Delapierre
Status of the Course: compulsory ((proposed in 2 different curricula at Bordeaux University)
Level of the Course: for students who have completed their M1
Teaching Period: I (Autumn)
Learning Outcomes:
Main Objectives :
General overview concerning the use of the tools of molecular, macromolecular, sol-gel chemistries and physico-chemistry to elaborate nanomaterials, control the organization and the properties of self-assembled macromolecular structures and organic-inorganic hybrid materials.
- To know the main fabrication processes of inorganic nanomaterials (quantum dots, metals, metal oxide);
- To be able to describe the basics, fundamental chemistry and physics of nanosystems;
- To know the basis of block copolymer self-assembly at the bulk state;
- To know the main properties and applications of block copolymer-based materials as well as the main techniques to characterize them;
- To manipulate simple physico-chemical concepts to describe functional hybrid materials;
- To know the main classes and applications of hybrid materials;
- To be able to propose different synthetic strategies towards functional hybrid materials.

Course content :
I Nanomaterials
I-1 General introduction
I-2 How to fabricate nanoparticles ?
I-3Confinement effect on physico-chemical properties (catalytic, optical, thermodynamic…)
I-4 Importance of the shape at the nanometer range scale
I-5 General conclusion
II Hybrids
II-1 Introduction to hybrid materials
II-2 Class I hybrids
II-3 Class II hybrids
II-4 Hybrid materials for optics
II-5 Intercalation chemistry - basic concepts
II-6 2D-hybrid materials
II-7 Multifunctional hybrid materials
II-8 Preparation routes and characterization of hybrid nanoparticles of controlled composition and morphology
II-9 Nanoobjects as building blocks: towards new functional materials
III Self-Assembly and Self-Organization of Block Copolymers
III-1 Generalities: uncompatibility, phase separation, self-assembly
III-2 From polymer mixtures to copolymers
III-3 Bulk structure of "flexible-flexible" block copolymers (phase diagram, order-disorder transition)
III-4 More complex structures (multiblocks, stars, "rigid-flexible", cycles)
III-5 Mixtures of copolymers and heteropolymers: compatibilization
III-6 Commercialized and potential applications.

Assessment Methods and Criteria: Close-book final exam (3H)
Study Material:
1) Functional Hybrid Materials, P. Gomez-Romero, C. Sanchez Eds, Wiley-VCH, Weinheim,2003.
2) Hybrid Materials, G. Kickelbick Eds, Wiley-VCH, Weinheim, 2007.
3) Developments in Block Copolymer Science and Technology, Ian W. Hamley, John Wiley & Sons, Chichester, 2004.
4) Nanoscience, P.Boisseau, P.Houdy, M.Lahmani Eds, Springer, 2007.
Course Homepage:
Evaluation: 0-20

Language of Instruction: English
Further Information: Other lecturers S.Ravaine, T.Toupance, R.Backov, G.Hadziioanou

Course name: Innovative & Composite Materials
Responsible teacher: F REBILLAT
Status of the Course: elective (proposed in 4 different curricula at Bordeaux University)
Level of the Course: for students who have completed their M1
Teaching Period: I (Autumn)
Learning Outcomes:
Objectives:
Whatever the nature of materials (organic, mineral), their structure can be tailored at different scales as soon as a right choice of process for manufactoring is done. This controlled degree of structuration allows new properties to be obtained, from nanometric to macroscopic scales.
Mastered competences:
To know how to make a material and to control its microstructure at different scales. To experience the physical et chemical phenomena that allows to modulate and/or modify the properties (chemical, physical (optic, electric, mechanic),...). Approach of the integrative chemistry, to manufacture materials according to requirements of the specifications.
Course content :
I- Methods for the fabrication of amorphous and crystallised ceramics: bulk and thin films
I-1 Sintering processes for ceramic including liquid sintering:
a. Mechanisms and parameters controlling the sintering steps,
b. Methods for the characterisations of the sintered ceramics,
c. Glass metals and vitroceramics
I-2 Ceramic coatings and thin films
a. Relationship between the processing technics (chemical end physical depositions) and the properties (morphology, composition,)
b. Example of applications (mechanic, optic, tribology,…)
II- Modifications of metals properties
Reminders on thermodynamics
Nucleation mechanism : associated driving force, critical radius…
Thermal treatments and control of precipitation states
Plastic deformation and precipitation hardening
Some examples
III – Porous materials
Generalities and definitions
Geometrical description
Experimental techniques to characterize porous materials
Properties and applications
IV- Les matériaux composites
Definition of the concept of composite matérials, rule of mixture about properties,
Various examples of applications and criteria of selection for these materials,
Introduction to the mechanical damage into composite materials.
The different kinds of reinforcements : nature and architecture
Criteria of failure for brittle materials (Weibull, Griffith...)
Organic matrix composites (OMC) (in view of glass, carbon, and organic fiber reinforcement): description of different classes of matrices, main properties of thermosetting and thermoplastic polymers applied to fiber composites materials. Use of crosslinking of liquid resins, and /or processing of thermoplastic molten polymers for bulk pieces.
Polymer main properties usefull for composites.Fiber / Matrix interactions and bonding.
Resin impregnation of reinforcements.
Types of processes of bulk pieces, injection, compression, filament winding, stamping, various types of molding, hand processes, discontinuous, continuous,.

Examples of industrial processes vs. processing type, vs. pieces fabrication, vs. matrix type.
The MMC (metallic matrix composites): Fiber / Matrix interactions and bonding., impregnation of fibrous textures by a metal, to have an interest in developing such composites
The CMC (ceramic matrix composites): specificity of junctions between brittle materials, the transposition of common ceramic manufacturing to the consolidation of fibrous or porous architectures, the thermostrucural applications
Assessment Methods and Criteria: Close-book final exam (3H)
Study Material:
Sol-gel process: J. Brinker,
J. Philibert, A. Vignes, Y. Bréchet et P. Combrade, Métallurgie du minerai au matériau, éd. Dunod, Paris, 1998.
P. Boch (sous la direction de), Matériaux et processus céramiques, Paris, Hermès Science Publications, 2001
W.D. Kingery, H.K. Bowen, D.R. Uhlmann,Introduction to Ceramics, A Wiley-Interscience Publication, 1975,
C. Filliatre et R. Daviaud, Introduction aux matériaux composites - 1 - Matrices organiques, édition CNRS, 1985
R. Naslain, Introduction aux matériaux composites 2. Matrices métalliques et céramiques, édition CNRS et IMC, 1985
D. Gay, Matériaux composites, édition Hermès, 1987
Course Homepage:
Evaluation: 0-20
Language of Instruction: English
Further Information:

Course name: Energy, communication and information
Responsible teacher: G. Hadziioannou
Status of the Course: elective ((proposed in 4 different curricula at Bordeaux University)
Level of the Course: for students who have completed their M1
Teaching Period: I (Autumn)
Learning Outcomes:
Objectives Enlargement of the usual vision of organic polymers ; Introduction to the optical and electrical properties of polymers with respect to their chemical structure, their formulation and shaping.
Knowledge of the optical and electrical properties of semi-conducting polymers, understanding of physical phenomena in polymer-based electronic devices : interactions with light, charge transport.
Course content I Introduction, overview
I-1 Examples of appllications of polymer-based electronic devices
I-2 General features of conjugated polymers
I-3 Operating principles of a LED
II Electronic Structure
II-1 Molecular structure / electronic properties relationships of conjugated polymers : orbital treatment
II-2 Polymers doping and electrical conduction
III Interaction of conjugated polymers with light
III-1 Non-linear polarization phenomena
III-2 Optical excitations
IV Charge transport in conjugated polymers
IV-1 Charges movement mecanisms
IV-2 Analysis methods at various scales
V Structure of conjugated polymers in the solid state
V-1 Molecular conformation, local order
V-2 Morphology
VI Synthesis and design
VI-1 Main synthesis methods of conjugated polymers
VI-2 Impact of synthetic tools on electronic properties
VII Applications and devices principles
Assessment Methods and Criteria: Close-book final exam (3H)
Study Material:

Groupe Français des Polymèrs: Propriétés Electriques des Polymères et Applications, 1993
Handbook of Conducting Polymers, 3rd Edition; Eds : T. A. Skotheim and J. R. reynolds, CRC Press, 2007

Course Homepage:
Evaluation: 0-20
Language of Instruction: English
Further Information:

Course name: Photonics, lasers and imaging
Responsible teacher: V. Jubera
Status of the Course: elective (proposed in 4 different curricula at Bordeaux University)
Level of the Course: for students who have completed their M1
Teaching Period: I (Autumn)
Learning Outcomes:
Objectives
- Introduction to molecules and materials characterization techniques in non linear quadratic optic
- Introduction to time-resolved spectroscopy : femtosecond temporality, methodology and applications
- Introduction to emission spectroscopy: Luminescence of transition elements and rare earths, Phosphors selection criteria, applications.
- General aspects of second order non-linear optics
- Molecular symmetry determination by hyper-Rayleigh diffusion
- Surfaces, interfaces and thin films characterization by second harmonic generation
- General aspects of physical-chemical events temporality
- Phenomena studied by pump-probe technologies
- Understanding of LASER processes and applications
- Understanding of luminescence mechanisms and interpretation of absorption and emission spectra (influence of the crystal structure on luminescence)

Course content
Part I : Introduction to non-linear optics
I.1-General aspects of 2nd order non-linear optics
I.1.a- Reminder : linear optics
I.1.b- Non-Linear Optics (NLO) phenomena : examples of NLO behaviours
I.1.c- Symmetry in quadratic NLO; Polarisability and 2nd order susceptibility
I.2- Molecular symmetry determination by hyper-Rayleigh diffusion (HRD)
I.2.a- General principles of HRD
I.2.b- Experimental technique and instrumentation
I.2.c- Molecular symmetry determination : principles and examples of applications
I.3- Surfaces, interfaces and thin films characterization
I.3.a- Second Harmonic Generation (SHG); Wave propagation in SHG
I.3.b- Experimental techniques and instrumentation
I.3.c- Determination of surfaces, interfaces and thin films symmetryminces
- Oxide glasses
- Organic materials and organised polymers

Part II: Introduction to time-resolved spectroscopy
II.1 Reminder : Radiation-Matter interaction
II.2 Towards temporality notion
II.3 Physical-chemical and photochemical apsects
II.4 Fundamental limits and scales
II.5 Process :From dynamics to kinetics
II.6 Requested tools : LASER methodologies
II.7 Pump-probe techniques
II.8 Some applications : materials sciences, biology
II.9 Photodissociation, photoprotection.

Part III : Luminescence of inorganic materials

III.1 Reminder : theory
III.2 Luminescence :
II.2.a Luminscence related to transition elements (d elements)
II.2.b Luminescence related to rare earths ions (f elements)
II.2.c Can the luminescence of a material be predicted?
III.3 Applications :
III.3.a Phosphor selection criteria.
III.3.b Applications (Lighting, Visualization, LASERs)
Assessment Methods and Criteria: Oral Examination
Study Material:
1) "Second-order nonlinear optical characterizations techniques : An Introduction", Thierry Verbiest, Koen Clays, Vincent Rodriguez, CRC Press, New York, 2009.
2) "Luminescent materials" G. Blasse et B.C. Grabmaier, Springer-Verlag Berlin Heidelberg (1994)
3) "Structure électronique des éléments de transition, l'atome dans le cristal" P. Caro, Presses universitaires de France, collection sup (1976).
4) "Spectrocopic properties of rare earths" B.G. Wybourne,Interscience publisher (1965)
5) "Optical spectroscopy Methods and Instrumentations" N V. Tkachenko, Elsevier, (2006)
6) "Femtochemistry and femtobiology: ultrafast reaction dynamics at atomic-scale resolution" V. Sundström Ed, Imperial College Press (1997)
Course Homepage:
Evaluation: 0-20
Language of Instruction: English
Further Information: other lecturer V. Rodriguez

Course name: Computational Chemistry
Responsible teacher: Jean-Christophe Soetens
Status of the Course: elective (proposed in 3 different curricula at Bordeaux University)
Level of the Course: for students who have completed their M1
Teaching Period: I (Autumn)
Learning Outcomes:
Objectives :
Numerical simulation is a complementary approach with respect to theroretical and experimental approaches, with important contributions to the study of microscopic systems, from isolated molecules to polymers, materials... This course will allow the students becoming familiar with underlying concepts of this scientific approach, and with the methods, potentialities and limits of various simulations methods..They will develop their ability to conduct and analyse a numerical simulation, to grasp the limits of commercial softwares, and ultimately to develop their own simulation tools. They will acquire a better understanding of the microscopical mechanisms underlying the chemical and physical properties of condensed matter, an ability to modelize micro/macroscopic phenomena and to correlate them to microscopic processes.
Program
1) Modelisation of condensed phases by numerical simulations
- general framework
- principles and methods
- from microscopic to macroscopic
2) Simulation techniques for thermodynamical assembly at equilibrium
- Monte Carlo (MC)
- Molecular Dynamics (MD)
3) Properties calculations
- determination of macroscopic quantities
- Links and comparison with experimental data
4) Interaction models
- molecular interactions
- Potential energy of a particles assembly

- concepts of surface, potential energy
5) Applications
- Time and distance scales
- supercomputing and supercomputers
- accessible phenomena
- overview of current techniques and softwares
Four practicals on computers will allow the students to gain experience in the use of the knowledge acquired during the course.
P1: Numerical experiment, concepts of statistical quality and ensemble average. Monte Carlo method.
P2: Ionic solutions structure simulation. Comparison with experiment.
P3 et P4: Discovery and applications of a materials modelisation software
Assessment Methods and Criteria: Close-book final exam (3H)
Study Material:
M.P. Allen, D.J. Tildesley, Computer Simulations of Liquids, Clarendon Press
D.A. McQuarrie, Statistical Mechanics, University Science Book
A. Gerschel, Liaisons intermoléculaires, CNRS Editions
Course Homepage:
Evaluation: 0-20
Language of Instruction: English
Further Information:

Course name: Applied Nanoscience
Responsible teacher: A. del Guerzo
Status of the Course: elective (proposed in 4 different curricula at Bordeaux University)
Level of the Course: for students who have completed their M1
Teaching Period: I (Autumn)
Learning Outcomes:
These multi-disciplinary courses, presented by chemists, expose the contribution of molecular and supramolecular concepts in various application areas, including renewable energy and information processing. The basic principles that are acquired, such as nano-structuring, design of molecules and of specific supramolecular interactions, will also enable the guided analysis of scientific publications.
Understand the molecular elements that generate a specific function in organized supramolecular systems and at the nanoscale.
Learn how to the design molecules and organic and inorganic assemblies for applications in nanosciences.
Know the principles of important technological applications.
Discover the importance of nanostructuring.
Learn how to analyse publications in the multidisciplinary field of nanoscience, with the knowledge of the application, (supra-)molecular approaches and characterization techniques.
Part I : Molecular Nanosciences
Chapter I : Introduction
• General definition of nanosciences
• The role of molecular chemistry
Chapter II: Applications 1: Renewable Energy
• Photoconversion of solar energy
• Innovative supramolecular systems for artificial photosynthesis
• Contribution of molecular and supramolecular chemistry
• Effects of nano-structuring
Chapter III: Applications 2: Information Technology
• New generation of organic screens
• Organic lighting
• Organic transistors and artificial noses
Chapter IV: Future Developments
• Single molecules and nano-addressable objects

• Molecular machines
Part II: Tools and Techniques for Nanosciences
• Chapter V: The techniques used for the study of nano-organic and inorganic systems. The contribution of molecular chemistry for the development of new techniques
• Chapter VI: Analysis of experimental data and publications
Part III: A short overview on Molecular Materials
• Chapter VII: Applications 3: Information Storage
• Chapter VIII: Applications 4: Nanoparticles of Molecular Materials
Assessment Methods and Criteria: Closed-book Final Exam (3h)
Study Material:
Course Homepage:
Evaluation: 0-20
Language of Instruction: English
Further Information:

Course name: Magnetic and dielectric properties
Responsible teacher: C. Mathonière
Status of the Course: elective (proposed in 4 different curricula at Bordeaux University)
Level of the Course: for students who have completed their M1
Teaching Period: I (Autumn)
Learning Outcomes:
The students will be able to describe the magnetic properties of molecular compounds and inorganic materials along with selected applications. The students will acquire the relevant knowledge and become familiar with dielectric and ferroelectric materials used in microelectronics and sensors industries. The students will acquire competencies on polarizable materials, their shapings and applications
Magnetic Properties
I. Compounds with one single magnetic center
Fundamental formula in magnetism and Curie law. Examples. Deviations from the Curie law : consequences of the orbital momentum (1 and 2 order)
Tutorial: Application of the Curie law for different ions: transition and lanthanides ions. Expression of the magnetic susceptibility in the case of the presence of the zero-field splitting (complete study with the S=1 spin).
II. Compounds with two magnetic centers in interaction
Exchange interaction: experiment and theory. Heisenberg Hamiltonian. Kahn's model. Goodenough-Kanamori rules. Comparison of the two models.
Tutorial: Examples of dinuclear compounds, prediction of the nature of the interaction.
III. Magnetic Ordering. Applications to non-conducting materials.
Magnetic ordering: through binuclear system to the solid in the mean-field approximation. Phase transition (notion of the order parameter and the critical temperature Tc). Criteria to get a high Tc (high |J|, high S …).
From molecules to networks: polynuclear compounds and Prussian blue analogs. Ferro- and ferrrimagnetic ordering. Antiferrromagnetic ordering in oxides.
Tutorial: Prussian blue analogs AMIICr(CN)6 : can we rationalize the evolution of their TC ?
Tutorial: Application of the Goodenough-Kanamori rules to oxides materials.
IV. Dynamic Phenomena: magnetic hysteresi .
Examples in molecular systems: single-molecule magnets. Approximation of the macrospin (giant spin).
Magnetization relaxation. Nanoparticules: Superparamagnetism. Dipolar interactions.
Tutorial: study of the Mn12O12 and/or a nanoparticule.
Magnetization process. Domains formation and observations. Domain walls. s
Dielectric properties
I) Background
- Dipoles, polarisation, dipolar interactions, microscopic models
- Complex dielectric permittivity, dielectric losses
- Frequency spectra: relaxations, resonances (…) fundamental relations
- Measuring dielectric properties: impedance spectroscopy, optical

spectroscopies
- Interfaces between electrodes and dielectric materials

II) low permittivity dielectrics
- The most used oxide in electronics: amorphous SiO_2
- Other oxides: Al_2O_3 , MgO, Ta_2O_5, TiO_2

III) high permittivity dielectrics
- Substituted alkali halides : KCl:OH, KCl:Li
- Ferroelectric materials: spontaneous polarisation, ferroelectric domains
Relaxor materials
Ferroic and multiferroic materials

IV) Chemical Bonding / Polarisability / Dielectric permittivity
- Simple oxides polarisability
- Case of transition metal oxides
- Anisotropy and permanent dipole in octahedral symmetry
- Influence on chemical bonding

V) Implementation of dielectric materials
- Shaping constraints
- Multilayer ceramic capacitors, contribution of grain boundaries
- Supercapacitors (Ta, Nb, Al)
- Thin films, nanoparticles
- Finite size effects in dielectrics
- Composites

Assessment Methods and Criteria: Closed-book Final Exam (3h)
Study Material:
Molecular Magnetism O. Kahn, VCH, 1993.
Magnétisme : I fondements et II matériaux et applications, EDPSciences
Les diélectriques : propriétés diélectriques des matériaux isolants, Coehlo Roland
Physique de l'état solide, Kittel Charles
Dielectric Relaxations in Solids, Jonscher, Andrew
Course Homepage:
Evaluation: 0-20
Language of Instruction: English
Further Information: other lecturers C. Desplanches, O. Toulemonde, M. Maglione, M. Josse

Course name: Bibliographic project
Responsible teacher: M. Josse
Status of the Course: compulsory
Level of the Course: for students who have completed their M1
Teaching Period: II (Spring)
Learning Outcomes:
Bibliographic analysis about a given research topic. This topic can be (or not) continued in master thesis.
The student will have to gather and to analyze the international literature (including patents) on a given topic under the supervision of a university staff. The student will be in charge of the writing of a synthesis of the different documents chosen including a critical analysis of the concepts described in these documents.
Assessment Methods and Criteria: Report**,** Oral Defense
Study Material:
Course Homepage:
Evaluation: 0-20
Language of Instruction: English
Further Information:

XXXX-XX **Inno Project (3 ECTS): See SD 3A: “Innovation and entrepreneurship education courses” document**

M2 UL HOST UNIVERSITY (second year students)

AUTUMN SEMESTER			
Code	Name	ECTS credits	
Compulsory		**23**	
CHIM9227-1	Quantum Chemistry	4	
PHYS3003-1	Functional Materials : theory and modeling	4	
CHIM9228-1	Macromolecular chemistry	4	
CHIM9256-1	Advanced solid state chemistry	4	
CHIM9230-1	Nanomaterials, (electro)synthesis and applications	4	
STRA????-?	Inno Project II	3	Collaborative new course with all partners, I&ENT
Elective		**10**	
PHYS3014-1	Physics and chemistry of materials : complements	2	
PHYS3004-1	Nanomaterials : theory and modeling	4	
PHYS3015-1	Electronic and vibrational spectroscopies	4	
CHIM9231-1	Characterization of biomaterials	4	
CHIM9232-1	Biohybrids : theory and modeling	4	
CHIM9233-1	Molecular logic	2	
CHIM9234-1	Polymers and environment	2	
CHIM9257-1	Introduction to solid state NMR	2	
CHIM9266-1	Characterization of nanostructures by scanning probe techniques	2	
PHYS3016-1	Physical characterization of materials and interfaces	4	
PHYS0096-1	Physics of superconductors	4	
PHYS3023-1	Theory of magnetism	4	
	TOTAL	**30**	
SPRING SEMESTER			
SMEM0040-?	Research master thesis	15	
STRA0019-?	Research master thesis (complements)	12	
	TOTAL	**27**	

UL COURSE DESCRIPTIONS

General remarks : *For each cours, a weblink is provided, where additional information can be found concerning the related course. All courses at the University of Liege are, in principle, presented in such a way that this kind of details is available online.*

Course name: CHIM9227-1 Quantum Chemistry (4 ECTS)
Responsible teacher: Françoise Remacle

Status of the Course : Compulsory
Level of the Course: Master level
Teaching Period: Autumn
Duration : 40h
Prerequisite knowledge and skills : Basic notions of quantum mechanics
Learning Outcomes: Basic notions of molecular electronic structure and practical applications of quantum chemistry.
Course content: Basic notions of quantum chemistry and of the computation of molecular electronic structure. Application to molecular structure, optical spectroscopy and chemical reactivity. The basic notions are illustrated by exercises and computer lab where the electronic structure of simple systems is computed.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9227-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : PHYS3003-1 Functional Materials : theory and modeling (4 ECTS)
Responsible teacher: Philippe Ghosez
Status of the Course : Compulsory
Level of the Course: Master level
Teaching Period: Autumn
Duration : 30h
Prerequisite knowledge and skills : Physics of materials
Learning Outcomes: The goal of this course is to provide to the student a microscopic understanding of the origin of coupling properties in functional materials.
Course content: Functionals (or "smart") materials are those materials that, due to their specific properties (dielectric, piezoelectric, ferroelectric, ferromagnetic, magneto-electric, electro-optic, ...) are playing an active role in devices such as memories, sensors, actuators, transductors and are in the heart of technological applications. The course will focus on the family of ABO_3 oxide with a perovskite structure and start with a review of the extremely various properties exhibited by these compounds nevertheless sharing the same structure. It will introduce first-principles (DFT), semi-empirical (effective Hamiltonians) and phenomenological techniques allowing the theoretical description of functional materials. It will then discuss the microscopic origin of various coupling properties as well as their temperature dependence. The course will describe applications in the fields of electronics and sensing. It will also mention the influence of finite size effects in nanostructures and the computational design of artificial materials with optimized properties.
Assessment Methods and Criteria: Oral exam after a written preparation
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/PHYS3003-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : CHIM9228-1 Macromolecular Chemistry (4 ECTS)
Responsible teacher: Christine Jérôme
Status of the Course : Compulsory
Level of the Course: Master level
Teaching Period: Autumn
Duration : 35h
Prerequisite knowledge and skills : Basic course introduction to macromolecular chemistry
Learning Outcomes: Understanding of the behavior of macromolecules in solution and at the solid state in function of the temperature and its implication in the characterisation and use of these materials.
Course content: This course studies macromolecules properties in solution (determination of molecular weight, ...) and at the solid state in function of temperature (Tg, rheology,...).
Assessment Methods and Criteria: Written and oral exams.
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9228-1.html
Evaluation : Grade range 0-20

Language of Instruction: English

Course name : CHIM9256-1 Advanced solid state chemistry (4 ECTS)
Responsible teacher: Bénédicte Vertruyen
Status of the Course : Compulsory
Level of the Course: Master level
Teaching Period: Autumn
Duration : 30h
Prerequisite knowledge and skills : Introductory courses in inorganic and solid state chemistry
Learning Outcomes: At the end of the course, the students will be able
- to propose experimental procedures for solid state synthesis by common methods
- to use their background knowledge to develop further knowledge by reading review papers
Course content: As a sequel to introductory courses, this course will consist in the analysis and discussion of papers from the recent literature. If necessary, more conventional lectures on specific topics will be organised. The course may be illustrated by a short lab project.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9256-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : CHIM9230-1 Nanomaterials, (electro)synthesis and applications (4 ECTS)
Responsible teacher: Christophe Detrembleur, Christine Jérôme
Status of the Course : Compulsory
Level of the Course: Master level
Teaching Period: Autumn
Duration : 30h
Prerequisite knowledge and skills : Basics in macromolecular chemistry
Learning Outcomes: The course is an introduction to nanotechnology and shows the impact on the development of novel materials with high performances. This course is given in English.
Course content: The course aims at giving the basis of nanotechnology by explaining the evolution of the properties of materials in relation to their size. In thesecond part of the course, the synthesis pathways to prepare nanomaterials are developed, together with their applications. Metallic nanoparticles, polymer nanoparticles for drug delivery, polymer/clays and polymer/carbon nanotubes nanocomposites are deeply discussed. Electrochemical preparation and applications of conjugated polymers in electrochemical devices are also thouroughly described.
Assessment Methods and Criteria: Written exam with opened questions
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9230-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

XXXX-XX Inno Project (3 ECTS): See SD 3A: “Innovation and entrepreneurship education courses” document

Course name : SMEM0040-1 Research master thesis (15 ECTS)
Responsible teacher: Board of teachers
Status of the Course : Compulsory
Level of the Course: Master level
Teaching Period: Spring
Duration :
Prerequisite knowledge and skills : A general education in physics or chemistry or materials science corresponding to 240 ECTS
Learning Outcomes: Education to scientific research
Course content: The student will work on an original research projet in one of the research groups involved in the Master program

Assessment Methods and Criteria: Assessment based on the quality of the written research report, of an oral seminar and of the answers to the reviewers' questions.
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/SMEM0040-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : STRA0019-1 Research master thesis (complements) (12 ECTS)
Responsible teacher: Board of teachers
Status of the Course : Compulsory
Level of the Course: Master level
Teaching Period: Spring
Duration :
Prerequisite knowledge and skills : A general education in physics or chemistry or materials science corresponding to 240 ECTS
Learning Outcomes: Education to scientific research
Course content: The student will work on an original research projet in one of the research groups involved in the Master program
Assessment Methods and Criteria: Assessment based on the quality of the written research report, of an oral seminar and of the answers to the reviewers' questions.
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/STRA0019-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : PHYS3014-1 Physics and chemistry of materials : complements (2 ECTS)
Responsible teacher: Board of teachers
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 20h
Prerequisite knowledge and skills : Basic courses in solid-state physics as well as in organic and inorganic chemistry.
Learning Outcomes: At the end of this course, the student will have filled the gaps in his/her background and will possess the knowledge required to assimilate the mandatory teachings of the Master programme.
Course content: The content of this course is adapted to each student on an individual basis, depending on his/her background knowledge, as obtained from his/her previous studies. If necessary, specific topics in physics and/or chemistry of materials will be developed and treated in order to fill possible gaps of the student background in these fields.
Assessment Methods and Criteria: The assessment method will be given by the teachers involved in the studied topics.
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/PHYS3014-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : PHYS3004-1 Nanomaterials : theory and modeling (4 ECTS)
Responsible teacher: Jean-Yves Raty
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 30h
Prerequisite knowledge and skills : Physics of materials
Learning Outcomes: Knowledge of the basics of simulation methods that can be used to simulate nanomaterials.
Course content: 1. Fundamental properties

2. Simulation techniques : Molecular dynamics - Monte Carlo sampling
3. Potentials : Classical - Semi-empirical - Pseudopotentials
4. Application to : Carbon nanotubes, Graphene, Semiconductor and Metal nanoparticles, Alloy nanoparticles
Assessment Methods and Criteria: Oral presentation of a personal work dealing with one of the course topics.
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/PHYS3004-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : PHYS3015-1 Electronic and vibrational spectroscopies (4 ECTS)
Responsible teacher: Matthieu Verstraete
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 30h
Prerequisite knowledge and skills : Basic Physics, Quantum mechanics, Electron-EM field interactions
Learning Outcomes: To gain an overview of different types of spectroscopy, and a deeper understanding of 1) how they relate to theories which can predict them and 2) how one can go about simulating a spectrum in practice.
An additional outcome will be practical experience with a numerical simulation program.
Course content: Different spectroscopic techniques are presented, with particular attention to electronic and vibrational spectroscopies.
The first part of the course covers the general theory of time dependent perturbations, and the derivation of several particular cases (at least IR and optical absorption).
The second half covers learning the basic usage of an ab initio spectroscopic simulation program (OCTOPUS), and the calculation of a basic spectrum, to be compared with experimental data.
Assessment Methods and Criteria: The exam is in 2 parts: a written report on the simulations which were carried out, followed by a 10-15 minute oral presentation (conference style)
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/PHYS3015-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : CHIM9231-1 Characterization of Biomaterials (4 ECTS)
Responsible teacher: Edwin De Pauw, Marie-Claire Gillet
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 30h
Prerequisite knowledge and skills : Notions in cellular and tissue biology
Learning Outcomes: The course is divided in three parts:
Initiation to the the basic techniques used for the culture of animal or human cells in vitro.
Biocompatibility and cytotoxicity
Interactions between biomaterials and cells or tissues at the site of implantation
Course content: Study and understanding the mecanisms of interactions between materials and cells or tissues at the site of implantation
Assessment Methods and Criteria: Oral presentation of article
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9231-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : CHIM9232-1 Biohybrids: theory and modeling (4 ECTS)
Responsible teacher: Françoise Remacle
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn

Duration : 30h
Prerequisite knowledge and skills : Basic notions of quantum chemistry
Learning Outcomes: Give an overview of the advanced methods of quantum chemistry that allow to study the properties of complex systems such as the supramolecular complexes, metallic clusters and nanostructures, hybrid complexes metallic cluster - organic ligand.
Course content: The course is devoted to the advanced methods of quantum chemistry that allow to investigate the properties of complex molecular and biohybrid systems and their reactivity including solvent effects.
Assessment Methods and Criteria: Oral exam
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9232-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : CHIM9233-1 Molecular logic (2 ECTS)
Responsible teacher: Françoise Remacle
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 15h
Prerequisite knowledge and skills : Basic principles of quantum mechanics and of molecular physical chemistry
Learning Outcomes: Fundamentals of (i) Molecular logic Classical and quantal, (ii) Logic machines : Combinational circuits and finite state machines, (iii) Quantum computing, (iv) search algorithm
Course content: The course begins with an Introduction to classical Boolean logic and to quantum logic. Then, the different approaches aiming at implementing logic machines at the molecular level are reviewed : (i) Molecular electronics, (ii) Implementation of logic operation by software, (ii) Implementation of concatenated logic gates at the hadware level, (iii) quantum computing. Several concrete examples are discussed : molecular combinations circuits, finite state molecular machines, implementation of search algorithms.
Assessment Methods and Criteria: Oral exam. Explain and comment an recent article devoted to molecular logic, chosen in a proposed selection.
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9233-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : CHIM9234-1 Polymers and environment (2 ECTS)
Responsible teacher: Philippe Lecomte
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 15h
Prerequisite knowledge and skills : A basic knowledge in organic chemistry and in macromolecular chemistry is required.
Learning Outcomes: The student will have to acquire all the knowledges related to the synthesis of macromoleculesand he will have to understand the impact of the modifications of the materiel at the molecular level onto the macrospcopic properties. The student will have to be able to discuss the implications on environment of both aspects
Course content: The different techniques used to synthesize homopolymers and copolymers (random and block) will be introduced (chain-growth polymerization, step-growth polymerization, anionic and cationic polymerizations, radical polymerization, coordination polymerization, ring-opening polymerization). These techniques will be compared in terms of environmental concerns. The concept of living polymerization will be introduced. A special attention will be paid to the synthesis of bio-based and biodegradable polymers. Finally, it will be shown that architecture of homopolymers (block copolymers, comb-shaped polymers, star-shaped polymers, branched polymers, networks) as well as the blending of different polymers enables to tailor the properties of polymer materials, which is usefull for many applications akin to environment.
Assessment Methods and Criteria: Oral exam with a written preparation.

Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9234-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : CHIM9257-1 Introduction to solid state NMR (2 ECTS)
Responsible teacher: Christian Damblon, Philippe Lecomte, Bénédicte Vertruyen
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 15h
Prerequisite knowledge and skills : Basic knowledge of liquid state NMR
Learning Outcomes: At the end of the course, students will be able to:
· identify the interactions involved in solid state NMR;
· understand and explain the main techniques of solid state NMR (MAS, CP, decoupling) and some common pulse sequences
· analyse experimental procedures and results from the literature.
Course content: 1. Revision of Background knowledge and introduction to solid-state NMR
2. Application to polymers (Philippe Lecomte), to inorganic materials (Bénédicte Vertryen)and to biological materials (Christian Damblon)
3. Lab visit and model experiments
Assessment Methods and Criteria: Final exam about theory and applications
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9257-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : CHIM9266-1 Characterization of nanostructures by scanning probe techniques (2 ECTS)
Responsible teacher: Anne-Sophie Duwez
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 15h
Prerequisite knowledge and skills : Good knowledge in physical chemistry and surface science
Learning Outcomes: Acquisition of a good basic knowledge of advances SPM techniques.
Learning independence. Search for information. Acquisition of questioning mind. Time management.
Course content: The course will discuss tools derived from SPM techniques to characterize and manipulate nanoobjetcs and molecules (especially AFM: imaging and single molecule force spectroscopy)
Assessment Methods and Criteria: Written examination
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/CHIM9266-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : PHYS3016-1 Physical characterization of materials and interfaces (4 ECTS)
Responsible teacher: Ngoc Duy Nguyen
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 30h
Prerequisite knowledge and skills : Basics of solid-state physics. Notions of electricity and wave optics.
Learning Outcomes: Description and analysis of experimental methods for the characterization of electronic and optical properties of materials and interfaces :
- Optical absorption - Photoluminescence - Electroluminescence - Spectroscopic ellipsometry - Transient photoconductivity - Admittance spectroscopy - ...

Course content: In this course, experimental methods for the characterization of electronic and optical properties of materials and interfaces will be reviewed. A detailed description will be presented for some of them and their practical implementation will be discussed.
Assessment Methods and Criteria: The lab assignment report is the major part of the evaluation. The other part will consist in the analysis and the discussion of a selected journal paper. The student will be tested on the experimental techniques used in the paper.
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/PHYS3016-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : PHYS0096-1 Physics of superconductors (4 ECTS)
Responsible teacher: Alejandro Silhanek
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 30h
Prerequisite knowledge and skills : It is convenient to have basic knowledge of mathematics and solid state physics.
Learning Outcomes: By the end of the course, the students will be able: * To know and understand the electric, thermodynamic and magnetic properties of superconductors as well as the main difference between a superconductor and a perfect conductor. * To understand how the confinement effects modify the ground state and the response of a superconducting system. * To understand the influence of the material microstructure on the conduction properties. * To know and understand the techniques used for visualizing the quantized magnetic flux. * To know and understand the way of controlling or manipulating the quantized magnetic flux.
Course content: This course presents an introduction to superconductivity.
Some of the concepts that will be tackled are:
- Perfect electrical conductivity - London model - Basic concepts of the microscopic theory (BCS) - Fluxoid quantization - Vortex structures - Thermodynamics of superconductors (Ginzburg-Landau) - Critical fields - Interaction between vortices - Surface effects - Trapping and periodic pinning - Self Organized criticality in Superconductors (Bean Model) - Vortex avalanches - Confinement effects in superconductors - Vortex ratchets and other rectification effects - Superconductor-ferromagnet hybrid systems
Assessment Methods and Criteria: Along the course each student must select a topic of interest related to the course and make a short presentation of about 15 minutes (20%). The final evaluation consists of a writen or oral exam (80%).
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/PHYS0096-1.html
Evaluation : Grade range 0-20
Language of Instruction: English

Course name : PHYS3023-1 Theory of magnetism (4 ECTS)
Responsible teacher: Eric Bousquet
Status of the Course : Elective
Level of the Course: Master level
Teaching Period: Autumn
Duration : 30h
Prerequisite knowledge and skills : Basics in solid-state physics and quantum mechanics are required to follow the lecture.
Learning Outcomes: - History of magnetism and magnetostatics
- Electronic and atomic magnetism
- Exchange interaction, ferro- and antiferro-magnetism
- Superexchange, double exchange
- Crystal field and magnetic anisotropy
- Ferrimagnetism and weak ferromagnetism

- Group theory in magnetic materials
- Experimental methods
- Magnetic materials and applications
- Nanomagnetism and finite size effects

Course content: This lecture aims at introducing the quantum theory of magnetism in solids.
Assessment Methods and Criteria: Oral examination
Course Homepage: http://progcours.ulg.ac.be/cocoon/en/cours/PHYS3023-1.html
Evaluation : Grade range 0-20
Language of Instruction: English