UNIVERSITY OF CRETE

STUDY GUIDE

DEPARTMENT OF MATERIALS SCIENCE AND TECHNOLOGY

2020

DEPARTMENT OF MATERIALS SCIENCE AND TECHNOLOGY

Voutes Campus 70013, Heraklion, Crete, Greece

Mathematics Building, Room E120, Voutes Campus
Tel. 2810 – 394270-2, Fax 2810 – 394273

Secretary:

Head Secretary:

Skouradaki Emilia

Other administrative Staff:

Athanassaki Ekaterini

Partali Maria

e-mail: secretariat@materials.uoc.gr

url: http://www.materials.uoc.gr

Contents

Overview of the Department of Materials Science and Technology

The Department of Materials Science and Technology (MST) was founded 2001, and the first undergraduate courses were offered in the academic year 2001-2002 to a student body of 50. The postgraduate (MSc) program was initiated shortly after, in the academic year 2003-2004. The Department is located in the Voutes campus. Its Secretariat can be found in the Mathematics Building, where lectures and laboratory practicals are held. The computing and laboratory infrastructure of the adjacent Institute of Technology and Research (including the laboratories of microelectronics, polymers, semiconductors, superconductors, surfaces, biochemistry, biomaterials, medical applications, laser applications for materials processing) are also available to conduct senior thesis and post-graduate (MSc, PhD and Post-Doc level) work in conjunction with the various group leaders.

The aspiration of the Department of Materials Science and Technology is to be established as ~~grow into~~ a modern, pioneering and dynamic center for the teaching and development of this cutting-edge field, and prepare its students to meet the needs of modern industry and economy. It also intends to contribute to the modern research developments in science and technology in an area with continuous and rapid growth on a medium- and long-term basis.

The Department's research activities focus on the development of new materials through the understanding of the relationship composition – structure – processing – properties. The Master's program leads to the acquisition of a Master of Science (M.Sc.) degree. The Department also accepts doctoral students whose work culminates into a Doctor of Philosophy (Ph.D.) degree. The development of the MSc program was based upon the extensive experience accumulated from long-standing postgraduate programs run by other Departments.

Departmental Administration

Chair of the Department: Anna Mitraki, Professor, tel. +30 2810 394095, email: mitraki@materials.uoc.gr

Vice Chairman: George Petekidis, Professor, tel. +30 2810 391490, email: georgp@materials.uoc.gr

Administrative Staff:

Head Secretary:

Emilia Skouradaki	tel. +30 2810394271	email: skouradaki@materials.uoc.gr

Other administrative Staff:

Ekaterini Athanassaki,	tel.+30 2810934462	email: k.athanasaki@materials.uoc.gr
Maria Partali,	tel. +30 2810394270	email: partalim@materials.uoc.gr
Charalambos Stratigis,	tel.+30 2810394272	email: stratigis@materials.uoc.gr

I. REGULATIONS AND CURRICULUM

1. Subject of Study – Departmental Staff

The objective of the studies in the MST, as already mentioned, is Materials Science and Technology. Materials Science is the understanding of the relationship between the composition, structure, processing, and properties of materials. Material Technology is the specialized design, synthesis, control and modification of materials to meet the demands of society. Scientists in the field design, synthesize, characterize and develop the wide variety of materials used in today's technological age to produce virtually all products from mechanical engineering machines and thousands of consumer products to advanced electronics as well as new types of medicines and biotech materials.

Research in the Department focuses on the following areas (with their respective laboratories):

- Biomaterials
- Polymer and Colloid Science
- Theoretical and Computational Material Science
- Magnetic Materials
- Optoelectronics and Photonics
- Materials Chemistry

2. Academic Staff

The Department's academic staff is composed of the Faculty, the Laboratory Instructors, Special Technical Personnel, Scientific Collaborators, as well as Affiliated Faculty from other Departments in the School of Exact and Technological Sciences of the University of Crete. The Department's academic staff represents a wide range of backgrounds (chemistry, physics, biology and engineering) that provides the necessary interdisciplinary mix for the implementation of the educational goals of the curriculum.

Faculty

Professors

Maria Vamvakaki has received the B.Sc. in Chemistry at the University of Crete. She holds a doctoral degree in Polymer Chemistry from the University of Sussex, U.K. where she did her graduate work with Profs. S. P. Armes and N. C. Billingham, on the synthesis of water-soluble polymers and their evaluation as ceramic dispersants. From 1997 to 1998 she was a post-doctoral associate at the School of Chemistry, Physics and Environmental Science at the University of Sussex, working on the synthesis and characterization of double-hydrophilic block copolymers and their self-assembly in water. In 1999 she became a Visiting Assistant Professor in Chemistry at the Department of Physical Sciences of the University of Cyprus while in 2000 she joined the group of Prof. C. S. Patrickios at the Chemistry Department of the University of Cyprus as a research associate where she worked on the synthesis, characterization, modelling and applications of model polymer networks. From 2001 to 2004 she was a visiting Professor at the Department of Materials Science and Technology of the University of Crete and a visiting scientist at the School of Chemistry, Physics and Environmental Science at the University of Sussex. She is affiliated researcher at FO.R.T.H.-Institute of Electronic Structure and Laser (I.E.S.L.) since 2003. In 2004 she was appointed Assistant Professor at the University of Crete, where she became an Associate Professor in 2011 and a Full Professor in 2018. She is Editor of Materials Science and Engineering C since 2017 and an Associate Editor of Frontiers in Bioengineering and Biotechnology since 2020. She is also a member of the Advisory Board of Polymer Chemistry since 2018.

Dimitrios Vlassopoulos

- Diploma, Chemical Engineering, National Technical University, Athens, 1983. PhD, Chemical Engineering, Princeton University, 1990.

- Industrial experience (Metelco, Greece, 1983-4 and Mobil R&D, USA, 1990-2). FORTH researcher since 1992 and University of Crete faculty since 2002.
- Visiting Professorships at the University of Delaware, KITP, ESPCI, ETH Zurich, DTU, INSA, Univ. catholique Louvain. European Editor, Rheologica Acta (2006-2011), Associate Editor, Soft Matter (2015-).
- Weissenberg Award, European Society of Rheology, 2015; Fellow, The Society of Rheology, 2018; Bingham Medal, The Society of Rheology, 2019; APS Fellow, 2019.

Anna Mitraki, BS Chemistry, University of Thessaloniki, Greece, 1981. PhD Biochemistry, Universite de Paris-Sud, Orsay, France, 1986 (work on enzyme folding, assembly and aggregation with Professor Jeannine Yon-Kahn). Post-doctoral associate (1987-1991) and then Research Scientist (1991-1994) at the Massachusetts Institute of Technology, Cambridge, MA, U.S.A. (work on folding and assembly of fibrous phage proteins with Professor Jonathan King). Research scientist at the Institut de Biologie Structurale in Grenoble, France (French National Research Center) from 1995 to 2004. Habilitation, Universite Joseph Fourier, Grenoble, France, in 2003, for work on structure, folding and assembly of beta-structured fibrous proteins and their self-assembling peptides. Since September 2004, Associate Professor, Department of Materials Science and Technology, University of Crete, Greece. Affiliated Research Scientist with the Institute for Electronic Structure and Laser, FORTH. Academic Editor, PLoS ONE (2009-2014, www.plosone.org). Since September 2014, Professor, Department of Materials Science and Technology, University of Crete, Greece.

Nikolaos Pelekanos obtained his PhD in 1991 from Brown University (USA), on the optical properties of two-dimensional II-VI compound semiconductors. After a number of post-doctoral stays in various European labs, including the France Telecom Research Center in Lannion and the Max-Planck Institute in Stuttgart, he joined the Semiconductor Physics Laboratory of CEA-Grenoble from 1995 until 2001. Next, he joined the Microelectronics Research group at FORTH in 2001 and the Materials Science and Technology Department of the University of Crete in 2003. His main research theme is the demonstration of novel semiconductor nanophotonic devices. He has coordinated/participated in numerous European, bilateral and national projects. He has obtained the "Solar Innovation 2010" award for his proposal on third-generation low-dimensional semiconductor solar cells, and more recently a Chair of Excellence LANEF, funded by the French government, for a project entitled "Nanowire Innovative Solar Cells". He has published over 220 publications (2700 citations, h=26) in refereed journals and conference proceedings and holds 6 technical patents.

George Petekidis received his Bachelor degree in Physics from the Aristotle University of Thessaloniki in 1989 and moved to the Department of Physics of the University of Crete and FORTH in 1990 for graduate studies. He was awarded a Master degree in Physics in 1995 and concluded his PhD thesis in Polymer Physics in 1997 working on the "Dynamics of Hairy-rod polymers". After serving his military service he moved to the Department of Physics and Astronomy of the University of Edinburgh with an individual Marie-Curie fellowship where he worked until 2002 under the supervision of Prof. P.N. Pusey on the "Dynamics of colloidal glasses under shear". In 2002 he joined FORTH initially with a return Marie-Curie fellowship and then (2004-2006) as an Associated researcher (grade C). In 2006 he moved to the Department of Materials Science and Technology of University of Crete where he is currently a Professor.

Pavlos Savvidis has received the B.Sc. in Physics of the University of Athens. He obtained his doctoral degree in Experimental Condensed Matter and Laser Physics from the University of Southampton in 2001 creating the first polariton amplifier. From 2002 to 2004 he was DARPA funded post-doctoral associate at the Department of Physics at Santa Barbara, USA, working on the terahertz dynamics in semiconductor nanostructures and Bloch Oscillators. In 2004 he was appointed Assistant Professor at the Department of Materials Science and Technology of the University of Crete. He is affiliated researcher of the Microelectronics Research Group at FO.R.T.H.-Institute of Electronic Structure and Laser (I.E.S.L.) since 2004. He was awarded 1year Leverhulme Fellowship in 2014 to work as visiting Professor at Cavendish Labs, University of Cambridge. His work on polaritonic devices, appeared in high impact journals such as Nature, Science, Nature Physics, Nature Comm. and PRLs. The results of many of these works were featured in News & Views and Perspectives sections of Nature and Science journals respectively.

Associate Professors

Gerasimos Armatas received his B.Sc. in Chemistry from University of Ioannina in 1998. He obtained his master in Bioinorganic Chemistry in 2000 and his doctoral degree in Chemistry in 2003 from the same

University. He did his PhD work with Prof. P. Pomonis on synthesis and pore structure determination of silicate mesoporous materials. From 2004 to 2006 he was a post-doctoral research associate at Chemistry Department of the Michigan State University in USA, working with Prof. Mercouri Kanatzidis on the synthesis of mesostructured elemental semiconductors such as silicon or germanium. While in 2006 he moved at Chemistry Department of the Northwestern University in IL, USA, where he worked on synthesis of mesoporous Ge-based intermetallic and metal chalcogenide semiconductors. In 2008 he was appointed Assistant Professor at the Department of Materials Science and Technology of the University of Crete.

Maria Kafesaki obtained her Ph.D. in 1997, from the Physics Department of the University of Crete, Greece. She has worked as post-doctoral researcher in the Consejo Superior de Investigaciones Cientificas (CSIC) in Madrid, Spain, and at the Institute of Electronic Structure and Laser (IESL) of the Foundation for Research and Technology Hellas (FORTH). From 2001 to 2011 she worked as Researcher (D, C, B) at FORTH-IESL. Her research is on the area of electromagnetic and elastic wave propagation in periodic and random media, with emphasis on photonic crystals and metamaterials, where she has a long time theoretical and computational experience. She has around 80 publications in refereed journals and conference proceedings (with ~3000 citations), she has participated in various European and national projects as well as in the organization of many international conferences and schools.

George Kioseoglou received his B.Sc. and M.Sc. in Physics from the University of Thessaloniki. He obtained his doctoral degree in experimental solid-state physics from the State University of New York at Buffalo in 1999 in the area of spectroscopic studies of electronic states in semiconductor heterostructures. From 1999 to 2001, he was a post-doctoral research associate at the Department of Physics SUNY at Buffalo/Brookhaven National Laboratory (Long Island, New York). In 2002 he moved to Washington DC as a postdoctoral associate at Naval Research Laboratory (NRL)/George Washington University where he continued his work on efficient electrical spin injection and detection in semiconductors. From 2004 to 2006 he was a National Research Council (NRC) post-doctoral Fellow with the materials physics branch at NRL. In 2007 he was appointed Associate Professor at the Department of Materials Science and Technology of the University of Crete. Prof. Kioseoglou has shared 3 times the NRL Alan Berman research publication award for his outstanding work on efficient electrical spin injection in GaAs and Si spin-LEDs [PRB 62, 8180 (2000), PRL 89, 166602 (2002), Nature Physics 3, 542 (2007)]. He has co-authored over 85 scientific publications in refereed journals and contributed more than 200 conference presentations; he has 4 very highly cited papers in spintronics [APL 80, 1240 (2002)-420 citations, PRB 62, 8180 (2000)-340 citations, APL 82, 4092 (2003)-220 citations, Nature Physics 3, 542 (2007)- 392 citations (data from Google Scholar - January 2018)]. He is an active member of the American Physical Society and serves in APS and MMM conferences.

George Kopidakis received a B.Sc. in Physics from the University of Crete and a Ph.D. in Condensed Matter Physics from Iowa State University in 1995. After his graduate work at Ames Laboratory-Iowa State University, USA, he worked as a research assistant professor at the Center for Atomic-Scale Materials Physics (CAMP), Dept. of Physics, Technical University of Denmark. He then moved to Laboratoire Leon Brillouin (CEA-CNRS), Saclay, France, initially with an individual Marie Curie EC post-doctoral fellowship and later as a CNRS research associate. He was a research associate at the Physics Dept. and a visiting associate professor at the Dept. of Materials Science and Technology, University of Crete, where he was appointed assistant professor in 2003. He is also affiliated researcher at FORTH since 2005.

Andreas Lyberatos received his B.Sc. in Physics from University in London in 1982. He obtained his PhD in Physics in 1986 from the same University. He did his PhD work with Prof. E.P. Wohlfarth on interaction effects in fine particle ferromagnets. He was a postdoctoral research fellow at the University of Central Lancashire (1989-1990), University of Manchester (1990-1991) and Keele University (1991-1996) in the U.K. working with Prof. R.W. Chantrell on magnetic viscosity and thermal fluctuations in micromagnetics. In 1996 he moved at the Physics department of the University of Crete, where he worked as a visiting Lecturer on Monte Carlo models of domain growth in ultra-thin films with perpendicular anisotropy. From 2000 to 2008, he was an independent research consultant of Seagate Technology in Pittsburgh, USA working on the switching speed of perpendicular recording media and heat assisted magnetic recording. In 2009 he moved to the Department of Materials Science and Technology, as a visiting lecturer (2009-2014) where he worked on atomistic models of FePt HAMR media and magnetic vortices. In 2014 he was appointed Associate Professor at the same Department and is currently working in ballistic thermal transport in HAMR media, finite size scaling theory and high temperature magnetization dynamics.

Dimitris Papazoglou got his BSc in 1991, his MSc on Radio-Electronics in 1995 and his PhD in 1998 on "Photorefractive materials in optical information processing systems", from the Physics Department of the Aristotle University of Thessaloniki, Greece. He joined the laser applications group in IESL-FORTH in 2000 as a postdoc and later on was appointed application scientist in 2003 investigating laser-mater interaction phenomena for ultra-short and short laser pulses with various materials (metals, dielectrics, bio-materials) during the LIFT process (Laser Induced Forward Transfer) making use of optical diagnostic methods. Concurrently, he was affiliated with the University of Crete as a Visiting Assistant Professor in the Physics Department teaching optics in undergraduate and graduate courses. In 2005, he joined the faculty of the Department of Materials Science and Technology of the University of Crete. He is also an affiliated researcher at IESL-FORTH where he carries out his research activities as an affiliated senior member of the UNIS group.

Ioannis N. Remediakis, got his bachelor (1997), masters (1998) PhD (2002) degrees from the Department of Physics, University of Crete. His PhD research (simulations for alloyed semiconductor surfaces) was performed at Harvard University. Between 2002 and 2008, he held teaching and research appointments at the University of Ioannina, the Technical University of Denmark (DTU) and the University of Crete. In 2008, he joined MST as Assistant Professor where he was tenured in 2012. He is also affiliated research Scientist with the Institute for Electronic Structure and Laser, FORTH.

Constantinos Stoumpos, in 2001 he attended the Chemistry Department at the University of Patras where he obtained both his B.S. (2006) and Ph. D. (2009) degrees, the latter under the supervision of Spyros P. Perlepes working on the coordination chemistry of 3d-metals targeting the discovery of new Single-Molecule Magnets (SMMs) and Molecular Nanomagnets (MNMs). In February 2010 he joined the group of Mercouri G. Kanatzidis at the Department of Chemistry of Northwestern University, IL, USA as a postdoctoral fellow working on the synthesis of p-block halide perovskites for near-IR optical applications. On January 2012 he moved to the Materials Science Division (MSD) of Argonne National Laboratory (ANL), IL, USA, where he worked on the single-crystal growth of dense, wide-bandgap halide and chalcohalide compounds for high energy radiation detection. In 2014 he returned to Northwestern University working on the development of halide perovskites for energy related applications. Following a short coterminous appointment as Lecturer in 2017 he was promoted to the Research Assistant Professor at Northwestern University in 2017. In 2018 he was appointed at the Department of Materials Science and Technology of the University of Crete as an Associate Professor.

Stelios Tzortzakis received his PhD from the Ecole Polytechnique (France, 2001) in Nonlinear Optics. He has worked in many research laboratories in France and Greece, and since 2003 he has held a CNRS position at the Ecole Polytechnique. In 2006 he was the recipient of a European Union Marie Curie Excellence Grant, with which he has founded and now leads the UNIS research group at IESL-FORTH in Greece, where he is a Principal Researcher. In 2011 he was appointed Associate Professor in the Materials Dept. of the University of Crete. He is a recognized expert in nonlinear laser propagation phenomena and has created the filamentation.org website, a unique information resource for the related scientific community.

Maria Chatzinikolaidou received her B.Sc. in Chemistry from the University of Essen, Germany and her doctoral degree in Biochemistry from the same university in 2004. Her PhD work focused on the immobilization and release kinetics of recombinant human bone morphogenetic protein 2 (rhBMP-2) from metal implant surfaces, under the supervision of Prof. H.P. Jennissen. From 2004 to 2006 she was a post-doctoral associate at the University Medical School of Essen working on the development of novel bioactive dental and bone implants. From 2006 to 2008 she was a post-doctoral fellow supported by the EU ENTER program at the Institute of Molecular Biology and Biotechnology, FORTH, performing research on biosensing protein and cell interactions with titanium surfaces by means of the quartz crystal microbalance technique. From 2007 to 2010 she was a Visiting Assistant Professor at the Department of Materials Science and Technology of the University of Crete teaching courses on "Biological Materials and Composite Biomaterials" and "Tissue Engineering". In 2010 she was appointed Assistant Professor at the Department of Materials Science and Technology, University of Crete. She served as Chair of the 28th Annual Conference of the European Society for Biomaterials (ESB) held in Athens (2017), and Program Chair of the Tissue Engineering and Regenerative Medicine International Society (TERMIS) EU Conference held in Rhodes (2019).

Nikolaos Chronis received a Bachelor in Engineering (B.E.) in mechanical engineering in 1998, from the Aristotle University of Thessaloniki with honors (graduated 1st out of 145 students in his class). He completed his Ph.D. in mechanical engineering from the University of California at Berkeley (USA) in 2004. From 2004-2006, he held a post-doctoral research position at Rockefeller University, New York, (USA). In 2006, he became a faculty at the Department of Mechanical Engineering at the University of

Michigan, Ann Arbor. In 2015, he joined the Department of Materials Science and Technology at the University of Crete. He is also a visiting Professor at the National Center for Scientific Research 'Demokritos'. He is the co-author of more 60 journal and peer-reviewed conference publications and inventor in 3 patents. Dr. Chronis is the recipient of the prestigious NIH Director's New Innovator Award.

Tenured Assistant Professors

Kelly Velonia has received the B.Sc. in Chemistry at the University of Crete. She holds a doctoral degree in Mechanistic Organic Chemistry from the University of Crete where she did her graduate work with Profs I. Smonou and G.J. Karabatsos. In 2000 she joined the group of Prof. R.J.M. Nolte at the Department of Organic Chemistry of the University of Nijmegen (RUN), The Netherlands, as a post-doctoral fellow. In 2001 she joined the group of Prof. F.C. De Schryver at the Department of Chemistry, University of Leuven (KUL), Belgium, as a post-doctoral fellow and in 2002 returned at the group of Prof. R.J.M. Nolte as a Marie Curie Individual Fellow. In 2004 she joined the Department of Organic Chemistry of the University of Geneva, Switzerland, as an Assistant Professor. In 2007 she was appointed Assistant Professor at the Department of Materials Science, University of Crete (tenure 2010).

English Instructors

Kalliopi Katsampoxaki-Hodgetts, School of Science and Technology, University of Crete

Emmanouil Sisamakis, School of Science and Technology, University of Crete

Laboratory Instructors

Konstantinos P. Papadopoulos

Emmanouil Spanakis

Stamatis Stamatiadis

Emmanouil Stratakis

Emmanouil Tilianakis

Special Technical Personnel

Dimitrions Stefanakis

Dimitrios Theodoridis

3. Curriculum structure and Learning Outcomes

The curriculum of the Department of Materials Science and Technology consists of core courses, which are compulsory (C), elective compulsory courses (EC, where the student is required to choose from a group of courses) and optional courses (O).

Table I: Regularly Offered Courses per Semester

Course Code	*1ST SEMESTER*	Hours				ECTS	Prerequisites
		T	P	L			
101	General Physics I	4	2	0	C	6	-
111	General Mathematics I	4	2	0	C	6	-
114	Computers I: Introduction to Programming	2	0	3	C	6	-

121	General Chemistry	4	2	0	C	6	-
141	Materials I: Introduction to Materials Science	3	1	0	C	6	-
011	English I	3	0	0	C	4	-
Course Code	***2^{ND} SEMESTER***	**Hours**				**ECTS**	**Prerequisites**
		T	**P**	**L**			
102	General Physics II	4	2	0	C	6	-
112	General Mathematics II	4	2	0	C	6	-
116	Applied Mathematics	3	2	0	C	6	-
122	Organic Chemistry	4	2	0	C	6	-
124	Chemistry Laboratory	2	0	4	C	8	121
012	English II	3	0	0	C	4	-
Course Code	***3^{RD} SEMESTER***	**Hours**				**ECTS**	**Prerequisites**
		T	**P**	**L**			
201	Contemporary Physics - Introduction to Quantum Mechanics	3	2	0	C	6	-
203	Physics Laboratory I: Mechanics - Heat	0	0	3	C	8	101
211	Differential Equations	3	2	0	C	6	111, 112
223	Inorganic Chemistry	4	1	0	C	6	121
225	Materials Chemistry Laboratory	2	0	4	C	8	124
260	Thermodynamics	3	1	0	C	6	112
215	Advanced Programming I	0	0	3	O	5	114
Course Code	***4^{TH} SEMESTER***	**Hours**				**ECTS**	**Prerequisites**
		T	**P**	**L**			
204	Physics Laboratory II: Electricity-Optics	0	0	3	C	8	102
232	Biochemistry and Molecular Biology	3	0	0	C	6	122
242	Materials III: Microelectronic-Optoelectronic Materials	4	0	0	C	6	-
243	Materials II: Polymers-Colloids	4	0	0	C	6	-
202	Modern Physics II: Matter and Light	3	1	0	EC1	6	201,116
212	Differential Equations II	3	1	0	EC1	6	211

213	Computers II: Introduction to Numerical Analysis	2	0	3	EC1	6	114, 116
222	Spectroscopy	3	0	0	O	5	-
248	Structural & Chemical Analysis of Materials	3	0	0	O	5	-
ΠΑΙ-016	Teaching Materials Science I	-	-	-	O	3	(laboratory assistants)
Course Code	***5TH SEMESTER***	**Hours**				**ECTS**	**Prerequisites**
		T	**P**	**L**			
301	Electromagnetism	3	2	0	C	6	102, 112
305	Solid-State Physics: Introduction	3	2	0	C	6	201
335	Molecular Cellular Biochemistry	3	0	0	C	6	122
343	Soft Materials Laboratory	1	0	5	C	8	243
391	Materials IV: Natural Biomaterials Science	3	0	0	C	6	122
349	Mechanical & Thermal Properties of Materials	3	0	0	O	5	-
ΠΑΙ-017	Teaching Materials Science II	-	-	-	O	3	(laboratory assistants)
ΠΡΑ-001	Practical Exercise I	-	-	-	O	5	-
Course Code	***6TH SEMESTER***	**Hours**				**ECTS**	**Prerequisites**
		T	**P**	**L**			
344	Solid State Materials Laboratory	1	0	5	C	8	204
362	Materials V: Ceramic and Magnetic Materials	3	0	0	C	6	201
461	Elements of Ceramics Science	3	0	0	EC2	6	-
302	Optics & Waves	3	0	0	O	5	102, 112
306	Solid-State Physics II	3	0	0	O	5	201
340	Transport Phenomena in Materials	3	0	0	O	5	211
346	Nanomaterials Surfaces Science	3	0	0	O	5	141
348	Materials & Environment	3	0	0	O	5	-
ΠΑΙ-018	Teaching Materials Science III	-	-	-	O	3	-
ΠΡΑ-002	Practical Exercise II	-	-	-	O	5	-

Course Code	7^{TH} *SEMESTER*	Hours				ECTS	Prerequisites
		T	P	L			
471	Elements of Colloidal Dispersions	3	0	0	EC2	6	243
481	Elements of Semiconductor Physics	3	0	0	EC2	6	242
483	Elements of Magnetic Materials	3	0	0	EC2	6	362
205	Innovation, Entrepreneurship and Intellectual Property	4	0	0	O	6	-
209	Innovation and Entrepreneurship	4	0	0	O	6	-
443	Nanomaterials & Biomaterials Laboratory	0	0	5	O	6	343
453	Crystal Chemistry	1	0	2	O	6	-
598	Bio-organic Nanostructures	3	0	0	O	5	121,122,012

Course Code	8^{TH} *SEMESTER*	Hours				ECTS	Prerequisites
		T	P	L			
447	Computational Materials Science	2	0	3	EC2	6	114
450	Polymer Physics	3	0	0	EC2	6	243
491	Biological Materials and Synthetic Biomaterials	3	0	0	EC2	6	232
207	Exploitation of Research Output and Entrepreneurship	4	0	0	O	6	-
410	Computer Control and Automation of Measuring Systems Laboratory	2	0	2	O	5	114
412	Solid State Chemistry	3	0	0	O	5	141
440	Technical Drawing Laboratory	2	0	2	O	5	-
442	Diploma Thesis	-	-	-	O	12	-
444	Properties & Selection of Materials	3	0	0	O	5	-
445	Fluid Dynamics	3	0	0	O	5	211
446	Electronic Microscopy	3	0	0	O	5	-
448	Special Chapters in Computational Materials Science	2	0	3	O	5	-

452	Polymer Synthesis	3	0	0	O	5	243
454	Rheology and Polymer Processing	3	0	0	O	5	211
462	Ceramic Materials and Properties	3	0	0	O	5	362
464	Special Chapters on Ceramic Materials	3	0	0	O	5	362
470	Synthesis & Characterization of Colloidal Dispersions	3	0	0	O	5	243
480	Heterostructures, Nanostructures & Semiconductor Nanotechnology	3	0	0	O	5	242
482	Introduction to Microelectronics	3	0	0	O	5	242
484	Optoelectrical and Photonic Materials	3	0	0	O	5	242
486	Semiconductor Processing Technology	3	0	0	O	5	242
488	Special Chapters on Magnetic Materials	3	0	0	O	5	362
490	Photonic Materials	4	0	0	O	5	-
492	Cellular Biology	3	0	0	O	5	232, 335
494	Introduction to Biomedical Mechanics	3	0	0	O	5	232 or 335
500	Symmetry in Materials Science	3	0	0	O	5	116, 305
512	Computational Materials Science II: Electronic Structure	2	0	3	O	5	305 and one of EC1
570	Special Chapters on Soft Materials	3	0	0	O	5	243
580	Optoelectronics & Lasers	3	0	0	O	5	242
582	Special Chapters on Optoelectronic Materials	3	0	0	O	5	242
594	Protein Motion and Molecular Machines	3	1	0	O	5	335
596	Molecular Imaging	3	0	0	O	5	-
9I1	Publication I	-	-	-	O	5	-
9I2	Publication II	-	-	-	O	5	-

The anticipated Learning Outcomes of the Undergraduate Study Program for the Bachelor Degree in the Department of Materials Science and Technology are the following: the students will understand the theories and basic principles of chemistry, physics, biology, mathematics and materials science that will allow them to acquire the interdisciplinary knowledge and scientific background of Materials Science, to promote students' free, creative and critical thinking, develop their ability to analyze, evaluate and solve contemporary problems related to the materials engineering area, develop a spirit of collaboration and teamwork, and specialize in modern research methods in cutting-edge and interdisciplinary optional scientific fields. In particular, the main sections of the program are:

• *Introductory Stage:* During the first three semesters students attend basic introductory courses in Physics, Chemistry, Mathematics, Materials Science and Computer Science. Their fundamental understanding will provide the necessary background in the basic concepts, as well as the knowledge required to proceed with their studies. At this stage, students are also expected to be acquainted with English terminology on materials science.

• *Basic Stage:* During the following three semesters, students attend Biology introductory courses, expand their laboratory experience, deepen their knowledge in Basic Materials Science with courses such as Thermodynamics (Classical and Statistical), Solid State Physics and Electromagnetism. Students are also introduced into basic categories of Materials such as Polymers-Colloids, Electronic Materials, Biomaterials, and Ceramic and Magnetic Materials.

• *Advanced stage:* The third stage enables students to further specialize in the various categories of Materials and attend a sufficient number of optional courses offered by the Department of Materials Science and Technology or other Departments of the University of Crete. The choice of these courses must be made by the student in a timely manner in order to adapt their studies to their interests and goals. Students are free to select the optional subjects of their choice in order to:

a. specialize in a particular field aiming either to enroll in postgraduate courses in Material Science or to pursue a technological career in modern engineering,

b. enrich their education in various fields of Natural Sciences and thus broaden their career prospects.

The Learning Outcomes of the Curriculum correspond to the 6th level of the EU classification for educational qualifications.

The weight of each course is stated in European Credit Transfer System (ECTS) units. The six-month workload of a student is the sum of the ECTS units of the courses in which this semester is enrolled. Enrolment is at most eight (8) courses per semester. Students from 5th year (9th semester) will be able to enroll up to ten (10) courses per semester.

Students of the Department of Materials Science and Technology can focus their undergraduate studies on one of the following areas:

- Biomaterials
- Polymers - Colloids
- Electronics - Optoelectronics - Photonics
- Magnetic Materials
- Ceramic Materials
- Nanostructured Materials
- Computational Materials Science

The following table (Table I) summarizes the listed courses and their individual characteristics, namely the semester of study to which each course normally corresponds, its weight in ECTS units, whether it is a core, compulsory or optional course and its prerequisite courses, that is courses containing the knowledge necessary to attend the course.

Elective Compulsory courses are divided into Elective Compulsory 1 and 2 (EC1 and EC2), from which the student is required to take at least 6 and 18 ECTS points, respectively. The extra units in the EC1 and EC2 courses can be converted into optional courses at the student's request. Up to 10 ECTS units or up to 20 ECTS units (through the ERASMUS+ program) will be given for student internships, as detailed below.

The list of elective courses is indicative. Upon approval of the department's meeting and before the new academic year begins, new courses may be added whenever possible.

Students of the current curriculum, may also chose subjects from the Unified Study Guide (as long as it is still valid) as optional courses provided that the courses they have successfully passed are not the same or equivalent.

Courses in other departments of the University of Crete: Students of the MST can attend courses offered by other departments of the University of Crete. These options are updated and announced every six months by the undergraduate committee, based on the courses offered by the other Departments of the University.

4. Obtaining a degree

Requirements for the Graduate Student Announcement: The requirements for obtaining a degree are:

1. Enroll in the Department and attend courses for at least eight (8) semesters.
2. Successful completion of at least 240 ECTS units, of which at least 226 ECTS units from the Department of Materials Science and Technology. Non-Departmental ECTS units are subject to the restrictions set out in Table II below.
3. Successful completion of all compulsory courses of the Department, listed in Table 1, which corresponds to 182 ECTS units (8 ECTS units in English and 174 ECTS units).
4. Successful completion of the student's specialization requirements.

A student is eligible to obtain a diploma based on the requirements of the study regulation applying during the year of the student's first enrolment in the Department of Materials Science and Technology. These requirements for the current study guide are summarized in the Table below.

Table II: Degree Requirements of the Department of Materials Science and Technology

Courses	ECTS	Details
Total	**≥240**	
Total in Department of Materials Science and Technology	≥226	Table I
Obligatory:	**182**	
Department of Materials Science and Technology (except English Language)	174	Table I
English Language	8	
Obligatory Elective: EC1	**≥6**	Table I
Obligatory Elective: EC2	**≥18**	Table I
Options:	**≥34**	
Department of Materials Science and Technology	≥20	Table I
Philosophy Studies	≤12	
Other Departments of the School of Sciences and Technology [1] and the School of Health Sciences	≤20	
Practical Training[1]	≤15	

[1] *Total courses in Philosophy Studies/Other Departments and Practical Exercises may not exceed 30 ECTS credits.*

Clarifications: There are two compulsory elective courses (EC1 and EC2) from which the student is required to take at least 6 and 18 ECTS points, respectively. The extra units in the EC1 and EC2 courses can be converted into optional courses at the student's request. Elective courses may also include courses in Philosophy, the School of Health Sciences as well as basic courses in other Departments of the School of Science and Technology. From the courses of the Humanities cycle the upper limit is 12 ECTS units. From the courses of other Departments of the Faculty of Science and Engineering and the School of Health Sciences the maximum allowed level is 20 ECTS.

The Committee of Studies may replace an elective/optional course of the Department of Materials Science and Technology with a course of another Department.

It is also possible for an undergraduate student to enroll in postgraduate courses of the Department but only after prior agreement and permission from the respective instructor who will approve of the course to be taken. The ECTS units of the postgraduate courses are included in the total score of the student.

5. Undergraduate studies

The grade of the degree is uniformly calculated for all AEIs in the country, according to Ministerial Decision F-141 / B3 / 2166 (FEK 308 / 18-6-87, vol. B). According to this decision, the average course scores are calculated using the following weighting factor for each course:

Table III: Course Weightings	
ECTS Course Units	**Weight Factor**
≤ 3	1,0
4 or 5	1,5
≥ 6	2,0

To calculate the grade of the degree, $\overline{B}$, multiply the score of each course by the weight factor of the course (see Table III) and the sum of the individual product is divided by the sum of the weight factors of all courses:

$$\overline{B} \equiv \frac{\sum_{i=1}^{N} \omega_i B_i}{\sum_{i=1}^{N} \omega_i}$$

Where B_i: overall grade of the degree (where $B_i \geq 5$), ω_i: weight factor according to Table III, and N: number of all courses all semesters with $B \geq 5$, which also meet the requirements of Table I

If a student has collected more than the corresponding minimum required ECTS credits for the degree program, some optional courses may not be taken into account in order to maximize the final grade, provided that the number of ECTS units corresponding to the remaining courses is sufficient to meet the requirements for obtaining the degree.

Average Progress Indicator: In addition to the above grade and the corresponding graduation mark, the "Average Progress Indicator" is defined; It is calculated for each student each October or November following the second exam period, according to the following algorithm:

$$\Pi \equiv \frac{N_\Delta}{N_o}\overline{B}$$

Where $\overline{B}$ is the average score, given by the above formula for the degree grades with *N* the number of all previous half course (with $B_i \geq 5$, which also satisfy the conditions of Table. I), N_Δ is the total ECTS units He has gathered the students of all the *N* classes and N_o total of ECTS credits that would have been collected by the student according to the standard curriculum, and which reads as follows:

After the:	1st year	2nd year	3rd year	4th year	5th year	6th year
No.	70	142	208	240	300	360

On the basis of the above average progress indicator, which is calculated and communicated to students each November, students are ranked in the 'annual success order' each year. The above average grades, progress indicators and success rates (yearly and diploma), can be used as one of the criteria for the award of honors, scholarships (IKY etc.).

Upgrade / Rating:

Students who have taken an exam for a course in January or June may also apply for the September re-take exam in the same academic year, after notifying the Secretariat from 1 to 20 July of each year. In this case, out of the two grades of the two exam periods only the greater mark applies.

Retaking or repeating a course to improve grades:

Students who want to improve their grades in a course that they have already passed can request a reset. As such, they must notify the Secretariat when registering for the new semester. If the student re-enrols in the same course in the next academic semester, then the latest grade will apply, while the previous grade will be deleted automatically with the student's enrolment.

Taking previously failed courses

Students have the opportunity to retake exams in previous years' courses which they failed and have not selected for the current academic year, provided that they apply to the Secretariat of the Department "Application for Courses" from 1 to 20 July of each year and that the course is offered in the current academic year by the department.

6. Standard Curriculum

Each semester, upon provisional consultation with their advisor, students select the course they wish to take provided that the formal requirements are met:

1. Students have met the prerequisites for this course.
2. Courses enrolled do not exceed the maximum number (8 per semester).
3. The selected course is offered during the specific semester.

The following tables provide a standard curriculum for the department:

Table III: Standard Basic Curriculum

1st Semester		ECTS
101	General Physics I	6
111	General Mathematics I	6
114	Computer Science I	6
121	General Chemistry	6
141	Materials I: Introduction to Materials Science	6
011	English I	4
	Total ECTS	**34**

2nd Semester		ECTS
102	General Physics II	6
112	General Mathematics II	6
116	Applied Mathematics	6
122	Organic Chemistry	6
124	Chemistry Laboratory	8
012	English II	4
	Total ECTS	**36**

3rd Semester		ECTS
201	Contemporary Physics - Introduction to Quantum Mechanics	6
223	Inorganic Chemistry	6
225	Materials Chemistry Laboratory	8
203	Physics Laboratory I: Mechanics - Heat	8
211	Differential Equations	6
260	Thermodynamics	6
	Total ECTS	**40**

4th Semester		ECTS
204	Physics Laboratory II: Electricity - Optics	8
232	Biochemistry and Molecular Biology	6
242	Materials III: Microelectronic - Optoelectronic Materials	6
243	Materials II: Polymers – Colloids	6
	Obligatory Elective 1	6
	Total ECTS	**32**

5th Semester		ECTS
301	Electromagnetism	6
305	Solid-State Physics: Introduction	6
335	Molecular Cellular Biochemistry	6
343	Soft Materials Laboratory	8
391	Materials IV: Natural Biomaterials Science	6
	Total ECTS	**32**

6th Semester		ECTS
362	Materials V: Ceramics and Magnetic Materials	6
344	Solid State Materials Laboratory	8
ΠΡΑ 001	Practical Exercise	5
	Elective Courses	15
	Total ECTS	**34**

7th Semester		ECTS
	Elective Courses or Obligatory Elective	16
	Total ECTS	**16**

8th Semester		ECTS
	Elective Courses or Obligatory Elective	16
	Total ECTS	**16**

The program offers a variety of options, which increase when the student completes the compulsory core courses at the suggested pace by the standard program. The choices depend on the interests of the student and institutional conditions. The Standard Curriculum as given in the tables above intends to assist the student in the first semesters of their studies. The normal weight of each semester (with normal progress) is about 35 ECTS on average. The standard program defines the compulsory courses as well as the proposed total number of ECTS units for elective courses. It is possible for students, in one semester, to take more or less of the proposed ECTS units for the elective courses.

A course can be classed as a "self-study" course when the number of registered or regularly attending n is:

(a) $n \leq 10$ for compulsory course

(b) $n \leq 5$ for a course of choice

If the course is converted into a self-study, the teacher must immediately inform the Committee of Studies. When the number of exams in the final examination of the course is less than 8 in case (a), or less than 4 in case (b), then the course is considered to be self-study.

7. Basic and elective courses

The courses of the Department of Science and Technology of Materials are coded with the letters "ETY" and in three digits. The first digit indicates the level of the lesson and usually corresponds (but not always) to the year in which the lesson is attended (according to Table I). The second digit is often related to the cognitive area of the course.

The compulsory courses for obtaining a degree are those specified in the Standard Curriculum - see Tables 9 and Table I. Table I also lists the optional compulsory courses and the TETY elective courses. The courses of electing other Departments, as already mentioned, are decided every year by the Undergraduate Studies Committee, based on the courses offered by the other Departments.

Due to the interdisciplinary nature of the Department of Materials Science and Technology, a significant number of courses offered by the other Departments of the University of Crete have a significant overlap with corresponding courses of the TETY. Because of this overlap, the courses of the other Departments that are considered equivalent to the courses offered by the TETY are not available for selection by the students. Table IV gives a brief description of these courses.

Table IV: Courses of other Departments with sufficient significant content overlap to be considered equivalent to courses of the Department of MST

Course Code	Course of non-MST Department	Equivalent course offered by the MST Department
Department of Physics		
ΦΥΣ-101	General Physics I	General Physics I (ETY-101)
ΦΥΣ-102	General Physics II	General Physics II (ETY-102)
ΦΥΣ-105	Physics Laboratory I	Physics Laboratory I: Mechanics - Heat (ETY-203)
ΦΥΣ-111	General Mathematics I	General Mathematics I (ETY-111)
ΦΥΣ-112	General Mathematics II	General Mathematics II (ETY-112)
ΦΥΣ-113	Mathematics for Physicists I	Applied Mathematics (ETY-116)
ΦΥΣ-151	Computers I	Computers I: Introduction to Programming (ETY-114)

Table IV: Courses of other Departments with sufficient significant content overlap to be considered equivalent to courses of the Department of MST		
Course Code	**Course of non-MST Department**	**Equivalent course offered by the MST Department**
ΦΥΣ-152	Computers II	Computers II: Introduction to Numerical Analysis (ETY-213)
ΦΥΣ-201	Introduction to Modern Physics I	Contemporary Physics - Introduction to Quantum Mechanics (ETY-201)
ΦΥΣ-207	Physics Laboratory II	Physics Laboratory II: Electricity-Optics (ETY-204)
ΦΥΣ-208	Physics Laboratory III	Physics Laboratory II: Electricity-Optics (ETY-204)
ΦΥΣ-211	Differential Equations I	Differential Equations (ETY-211)
ΦΥΣ-273	Introduction to Microelectronics	Introduction to Microelectronics (ETY-482)
ΦΥΣ-306	Thermodynamics	Thermodynamics (ETY-260)
ΦΥΣ-351	Computational Physics I	Computational Materials Science I (ETY-447)
ΦΥΣ-371	Introduction to Semiconductor Physics	Elements of Semiconductor Physics (ETY-481)
ΦΥΣ-411	Introduction to Solid State Physics	Solid-State Physics: Introduction (ETY-305)
ΦΥΣ-446	Physics and Physical Chemistry of Polymers	Polymer Physics (ETY-450)
ΦΥΣ-570	Structural and Chemical Analysis of Materials	Structural & Chemical Analysis of Materials (ETY-248)
Department of Mathematics		
ΜΑΘ-102	Calculus I	General Mathematics I (ETY-111)
ΜΑΘ-103	Calculus II	General Mathematics II (ETY-112)
ΜΑΘ-106	Programming	Computers I: Introduction to Programming (ETY-114)
ΜΑΘ-213	Partial Differential Equations	Differential Equations (ETY-211)
ΜΑΘ-216	Vector Calculus and Differential Equations	Differential Equations (ETY-211)
Department of Chemistry		
ΧΗΜ-043	Principles of Chemistry	General Chemistry (ETY 121)
ΧΗΜ-044	Quantitative and Qualitative Analysis	General Chemistry (ETY 121)
ΧΗΜ-047	General Chemistry Laboratory	Chemistry Laboratory (ETY 124)
ΧΗΜ-101	General Chemistry I	General Chemistry (ETY-121)
ΧΗΜ-201	Organic Chemistry I	Organic Chemistry (ETY 122)

Table IV: Courses of other Departments with sufficient significant content overlap to be considered equivalent to courses of the Department of MST		
Course Code	**Course of non-MST Department**	**Equivalent course offered by the MST Department**
XHM-202	Organic Chemistry II	Organic Chemistry (ETY 122)
XHM-303	Physical Chemistry I	Thermodynamics (ETY-244)
XHM-401	Inorganic Chemistry I	Inorganic Chemistry (ETY 223)
XHM-402	Inorganic Chemistry II	Inorganic Chemistry (ETY 223)
XHM-049	Physical Chemistry II	Thermodynamics (ETY-244), Contemporary Physics - Introduction to Quantum Mechanics (ETY-201)
Department of Biology		
BIOΛ-105K	General Chemistry	General Chemistry (ETY-121)
BIOΛ-107K	Organic Chemistry I	Organic Chemistry (ETY-122)
BIOΛ-150K	Cell Biology	Cell Biology (ETY-492)
BIOΛ-154K	Biochemistry I	Biochemistry and Molecular Biology (ETY-232)
BIOΛ-252M	Biochemistry II	Molecular Cell Biochemistry (ETY335)
Department of Computer Science		
HY-100	Introduction to Computer Science	Computers 0 (ETY-113) – not offered any longer

8. Diploma thesis

Students have the option to engage in research work under the guidance of a teacher-advisor, and present the outcome of their work in a dissertation. Students who choose to do so, receive 12 ECTS points. The thesis may be written in Greek or English. The diploma is awarded after a public presentation, followed by an oral examination by a two-member panel of teachers. At least one member of the committee should be a professor in the department, while the other member may come from another department or institution or be a researcher at a recognised research center or a post graduate member of the Department holding a Ph.D. In each case, the members of the committee are appointed by the Department's Diplomatic Officer on the proposal of the supervising professor.

The Graduation Thesis is graded by the Bilateral Committee. The ECTS units from the thesis belong to the ECTS units of TETY.

Publication of a student in a valid international peer-reviewed scientific journal or in proceedings of a standing international peer-reviewed conference is considered equivalent to a special course and gives the student five (5) ECTS units of grade, with no grade. The file is recorded with code 9 I 1 (where I = 0,1, … 9) and by name, publication 1. If there is a second publication by the same student, it is recorded with code 9 I 2 (where I = 0,1, ... 9) and by name, publication 2.

9. Student internships

By the end of the 4th semester, students have the opportunity to work preferably <u>during the summer in Greek and international organizations and companies in the public and private sector conducting activities</u> relevant to the Department. These internships aim for the participant to gain experience, expand the knowledge and specialize in subjects related to materials and material's technological applications. They also give the opportunity to adapt and function within a professional environment and to develop the ability of working as a member of a team. The Department offers two free elective courses entitled Practice I (PR-001) and Practice II (PR-002), which they last 2 months per subject and they are full time occupation. To participate in an internship program, following the provision of a detailed report of the student's education and a description of the employment program and its duration prepared by the student and the institution offering the position, students need to apply for approval but the Study Committee. Based on the report the Study Committee judges the importance of the program in ECTS (up to 5 ECTS points per period). Upon completion of the course, the student submits an 'activity report', which is evaluated by the Student Committee which decides whether or not to approve the ECTS units decided upon at the time of approval of the program. This way students can be awarded a total of up to 10 ECTS units to meet the requirements of the Graduate Program. Practical ECTS, registered as an elective course.

Students have also the option to participate in internships programs abroad, in Universities or Research Centers and Institutions in the context of ERASMUS+ program. In that case they may be awarded up to 15 ECTS for two months internships and up to 20 ECTS for three months internship. Out of these credits 10 and 15 respectively are taken into account for the requirements of the Graduate Program, while the rest are listed in the Diploma appendix. In any case, ECTS credits from internship for the requirements of the Graduation Program cannot exceed the total of 15 units.

The maximum number of students who can apply is determined annually by the funding provided for the program. The student selection and ranking criterion is the Individual Progress Index. In the case of even scores, eligible is considered the student with the higher number of registered ECTS units.

To be considered complete, the Internship Application must include: a) Application Form provided by the student's administration office and completed by the student; b) Detailed Scoreboard. The deadline for application submission is announced each year by the Department. Applications are collected by the Secretariat of the Department.

Students are selected by the Department's Internship Committee and endorsed by the Department's Undergraduate Studies Committee. The results of the selection are made known to the students in the Secretariat announcement board and by email. Objections to the selection process can be submitted within 5 working days after the announcement of the results. Complaints are examined by the Practice Appeals Committee.

Enrolment of the course is accompanied by a grade obtained by taking into account the student's assessment by the institution providing the Internship position, a report written and delivered after they complete the Internship and the oral examination of the student upon completion of the Internship by a member of the department assigned by the Internship Committee.

Detailed information on the process that a student must follow in order to complete an Internship can be found in the Internship Guide, at the course web site. Any updates in the Internship Guide have to be endorsed by the Undergraduate Studies Committee of the Department.

Supervision of the Practice is carried out by the Practitioner scientifically appointed by the General Assembly of the Department.

10. Lab Classes

The completion of lab classes there may also require taking a final examination. This is decided by the teacher and communicated to the students at the beginning of the lesson. For any lab courses offered in both semesters, failure results to a complete repetition of the lab. Exceptions to this rule may be made after recommendation of the teacher and the decision of the Committee on Studies.

Students wishing to attend the Chemistry Laboratory (ETY 214), the Materials Chemistry Laboratory (ETY-225), the Soft Matter Laboratory (ETY-343) and Solid State Material Laboratory must have attended the department's safety seminar. The seminar takes place every year at the beginning of the spring semester

Students in labs are preferably participating in groups of two per experiment. The laboratory instructor decides whether the processing and analysis of the measurements and its presentation in the laboratory exercise report will be done by each student individually or collectively by the group.

Each student is required to maintain a personal laboratory notebook (standard numbered pages). This booklet shall contain all information on the preparation and execution of the experiment, the date of the experiment, the measurements, the various calculations, the schematic layout or the electrical circuits and any additional information on the experiment and the instruments are given by the teacher and the assistants. This material is not written for the main purpose of presenting it to the teacher or assistants, but to serve as an exclusive source for the laboratory reference data, by the student himself, even if the report is compiled much later after the experiment has been carried out including possible examinations of the laboratory course at the end of the semester. All recordings in the laboratory notebook must be made during each exercise. At the end of each exercise and before the student leaves, the instructor signs the last recording and checks the content of the notebook. Missing data will be proof of student's non-participation in the respective exercise. A citation or measurement that does not appear in the notes of each student's lab notebook is not accepted. The student should be prepared to perform the exercise before coming to the lab.

This preparation includes:

- The study of the subject of the experiment from the corresponding course books, laboratory guide and related literature.
- Keeping notes in the laboratory notebook so that information on the units, physical constants and formulas required are readily available at the time of the experiment.
- The design in the laboratory notebook of the experimental devices and setup

Laboratory reports should include:

- A very brief introduction (typically 200 to 300 words) for the purpose of the experiment and a summary of the related theory.
- A diagram of the experimental setup with brief comments, if needed, on the process of the experiment and the conditions under which the measurements were made.
- The formulas that are needed to perform and analyze the experiment.
- Tables with experimental results and their analysis as well as measurement errors, when requested.
- All graphs required to analyze the data and present the results.
- Brief conclusions and comments.

The guidelines vary, to some extent, with the specific subject of each lab. There are typical sample reports for each laboratory.

The report, as well as the personal notebook, consist evidence of attendance for the student. Students who have more than one unjustified absence are required to enroll in the lab the following year or semester.

11. Student selection criteria in laboratories

Due to the increasing number of admissions to the Department and the limited laboratory facilities of the TETY that allow for the correct and safe education of a finite number of students per semester, selection criteria for the attendance of the lab classes are adopted, if necessary.

These criteria as well as the maximum number of students in each laboratory (called the maximum laboratory capacity) are described below:

Abbreviations:

Maximum laboratory capacity: MW

Chemistry Lab: EX

Physics Laboratory I - Mechanical / Thermodynamics: EPI

Physics Lab II - Electromotor / Optics: EPI

Laboratory of Materials Chemistry: LXI

Soft Matter Laboratory: PCM

Solid State Materials Laboratory: NSS

Criteria for selecting students to attend a lab class (in case those who have passed the prerequisites exceed MU). Selection will be made by filling the following criteria in the order listed, until the MS is completed:

- Students attending the workshop for the first time in the YEAR taught (i.e. successfully following the department's curriculum)
- Students attending the lab for the first or second time (provided they were below the base of the written laboratory part - first-time reports) and are in the LAST SEMESTER BEFORE being expelled as required by law. A student who wishes to attend for the third time or who has a low BUT above the base mark in the pure laboratory part (references) does not fall under this criterion.
- Students attending the workshop one year later than the year recommended in the curriculum
- Students who are legally bound to discontinue their course in the next twelve months Students attending the laboratory practicals at a later time than recommended in the curriculum

In the SPECIAL case where students who meet criteria 1 and 2 exceed the maximum capacity then they will be given the opportunity to attend labs and supernumeraries. This will be done by increasing the number of students per group or the number of classes per week following the decision of the teachers of each course. If students who fall within the last of the above criteria which meet the MA of the laboratory exceed the maximum capacity then they will be selected on the basis of the progress indicator.

Laboratory Maximum Capacity (ML)

LX lab is DEFINED by the maximum number

- segments per week,
- laboratory weeks specifying the number of groups per segment and
- students per group

Based on the correct and safe education of students and given the maximum capacity imposed by labs during the 13 teaching weeks per semester.

The following maximum capacities are provided:

1. EX, EPI and EPI: 3 laboratory sections per week.
2. LFS, LFS and NFS: 2 laboratory sections per week.

Consequently, we have:

Maximum Capacity (ML) = number of courses x number of weeks available x 3 students per group

1. Maximum EX capacity: 96 students
2. Maximum capacity of EPI and EPI: 99 students.
3. Maximum capacity of LCI, LCI and NSI: 60 students.

12. Foreign language

Today, more than ever, within a united Europe with all the new prospects that appear in the education and the job market (e.g. international student exchange programs such as ERASMUS etc.), speaking a foreign language, especially Academic English, is a vital component of success.

In the Department of Materials Science and Technology of the University of Crete, students are required to successfully complete two thirteen-week English modules and receive a total of 8 ECTS points before they can graduate. The main purpose of the two semesters of English is to teach students basic science terminology and academic writing and presentation skills, as well as to prepare them for the study of scientific texts and books of their specialty.

13. Educational Qualification - Teaching Eligibility

Detailed information is provided in the following link:

http://www.materials.uoc.gr/el/undergrad/Syllabus/ppde.pdf.

II. ANALYTICAL DESCRIPTION OF COURSES

011 English I

O

Teaching Hours: 3-0-0, ECTS: 4

Prerequisite Courses: -

1st Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY011/

Learning Outcomes

The main objective of the English for Materials science 1 is for students to learn scientific terminology but also academic skills pertaining to formality, caution, legitimate paraphrasing, writing citations and synthesizing sources, critical writing, essay writing (with documented evidence), peer-feedback and academic presentations.

Syllabus

Introduction to Formality and Academic style. Students notice formality, citations and reference conventions and following a model text, produce their own. Reference and citation guides are provided for guidance. Students are asked to send an email to their instructor taking into account issues of politeness and formality.

Week 2 Students will read a text about **Types of Materials** and learn how to transfer information **from text to slides**. Listening practice: Students will practice **different note-taking styles**. Students will practice giving presentations using opening phrases and signposting language.

Week 3 Students will be using google docs to complete tasks collaboratively about different types of **Metals and their properties**. Students will be reading an article on the FUTURE of metals in order to identify topic sentences, support sentences and concluding sentences in paragraphs. Then, they will **produce their own paragraph** following prompts.

Week 4 Students will read an article and listen to a video about the scientific method and answer a **quiz.** They will look at statistical data, **graphs and charts** and learn how to **write a report** using appropriate linking words and terminology to express upward or downward trends, ratios, averages and numbers. Students will use information to produce a variety of **visuals: mind-maps, diagrams, word tables or schemes**.

Week 5 Students will watch a video about **bio printing** and then will compare different types of writing on the same topic **"Bio-printing (2019)".** They will be asked to notice the structure, the language and some conventions of a **scientific article** about Graphene, a relevant blog post on Graphene and a school textbook entry.

Week 6 Students will have a workshop on **"How to give effective presentations"** and a model presentation on **"bio-printing"** given by senior students whose presentations were deemed to be one of the best ones the year before. Students will be provided with *criteria for peer-evaluation* to complete during the student presentation and then discuss the student presentation strengths and weaknesses with the teacher and the presenters. Kindly note that attendance is compulsory for all.

Week 7 Students will **classify and identify properties** of *solids, liquids and gases* (using the English for Chemistry EAP textbook, Unit 1) Reading and Listening tasks. Students will be asked to notice and use **legitimate** paraphrasing **strategies** in order to produce a paragraph with citations and references.

Week 8 Students will be listening and reading a variety of listening and reading sources about **Ceramics and advanced Ceramics** in order to include all information elements, reminder phrases and references required for Summary **writing**. Language focus Passive voice

Week 9 Students will be introduced to essay writing (**argumentative essay, counterarguments**) making a distinction between descriptive, evaluative, cautious and biased language. Reading and Listening Practice on the topic of **Composites**. Students will be practicing answering **mock exam reading comprehension questions** and tasks.

Week 10 Following a listening and a reading on Polymers (from the book English for Chemistry EAP Unit 11) students will be asked to make a mind map connecting properties of Polymers such as thermosetting, thermoplastic, linear, branched, cross-linked, fibers, plastics and elastomers, solubility and rigidity. Language focus: Gerund and infinitive Students will be re-writing sentences avoiding wordiness

Weeks 11 and 12 Student Presentations (Slides need to be in pptx or pdf format and student need to bring their file in a usb stick)

Bibliography

- Katsampoxaki-Hodgetts K. (2017) English for Chemistry EAP, Disigma Publications

https://www.disigma.gr/english-for-chemistry-eap.html

012. English II

O

Teaching Hours: 3-0-0, ECTS: 4

Prerequisite Courses: -

2nd Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY012/

https://new.edmodo.com/groups/e-mat-2-2019-31089866

Learning Outcomes

The learning goals that students should have achieved at the end of the lesson are the following:

The course is intended to teach students English terminology on subjects of materials science and general science and scientific approach and cooperation.

It is expected that after the successful completion of the course and completion of the specified assessment, individual work, individual presentation and group work required by the students, they will be able to:

- Seek, recall and work with relative ease with texts that contain terminology related to their specialty and subject matter.
- Create various types of well-structured materials science texts and research communication documents with differentiated goals and practices.
- Easily read and understand scientific papers and communications related to their subject matter.
- Evaluate sample writing in English, and provide documentation services related to their subject matter.
- Describe in English the research results or research and experimental processes to participants and public bodies with a view to seeking international funding.
- Draw conclusions from data they find in sources in English regarding their subject matter.

Have fluency in writing, spoken interaction, listening, written comprehension, and productive speech at a level equal to or greater than the B2+ of the Common European Framework of Reference of the Council of Europe in terms of their subject matter.

Syllabus

The class goal is to act as a continuation of the hands-on introduction to English academic texts and terminology related to Materials Science. Major topics covered: Matter and materials structure, molecular physics, polymers, modern materials science applications and scientific method, and research documentation. Further aid is offered for the familiarization with authentic, subject specific texts and vocabulary. Development of reading skills and techniques. Additional writing skills to be developed: Introduction to Euro CVs, introduction to hands-on use of research databases and electronic resources in English.

The course is taught solely in English and has the following structure:

- Nine lectures covering the main topics outlined in the class goals, supplemented by relevant texts, multimedia and exercises.
- During this course, a combination of teaching practices is used which aim to optimize the participation and learning of the participating students. Thus, in parallel with a multimedia-enhanced presentation of the themes of each lecture in English, a form of continuous assessment is carried out through a series of graded

Bibliography

- Stafilidis, D. (2009) Dictionary of Technology and Science, English-Greek Dictionary, Greek-English Dictionary, Stafilidis Technical Scientific Publications, Athens
- Sisamakis, M. (2019) Materials Science II course lecture notes (ver. 2)

101. General Physics I

O

Teaching Hours: 4-2-1, ECTS: 6

Prerequisite Courses: -

1st Semester

http://theory.materials.uoc.gr/courses/gfI/

Learning Outcomes

By the end of the course, students are expected to:

1. Consolidate high school classical mechanics albeit at a higher mathematics level.
2. Acquire critical thinking and the ability to develop physical models and solve problems.
3. Get accustomed to the mathematical formulation of the laws of physics: for this purpose, calculus and very simple differential equations are used.
4. Acquire the relevant background and skills for understanding materials physics in the more advanced theoretical and laboratory courses that follow.

Syllabus

1. Physics in Materials Science, structure of matter and physical models, classical and modern Physics, Classical Mechanics
2. Introduction, fundamental and derived quantities, units, dimensional analysis, order-of-magnitude calculations, significant figures
3. Kinematics, motion in one dimension, position, displacement, average and instantaneous velocity, constant velocity motion, average and instantaneous acceleration, motion with constant acceleration, free fall, kinematic equations derived from calculus
4. Motion in three dimensions, position, velocity, acceleration vectors, motion in two dimensions with constant acceleration, projectile motion, curved orbit motion, tangential and radial acceleration, uniform circular motion, relative velocity and acceleration
5. The concept of force, Newton's 1st law and inertial frames, Newton's 2nd law, gravitational force and weight, Newton's 3rd law
6. Applications of Newton's laws, forces of friction, circular motion, motion in accelerated frames, motion in the presence of resistive forces
7. Energy of a system, work done by constant force, work of varying force, kinetic energy and the work-kinetic energy theorem, potential energy of a system, conservative and non-conservative forces, relationship between conservative forces and potential energy, energy diagrams and equilibrium of a system.
8. Isolated and non-isolated systems, conservation of energy, changes in mechanical energy for non-conservative forces, power

9. Linear momentum, isolated and non-isolated systems, momentum conservation, impulse of a force, impulse-momentum theorem, elastic and inelastic collision, perfectly inelastic (plastic) collision, collision in two dimensions, center of mass of a system of particles and of an extended object, physical significance and usefulness of the center of mass, deformable systems, rocket propulsion
10. Rotation of a rigid object about a fixed axis, angular position, velocity, acceleration, quantities of rotational and translational motion, rotational kinetic energy, calculation of moments of inertia, torque, relationship between torque and angular acceleration, energy in rotational motion, rolling motion of a rigid object
11. Angular momentum of a rotating particle and of a system of particles, non-isolated system, angular momentum of a rigid object, isolated system and angular momentum conservation
12. Static equilibrium and elasticity, elastic properties of solids
13. Oscillatory motion, harmonic oscillator, damped and forced oscillations

Bibliography

- R.A. Serway, J.W. Jewett, Jr., Physics for Scientists and Engineers, Mechanics, Oscillations and Mechanical Waves, Thermodynamics, Relativity, 8th edition, Greek translation Kleidarithmos Editions, Athens (2012).
- H.D. Young, R.A. Freedman, University Physics with Modern Physics, Greek translation, Volume A', Mechanics-Waves, 11th edition, Greek translation, 2nd Greek edition, Papazisi Editions, Athens (2009).
- P.G. Hewitt, Conceptual Physics, 9th American edition, Greek translation, Crete University Press, Heraklion (2011).
- H.C. Ohanian, Physics, Norton, London, (1985), Greek translation, Symmetria Editions, Athens (1991)].
- C. Kittel, W.D. Knight, M.A. Ruderman, Mechanics: Berkeley Physics Course, Volume I, Symmetria Editions, Athens (1978).
- R.P. Feynman, R.B. Leighton, M. Sands, The Feynman Lectures on Physics, Volume I, Addison-Wesley (1963)

102. General Physics II

O

Teaching Hours: 4-2-0, ECTS: 6

Prerequisite Courses: -

2nd Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY102/

Learning Outcomes

The course covers the physics of electricity, magnetism and optics, using mathematics on an advanced level compared to the corresponding requirements in secondary education. The course Learning Outcomes are:

- Understanding basic physics laws and concepts in the fields of electricity, magnetism and optics.
- Employing the acquired knowledge to analyze and solve respective physics problems with the use of calculus and simple differential equations.
- Acquisition of the basic background required to follow courses on electromagnetism (ETY-301) and optics (ETY-302) on an advanced undergraduate level

Syllabus

- Electric field, Coulomb's law, Gauss law.
- Electric potential
- Capacitors, dielectrics, current and resistance.

- DC circuits, magnetic fields
- Sources of magnetic field, Biot-Savart law, Ampere's law.
- Faraday's law, electromagnetic induction, solenoids
- AC circuits
- Nature of light
- Geometrical optics, reflection, refraction
- Interference

Bibliography

- R.A. Serway and Jewett, "Physics for Scientists and Engineers", Vol II, Cengage Learning, Greek translation: Kleidarithmos Publishing (2013).
- D.C. Giancoli, "Physics for Scientists and Engineers", Vol II, Pearson, Greek translation: Tziola Publishing (2017).
- D. Halliday, R. Resnick, J. Walker, "Physics", Vol. II, Wiley, Greek translation: Gutenberg Publishing (2008).
- H.D. Young, "University Physics with modern Physics", Vol. II, Pearson, Greek translation: Papazisis Publishing (2009)
  (the aforementioned books cover the course in its entirety)
- P.G. Hewitt, "Conceptual Physics", Vol. II, Pearson, Greek translation: University of Crete Publishing (1994)
- R.P. Feynman, R.B. Leighton, Sands, M., "The Feynman Lectures on Physics", Vol. I and II, Addison-Wesley (1963) (reference book for specialized topics)

111. General Mathematics I

O

Teaching Hours: 4-2-0, ECTS: 6

Prerequisite Courses: -

1st Semester

https://elearn.uoc.gr/login/index.php

Learning Outcomes

- Compute limits of sequences, series and functions.
- Compute derivative of functions using proper theorems and methods.
- Use derivatives to find max/min values of functions and solve Initial value problems (IVP).
- Find Taylor series of simple functions and use them to approximate values of functions
- Compute define and indefine integrals.
- Use integrals to solve problems from physical sciences and engineering.

Syllabus

- Sequences, limits of sequences, properties.
- Functions, elementary functions, limits of functions, properties.
- Continuity. The maximum value theorem. The intermediate value theorem.
- The derivative of a function, properties. Chain rule, inverse function rule. The theorems of Fermat and Rolle, the mean value theorem. Higher derivatives. Graphing using first and second derivatives. L'Hôpital's rule.
- Applications of derivatives. Initial value problems (IVP). Taylor series.
- Definite integrals, properties, examples.
- Indefinite integrals, the fundamental theorem of calculus. Integration techniques. Applications in computing areas, volumes, etc. Improper integrals.
- Applications of integrals.
- Series, convergence, absolute convergence. Convergence tests. Power series, radius of convergence. Taylor series.

Bibliography

- *J. Hass, C. Heil, M. Weir, Thomas Calculus, Crete University Press, 2018.*

112. General Mathematics II

O

Teaching Hours: 4-2-0, ECTS: 6

Prerequisite Courses: -

2nd Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY112/

Learning Outcomes

The learning goals that students should have achieved at the end of the lesson are the following:

Familiarization with vector algebra and differential and integral calculus especially in two and three but also in higher dimensions, with an eye to applications in problems of classical physics

Syllabus

Summary of topics to be covered in the course:

- Vector algebra, operations and geometry in two, three or higher dimensions. Linear transformations and matrices. Determinants.
- Real and vector functions of vectorial variables (of several real variables). Graphical representation. Limits. Continuity. Differentiation and fundamental properties thereof. Definition and calculus of the "grad", "div" and "curl" operators. Taylor's theorem. Implicit function theorem.
- Extrema. Extension of methods for finding maxima and minima to functions of a vectorial variable. Quadratic forms. Constrained extrema, Lagrange multipliers.
- Parametric curves. Line integrals.
- Multiple integrals. Change of variables in multiple integration.
- Parametric surfaces. Surface integrals.
- Integral theorems of vector calculus (Green's, Stokes' and Gauss' s theorems).
- Improper integrals in one or more dimensions.
- Applications to mechanics and electromagnetism

Bibliography

- Marsden and Tromba, Vector Calculus, Translation – Copy Edit: A.Giannopoulos, D. Karagiannakis, Crete University Press (1992) – edition 2017 (Vector Calculus, 3rd edition)
- THOMAS Calculus, [George B. Thomas, Jr.,] Joel Hass, Christopher Heil, Maurice D. Weir, Crete University Press (2018)
- M.R. Spiegel, Advanced Calculus, Schaum's Outline Series.
- Tom Apostol, Differential and Integral Calculus II, Atlantis (1990)

114. Computers I: Introduction to Programming

O

Teaching Hours: 2-0-3, ECTS: 6

Prerequisite Courses: -

1st Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY114/

Learning Outcomes

Upon successful completion of the course, students will be familiar with the basic concepts of structured programming and will be able to develop and implement simple algorithms in Fortran. The students will have acquired the necessary knowledge and experience to tackle the computational problems they will face in their studies and beyond.

Syllabus

- Variables-Constants. Fundamental Fortran 95 types (INTEGER, REAL, COMPLEX, LOGICAL, CHARACTER). Numerical Operators. Assignement. Code development guidelines.
- Intrinsic numerical functions and subroutines.
- Control statements (IF, SELECT CASE). Comparison operators. Logical operators. Loop constructs (DO) and associate statements (CYCLE, EXIT).
- Arrays, static and dynamic (ALLOCATE, DEALLOCATE). Elemental operators and intrinsic functions.
- Functions - Subroutines.
- Derived types – MODULE.
- Algorithms for sorting and searching

Bibliography

- Lecturer’s notes
- Fortran 77/90/95 and Fortran 2003, A. Karakos Kleidarithmos publishing, 2008.
- Introductions to Fortran 90/95/2003, N. Karampetakis, Zitis publishing, 2011

116. Applied Mathematics

O

Teaching Hours: 3-2-0, ECTS: 6

Prerequisite Courses: -

2nd Semester

http://gate.iesl.forth.gr/~kafesaki/Applied-Mathematics/

Learning Outcomes

The course is an introduction to four disciplines of Mathematics which are considered essential for the study and understanding of Material Science: Complex Analysis, Linear Algebra, Fourier Analysis, Probability Theory.

The learning goals that students should have achieved at the end of the course are:

- Knowledge and understanding of all concepts developed in the course (knowledge+understanding+analysis)
- Ability to utilize and use the concepts and mathematical "tools" introduced in the course to solve Materials Science problems (composition+application)
- Ability to independently explore more complex Mathematics topics (related to the four mathematics disciplines introduced in the course) that may be required to study specific Materials Science topics.

Syllabus

A. Complex analysis

Complex numbers, complex functions, complex function derivation, complex function integration, complex series (Taylor and Laurant), Gamma function

B. Linear Algebra (Vectors, Matrices)

Vector spaces and vectors, operators and matrices, linear systems of equations eigenvalue problems for matrices

C. Fourier analysis

Fourier series, Fourier transforms, Dirac Delta function

D. Probability Theory

The concept of probability, permutations and combinations, random variables and probability distributions, expected value, variance

Bibliography

- *Course notes:*

http://esperia.iesl.forth.gr/~kafesaki/Applied-Mathematics/notes.html (relatively brief)

https://www.materials.uoc.gr/el/undergrad/courses/ETY116new/notes.pdf (more analytic)

- S. Sokolnikoff & R. M. Redheffer, *Mathematics for Physicists and Engineers*, Edition by National Technical University of Athens, 2001 Athens (in Greek)
- I. Vergados, *Mathematical Methods of Physics*, Vol. I, Crete University Press, Heraklion (in Greek)
- K. F. Riley, M. P. Hobson, S. J. Bence, *Mathematical Methods for Physics and Engineering*, Cambridge University Press
- G. Arfken, *Mathematical Methods for Physicists*, Academic Press, New York (1995)
- G. Strang, *Linear Algebra and Applications*, Crete University Press, Heraklion (in Greek)
- P. Hoel, S. Port, C. Stone, Introduction to Probability Theory, Crete University Press, Heraklion (in Greek)

121. General Chemistry

O

Teaching Hours: 4-2-0, ECTS: 6

Prerequisite Courses: -

1th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY121/

Learning Outcomes

General Chemistry is a course that deals with the fundamental concepts of chemistry. The course's goal is to introduce the Materials Science and Technology (MST) first-year students to the properties of chemical substances focusing on the chemical aspects of Materials' Science. Upon completion of the course, the students will be able to understand concepts such as:

1. To familiarize with…
    - Basic Chemistry Principles

2. To acquire the basic knowledge of …
    - Atomic and Molecular Structure of Matter
    - States of Matter and Solutions
    - Chemical Reactions and Chemical equilibria

Syllabus

- Basic Chemistry knowledge: Measuring units, Balancing of chemical reactions

- Atomic and molecular structure of Matter: The structure of the atom, atomic orbitals, Periodic Table and the periodic properties of elements, Chemical bond and bond theories, Molecular geometry, Molecular orbitals
- States of Matter and Solutions: Gas Phase, Ideal-gas equation, Kinetic Theory of Gases, Liquid phase, Intermolecular forces, Phase diagrams, Solid phase, Structure of Solids, Bonding in solids, Alloys, Metals-Semiconductors-Insulators, Polymers, Nanomaterials, Solution Properties, Colligative properties
- Chemical Reactions and Chemical equilibria: Mechanism of chemical reactions, order of reaction, Chemical equilibrium, LeChatelier principle, Acid-base equilibrium, acid-base classification, common-ion effect

Bibliography

- T. L. Brown, H. E. Lemay, B. E Bursten, C. J. Murphy, P. M. Woodward, M. W. Stoltzfus «Chemistry, Central Science», 13^{η} edition, Ziti publications 2016
- D. D. Ebbing, S. D. Gammon «General Chemistry» 10^{η} edition, Travlos publications 2014
- P. Atkins, L. Jones, L. Laverman «Chemistry Principles» 1^{st} edition, Utopia publications 2018

122. Organic Chemistry

O

Teaching Hours: 4-2-0, ECTS: 6

Prerequisite Courses: -

2^{nd} Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY122/

https://122organicchemistry.wordpress.com/

Learning Outcomes

The organic chemistry course is an introductory course designed to provide basic organic chemistry knowledge necessary to understand and comply to other undergraduate general background courses such as chemistry of materials, polymer chemistry, biochemistry and biomaterials.

Upon successful completion of this course the students will be able to:

- Understand and draw the structure of widely used organic compounds and entities,
- Recognize and name the different classes of organic compounds and identify their properties,
- Know and understand all basic organic chemistry principles such as the nature of chemical bonds, isomerism, stereochemistry, chemical reactions and (curly arrow) mechanisms.
- Correlate the structure of an organic compound with physical properties (such as relative boiling point, melting point, solubility),
- Understand basic organic reaction mechanisms and use them to comprehend, design and synthesize new materials,
- To meet the needs of laboratory courses (general background and specialized courses) involving synthesis of organic compounds,
- To work in multidisciplinary environments requiring basic organic chemistry understanding (within the framework of a diploma thesis or Erasmus).

Syllabus

Structure, bonding, molecular properties and nature of organic compounds. Molecular representations. Acids and Bases. Alkanes and Cycloalkanes. Stereoisomerism. Stereochemistry. Chemical reactivity. Mechanisms of organic reactions. Substitution reactions. Alkenes: Structure, nucleophilic substitution and elimination reactions. Alkynes. Alkyl Halides. Determination of organic compound structures: Introduction to mass spectrometry (MS), infrared spectroscopy (IR), nuclear magnetic resonance spectroscopy (NMR), ultraviolet spectroscopy (UV). Radical reactions. Introduction to aromatic compounds, hydrocarbons, aminoacids, peptides, proteins and lipids.

Bibliography

- Organic Chemistry for Life Sciences, David Klein, Utopia Publications, Athens, 2015.
- Organic Chemistry, John McMurry, Crete University Press, Heraklion, 2012

124. Chemistry Laboratory Course

O

Teaching Hours: 2-0-4, ECTS: 8

Prerequisite Courses: 121

2^{nd} Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY124/

Learning Outcomes

Students at the end of the course are expected to:

- Familiarize themselves with the conditions of conducting a laboratory course as well as with the rules of operation and the safety rules that govern a Laboratory course.
- To know basic analytical techniques that are expected if they use in their professional life such as titration, infiltration, sinking, quality analysis, preparation of solutions of specific concentration and content, dilutions of solutions.
- Be able to know the use of basic chemical utensils such as the pipette, the burette, the volumetric and conical flask, the volumetric cylinder as well as the use of certain devices such as the analytical scale, the drying oven, the UV lamp etc.
- Be prepared to attend more demanding laboratory courses such as the teaching of the next laboratory courses of the Department.

Syllabus

- Basic Laboratory Techniques
- Chemical equilibrium, Weak electrolyte ionizations (salt hydrolysis, buffer solutions, indicators)
- Pehametric titration (equivalent point, determination of the constant of a weak acid)
- Titration analysis (acid-base, complexes, Iodometry),
- Photospectroscopy
- Characteristic reactions and systematic semi-quantitative analysis of cations and anions.
- Chromatography (Thins Layer Chromatography (TLC))
- Gravimetric analysis methods

Bibliography

- M. Vamvakaki, Handbook of General Chemistry Laboratory, University of Crete, Heraklion, (2003).
- J. H. Nelson, K. C. Kemp, Lab Experiments, Prentice Hall (2000).
- L. Peck, K. J. Irgolic, Measurement and Synthesis in the Chemistry Laboratory, Prentice Hall (1998).
- G. M. Bodner, H. L. Pardue, Chemistry: An Experimental Science, John Wiley & Sons (1994).
- J. H. Nelson, K. C. Kemp, B. L. Bursten, Chemistry: The Central Science: Laboratory Experiments, Prentice Hall College Division (1996).
- S. L. Murov, B. Stedjee, Experiments in Basic Chemistry, 4th Edition, John Wiley & Sons (1996).
- R. A. D. Wentworth, Experiments in General Chemistry, Houghton Mifflin College (1999).
- S. L. Murov, Experiments in General Chemistry: Laboratory Manual to Accompany Umland/Bellama's General Chemistry, Brooks/Cole Pub Co. (1998).

141. Materials I: Introduction to Materials Science

O

Teaching Hours: 3-1-0, ECTS: 6

Prerequisite Courses: -

1st Semester

http://www.materials.uoc.gr/el/undergrad/courses/ETY141

Learning Outcomes

- To **get acquainted** with the basic characteristics of the interdisciplinary approach of Materials Science that combines Physics, Chemistry and Mathematics.
- To **connect** the macroscopic properties of materials with the various levels of structure (atoms, bonds, crystal lattice)
- To **know** the basic quantities that describe the mechanical, thermal and electrical properties of materials.
- To **become acquainted** with the experimental methods of analysis of the structure and composition of matter and to **know** the principles on which they are based.
- To **become familiar** with the strategies of design and selection of materials as well as the open problems of the field.

Syllabus

- **Introduction**
- **Categories of Materials-Applications-Examples**

  Metals, Ceramics, Polymers, Composite Materials

- **Atomic Structure**

  Structure and constituents of atoms, Fundamentals of Quantum Mechanics, Quantum mechanical description of atoms

- **Bonds**

  Forces between atoms, Potential, Ionic bonds, *Ionization potential, Electron Affinity,* Covalent bonds, Metallic bonds, Secondary Bonds, *Wan der Waals bonds, Hydrogen bonds*

- **Structure**

  Crystalline, amorphous materials, *Unit cell, Atomic Packing Factor (APF),* Metallic crystals, (FCC), (BCC), (HCP), Ionic solids, Covalent solids, Crystal Lattice, *Crystal systems, Crystallographic directions, Crystallographic planes,* Structural analysis techniques, *X*-ray Diffraction (XRD)

- **Mechanical Properties**

  Deformation, Mechanical Stress, Elastic behavior, Plastic behavior, *Tensile strength, Ductility, Resilience, Toughness,* Hardness.

- **Thermal Properties**

  Heat Capacity, *Phonons,* Thermal Expansion, Thermal conductivity, Thermal stress-resistance to thermal shock

- **Electrical Properties**

  Ohm’s law, electrical conductivity, Electrical properties at the atomic scale, *Energy bands, Fermi energy, Carrier mobility and conductivity,* Electrical properties of metals, Semiconductors, Ionic ceramics, Electrical properties of polymers, Conductive polymers

Bibliography

- W. D. Callister, *“Materials Science and Engineering”*, Willey (2001)

- Michael F. Ashby, Hugh Shercliff, David Cebon, *"Materials: Engineering, Science, Processing and Design"*, Butterworth-Heinemann, (2007)

201. Modern Physics: Introduction to Quantum Mechanics

O

Teaching Hours: 3-2-0, ECTS: 6

Prerequisite Courses: -

3rd Semester

http://esperia.iesl.forth.gr/~kafesaki/Modern-Physics/

Learning Outcomes

The course is an introduction to Quantum Mechanics and its applications to simple, basic systems, essential for the study and understanding of the structure of matter.

The learning objectives that students should have achieved at the end of the course are:

- To know, understand and be able to use all the concepts developed in the course concerning the behaviour of matter on a microscopic scale.
- Be able to use the concepts learned and the knowledge gained to study and understand / interpret the behaviour of more complex systems than those presented in the course (eg complex atoms, molecules and their spectra, magnetic materials, light-material interaction, etc.) which are fundamental in many areas of Materials Science.
- To be able to study on their own (with the bases they acquired in the course) more complex and advanced subjects of Quantum Mechanics which may be required for the study of special topics of Materials Science.

Syllabus

A) The crisis of Classical Physics and the Old Quantum Theory:

- The wave-particle duality for light: black body radiation, photoelectric effect, Compton effect, the particle-like nature of light

- The wave-particle duality for matter: atomic spectra, Bohr's theory, matter-waves (de Broglie waves). The position-momentum uncertainty principle, its interpretation and its consequences (atomic stability, order of magnitude of atomic and nuclear energies, etc.)

B) Introduction to Modern Quantum Mechanics:

- Quantum mechanics in one dimension: Schrödinger equation in one dimension, wave function and its statistical interpretation. Simple one-dimensional quantum mechanical systems and quantization of energy: the infinite square well, the finite square well (qualitative study), the harmonic oscillator, the step-function potential, the rectangular barrier potential and the tunneling effect.

- Quantum mechanics in three dimensions: Schrödinger equation in three dimensions. The hydrogen atom (spherically symmetric solutions, ground state, states with angular dependence (mainly qualitatively)). Atom in a magnetic field. Spin and Pauli's Exclusion Principle. Atoms with more than one electron. The periodic system of elements. Selection Rules for atomic transitions.

C) Quantum Mechanics in more complex systems (briefly and mainly qualitatively):

- Molecules: The basic theory of chemical bonding; simple molecules (H2, H2O). The phenomenon of hybridization. Rotation and oscillation of diatomic molecules; molecular spectra.

- Solids: The theory of energy bands. Fermi energy. Conductors, semiconductors, insulators and their conductivity. Semiconductor doping and applications (brief description).

Bibliography

- Course notes from the course web-page: http://esperia.iesl.forth.gr/~kafesaki/Modern-Physics/lectures/
- Material from the online course of the platform Mathesis «Introduction to Quantum Physics I: The basic principles» (in Greek) at https://mathesis.cup.gr/courses/Mathesis/Phys1/2015_T1/course/; instructor Stefanos Trachanas
- Material from the online course of the platform Mathesis «Introduction to Quantum Physics II: The main applications» (in Greek) at https://mathesis.cup.gr/courses/course-v1:Physics+Phys1.2+18F/course/; instructor Stefanos Trachanas.
- Stefanos Trachanas, Quantum Mechanics I, Crete University Press 2005, Heraklion (in Greek)
- Stefanos Trachanas, Elementary Quantum Mechanics, e-book, Crete University Press (in Greek)
- R. Serway, Physics for Scientists and Engineers, Vol IV, translated to Greek and edited by L. Resvanis
- R. Eisberg, R. Resnick, Quantum Physics of Atoms, molecules, solids and particles, Wiley, London (1974)
- R. Feynman, Leighton and R. Sands, The Feynman Lectures in Physics, Vol III, Addison-Wesley, Reading (1965)

202. Modern Physics II: Matter and Light

OE1

Teaching Hours: 3-1-0, ECTS: 6

Prerequisite Courses: 201, 116

4th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY202/

Learning Outcomes

Students at the end of the course:
- They will possess advanced knowledge and skills (critical understanding of theories and principles) in the field of modern quantum mechanics with emphasis on the structure of matter and its interaction with electromagnetic radiation.
- They will be able to use the knowledge they acquired in a way that shows a professional approach to their work.
- They will be able to gather and interpret elements of the subject to form scientifically documented opinion, both on scientific and social/ethical issues. (e.g. risks of new technologies to human health).
- They will be able to communicate information and solutions to the subject of the course (structure of matter and interaction with electromagnetic radiation) to both a specialized and non-specialized audience.
- They will have developed those knowledge-acquiring skills, which they need to pursue further studies with a high degree of autonomy.

Syllabus

- Mathematical foundations of quantum mechanics, Hermitian operators, Eigenvalues, continuous and discrete spectrum. Conservation laws.
- Dirac formalism, Harmonic oscillator, Angular momentum, Spin, synthesis of spins.
- Atoms, solids, band structure
- Time-Dependent Problems, Approximation Techniques in Time-Dependent Problems. Laser radiation and interaction with matter.

Bibliography

- S. Trachanas. Quantum Mechanics, vol. II (New Edition), Crete University Press (2008).
- A. Messiah, Quantum Mechanics, Dover (1999).

- R. Shankar, Principles of Quantum Mecahnics, Plenum Press (1994).
- E. Merzbacher, Quantum Mechanics, John Wiley & Sons, 3rd Edition (1998).
- J. Sakurai, Modern Quantum Mechanics, Addison Wesley (1994).

203. Physics Laboratory I

O

Teaching Hours: 0-0-3, ECTS: 8

Prerequisite Courses: 101

3rd Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY203/

Learning Outcomes

After successfully completing the course, the students:

- Through the experiments the students acquire a better understanding of basic laws of physics (knowledge)
- Are able to use, on a basic level, specialized measurement instruments such as laser, photogates and Computer Assisted Measurements. (skill)
- Are able, starting from experimental data, to provide a report analysing and presenting the results. (competence)
- Can assess the quality and the reliability of experimental data. (competence).

Syllabus

Educational quantitative experiments on simple physics phenomena.

Includes linear and rotational motion, oscillations, circular motion, simple and compound pendulum, heating and phase-change. The students perform verificatory experiments for basic laws of physics: Newtons laws of motion, Hook's law on elasticity, basic laws of calorimetry.

In the experiments are used basic and more specialized instruments and techniques for the measurements of physical quantities. Thermometer, Stopwatch, Vernier Caliper, Micrometer Caliper, laser, photogate, computer assisted measurements.,

The experimental process is followed by basic data processing and analysis: average value, standard deviation, linear least square regression, error in measured and calculated quantities.

Finally, the experimental procedure and the results are summarised in a report which is written by a group of students (usually triad).

Bibliography

- Andreas Zezas, Notes for Physics Lab I, Mechanics and Thermodynamics, Department of Physics, University of Crete 2013 (only in Greek)
- Chr. Chaldoupis, Physics Lab Exercises, Mechanics-Heat Transfer, University of Crete, Heraklion (1996). (only in Greek)
- R.A. Serway, Physics for Scientists and Engineers, Volume I: Mechnanics, Athens (1991).
- D. Halliday and R. Resnick, Physics, Part A, 3η edition, Editor Pnevmatikos, Athens (1986).
- F.W. Sears, M.W. Zemasky and H.D Young, University Physics, Addison Wesley (1981).

204. Physics Laboratory II: Electromagnetism - Optics

O

Teaching Hours: 0-0-3, ECTS: 8

Prerequisite Courses: 102

4th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY204

Learning Outcomes

A) The knowledge which the students will acquire upon successful completion of the course comprises:

- the basic laws governing physical phenomena and physical processes in particular fields of Electricity, Magnetism and Optics as described in the Syllabus Section
- the concepts of experimental measurement, absolute and relative experimental errors and their sources, and how to present results with meaningful significant digits
- the construction of correct two-dimensional graphical representations of the evolution of two physical quantities with each other

B) The skills which the students will acquire upon successful completion of the course are:

- understanding of a physical problem related to Electromagnetism or Optics, especially one that needs an experimental approach in order to be solved and finding the correct methodology necessary for answering to the specific problem
- choosing the right instruments or modules for the implementation of an experimental setup, making correct interconnections between them with/or without the aid of a control computer, finding the useful range of instrument/module functionality for each specific experimental need
- conducting experimental measurements, in-situ assessing of their reliability based on known physical laws and expectations
- analyzing experimental data. This includes calculations of the values of experimental quantities and of their expected errors as a measure of trust on these values. Analysis includes the ability i) to perform correct graphical representations that reveal, upon sight, the relationship between two physical quantities and ii) to find the mathematical description of this relationship using the least-squares fit formalism
- writing laboratory reports that include i) title and purpose of conducting each experiment, ii) summary of the methodology, instrumentation, setup, and theoretical physical background to be used in order to achieve the goals of the experiment, iii) comprehensive presentation of experimental procedure and experimental data iv) analysis of the experimental data, formally presenting the corresponding calculations and results on the needed experimental values.
- assessment of the experimental results by i) verifying (or not) expected physical laws, quantities or constants within the range of trust imposed by experimental error ii) commenting on the experiment-dependent true sources of error and iii) proposing ways to remedy or bypass these errors in future attempts to run the same experiments, as a way to improve the accuracy of the experimental values

The students also learn how to use a computer in writing experimental reports and in order to construct graphs and analyze experimental data through the use of corresponding spreadsheet preparation and editing software

C) The competences which the students will acquire upon successful completion of the course are:

- the ability to design the proper experimental procedure for addressing physical problems based on known physical laws
- the ability to cooperate with other people, as part of a team, in designing and implementing the above-mentioned procedure, in collecting and analyzing experimental data, in assessing experimental results and in writing experimental reports
- the ability to recognize *in-vivo* and correct or bypass errors or even modify certain steps throughout the process of implementation of an experimental task in order to reach to the answer the safest and most unambiguous way.

Syllabus

Introduction I: Theory of experimental measurement and error
Introduction II: Construction of 2D diagrams and the Least-Square Fit Method

Laboratory Exercises from Electricity and Magnetism

H1. Construction and operation of DC electrical circuits, Ohm's law, Kirchhoff's rules, simple electrical measurements
H2. Construction and operation of AC electrical circuits, RLC combination, using the Oscilloscope, study of resonance
H3. Electrolytic dissociation and Faraday's laws in Copper Sulfate and dilute Sulfuric acid aqueous solutions.
H4. Ampere's law and magnetic field in solenoids
H5. Gauss law, electric field and force between the parallel plates of an plane capacitor.

Optics Laboratory Exercises

O1. Linear Optics and rules governing the functionality of thin lenses and their combinations.
O2. Dispersion phenomena in light. Refraction and Fresnel laws in an optical prism.
O3. Wave optics phenomena: Fraunhoffer diffraction and Interference

Bibliography

- Emmanuel Spanakis 'Laboratory Exercises: Electricity-Magnetism', Department of Materials Science and Technology, University of Crete, Heraklion 2017 **(in Greek only)**
- P. Rakintzis and T. Tzouros "Notes on Laboratory III -Optics", Department of Physics, University of Crete, Heraklion 2013 **(in Greek only)**
- R.A. Serway and J.W. Jewett, Jr. "Physics for Scientists and Engineers: Electricity and Magnetism. Light and Optics. Modern Physics" **(translated in Greek and published by Kleidarithmos, 2013)**
- H.D. Young and R.A. Freedman " University Physics with Modern Physics: Electromagnetism and Optics" **(translated in Greek and published by Papazisis, 2010)**
- Especially for the Electrolytic Dissociation experiment related chapters from the following books are suggested:
- Darell D. Ebbing, Steven D. Gammon "General Chemistry" 6th Edition **(translated in Greek and published by Editor** Travlos**, 2002)**

  ii) Petros P. Karagianides "Inorganic Chemistry", Zitis Publications, 2016 **(in Greek only)**

205. Innovation, Entrepreneurship and Intellectual Property

E

Teaching Hours: 4-0-0, ECTS: 6

Prerequisite Courses: -

7th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY205/

Learning Outcomes

- At the end of the course students are expected:
- To familiarize themselves with how the science of economics interprets the effects of technological change and birth of innovations.
- To know the mechanism with which intellectual property and its management create or destroy innovation
- To learn the different types of intellectual property
- To learn the basic procedures of intellectual property filing and protection

Syllabus

- The phases of innovation and its evolution mechanisms,
- The effects of diffusion and substitution of innovations and product life-cycle
- Innovation and standardization
- Measuring innovation in economics, academia and firms
- Microeconomic and macroeconomic effects of innovation and intellectual property
- Patents, trademarks, copyright, software, open source technologies, international treaties, filing procedures
- Familiarization with the national filing procedures
- Patent searches and the motivation of the research activity
- Intellectual property as business tool
- Lectures of specialists in intellectual property

Bibliography

- Greenhalgh, C. and Rogers, M. (2010), Innovation Property and Economic Growth, Princeton Univ. Press, ISBN: 9780691137995
- Swann, G.M. (2009), The Economics of Innovation: An Introduction, Edward Elgar Publishing, ISBN: 978 1 84844 006 7.
- EspaceNet – European Patent Office Database for patent search

207. Exploitation of Research Output and Entrepreneurship

E

Teaching Hours: 4-0-0, ECTS: 6

Prerequisite Courses: -

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY207

Learning Outcomes

At the end of the course students are expected:
- To familiarize themselves with the mechanisms of berth, maturation and diffusion of intellectual property.
- To know how intellectual property policy shapes the research process.
- To know the research and innovation policies in Greece and in the EU.
- To learn in practice how academic institutions transfer technology in the market, either in the form of spin-offs or through licensing.

Syllabus

- The research process and the birth of knowledge,
- The global process of knowledge diffusion,
- Technology matureness and the dilemma of technology protection,
- Knowledge and intellectual property diffusion through research consortia,
- The effect of patent filing in forming the public research policy and the dissemination of the academic knowledge.
- National and regional research and economic growth policies – smart specialization strategy,
- The new research structures and policies in the EU – Horizon Europe 2021-2027,
- The role of universities in the creation of spin-offs and startups in the local economic growth.
- Lectures for executives form technology transfer offices, for researchers who have “passed the entrepreneurial Roubicon”, as well as from executives from industry.

<u>Bibliography</u>

- Greenhalgh, C. and Rogers, M. (2010), Innovation Property and Economic Growth, Princeton Univ. Press, ISBN: 9780691137995
- Swann, G.M. (2009), The Economics of Innovation: An Introduction, Edward Elgar Publishing, ISBN: 978 1 84844 006 7

209. Innovation and Entrepreneurship

E

Teaching Hours: 4-0-0, ECTS: 6

Prerequisite Courses: -

7th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY209/

<u>Learning Outcomes</u>

At the end of the course students are expected:

- To familiarize themselves with the characteristics of the entrepreneur, their traits & typology.
- To know how innovation leads to new product development and differentiation form the competition.
- To know how geographic, social, cultural and economic proximity, as well as participating in social networks and in innovation systems helps the birth of innovations and new products.
- To learn how to recognize entrepreneurial opportunities and design products according to the principles of sustainable development.
- To learn how to design a firm and how to raise funding.

<u>Syllabus</u>

- Innovation and the characteristics of startup entrepreneurs
- Geographic, social, cultural and economic proximity – innovations systems – science & technology parks – startup incubators & accelerators.
- Entrepreneurship, modern global challenges and sustainable development
- Social Economy & entrepreneurship
- New technologies & private investments
- From the idea to business
- The basics of a business plan
- Elements of marketing
- Sources of venture funding
- Lectures of executives from public organisations/institutions, private firms and venture capitals

<u>Bibliography</u>

- Andrew Metrick, Ayako Yasuda Venture Capital and the Finance of Innovation, ISBN-13: 978-0470454701
- Handbook of Entrepreneurship Research: An Interdisciplinary Survey and Introduction, Springer New York Dordrecht Heidelberg London, ISBN 978-1-4419-1190-2
- The Handbook of Small & Medium-sized Entrepreneur - Practical Guide for a Profitable Small & Medium-sized Firm, Nikos E. Skoulas, Editions NSA, ISBN: 960406276X

211. Differential Equations I

O

Teaching Hours: 3-2-0, ECTS: 6

Prerequisite Courses: 112. 111

3rd Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY211/

Learning Outcomes

At the end of the course, students are expected:

- To familiarize themselves with the solution of simple first and second order differential equations
- To know very well the methodology of solving higher-order linear differential equations
- To be able to use this knowledge to solve physical problems mainly from the fields of mechanics and electricity

Syllabus

1. First-order differential equations:

Introductory concepts. The problem of initial conditions. The concept of the general solution of a differential equation. Equations with separable variables, first order homogeneous equations. Exact equations and integral factors. Bernoulli equation. Simple applications.

2. Second-order Differential Equations:

Linear Equations with constant coefficients. Non- homogeneous equations with simple functions. Euler Equations, homogeneous and non-homogeneous. 2nd order equations reduced to 1st order because of symmetry.

3. Newton's differential Equation:

Applications to basic Mechanics problems. Motion under different friction laws in a homogeneous gravitational field. Harmonic Oscillation with and without friction. Forced Harmonic Oscillation with and without friction. Problems from electricity based on mechanical analogues.

4. General Study of Linear Differential Equations: Concepts and Techniques

The principle of superposition. Linear independence and dependence. Vronskian and its uses. Calculation of the second solution when one solution is known. Decrease of the order. Complete solution of the non- homogeneous equation when the solutions of the homogeneous are known.

5. Linear Differential Equations of higher order with constant coefficients

Homogeneous, non-homogeneous

6. Systems of Linear Differential Equations with constant coefficients

The method of elimination and exponential replacement. Solving methods and use of matrices. Normal oscillations and applications to coupled oscillation and electrical circuit problems.

7. Linear Differential Equations with variable coefficients

From Taylor series to Frobenius. Examples. Convergence and critical points

Bibliography

- S. Trachanas, Ordinary Differential Equations, Crete University Press, Heraklion (2002)
- Thomas Kyventidis, Differential Equations, Vol I, ZHTH 1996 Thessaloniki, Greece
- S. Trachanas, Partial Differential Equations, Crete University Press, Heraklion (2001)
- W.E. Boyce, R.C. Di Prima, Elementary Differential Equations and Boundary Value Problems, Wiley 8th edition, 2004
- G.F. Simmons, Differential Equations with Applications and Historical Notes, McGraw-Hill (1991)

212. Differential Equations II

OE1

Teaching Hours: 3-1-0, ECTS: 6

Prerequisite Courses: 211

4th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY212/

Learning Outcomes

The main course objective is to provide a modern education on partial differential equations. The course Learning Outcomes are as follows:

- Demonstrated knowledge and understanding of the mathematical principles of second order differential equations.
- Advanced ability to apply this knowledge in order to solve realistic problems in physics.

Syllabus

- Partial differential equations (PDE) by function elimination. General form of 2nd order differential equations. Wave, Laplace and heat equations.
- Method of separation of variables. PDE is three dimensions. Superposition principle. Initial and boundary conditions.
- Sturm-Liouville equation. Eigenvalue problem. Expressing a function as a series of eigenfuctions. Degeneracy.
- Fourier series. Parseval's theorem.
- PDE in finite domains. 2-dimensional Laplace equation in Cartesian and spherical polar coordinates. Legendre polynomials. 2-dimensional wave equation in polar coordinates. Bessel functions.
- Complex Fourier series. Fourier transformation. Delta functions. PDE in infinite domains.
- Inhomogeneous PDE's. Green's functions method.

Bibliography

- S. Trahanas, "Partial Differential Equations" (in Greek), University of Crete Publishing (2001).
- W.A. Strauss, "Partial Differential Equations", Wiley, Greek translation: National Technical University Publishing (2007).
- I. Vergados, "Mathematical Methods of Physics I" (in Greek), University of Crete Publishing (2005)
- I. Vergados, II, "Mathematical Methods of Physics II" (in Greek), Symmetria Publishing, Athens (2004)
- W.E. Boyce and R.C. DiPrima, D.B. Meade, "Elementary differential equations", Wiley, Greek translation: National Technical University Publishing (1999).

213. Computers II: Introduction to Numerical Analysis

OE1

Teaching Hours: 2-0-3, ECTS: 6

Prerequisite Courses: 114, 116

4th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY213/

Learning Outcomes

Upon successful completion of the course, students will

- know the basic numerical methods for solving computational mathematical problems and will be able to develop complex computer programs in order to implement them.
- be prepared for other computational courses in the curriculum: Computational Materials Science I (ETY-447) and II (ETY-512), Special topics in Computational Materials Science (ETY448), etc.

- be able to understand and apply other numerical methods to solve complex mathematical and physical problems.

Syllabus

Numeral systems. IEEE Standards for integer and floating point numbers. Computer representation of numbers.

Numerical solution of a nonlimear equation. Definitions, useful theorems. Methods: bisection, regula falsi, secant, Muller, fixed point, Householder (Newton-Raphson, Halley).

Systems of linear equations. Direct methods (Gauss elimination, Gauss-Jordan, LU). Iterative methods (Gauss-Seidel, Jacobi, SOR). Other methods. Applications: calculation of the determinant of a matrix, inverse matrix, matrix eigenvalues and eigenvectors. Numerical solution of systems of nonlinear equations.

Function/set of points approximation: Interpolation of polynomial, rational, piecewise polynomial, spline. Runge phenomenon. Numerical differentiation.

Least squares approximation: line, polynomial, logarithmic and exponential. Correlation coefficient. Numerical quadrature. Trapezoid and Simpson rules. Newton-Cotes formulas. Gauss quadrature methods (Legendre, Hermite, Laguerre, Chebyshev). Clenshaw–Curtis method. Other methods.

Numerical solution of initial value problems of first order ordinary differential equations (ODE). Methods: Euler (explicit/implicit), Taylor, Runge-Kutta 2nd and 4th orders. Systems of ODEs. Higher order ODEs.

Other topics (FFT, optimization, etc.)

Bibliography

- Grammatikakis M., Kopidakis G., Stamatiadis S.- Introduction to Numerical Analysis, Lecture and Lab Notes (in Greek) (http://www.materials.uoc.gr/el/undergrad/courses/ETY213/notes.pdf)
- Forsythe G.E., Malcom M.A., Moler C.B.- Computer Methods for Mathematical Computations.
- Akrivis G.D., Dougalis V.A.- Introduction to Numerical Analysis (in Greek)

215. Advanced Programming I: Introduction to the C++ Programming Language

E

Teaching Hours: 1-0-3, ECTS: 5

Prerequisite Courses: 114

3rd Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY215/

Learning Outcomes

Upon successful completion of the course, the students will

- have deepen their knowledge of the basic concepts of structured programming
- be familiar with certain advanced programming concepts, as implemented in C++ (such as the Standard Library components and object-oriented programming).
- be able to develop complex, safe and fast code as well as understand or even plan code in programming languages with features simlilar to those of C++.

Syllabus

A) General:

- Introduction - Fundamental types and operators of C++. C++ syntax, reserved keywords, naming rules. Fundamental types: boolean, character, integer, real, complex.
  The "void" type. Enumerations. Declarations and scope of variables and constants. Structures.
- Arithmetic operators, priorities. Namespaces, references, pointers.
- Control structures, Loops.
- If statement, (?:) operator, the switch statement, the assert function. Loop structures: while, do while, for. continue, break statements.
- Functions
- Function definition, declaration and usage. the main function. Overloading, function template. Math functions.
- Exceptions.

B) Standard Library

- Containers: vector, deque, list, set/multiset, map/multimap. Iterators. Algorithms, function objects, lambda functions, adapters.

C) Object-Oriented Programming: Introduction to classes: encapsulation, inheritance, polymorphism.

D) Other topics

- Large program structure.
- Interface to Fortran and C.

Bibliography

- Notes: (https://www.materials.uoc.gr/el/undergrad/courses/ETY215/notes.pdf)
- Bjarne Stroustrup. Programming - Principles and Practice Using C++ (Second Edition), Addison Wesley, Reading, MA, USA, 2014.
- Stanley B. Lippman, Josée Lajoie and Barbara E. Moo. C++ Primer. Addison Wesley, Reading, MA, USA, fifth edition, August 2012.
- Nicolai M. Josuttis. The C++ Standard Library: A Tutorial and Reference. Addison Wesley, Reading, MA, USA, March 2012.
- Bjarne Stroustrup. The C++ Programming Language. Addison Wesley, Reading, MA, USA, fourth edition, 2013.

222. Spectroscopy

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: -

4th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY222

Learning Outcomes

The understanding by students the basic principles and concepts of using modern spectroscopic techniques in the field of materials science.

At the end of the lectures the students to obtain the basic experience of how important are the spectroscopic techniques to their science.

Syllabus

- Introduction
- Vibrational spectroscopy of molecules

- Group Theory
- Raman and SERS spectroscopic methods
- FT-IR spectroscopy
- Nuclear Magnetic Resonance (NMR) spectroscopy
- Laser spectroscopy (Laser Induced Fluorescence/LIF and Laser Induced Breakdown Spectroscopy/ LIBS)
- X-ray Fluorescence (XRF) spectroscopy
- Students Presentations

Bibliography

- P. Atkins, J. De Paula, "Physical Chemistry" Publications of Crete University, 2018
- Skoog, Holler, Crouch, "Principles of Instrumental Analysis", 6th Edition, 2007
- D. C. Harris, "Quantitative chemical analysis", Volume B, Publications of Crete University, 2010
- D.C. Harris, M.D. Bertolucci, "Symmetry and Spectroscopy" (Dover, NY 1978)

223. Inorganic Chemistry

O

Teaching Hours: 4-1-0, ECTS: 6

Prerequisite Courses: 121

3rd Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY223

Learning Outcomes

The course includes an introduction to the basic principles that govern the chemical reactivity and physicochemical properties of elements with emphasis on those of transition metals. The structure of transition metal complexes in terms of chemical activity and energy stability is described.

The learning goals of the course are:

- Consolidate the basic principles that govern the chemical reactivity of elements, especially of transition metals.
- Acquire the knowledge necessary to understand the structure of inorganic complexes and the factors affecting their chemical stability.
- The course aims at understanding the physicochemical principles that characterize the growth and properties of inorganic supramolecular solids.

Syllabus

- Electron Configuration and Chemical Periodicity

  The physical and chemical properties and the tendency of elements to form particular compounds in relation to their position in the periodic table.

- Acid-Base and Donor-Acceptor Principles

  Pearson acid-base concept (HSAB). Definitions of Arrhenius, Bronsted-Lowry, and Lewis acids and bases. Acid-base strength classification and factors affecting it.

- Electrochemistry

  Electrode potentials, redox reactions and electrochemical cells (voltaic and electrolytic cells). Relative strength of oxidizing and reducing agents. Free energy (Gibbs) and electrical work (Standard cell potential and the equilibrium constant). The effect of concentration on cell potential (Nernst equation) Corrosion: An example of environmental electrochemistry. Protecting against corrosion.

- Transition Elements: Electronic Configuration and Bonds

  Electronic configuration and oxidation states of the transition metals and their ions. Valence bond theory and orbital hybridization. Crystal field theory. Molecular orbital theory. Crystal field splitting of energy of d-orbitals (high-spin and low-spin symmetry compounds). Strong and weak-field ligands. Spectrochemical series. Magnetic properties of transition metal complexes (paramagnetic and diamagnetic complexes). Absorption spectroscopy (electronic spectra of d^n ions, charge transfer spectra: allowed/forbidden electronic transitions). Jahn-Teller distortion. Color of transition metals.

- Coordination Chemistry: Structure

  Compounds with coordination number 2 (linear), 3 (trigonal planar and trigonal pyramidal), 4 (tetrahedral and square planar arrangement), 5 (tetragonal pyramidal and trigonal dipyramidal), 6 (octahedral and triangular prismatic), 7 (pentagonal dipyramid, substituted octahedral and substituted triangular prismatic) and 8 (triangular dodecahedron and square antiprismatic). Isomerism in coordination compounds.

- Coordination Chemistry: Rates and Mechanisms of Chemical Reactions

  Reactions of nucleophilic substitution in transition metal compounds. Trans effect. Factors that influence reaction rate. Racemic mixtures and isomerization. Electron-transfer reaction mechanisms (outer and inner sphere mechanisms).

- Solid State Chemistry

  Synthesis of inorganic ionic and covalent compounds. Crystalline inorganic solids (Ionic and supramolecular 3D structures, laminate structures). Amorphous inorganic solids (Ceramics and glasses).

Bibliography

- “Inorganic Chemistry”, 2nd Ed., Catherine E. Housecroft, Alan G. Sharpe (Greek edition: N. Hatziliadis, T. Kampanos, A. Keramidas, S. Perlepes), Unibooks IKE, 2017.

  The book comprehensively covers the Syllabus of the course.

- P.P. Karagiannidis, "Inorganic Chemistry", 3rd Ed., ZHTH Publishers, Thessaloniki, 2008.

  The book largely covers the Syllabus of the course.

225. Chemistry of Materials Laboratory Course

O

Teaching Hours: 2-0-4, ECTS: 8

Prerequisite Courses: 124

3rd Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY225/

Learning Outcomes

Students at the end of the course are expected to:

- Familiarize themselves with experimental practice and safety rules during the experimental process in more demanding experiments such as composing materials.
- To know the experimental procedures that follow for the synthesis of useful materials such as zeolites, complexes, polymers and superconductors.
- To be able to evaluate the synthetic course of a material and to find ways to determine the result of the composition by applying appropriate characterization methods depending on the material they have to do.
- Familiarize themselves with material characterization instruments such as the Ultraviolet-visible

photometer (UV-vis), Infrared spectroscope (IR), X-ray diffraction (XRD), microscope, etc.

Syllabus

Solid-state synthesis and superconductivity testing of inorganic material. Determination of average oxide state of the atoms with iodine titration.

Hydrothermic synthesis of Zeolite NaX and characterization of the material using infrared spectroscopy.

Synthesis and characterization of CdS nanoparticles by the aid of organic stabilizers. Characterization with UV-vis spectroscopy and X ray diffraction.

Synthesis of complex compounds $[Co(NH_3)_4CO_3]NO_3$ and $[Co(NH_3)_5Cl]Cl_2$. Determination of energy difference between d-orbitals t2g and eg of the various octahedral complex compounds with electronic absorbance spectroscopy.

Kinetics of the substitutional reaction of the compound $[Co(NH_3)_5Cl]Cl_2$.

Lower critical solubility temperature of macromolecules. Effect of homopolymerization on the lower critical solubility temperature of a given macromolecule.

Modification of the side chain of a polymer. Characterization with Infrared spectroscopy.

Condensation and photopolymerization on a surface of silicon oxide. Characterization of the surface properties.

Bibliography

- Murray Zanger, James, R. Mackee, "Small Scale Syntheses, A Laboratory Textobook of Organic Chemistry", Wm. C. Brown Publishers, 1995
- Stanley, R. Sandler, Wolf Karlo, Jo-Anne Bonesteel, Eli M. Pearce, "Polymer Synthesis and Characterization, A Laboratory Manual" Academic Press, California, USA, 1998
- Francesco Trotta, Davice Cantamessa, Marco Zanetti, "Journal of Inclusion Phenomena and Macrocyclic Chemistry", 37, 83-92, 2000
- Gregory S. Girolami, Thomas B. Rauchfuss, Robert J. Angelici, "Synthesis and Technique in Inorganic Chemistry: A Laboratory Manual", 3rd ed., University Science Books, Sausalito, USA, 1999.
- Zvi Szafran, Ronald M. Pike, Mono M. Singh, "Microscale Inorganic Chemistry: A Comprehensive Laboratory Experience", John Wiley & Sons, New York, 1991.

232. Biochemistry & Molecular Biology

O

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: 122

4th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY232/

Learning Outcomes

The course outline includes an introduction to the basic concepts of molecular design of life, structure and function of fundamental biochemical molecules, biochemical evolution and the flow of genetic information. The learning goals that students should have achieved at the end of the lesson are the following:

- To become familiar with the molecular design of life
- To consolidate the notions of structure and function of the fundamental biochemical molecules used by nature as building blocks (nucleic acids, proteins, carbohydrates, lipids)
- To be conceptually prepared to follow the course of natural biomaterials and their applications (course ETY-391).

Syllabus

- Biochemical evolution
- Structure and function of proteins
- DNA, RNA and the flow of genetic information
- Exploring evolution
- Enzymes: basic principles and kinetics
- Catalytic strategies
- Carbohydrates and lipids
- Moreover, during the last two academic years, an invited lecture is given by Professor Ioannis Iliopoulos of the Medical School on SwissProt and BLAST search software, along with an introductory lecture on Bioinformatics.

Bibliography

- Stryer L., "Biochemistry and Molecular Biology", Greek Translation, 8th Edition, Crete University Press, 2015

242. Materials III: Microelectronic - Optoelectronic - Magnetic Materials

O

Teaching Hours: 4-0-0, ECTS: 6

Prerequisite Courses: -

4th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY242/

Learning Outcomes

- Understand basic optical and electrical properties of semiconductors associated with crystalline structure, energy bands and impurities.
- Understand basic physical principles of operation of semiconductor devices.
- Knowledge of basic semiconductor growth and fabrication processes such as optical lithography, thermal and e-beam metal and dielectric deposition, wet and dry chemical etching.
  - Apply knowledge to select purpose specific semiconductor materials and design devices such as LEDs, detectors and laser diodes.
  - General overview of modern developments in the rapidly expanding field of optoelectronic semiconductor devices

Syllabus

The aim of the course is introduction to fundamental properties of semiconductor materials and their application in modern microelectronic and optoelectronic devices.

- Introduction to solid state materials - crystal structures –reciprocal lattice -Brillouin zone
- Bandgaps in semiconductors – properties of conduction and valence bands - band structure – bandgap engineering
- Fermi distribution – density of states – intrinsic and extrinsic carrier concentrations – n and p type doping - extrinsic semiconductor Fermi energy level
- Material growth and basics of semiconductor device fabrication - photolithography
- Electronic and electric properties of semiconductors, carrier transport by diffusion and drift
- Homo and heterojunctions - PN diodes
- Optical properties of semiconductors, absorption, spontaneous and stimulated emission
- Excitons: Origin, electronic levels and properties , radiative and nonradiative recombination
- Semiconductors Quantum structures, density of states
- Optoelectronics devices (LED, Laser diodes, photodetectors)

Bibliography

- J. Singh, “Optoelectronic”
- S.O. Kasap, “Principles of Electronic Materials & Layouts”

243. Materials II: Polymers & Colloids

O

Teaching Hours: 4-0-0, ECTS: 6

Prerequisite Courses: -

4th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY243/

Learning Outcomes

The course is a first introduction to Soft Matter with emphasis on Polymers and Colloids. The outline includes the study of their building blocks such as the polymeric chains and colloidal particles with emphasis on their molecular characteristics, their interactions, their thermodynamic behavior and their structure and self-organization in solution.

The learning goals that students should have achieved at the end of the lesson are the following:

- Familiarize with Soft materials and learn to distinguish between different types of systems
- To consolidate the Physical mechanisms responsible for the structure of polymer chains their interactions and thermodynamic phase behavior.
- To understand the role of Interparticle interactions between colloidal particles in their self-assembly in crystal phases and out of equilibrium glasses and gels
- To provide the knowledge background for students to follow more advanced elective courses in Colloidal Dispersions and Polymer Physics (ETY-471 and ETY-450).

Syllabus

Introduction

Examples of Soft Matter systems: Polymers, Colloids, Biomaterials, Surfactants and Micelles, Liquid Crystals, Emulsions and Foams.

Polymers

- Introduction
- Types and names of polymeric systems
- Basic examples in Polymer Synthesis
- Macromolecular characterization, Chain architecture, Molecular weight, End-to-end distance and Radius of gyration
- Solutions, concentration regimes, interactions
- Phase behavior
- Amorphous and Crystalline polymers. Elastomers
- Polymer mixtures and copolymers

Colloids

- Introduction
- Types of colloidal systems
- Colloidal Interaction, colloidal stabilization
- Colloid-polymer mixtures
- Dense suspensions and crystals
- Colloidal glasses and gels

Bibliography

- Course notes (G. Petekidis)
- W.D. Callister, Jr. Materials Science and Engineering, An introduction,
- 5th edition, John Willey and Sons, New York, 1999.
- I. W. Hamley, Introduction to soft Matter, John Willey and Sons, New York, 2000.
- R.A.L. Jones, Soft Condensed Matter, Oxford University Press. Oxford, 2002.
- K. Panagiotou, Polymer Science and Technology, Pegasus press, Thessaloniki 1996.
- K. Panagiotou, Interfacial Phenomena and Colloidal Systems, Ziti press, Thessaloniki 1998.
- D. F. Evans, H. Wennerström, The Colloidal Domain, Where Physics, Chemistry, Biology and Technology meet, 2nd Edition, John Willey and Sons, New York, 1999.

248. Structural and Chemical Analysis of Materials

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: -

4th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY248/

Learning Outcomes

A) The knowledge which the students will acquire upon successful completion of the course comprises:

Radiation-matter interaction. Theory of elastic scattering. Elastic scattering from isolated atoms. Theory of X-Ray, neutron, electron diffraction. Secondary emission. Absorption of radiation from materials. Emission-detection-measurement of radiation. UV/vis, FT-IR, Fluorescence spectroscopy. X-Ray absorption spectroscopy. NMR. Scanning and Transmission Electron Microscopy. Electron spectroscopy for analysis of materials surfaces and interfaces.

B) The skills which the students will acquire upon successful completion of the course are:

a) mastering real-life experimental techniques and instrumentation which are widely used for the structural and chemical characterization of materials such as X-Ray diffractometry, UV-Vis spectroscopy, FT-IR spectroscopy, Raman spectroscopy, Fluorescence Spectroscopy, Nuclear Magnetic Resonance (NMR), Scanning and Transmission Electron microscopy

b) choosing the right instruments or equipment for the chemical and structural analysis of materials added by finding the, application dependent, useful range of functionality for each specific experimental technique.

c) the students also learn how to use a computer for preparing an oral presentation that includes text, arrays and charts, two- and three-dimensional graphical representations, images and video.

C) The competence which the students will acquire upon successful completion of the course is

a) the ability to decide on and properly utilize the proper experimental technique for a specific structural and/or chemical characterization of materials

b) the ability to correctly assess and utilize results presented by other scientists regarding the aforementioned specific characterizations of different classes of materials.

Syllabus

Introduction

Types of radiation, Energy-wavelength relation, Radiation applications to Materials Science, Atomic theory, Atomic energy levels.

Radiation-Matter interaction

Electromagnetic waves, Electromagnetic spectrum, Ionizing (X-Ray) and non-ionizing radiation, Study of the interaction of beams with electrons/neutrons/ions. Basic principles of elastic scattering (amplitude/intensity of radiation). Elastic scattering from isolated atoms.

X-Ray diffraction

Theory, Emission of X-rays and affecting factors (potential, current etc.), Absorption of X-rays, Detection of X-rays and measurement of their intensity, Crystallography, Crystal lattice, Primitive cell, Crystalline planes, Instrumentation, Application of X-rays to materials characterisation, X-Ray Fluorescence (XRF), X-Ray Photoelectron Spectroscopy (XPS), Principle of Operation, Information available to materials science (chemical composition, bond arrangements, etc.).

Ultraviolet-Visible (UV-Vis) spectroscopy

Beer-Lambert Law, Electronic transitions, Visible range of the spectrum, Color - wavelength relation, Typical examples of chemical compound spectra, Absorption/Transmission/Reflection spectra in liquid and solid samples.

Fourier Transform - Infrared spectroscopy (FT-IR)

Dipolar moment, Vibrational/Rotational energy levels, Types of molecular vibrational motion, Selection rules, Instrumentation, Michelson Interferometer, Typical FT-IR spectra of organic compounds, Attenuated Total Reflectance (ATR), Applications.

Raman spectroscopy

Basic principles, Stokes/Anti-Stokes lines, Polarization, Vibration - Rotation types, Selection rules, Comparison with FT-IR: similarities and differences, laser, Instrumentation, Typical Raman spectra of organic and inorganic compounds / materials, Applications.

Fluorescence Spectroscopy

Basic principles, Electronic transitions (ground and excited states), Selection rules, Instrumentation (fluorimeter), Typical fluorescence spectra of compounds, Laser Induced Fluorescence (LIF), Applications.

Nuclear Magnetic Resonance (NMR)

Magnetic field, spin, fission, Principle of chemical shift, Spectrum Types (Hydrogen 1H and Carbon 13C), Single and Multidimensional spectra (COSY, HMQC, etc.), Instrumentation, Applications in organic compounds.

Electron microscopy

Aspects of an optical microscope (focusing lens, objective lens, magnification), Scanning Electron Microscopy (SEM), Instrumentation, Examples, Transmission Electron Microscopy (TEM), Instrumentation, Examples, Comparison between SEM/TEM microscopes, Combination of an Electron Microscope with Energy Dispersive Spectroscopy (EDS).

Bibliography

- J. P. Eberhart, "Structural and Chemical Analysis of Materials", John Willey & Sons Inc., 1991.
- P.E.J. Flewitt, R.K. Wild, "Physical Methods for Materials Characterization", IOP Publ., London (1994)
- H.-M. Tong and L.T. Nguyen, Eds., "New Characterization Techniques for Thin Polymer Films", Wiley, New York (1990)
- D. A. Skoog, F. J. Holler and T. A. Nieman, "Principles of Instrumental Analysis", 5th Edition, Saunders College Publishing, Philadelphia (1998)

260. Thermodynamics

O

Teaching Hours: 4-3-0, ECTS: 6

Prerequisite Courses: 112

3rd Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY260/

Learning Outcomes

Understanding of the laws of thermodynamics and their applications with emphasis on phase diagrams of materials. Develop critical thinking on the topic and analytic ability to solve problems. Rational approach to problems aiming at strict wording of problem data and assumptions as well as quantitative analysis. Develop ability to assess knowledge and understand the physical meaning of concepts and the results of experimental or theoretical analysis.

Syllabus

The course involves a lengthy discussion of classical thermodynamics with emphasis on entropy changes and phase equilibria and a short basic introduction to statistical thermodynamics with main focus the most probable distribution and the microscopic description of entropy.

- Elementary introduction to the goals of Thermodynamics: energy, heat, systems, variables and equilibrium
- Zeroth Law of Thermodynamics
- Ideal and Real Gases
- First Law, Internal Energy, Enthalpy, heat capacity
- Second Law, Entropy and Reversibility
- Third Law
- Thermodynamic Functions, Chemical Potential
- Phase Transitions, Equilibrium
- Mixtures, Phase Diagrams, Phase Rule
- Elementary Probability Theory and Statistical Physics
- Canonical Ensemble
- Microscopic States and Entropy, Fundamental Equations
- Equations of State, Phase Transitions

Bibliography

- P.W. Atkins "Physical Chemistry", 9th Edition, Greek Translation, Crete University Press
- Instructor's notes on elementary statistical thermodynamics

301. Electromagnetism

O

Teaching Hours: 3-2-0, ECTS: 6

Prerequisite Courses: 102, 112

5th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY301/

Learning Outcomes

The course aims at providing students with a deep understanding of the mathematical theory of electromagnetism. The course Learning Outcomes are:

- Demonstrated knowledge and understanding of the mathematical foundations of the theory of electromagnetism.
- Use of the acquired knowledge and physical perception for effective analysis and solution of complex problems in electromagnetism.

Syllabus

- Mathematical tools from vector analysis

- Electrostatics: Divergence and curl of electric field, Gauss law, electric potential, Poisson and Laplace equation, electrostatic energy. Electrostatic calculations (uniqueness theorem, electrostatic images, separation of variables, electric dipoles). Dielectrics (polarization, bound charges, electric displacement, linear dielectric materials)

- Magnetostatics: Lorentz field, Biot-Savart law, Divergence and curl of magnetic field, magnetic vector potential. Magnetization, demagnetizing field, magnetizing field H, Ampere's law, linear and non-linear magnetic media.

- Maxwell's equations

Bibliography

- D.J. Griffiths, "Introduction to Electrodynamics", Vol II, Cambridge, Greek translation: University of Crete Publishing (2011).
- I.S. Grant and W.R. Phillips, "Electromagnetism", Wiley (1990).
- R.K. Wangsness, "Electromagnetic fields", Wiley (1986).
- D. Corson and P. Lorrain," Introduction to Electromagnetic Fields and Waves", Freeman (1962).
- L. Landau, "Electrodynamics of continuous media", Oxford Univ. Press. (1984).

302. Optics and Waves

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 102, 112

6th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY302/

Learning Outcomes

- Foundation of **knowledge** on the physics of Waves and Optics.
- **Understanding** of transverse waves and their polarization as well as the effect of optical anisotropy.
- **Application** in polarizing optical systems
- **Understanding** the basic principles of operation of optical systems
- **Application** of basic strategies of design and analysis of optical systems

Syllabus

- **Introduction**,
  Waves in nature, Longitudinal and transverse waves, Wave propagation, Huygens-Fresnel principle,

- **Electromagnetism**,
  Maxwell equations, Geometrical Optics, ,

- **Imaging,**
  Fermat's principle Snell law, Lenses and Mirrors, Optical Aberrations, Basic principles of Optical engineering,

- S**ources and detectors of optical radiation**,
  Black body radiation, diodes, Lasers, Photometry, Photomultipliers, Photodiodes, CCD sensors.

- **Polarization**,
  Jones and Stokes representation, Optical anisotropy and Dichroism,

- **Interference**,
  Interferometers and Optical metrology,

- **Diffraction**,
  Fresnel and Fresnel-Kirchhoff diffraction integrals, Fraunhofer diffraction, diffraction from various apertures, resolution of optical systems

Bibliography

- "Topics in Optics", E. Hecht, translated in Greek as "Οπτική" from I. Spyridelis, Schaum's Outline Series.
- "Optics", E. Hecht, Addison-Wesley, (2001).
- "Introduction to Modern Optics", G.R. Fowles, Dover, (1989).
- "Principles of Optics", M. Born, E. Wolf.
- "Introduction to Fourier Optics", J. W. Goodman, McGraw-Hill, (1996).

305. Solid-State Physics: Introduction

O

Teaching Hours: 3-2-0, ECTS: 6

Prerequisite Courses: 201

5th Semester

http://theory.materials.uoc.gr/courses/fsk/

Learning Outcomes

By the end of the course, students are expected to

- Become familiar with quantities that tell if if a material is (a) hard or soft (b) heats up easily or not (c) conducts electricity (d) is transparent or (e) is affected by magnetic fields.
- Know simple crystal structures and calculate their basic structural properties, as well as quantities that describe the main properties of a material and the characteristic order of magnitude for their numerical values.
- Have learned to calculate the approximate density, the distance between adjacent atoms, modulus, heat capacity, dielectric constant, refractive index, magnetoresistance in simple solids. They should have understood the mechanisms of quantum motion of electrons and the thermal motion of atoms in solids.

Syllabus

This course is an introduction to the relationships connecting atomic structure and macroscopic properties of solids. It includes an introduction to the calculus of periodic functions of three variables, including Bravais Lattices.

Two simple models are used throughout the class: the homogeneous solid (Jellium) and the linear combination of atomic orbitals (LCAO). Through these models, all key properties of solids are introduced to the students, including mechanical, thermal, electrical, optical and magnetic properties. Relationships between quantities that describe different properties are highlighted.

Course content:

- Basic physical properties of solids. Dimensional analysis and estimations of orders of magnitude.
- Crystal lattices and periodicity. Bravais- and composite lattices. Lattice- and basis vectors. Reciprocal lattice and Brillouin zone. Bloch's theorem.
- The model of homogeneous solid (jellium) and first-principles calculations for the cohesive energy, density and bulk modulus.
- Motion of electrons motion in the homogeneous solid - Fermi model.
- Motion of ions in the homogeneous solid - Debye model.
- Thermal properties of solids.
- Motion of electrons and ions in realistic materials.

- Electrical, magnetic and optical properties.

Bibliography

- E. N. Economou, The Physics of Solids, Crete University Press Springer-Verlag (2010).
- C. Kittel, Introduction to solid state physics Wiley, New York (1976)
- R. A. Levy, Principles of Solid State Physics, Academic Press (1968)
- N. W. Ashcroft - N. D. Mermin, Solid state physics, Holt, Rinehart and Winston, New York (2012)
- S. Trachanas, An Introduction to Quantum Physics: A First Course for Physicists, Chemists, Materials Scientists, and Engineers, Wiley (2018)
- E. Kaxiras, Atomic and electronic structure of solids, Cambridge University Press (2003)

306. Solid State Physics II: Electronic and Magnetic Properties

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 201

6th Semester

http://theory.materials.uoc.gr/courses/fskII/

Learning Outcomes

The course addresses students who are interested in understanding the relationship between the atomic and electronic structure of solid materials with their macroscopic properties as well as with the properties that render them invaluable in modern technology. The course covers topics such as the relation between atomic configuration and electronic structure (electronic energy states, bands and gaps), how this determines conductors, semiconductors and insulators, the interaction of materials with the electromagnetic field. The learning goals that should have been achieved by the end of the course are:

- Students understand the basics of quantum theory of solids required for electric properties description.
- Students should be able to explore the interaction of materials with electromagnetic fields.
- Students become familiar with the most important aspects of the electronic, optical, magnetic properties of materials so that they can understand the design and operation of electronic and magnetic devices in more advanced courses.

Syllabus

- Structural properties review
- Quantum mechanics review
- Electron motion
- Electrical conductivity in crystalline metals and alloys
- Electrical conductivity in crystalline semiconductors, insulators
- Optical properties of materials
- Magnetic properties of materials
- Superconductivity

Bibliography

- E.N. Economou, Solid State Physics, Volume I, Metals, Semiconductors, Insulators, Crete University Press, Heraklion (1997).
- C. Kittel, Introduction to Solid State Physics, 5th Edition, Greek translation, Pneumatikos Editions, Athens (1979).
- E.N. Economou, Solid State Physics, Volume II, Order, Disorder, Correlations, Crete University Press, Heraklion (2003).

- S. Trachanas, Quantum Mechanics I: Fundamental Principles, Simple Systems, Structure of Matter. A Basic Introduction for Physicists, Chemists and Engineers, Crete University Press, Heraklion (2005).
- W.D. Callister, Jr., Materials Science and Engineering, 5th Edition, Greek translation, Tziola Editions, Thessaloniki (2004).
- I. Harald, L. Hans, Solid-State Physics. An Introduction to Principles of Materials Science, Greek Translation, Ziti Editions, Thessaloniki (2012).
- P. Robert, Electrical and Magnetic Properties of Materials, Artech House, Norwood MA (1988).
- W.A. Harrison, Electronic Structure and the Properties of Solids: The Physics of the Chemical Bond, Dover, New York (1989).
- R.C. O' Handley, Modern Magnetic Materials: Principles and Applications, Wiley (2000).

335. Molecular Cellular Biochemistry

O

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: 122

5th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY335/

Learning Outcomes

The course outline includes the study of cells and cell structures, the transport mechanisms of molecules and ions in cells, the signaling pathways and the interaction of cells with the environment. The learning goals that students should have achieved at the end of the lesson are the following:

- To become familiar with cells, cellular structures and biochemical reactions within cells
- To consolidate the notions of the biochemical ques of signaling pathways to various cell responses
- To use this knowledge towards the understanding of cellular functions
- To be conceptually prepared to follow the course of biological materials and composite biomaterials and their applications (course ETY-491).

Syllabus

- Introduction to the cell
- Lipids and biological membranes
- Cell membrane transport
- Signaling pathways
- DNA replication, repair and recombination
- Metabolism
- Immunological responses and introduction to the immune system
- mRNA translation
- Sensation/esthetic systems
- Cell-cell interactions and extracellular matrix

Bibliography

- Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, Biochemistry, 8th Edition, University Press Crete 2018

  The book covers at 100% the molecular cellular biochemistry aspects of the course.

340. Transport Phenomena in Materials Science

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 211

6th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY340/

Learning Outcomes

The course includes an introduction to the basic principles governing processing of materials and their response to external stimuli. It focuses on the description of momentum, heat and mass transport with emphasis on Newtonian fluids.

The learning goals of the course are:

- Familiarization of students with the laws of Newton, Fourier and Fick, and their applications in processes where materials are used.
- Deep understanding of the methodolody of development of conservation balances and the solution of simple cases with appropriate selection of initial and boundary conditions and with appropriate assumptions.
- Preparation of students for advances courses such as rheology and processing of polymeric materials

Syllabus

Introductory concepts:

Fluids – fluid statics. What are transport phenomena. Conservation principles. Elements of vector and tensor analysis.

Momentum transport.

Viscosity and mechanisms of momentum transport. Microscopic momentum balances gia steady laminar flow. Macroscopic momentum balances. Mechanical energy.

Heat transport.

Heat conduction and mechanisms of thermal energy transport. Microscopic balances in laminar flow. Macroscopic balances.

Mass transport.

Diffusion and mechanisms of mass transport. Microscopic balances in laminar flow. Macroscopic balances

Bibliography

- Instructor's notes (course webpage).
- R. Bird, W. Stewart, E. Lightfoot, Transport phenomena, 2nd Ed., Wiley, NY, 2001. Latest edition is also translated in Greek, publisher: A. TZIOLAS (2017).
- J. Welty, R. Wilson, C. Wixks, Fundamentals of momentum, heat and mass transfer, 2nd ed., Wiley, NY, 1976.
- R. S. Brodkey, H. C. Hershey (translation K.E. Labdakis), Transport phenomena, Greek, publisher: A. TZIOLAS, 2001.
- R. W. Fox, A. T. McDonald, P. J. Pritchard, Introduction to fluid mechanics, 6th ed., Wiley, NY, 2006.

343. Soft Matter Laboratory

O

Teaching Hours: 1-0-5, ECTS: 8

Prerequisite Courses: 243

5th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY343/

Learning Outcomes

At the end of the course the students are expected to:

- Be familiar with the main techniques used in the synthesis and characterization of soft matter
- To acquire knowledge of the basic theoretical principles of the methods for polymer and colloid synthesis
- To acquire theoretical and practical training on the basic characterization techniques used for the determination of the thermal and mechanical properties of soft matter
- To be ready to carry out their diploma thesis or graduate studies in the field of soft matter

Syllabus

Theory

- Introduction:

  Type of Polymers, Colloids, Nomenclature, Polymerization Techniques, Molecular Weight, Size-Shape of Polymers, Applications

- Polymerization Methods & Polymer Reactions:

  Polycondensation, Free-Radical, Ionic, Copolymerization

- Molecular characterization of Polymers:

  Determination of Absolute Molecular Weight (Static Light Scattering)
  Size Exclusion Chromatography (SEC) Viscosity measurements
  Polymer Composition-Nuclear Magnetic Resonance (NMR) Spectroscopy

- Thermal Properties:

  Crystallization, Glass Transition, Elastomers, Methods for the determination of the thermal transitions

- Mechanical Properties:

  Viscosity, Viscosity Nomenclature for Dissolutions, Flow curve, Viscosity as a function of volume fraction, Viscosity Measurements, Tensile, Hardness.

Lab experiments

1. Soft Matter Synthesis

1.1 Synthesis of Polystyrene homopolymer by Bulk Free-Radical Polymerization

1.2 Synthesis of Random Polystyrene-co-Poly(butyl methacrylate) by Solution Free-Radical Copolymerization

1.3 Synthesis of Polystyrene Colloids by Emulsion Polymerization

1.4 Synthesis of a Poly(acrylic acid) Random Polymer Network

2. Soft Matter Characterization

2.1 Determination of Thermal Transitions of Polymers by Differential Scanning Calorimetry (DSC)

2.2 Determination of the Molecular Weight Distribution of Polymers by Size Exclusion Chromatography (SEC)

2.3 Investigation of the Thermal and Mechanical durability of Polymers and Hybrid Materials by Thermogravimetric Analysis (TGA) and Mechanical Analysis (Hardness)

2.4 Determination of the Particle Size and Investigation of the Rheological Properties of Colloidal Systems by Optical Microcopy and rheology

Bibliography

- Laboratory experiments in Synthesis and Characterization of Soft Matter, M. Vamvakaki, S. Parouti, K. Chrisopoulou, Heraklion, September 2004.
- Allcock, H.R.; Lampe, F.W. Contemporary Polymer Chemistry, 2nd ed., Prentice Hall, Englewood Cliffs, 1990.
- Hiemenz, P.C. Polymer Chemistry: The Basic Concepts, Marcel Dekker, NY, 1984.
- Young, R.J.; Lovell, P.A. Introduction to Polymers, 2nd ed., Chapman & Hall, 1996.

344. Solid State Materials Laboratory

Core

Teaching Hours: 1-0-5, ECTS: 8

Prerequisite Courses: 204

6th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY344/

Learning Outcomes

A) The knowledge which the students will acquire upon successful completion of the course comprises:

i. basic elements of semiconductor physics and technology (conductivity, carrier type, types of dopants, thermal diffusion doping) and of semiconductor diodes
ii. basic aspects and use of high dielectric permittivity materials, fabrication of powders and pellets using liquid chemistry followed by high-temperature calcination, structural characterization by X-Ray diffractometry and dielectric assessment by impedance spectroscopy and its thermal dependence
iii. basic aspects of magnetron sputtering and its use in the preparation of thin metallic films
iv. mechanical properties of metals and their study using uniaxial stress-strain measurements (tensile strength) and hardness tests. Study of implications after thermal treatment.
v. introductory elements on nanomaterials and their unique properties using two approaches:

a) preparation of metallic nanoparticles and study of plasmon resonance
b) preparation of photocatalytic nanopowders and application in organic pollutant dissociation (mineralization)

B) The skills which the students will acquire upon successful completion of the course are:

α) mastering experimental techniques which are widely used in solid-state materials science and technology such as X-Ray diffractometry, Impedance Spectroscopy using Lock-In Amplifiers, Van der Pauw Conductivity, Hall sensing of carrier type, Ellipsometry, Sputtering, Tensile strength and Hardness measurements, UV-Vis absorption spectroscopy etc.

β) choosing the right instruments or modules for the implementation of an experimental setup in materials science, making correct interconnections between them with/or without the aid of a control computer, finding the useful range of instrument/module functionality for each specific experimental need

χ) conducting experimental measurements, in-situ assessing of their reliability based on known material properties

δ) analyzing experimental data. This includes calculations of the values of experimental quantities and of their expected errors as a measure of trust on these values. Analysis includes the ability i) to perform correct graphical representations that reveal, upon sight, the relationship between two quantities and ii) to find the mathematical description of this relationship using the least-squares fit formalism

ε) writing laboratory reports that include i) title and purpose of conducting each experiment, ii) summary of the methodology, instrumentation and setup to be used in order to achieve the goals of the experiment and introduction on materials to be studied along with their specific characteristics and properties, iii) comprehensive presentation of experimental procedure and experimental data iv) analysis of the experimental data, formally presenting the corresponding calculations and results on the needed experimental values.

ϕ) assessment of the experimental results by i) verifying (or not) the expected material, ii) studying of its known properties with assessment of material quality always within the range of trust imposed by experimental error and iii) proposing ways to remedy or bypass methodology drawbacks in future attempts to run the same fabrication and/or characterization experiments, as a way to improve the quality of materials and the accuracy of the experimental results

The students also learn how to use a computer in writing experimental reports and in order to construct graphs and analyze experimental data through the use of corresponding spreadsheet preparation and editing software

C) The competences which the students will acquire upon successful completion of the course are:

a) the ability to design the proper experimental procedure and use the proper experimental techniques for fabrication and characterization of solid-state materials
b) the ability to cooperate with other people, as part of a team, in designing and implementing the above-mentioned procedure, in collecting and analyzing experimental data, in assessing experimental results and in writing experimental reports
    a. the ability to recognize *in-vivo* and correct or bypass errors or even modify certain steps throughout the process of implementation of an experimental task in order to reach the answer the safest and most unambiguous way.

<u>Syllabus</u>

1. Doping of silicon

Introduction. Thermal Diffusion doping. Fick's law. Diffusion coefficients and Einstein's relation. Predeposition and drive-in diffusion processes. RCA cleaning of silicon wafers. Spin-coating of spin-on boron diffusants. Fabrication of a p^+n junction. Introduction to Ellipsometry. Thickness measurement of a thin thermal oxide on silicon

2. Preparation of $BaTiO_3$ dielectric with the Pechini method

Introduction to high permittivity dielectric materials. Dielectric polarization mechanisms, dependence of dielectric permittivity on frequency and temperature. Ferroelectrics: Barium Titanate. Structural properties and Curie (temperature) phase transition. Aspects on preparation of barium titanate powders with the Pechini method: esterification-polymerisation-grinding-calcination-sintering

3. Sputtering and thin-film deposition

Introduction to dc magnetron sputtering: Townsend relation-Paschen curve. Plasma creation. Ion-collision stimulated sublimation of a metal target. Need of the 'magnetron'. Arrival of atoms, adsorption, clustering and nucleation, 2D (Frank-Van der Merwe) and 3D (Volmer-Weber) growth of thin films. Study of the dependence of thin-film growth rate on chamber pressure and operating ion current. Resistivity measurements (4pt probe technique) on thin metal films and dependence on the growth rate

4. Electrical characterization of doped semiconductors

Introduction to the electrical properties of semiconductors: case study on silicon. Elipsometric measurement of thermal oxide thickness and chemical etching of the oxide. Paint and fire technique for making metal contacts on silicon. Van der Pauw measurement of conductivity. Hall measurement of carrier type and mobility. Acquiring a dark current-voltage curve of a silicon diode. Measurement of ideality factor.

5. Structural and dielectric characterization of an insulator

Basic elements of X-Ray diffraction on single crystals and polycrystalline materials: Bragg notation and Laue equations, crystallite size and distortion effects. Application on $BaTiO_3$.

Introduction in the Lock-In amplification technique. Use of a lock-in amplifier for measuring the dielectric permittivity of $BaTiO_3$ as an active material in capacitors: study of an RC circuit, dependence of circuit current on frequency and capacitor temperature. Estimation of Curie temperature and type of dielectric phase transition.

- Mechanical properties of metals

Mechanical behavior of metals under tensile uniaxial loading: elastic, inelastic and plastic deformation. Young's modulus, resilience, toughness, yield stress and fraction point of aluminum alloys. Introduction and implementation of a Brinell hardness test on carbon steel and bronze specimens. Effect of high temperature treatment and of cooling rate on the hardness of these materials.

- Synthesis and optical properties of gold nanoparticle colloids

Properties and applications of gold nanoparticles. Synthesis of colloidal gold nanoparticles by the citrate gel (Turkevich) method: chemical reactions and their effect on the size and shape of the nanoparticles. Introduction in light propagation through dispersive media. Absorption, scattering and Plasmon resonance in dilute nanoparticle aqueous solutions. Nanoparticle size and shape effects on the resonant absorption of colloidal gold as measured by UV-Vis spectrometry.

- Titanium dioxide and application in photocatalysis

Properties and applications of Titanium dioxide. Synthesis of nanopowders using the sol-gel method followed by calcination in oxygen-rich ambient: study on how the chemical reactions and post-synthesis heat treatment affect the size and crystallinity of the grains. Study of the mechanism of UV-excited photocatalytic action of TiO_2 on the dissociation (mineralization) of organic pollutants: case study on "methylene blue". Paths for radical formation on the surface of the grains and radical contribution to the enhancement of pollutant dissociation: effects of grain size and UV wavelength. Rate of photocatalytic dissociation: the Langmuir-Hinshelwood model

Bibliography

- Emmanuel Spanakis "Solid State Materials Laboratory. Lab manual", Department of Materials Science and Technology, University of Crete, Heraklion 2013 **(in Greek only)**
- Callister Wılliam D. " Materials science & Engineering" 9th Edition, Wiley, New York, 2014
- C. Kittel “Introduction to Solid State Physics”, 5th Edition, Wiley, New York, 1976
- D. L. Smith “Thin-Film Deposition” McGraw-Hill, Boston, 1995
- S. M. Sze “Physics and Technology of Semiconductor Devices” Wiley, New York, 1981
- M. Barsoum "Fundamentals of ceramics", Mc Graw-Hill, 1997

346. Nanomaterials for Energy and Environment

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 141

5th Semester

http://theory.materials.uoc.gr/courses/een/

Learning Outcomes

By the end of the course, students are expected to

- Become familiar with basic concepts of Nanophysics, Nanochemistry and Surface Science, understanding key differences between macroscopic and nano-physics and becoming familiar with key mechanisms that take place in solar cells, modern batteries and other devices for energy conversion.
- Know key differences between meso- and nanophysics, as well as the basic physical and chemical properties that are common to many nanomaterials.
- Be introduced to important branches of Materials Science, in particular materials for data storage, sensors, batteries, photovoltaics, while they revisit basic concepts of crystallography, chemical kinetics and solid-state physics.

Syllabus

This course focuses on fundamental theoretical and experimental concepts/techniques used for studies of solid surfaces and nanomaterials, in particular systems used in devices for energy conversion and storage, as well as environmental applications.
Modern nanotechnology allows for the synthesis and characterization of systems in which the basic units have dimensions of few nanometers. Such systems are used in electronics (processors, memories) in chemical industry (catalysts), in medicine (drug delivery) and in optoelectronics (photovoltaics).

Topics Covered:

- Principles of nanophysics: specific area, quantum confinement, quantum dots, Coulomb blockade.
- Atomic structure of solid surfaces and crystallography in two dimensions.
- Surface energy, surface tension and shape of nanoparticles
- Adsorption, active sites. Sensors. Catalysis and degradation of pollutants.
- Nanomaterials for solar cells: From Gratzel cell to perovskites.
- Nanomaterials for wind turbines and for other renewable energy systems.
- Nanomaterials for batteries.

Bibliography

- Edward L. Wolf, Nanophysics and Nanotechnology, Wiley-VCH, Weinheim 2006.
- P. W. Atkins, Physical Chemistry, Oxford University Press, Oxford 1998.
- Ib Chorkendorff and J. W. Niemantsverdriet, Concepts of modern catalysis and kinetics, Wiley-VCH, Weinheim 2006.
- Nanotechnology, wikibooks.

348. Materials and Environment

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: -

6th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY348/

Learning Outcomes

The course covers at the basic level the basic categories of nanomaterials, polymers, building materials, catalysts, adsorbents following two directions a) the use and application of these materials in environmental technologies and b) the impact of these materials on the environment during their production, use and disposal after the end of their life cycle as well as their recycling.

- Understanding the basic parameters of environmental pollution.
- Understanding the importance of the structure of materials in relation to their function and physical properties.
- To gain deeper knowledge of the connection of the physicochemical properties of the materials with respect to their environmental behavior.
- Introduction to the use of new innovative anti-pollution materials

Syllabus

- Introduction - environmental pollution
- Physicochemicals of materials
- Water-solid transfer process
- The use of materials for pollution processing
- Different lighting
- Exhaust settlement
- Low cost accessories

- Molecular impact
- Polymer-basic principles-properties
- Environmental behavior and environmental impact of multilateral materials
- Biodegradable polymer
- Cement - concrete
- Asbestos

Bibliography

- Deligiannakis, I. Materials and Environment 2011 publisher: A. TZIOLAS

- Environmental Nanotechnology: Applications and Impacts of Nanomaterials (1st Ed) M. Wiesner, J.-Y. Bottero, McGraw-Hill Education, 2007.
- Degradable Polymers, Recycling, and Plastics Waste Management A-C. Albertson, S.J, Huang, 1995 Marcel-Dekker
- Materials Characterization Techniques, Sam Zhang, Lin Li, Ashok Kumar (2008) CRC Press.
- Physical Methods for Materials Characterisation, Peter E.J. Flewitt, R.K. Wild (2003) CRC Press

349. Mechanical and Thermal Properties of Materials

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: -

5th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY349/

Learning Outcomes

The course introduces the basic Mechanical and Thermal properties of solids as well as methods for characterizing materials We will deal with metals, ceramics, polymers as well as composites. The properties of the materials will be related to their microscopic description (bonds, structure), which will explain similarities and differences in their mechanical and thermal properties. Emphasis will be given on the use of these materials both in everyday objects and in more demanding environments. We will present methods of optimizing properties according to the intended use.

Syllabus

- Introduction. Material Classification. Microstructure and links between atoms
- Crystal structures and their effect on properties
- Mechanical Properties of Metals I. Stress and Strain. Elastic deformation. Plastic deformation
- Mechanical properties of metals II. Material property fluctuations. Design - safety factors. Characteristics of dislocations and their effect on plastic deformation.
- Mechanical properties of metals III. Metal reinforcement mechanism. Material failure. Improvement of mechanical properties of heat-treated metals and alloys.
- Mechanical Properties of Ceramics. Brittle fracture of ceramics, fracture toughness in flat deformation. Elastic tension-strength behavior. Mechanisms of plastic deformation in crystalline and non-crystalline ceramics. Introducing the concept of viscosity. Effect of porosity on modulus of elasticity and bending strength. Hardness. Creep in ceramics.
- Applications and processes of ceramics. Glasses. Glass ceramics. Clay products. Refractory materials. Abrasive ceramics. Mortar. Carbon: Diamond, graphite, carbon fiber. Advanced ceramics: microelectromechanical systems, carbon nanotubes, graphene, 2D materials.
- Mechanical Properties of Polymers I. Examples of natural and artificial polymers. Strain-deformation behavior in brittle, plastic and fully elastic polymers (elastomers). Temperature dependence of the stress-deformation relationship. Effect of deformation rate on mechanical behavior. Macroscopic deformation of polymers. Viscoelastic deformation. Viscosity elasticity measure. Viscoelastic creep.

- Mechanical Properties of Polymers II. Polymer breaking. Impact strength. Fatigue. Resistance to cracking and hardness. Polymers deformation and reinforcement mechanisms. Type of Polymers.
- Thermal properties of materials. Heat capacity, specific heat, temperature dependence of heat capacity. Thermal expansion. Thermal conductivity. Thermal stresses.

Bibliography

- Lecture notes
- ‘Material science and engineering’, William D. Callister, 2008
- Norman E. Dowling, ‘Mechanical Behavior of Materials’, 3rd Edition, Pearson Education, 2007
- M. Ward and J. Sweeney, ‘An Introduction to the Mechanical Properties of Solid Polymers’, Wiley 2nd Edition, 2004

362. Materials V: Ceramic and Magnetic Materials

O

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: 201

6th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY362/

Learning Outcomes

At the end of the course, students are expected:

- To familiarize themselves with the fundamental principles of magnetism
- To know very well the methodology of solving problems related to magnetic and ceramic materials
- To be able to use this knowledge to solve physical problems

Syllabus

Magnetic moment, Magnetization, Special Magnetization, Magnetic susceptibility

- Diamagnetism
- Paramagnetism: Classical and a Quantum theory
- Currie and Currie-Weiss laws
- Langevin and Brillouin functions
- Ferromagnetism, classical and quantum theory
- Law of corresponding States
- Weiss areas, Magnetic Anisotropy
- Soft and hard Magnetic Materials
- Anti-ferromagnetism
- Low dimensional interactions, Spin glass, super-paramagnetism
- Magnetization and thermodynamic properties
- Magneto-Resistance and Giant Magento-Resistance

Introduction to Ceramics

- Sintering and microstructure development
- Bonds on Ceramic Materials
- Silicate grids
- Imperfections. Kroger-Vink terminology
- Influence of chemical forces and structure on the physical properties
- Mechanical and Thermal Properties

Bibliography

- B.D. Cullity and C.D. Graham, “Introduction to Magnetic Materials”, 2nd edition, Willey and IEEE.
- Notes from the instructor on the course’s website.
- David Jiles, “Introduction to Magnetism and magnetic Materials”, 2nd edition, Chapman & Hall (1998)
- W.D. Callister JR, “Fundamentals of Materials Science and Engineering”, John Willey, and Sons Inc. 2001.
- M.W. Barsoum, “Fundamentals of Ceramics”, Taylor and Francis group, 2003.
- X.P. Ftikos, “Science and Techniques of Ceramics”, EMP University Press, 2005.

391. Materials IV: Natural Biomaterials

O

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: 122

5th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY391/

Learning Outcomes

The course outline includes the study of materials of biological origin, their molecular structure and architecture, the mechanisms of self-organization and their properties as materials. The learning goals that students should have achieved at the end of the lesson are the following:

- To become familiar with materials of biological origin
- To consolidate the notions of the structural mechanisms used by Nature to create materials with defined properties
- To use this knowledge towards the design of biomimetic materials
- To be conceptually prepared to follow the course of biological materials and composite biomaterials and their applications (course ETY-491).

Syllabus

- Biological introduction
- Examples of biological materials
- Collagen-Gelatin-Elastin-Keratin
- Silk, spider webs, mussel collagen, amyloid fibrils
- Cellulose, starch, cotton
- Biological composite materials: nacre, chitin, bones, teeth
- Diatomes and magnetotactic bacteria
- Keratin, muscle structure and examples of molecular motors: cytoskeleton, kinesin, bacterial flagellae, flagellin
- Design of biomimetic materials

Bibliography

- C. Branden and J. Tooze, "Introduction to protein structure», Garland Publishing. Greek translation, Basdra Academic Editions, 2019
- J. Howard, "Mechanics of the motor proteins and the cytoskeleton", Palgrave Macmillan (2001)

410. Automation Laboratory

E

Teaching Hours: 2-0-2, ECTS: 5

Prerequisite Courses: 114

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY410/

Learning Outcomes

- Understand basic programming concepts by writing data collection programs, in visual programming languages such as LabVIEW / Vee and their successful implementation.
- Understanding the basic "Troubleshooting" procedures
- Ability of students to run LabVIEW / Vee programs written by the teacher or others for data collection, manipulation and storage.
- Connection of various measuring devices with the computers running LabVIEW / Vee
- Collection and storage of data using LabVIEW / Vee programs written by the students.
- Transfer data to Excel and other data analyzing programs for further analysis (data statistics, graphing)

Syllabus

The aim of the course is to practice and familiarize students with "visual" programming methods that allow the creation of graphic / user interface for collecting, handling and processing data collected from various instruments during experimental measurements, such as: oscillographs, pulse generators, analog / digital converters, automated translation stages, variety of field measuring instruments. Students learn basic programming steps with LabVIEW / Agilent Vee and will be able to read, use, and modify programs written by the teacher and others. LabVIEW / Agilent Vee will be used on Windows XP, Vista operating environments.

Bibliography

- «VEE Pro: practical graphical programming», Robert B Angus; Thomas E Hulbert, London, Springer, 2005.
- LabVIEW for Everyone: Graphical Programming Made Easy and Fun, Jeffrey Travis, James Kring, Jim Kring, ISBN:0131856723, Published by Prentice Hall, "Visual Programming," N. C. Shu, 1988.
- "Principles of Visual Programming Systems," S.-K. Chang, editor, 1990.

412 Solid State Chemistry

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 141

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY412/
https://www.materials.uoc.gr/garmatas/teaching.html

Learning Outcomes

The learning goals of the course are:

- Understanding of the basic principles regarding the crystal structures, bonding forces, and the electrochemical, optical and semiconducting properties of materials.
- The crystal structure and physical properties of inorganic materials.
- An overview of the synthetic methods and physicochemical techniques for the synthesis and characterization of materials.

Syllabus

- Introduction to solid state chemistry, chemical classification of solids, dispersion forces, close packed structures, crystal structures, Bravais lattices and unit cells, Miller indices, symmetry operations and symmetry elements.
- Bonding in solid, ionic, covalent and metallic crystals, typical structural types, intermolecular forces, ionic radius, ionic and molecular structures, lattice energy, ionic compound properties.
- Structural defects (Schottky and Frenkel), chemical impurities and non-stoichiometric crystals, Vegard's law, non-stoichiometric oxide (FeO, TiOx) electronic properties, solid solutions.
- Crystallography and diffraction techniques, X-ray diffraction in crystalline solids, Miller index assignment, crystal structure identification, crystallite size, atomic scattering factor, small-angle X-ray scattering.
- Scanning and transmission electron microscopy (SEM/TEM), electron scattering, X-ray energy dispersive microscopy (EDS), electron energy loss spectroscopy (EELS), Auger spectroscopy, X-ray photoelectron spectroscopy (XPS), cathodoluminescence (CL), electron diffraction.
- Ceramic materials synthesis, solid state reaction, combustion synthesis, pure crystals with vapour-phase transfer, vapor chemical deposition (CVD), atomic layer deposition (ALD), sol-gel method, citric method, hydrothermal and solvothermal synthesis, ceramic methods.
- Inorganic composite materials and applications: Solid-state galvanic cells, lithium-ion batteries, fuel cells (PAFC, MCFC, SOFC), electrochromism.
- Zeolites, mesoporous aluminosilicate frameworks, synthesis, chemical composition, crystal structure, catalytic properties.

Bibliography

- Anthony R. West, *Solid State Chemistry and its Applications,* 2nd Edition, Wiley, 2014.
- Lesley E. Smart, Elaine A. Moore, *Solid State Chemistry: An Introduction,* 3rd Edition, Taylor & Francis Group, 2005.

440. Laboratory of Manufacturing and Mechanical Design

E

Teaching Hours: 2-0-2, ECTS: 5

Prerequisite Courses: -

8^{th} Semester

Web Site: https://www.materials.uoc.gr/el/undergrad/courses/ETY440/

Learning Outcomes

Upon completion of the course, students will:
- Get acquainted with the a CAD design software
- Obtain state-of-the-art specialized knowledge on the principles of design and manufacturing of two and three dimensional objects that consist the basis for innovative thinking
- Obtain specialized skills in solving problems – required for research – such as skills in projecting and reproducing objects in space.

Syllabus

- Introduction to the Course
- Geometrical 2-dimensional structures – Different views
- Geometrical 3-dimensional structures – Cross Sectional Views
- Graphical Representations – Diagrams
- Introductions to Mechanical Design

- Basic elements of Mechanical Design
- Manufacturing of a mechanical design
- Design and rules of standardized mechanical elements
- Specialized mechanical design elements
- Computer-Aided Design (CAD)

Bibliography

- Lecturer's notes

445. Fluid Dynamics

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 211

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY445/

Learning Outcomes

Upon completion of the course, students will:

- Get acquainted with mathematical description of balance of mass, energy and momentum
- Understand of various physical parameters of fluid mechanics needed for solving problems.
- Understand the differences between Newtonian and Non-Newtonian fluids and their importance
- Understand of the importance and applicability of fluid dynamics in processing materials
- Gain basic and advanced knowledge that result in critical understanding of the theory and principles of fluid dynamics.
- Obtain specialized skills in solving problems in fluid dynamics – skills that required for research in order to develop new concepts and processes that can be integrated into different fields.

Syllabus

- Introductory Concepts (fluids and soft matter, polymers, colloids, etc.)
- Basic element of vector calculus
- Principal of mechanics of Newtonian fluids (liquids, laminar flows)
- Molecular definition of viscosity
- Conservation of Momentum, microscopic and macroscopic balances of forces and momentum
- Non-Newtonian fluids
- Dimensionless analysis
- Boundary layers, hydrodynamics, external flow, friction coefficient
- Special topics (turbulent flow, energy, time dependent flows)

Bibliography

- Fundamentals of Fluid Mechanics", by Munson, Okiishi, Huebsch, Rothmayer (7th Edition, Wiley)

446. Electron Microscopy

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: -

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY446

Learning Outcomes

This is an introductory course in theory and practical use of the electron microscope, including transmission electron microscopy (TEM) and scanning electron microscopy (SEM). It consists of lectures that focus on the theory, fundamental operating principles, specimen preparation techniques, X-ray microanalysis and electron diffraction on electron microscopes.

Students at the end of the course are expected:

- To know the basic principles that govern the scattering of electrons and the operation of electromagnetic lenses.
- To understand the basic principles that characterize the scattering and diffraction of electrons.

Syllabus

- Introduction to electron microscopy: scanning (SEM) and transmission (TEM) electron microscopy - conventional and high-resolution imaging.
- Electron scattering and diffraction.
- Wave-particle duality of electrons.
- Electron diffraction: reciprocal lattice, selected area electron diffraction, beam scattering, image analysis.
- Dark-field and bright-filed TEM images.
- Energy-dispersive X-ray spectroscopy (EDS).
- Principles and practice of electron microscope operation and specimen preparation

Bibliography

- Powerpoint slides of the course.
- Marc De Graef, Introduction to Conventional Transmission Electron Microscopy, Cambridge University Press (2003).
- Stanley L. Flegler, John W. Heckman, Karen L. Klomparens, Scanning and Transmission Electron Microscopy: An Introduction, Oxford University Press (1995).

447. Computational Materials Science

OE2

Teaching Hours: 2-0-3, ECTS: 6

Prerequisite Courses: 114

8th Semester

http://theory.materials.uoc.gr/courses/yey/

Learning Outcomes

By the end of the course, students are expected to:

- Know the basic techniques used for the theoretical study of materials using computers.
- Become familiar with appropriate modeling and simulation methods for understanding the materials structure-properties relationship as well as the processes involved in several materials science problems.
- Acquire a fundamental background in state-of-the-art programming, modelling and simulation of materials.
- Develop scientific computing and software related technical skills.
- Acquire hands-on experience in modeling complex phenomena and in solving challenging problems in materials science.

Syllabus

- Introduction to materials models for computer simulations
- Length and time scales hierarchy in modeling materials structure and processes (quantum mechanical, atomistic, mesoscopic, continuum).
- Fundamental background for classical simulations
- Brief review of classical mechanics, statistical physics, methods of numerical integration and solution of differential equations.
- Atomic-level simulations
- Interatomic interaction potentials. Molecular dynamics method. Monte Carlo method. Initial conditions, crystal lattice construction, defects. Boundary conditions. Methods for constant temperature or/and pressure simulations.
- Results analysis
- Equilibrium properties, structural, mechanical, dynamical properties. Specific materials properties calculation with realistic interaction potentials and comparison with experiments.
- Introduction to first principles calculations
- The basics of density functional theory. Structural and elastic properties calculations.
- Mesoscopic and continuum simulations
- Coarse-grain method. Space discretization. Finite difference and finite element methods. Applications (e.g., dislocation dynamics, electromagnetic wave propagation). Cellular automata.
- Combining methods
- Concurrent and hierarchical combination of models. Multiple scale simulations

Bibliography

- A.N. Andriotis, Computational Physics, 2nd Edition, Anikoula Editions, Athens (2016).
- J.M. Thijssen, Computational Physics, Cambridge University Press, Cambridge, New York (1999).
- D. Raabe, Computational Materials Science: The Simulation of Materials Microstructures and Properties, Wiley-VCH, Weinheim, New York (1998).
- M. P. Allen, D.J. Tildesley, Computer Simulation of Liquids, Clarendon Press, Oxford (1990).
- D. Frenkel, B. Smit, Understanding Molecular Simulation: from Algorithms to Applications, Academic Press, San Diego, (1996).
- K. Ohno, K. Esfarjani, and Y. Kawazoe, Introduction to Computational Materials Science: from Ab Initio to Monte Carlo Methods, Springer-Verlag, Berlin, New York (1999).
- K. Binder, D.W. Heermann, Monte Carlo Simulation in Statistical Physics: An Introduction, Springer, Berlin, New York (1997).
- K. Binder, Monte Carlo and Molecular Dynamics Simulations in Polymer Sciences, Oxford University Press, Oxford, New York (1995).
- D.C. Rapaport, The art of Molecular Dynamics Simulation, Cambridge University Press, Cambridge, New York (2004, 1998).

448. Special Chapters in Computational Materials Science

Core

Teaching Hours: 2-0-3, ECTS: 5

Prerequisite Courses: -

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY448/

Learning Outcomes

- Development of interdisciplinary and critical thinking
- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Production of free, creative and inductive thinking

Syllabus

The course consists of two parts. In the first part, key concepts of basic numerical methods are presented. In the second part, the student is introduced to basic applications to specific materials (metals, insulators, semiconductors) and specific conditions.

A. Basic concepts of computational methods.

- Principles of numerical analysis.
- Partial Differential Equations (PDEs).
- Solving PDEs using Finite Difference methods.

B. Applications to modelling of natural processes that are described by PDEs. An indicative list of topics covered includes:

- Heat transfer equation in one dimension.
- Propagation of Electromagnetic Waves.
- Irradiation of surfaces by lasers.
- Mechanical properties of materials.

Bibliography

- A.N. Andriotis, Computational Physics, Athens (1995).
- M. Thijssen, Computational Physics, Cambridge University Press, Cambridge, New York (1999).
- *Burden R., and Faires D., 'Numerical Analysis', Brooke and Cole, Pacific Rode, USA, (2001)*

450. Polymer Physics

E

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: 243

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY450/

Learning Outcomes

Detailed discussion of basic properties of polymers, statics and dynamics. The course assumes elementary knowledge on the topic. The full list of topics is shown below but not all are covered. After the discussion of statics and elements of macromolecular motion, some special topics are covered depending on the interests of students.

The learning goals of the course are:

- Familiarization of students with basic parameters and scaling theories of polymers.
- Analysis of polymer properties, comparison of theoretical predictions and experimental measurements
- Understanding the importance of polymers in the production of several everyday life products.

Syllabus

- Macromolecules and Characteristic Length, time and energy scales

- Characteristics of glasses, crystals, networks, melt.
- Statistics of Polymer Chains
- Polymer Chain Elasticity
- Polymer Solutions and Solvent Quality- Characteristic Sizes and Phase Diagram
- Polymer blends
- Macromolecular motion, Coarse-Graining, Viscoelasticity and Diffusion
- Dynamics of Unentangled Chains (Rouse and Zimm models), Predictions for Rheology and Diffusion
- Dynamic Light Scattering, Dynamic Structure Factor
- Networks and Gels
- Dynamic Mechanical Spectroscopy and Time Temperature Superposition
- Entangled Chains-Entanglements: Reptation and the deGennes-Doi-Edwards model

Bibliography

- Instructor's notes (on the web, in Greek)
- M. Rubinstein, R. H. Colby, Polymer Physics, Oxford, NY, 2003.
- G. Strobl, The physics of polymers, Springer, NY, 1997.
- M. Doi, Introduction to polymer physics, Oxford, NY, 1995.

452. Polymer Synthesis

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 243

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY452/

Learning Outcomes

In this course the basic polymerization methods used in polymer synthesis are described. The mechanisms of the polymerisation methods and the kinetics of the reactions are discussed in detail. The effect of the reaction kinetics on the reaction rate and the polymer characteristics are also discussed. Finally, the basic macromolecular characterization techniques are presented. The students choose contemporary research topics in polymer synthesis for presentation (Project-Compulsory).

The learning objectives of the course are the following:

1. Understanding the effect of the polymerization method on the polymer characteristics.
2. Consolidate the basic principles of the polymerization kinetics and be able to predict the macromolecular characteristics.
3. Familiarize the students with the macromolecular characterization techniques
4. Gain experience in studying the international scientific literature and present scientific topics

Syllabus

1. Basic Concepts – Polymer Nomenclature
    - Classification of polymers
2. Polymer Microstructure: Monomer architecture, orientation, tacticity, isomers
3. Average molecular weights - Properties
4. Size and shape of macromolecules
5. Types of polymerization reactions
6. Condensation or step-growth polymerization
8. Type of step reactions
9. Molecular weight and polydispersity
10. Kinetics of condensation polymerization

11. Examples
12. Industrial methods of condensation polymerization
    - Addition of Chain-growth Polymerization
9. Free-radical polymerization
10. Mechanism of free-radical polymerization
11. Molecular weight and polydispersity
12. Kinetics of free-radical polymerization
13. Examples
14. Industrial methods of free-radical polymerization
15. Copolymerization
16. Copolymerization Kinetics
    - Anionic Polymerization
    - Mechanism of anionic polymerization
10. Molecular weight and polydispersity
11. Kinetics of anionic polymerization
12. Macromolecular architectures accessible via anionic polymerization
    - Group Transfer Polymerization
13. Cationic Polymerization
12. Mechanism of cationic polymerization
13. Molecular weight and polydispersity
14. Kinetics of cationic polymerization
    - Polymer modification reactions
15. Polymer Characterization

- Determination of molecular weight and molecular weight distribution
- Determination of polymer composition
- Determination of polymer tacticity

Bibliography

- Allcock, H.R.; Lampe, F.W. Contemporary Polymer Chemistry, 2nd ed., Prentice Hall, Englewood Cliffs, 1990.
- Hiemenz, P.C. Polymer Chemistry: The Basic Concepts, Marcel Dekker, NY, 1984.
- Young, R.J.; Lovell, P.A. Introduction to Polymers, 2nd ed., Chapman & Hall, 1996.
- Stevens, M.P. Polymer Chemistry: An Introduction, 2nd ed., Oxford Univ. Press, 1990

453 Crystal Chemistry

E

Teaching Hours: 2-0-2, ECTS: 6

Prerequisite Courses: -

7th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY453/

Learning Outcomes

The course discusses the study of inorganic crystalline solids. The crystal structures of the elements, binary, ternary and modular compounds is presented. Correlation between electronic structure and crystal structure using the LCAO approach. Defects in crystals and how those affect the physical properties of the solids (semiconductors, scintillators, transparent conducting oxides, etc.). Methods of crystal growth and structural characterization with X-ray diffraction. Modern technological applications of inorganic materials. The main educational goals that the students will achieve upon completion of the course include:

1. To familiarize with…

- **The structure of solids**: Description and classifications of crystals through polyhedral representations of inorganic crystal structures.
- **Band structure**: Electronic structure derived from crystal structure. Structure-property relations.
- **Non-stoichiometry and defects in crystals:** Manipulation and control of the physical properties of solids.

1. To acquire the basic knowledge of…

- **Synthetic methods and basic structural characterization in inorganic solids:** Crystal Growth of single-crystals, polycrystalline and amorphous solids
- **Application of Inorganic compounds in technology**

Syllabus

1. Structure types of Solids

- Metals and Nonmetals
- Binary compounds: AB, AB_2, AB_3, A_2B_3, A_xB_y
- Ternary compounds: ABX_2, ABX_3, AB_3, AB_2X_4, A_2BX_4, AB_2X_2
- Intermetallics and Zintl Phases
  Modular compounds: Polytypes, Homologous series and misfit layered compounds

2. Band structure (based on R. Hoffmann review).

- Constructing "Spaghetti" diagrams starting from molecular orbitals.
- Electronic instability (Peierls distortion, Jahn-Teller effect)
- Density of states, band folding, direct and indirect bandgap
- Quantum confinement: Low-dimensional materials, Quantum wells, Quantum wires, Quantum dots

3. Non-Stoichiometry and Defects in Crystals

- Nonstoichiometry and diffusion. Thermal quenching, sintering, and annealing.
- Phase diagrams, eutectics, spinodal decomposition and solid solutions.
- Phase transitions. Phase transitions in inorganic solids, crystals and amorphous solids.

4. Synthesis methods

- Solid-state synthesis, wet synthesis, solvothermal synthesis
- Crystal Growth
  Growth from melts, solutions and vapor transport.
- Structural characterization
  Structure determination from single-crystals and crystalline powders. Characterization of amorphous solids (Pair Distribution Functions (PDF))

5. Applications of Inorganic Compounds in Modern Era Technology

- ***Inorganic Semiconductors in Optoelectronics***

  Photodiodes in Photovoltaics, Detectors and LED's

- ***Porous Materials***

  Gas Separation and Catalysis

- ***Hydrogen Technology***

  Production, Storage and Reactivity

- ***Energy Storage***

Solid State Batteries

Bibliography

- Ulrich Müller, «*Inorganic Structural Chemistry*», 2nd Edition, Wiley 2006.
- Alexander F. Wells, «*Structural Inorganic Chemistry*», 5th Edition, Oxford University Press 1984.
- Roald Hoffmann, «*How Chemistry and Physics Meet in the Solid State*», *Angew. Chem. Int. Ed. Engl.* (1987) 846-878
- Anthony R. West. «*Solid State Chemistry and Its Applications*», 2nd Edition, Wiley 2014.
- Richard J. D. Tiley, «*Defects in Solids*», Wiley 2008
- Giovanni Ferraris, Emil Mackovicky, Stefano, Merlino, «*Crystallography of Modular Materials*», IUCr 2004.
- Erwin Parthé «*Crystal Chemistry of Tetrahedral Structures*» CRC Press 1964

454. Rheology and Polymer Processing

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 211

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY454/

Learning Outcomes

The course includes a simple description of processing of polymeric systems.

The learning goals of the course are:

- Familiarization of students with various methods of polymer processing.
- Addressing simple problems of polymer processing with synthesis of knowledge from polymers and transport phenomena
- Understanding the importance of polymers in the production of several everyday life products.

Syllabus

- Molecular origin of viscosity, entropic origin of elasticity.
- Non-Newtonian fluids and linear viscoelasticity.
- Constitutive equations and non-Newtonian phenomena.
- Introduction to polymer processing.
- Flow of polymer melts in conduits.
- Examples of polymer processing operations (extrudate swell and melt fracture, extrusion of thermoplastics, calendaring, blow molding).
- Special topics (main forces – excluded volume, van der Waals, electrostatic, hydrodynamic, hydrogen bonding, applications in rheology of polymer melts and solutions, hard and soft spheres, concentration dispersions and microstructure, thixotropy, sedimentation, rheometry, extensional rheology

Bibliography

- E. Mitsoulis, Basic principles of polymer processing (in Greek), NTUA 1999
- Z. Tadmor, C. G. Gogos, Principles of polymer processing, Wiley, New York 1979
- D. G. Baird, D. Collias, Polymer processing: principles and design, Wiley, New York 1998
- F. A. Morrison, Understanding rheology, Oxford, New York 2000
- R. G. Larson, The structure and rheology of complex fluids, Oxford, NY 1999
- C. Macoscko, Rheology, WCH, NY 1994

- J. Vlachopoulos, N. D. Polychronopoulos, Understanding rheology and technology of polymer extrusion, Polydynamics Inc., Ontario, Canada 2019.
- M. M. Denn, Polymer melt processing, Cambridge, NY 2008
- A. N. Wilkinson, A. J. Ryan, Polymer processing and structure development, Kluwer, NY 1999.

461. Introduction to Ceramics

OE2

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: -

6th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY461/

Learning Outcomes

It develops the basic concepts of Ceramic Materials Science. In addition to an important theoretical background in the field of ceramics, it offers students the opportunity to see the applications and possibilities of using these materials in a wide range of applications, ranging from classical applications of everyday life to advanced state-of-the-art applications, such as sensors and spacecraft units.

The course also teaches characterization and analysis techniques, which are important for the student in the industry, both in the product line and in the field of development research. Following:

- Familiarizing students with ceramic materials
- Consolidation of the structural mechanisms for the creation of ceramic materials with defined properties
- Using this knowledge to properly apply ceramic materials in the various fields.

Syllabus

- Definition - properties and applications of ceramic materials
- Individual structure and individual construction of ceramic materials
- Mechanical properties of ceramic materials
- Thermal properties of ceramic materials
- Electrical properties of ceramic materials
- Production of ceramic items
- Sintering
- Characteristics and analysis techniques
- Introduction to composite materials
- Presentation

Bibliography

- Barsoum M., Fundamentals of Ceramics, 2003 Institute of Physics Publishing
- Bristol and Philadelphia
- Ftikos C. (2005). Ceramics Science and Technique, NTUA University Publications
- Vatalis A. (2008) Material Science and Technology, Ziti Publications

462. Ceramic Materials and Properties

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 362

8^{th} Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY462/

Learning Outcomes

It develops the basic concepts of Ceramic Materials Science. In addition to an important theoretical background in the field of ceramics, it offers students the opportunity to see the applications and possibilities of using these materials in a wide range of applications, ranging from classical applications of everyday life to advanced state-of-the-art applications, such as sensors and spacecraft units.

The course also teaches characterization and analysis techniques, which are important for the student in the industry, both in the product line and in the field of development research. Following:

- Familiarizing students with ceramic materials
- Consolidation of the structural mechanisms for the creation of ceramic materials with defined properties
- Using this knowledge to properly apply ceramic materials in the various fields.

Syllabus

- Definition - properties of ceramic materials
- Thermal Properties
- Optical Properties
- Plastic Shaping - Viscous Flow - Pressure
- Elasticity - Inelasticity - Strength
- Trends
- Electrical Conductivity
- Dielectric Properties: Linear and Nonlinear
- Magnetic Properties

Bibliography

- Barsoum M., Fundamentals of Ceramics, 2003 Institute of Physics Publishing
- Bristol and Philadelphia
- W. David Kingery, H. K. Bowen, Donald R. Uhlmann, Introduction to Ceramics 2^{nd} edition, John Wiley & Sons (1976)
- Supportive learning through valid online scientific sources: www.eke.gr, www.acers.org

464. Special Chapters on Ceramic Materials

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 362

8^{th} Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY464/

Learning Outcomes

The instructor selects the material in this course in order to introduce students to contemporary research topics in advanced ceramic materials of great technological resonance.

The learning goals that students should have achieved at the end of the lesson are:

- familiarizing students with advanced ceramic materials
- consolidation of the structural mechanisms for the creation of ceramic materials with defined properties important to the modern age.
- using this knowledge to properly apply ceramic materials in the various fields.

Syllabus

The following is a limited list of such topics but the instructor has the option to choose outside them as well.

- Copper Perovskites: High Critical Temperature Superconductors
- Manganites: Giant and Colossal Magnetoresistance
- Piezoelectric Materials
- Ferroelectric Materials
- Rapid Ionic Conduits

Bibliography

Selected articles from international scientific journals

470. Synthesis and Characterisation of Colloidal Dispersions

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 243

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY470/

Learning Outcomes

The course is an introduction to synthesis and characterization of colloidal dispersions aiming in providing a bit more advanced knowledge on the two topics compared to ETY-243. The learning goals that students should have achieved at the end of the lesson are the following:

- Familiarize with main types of synthesis of colloidal particles and the methods used for their characterization.
- Understand how the main experimental tools (scattering, microscopy, rheology etc.) work and how they are used to probe dilute and concentrated dispersions of colloidal particles

Syllabus

- Introduction
- Synthesis of colloidal dispersions
- Emulsion polymerization, synthesis of latex particles, microgels
- Dispersion polymerization
- Poly-condensation polymerization
- Characterization of colloidal particles: Sizes and polydispersity
- Particle surface characterization, wetting phenomena
- Dispersion characterization: Particle stability, agglomeration and aggregation,
- Sedimentation
- Experimental techniques for characterization:
- Optical microscopy
- Light scattering
- Electrochemical methods
- Rheology

Bibliography

- Course notes (Prof. G. Petekidis)
- R. J. Hunter, Foundations of Colloid Science, Oxford, University Press, New York, 2001
- W.B. Russel, D.A. Saville, W.R. Schowalter, Colloidal Dispersions, Cambridge University Press, 1989
- K. Panagiotou, Interfacial phenomena and Colloidal systems 1998.
- D. F. Evans, H. Wennerström, The Colloidal Domain, Where Physics, Chemistry, Biology and Technology meet, 2nd Edition, John Willey and Sons, New York, 1999.
- R. M. Fitch, "Polymer Colloids, A comprehensive introduction", Academic Press, London, 1997

471. Introduction to Colloidal Dispersions

E

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: 243

7th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY471/

Learning Outcomes

The course is an introduction to colloidal dispersions aiming in providing a basic knowledge on colloidal interactions, phase behavior and colloidal dynamics. The learning goals that students should have achieved at the end of the lesson are the following:

- Familiarize with Colloidal systems and the main physical mechanisms governing their behavior
- Understand the role of colloidal interactions in the stability of colloidal dispersions and the thermodynamic phase behavior as well as in the formation of out of equilibrium states such as glasses and gels
- To understand Brownian motion, and the characteristics of diffusion

Syllabus

Introduction

Examples of Soft Matter systems: Polymers, Colloids, Biomaterials, Surfactants and Micelles, Liquid Crystals, Emulsions and Foams.

Polymers

- Introduction
- Types and names of polymeric systems
- Basic examples in Polymer Synthesis
- Macromolecular characterization, Chain architecture, Molecular weight, End-to-end distance and Radius of gyration
- Solutions, concentration regimes, interactions
- Phase behavior
- Amorphous and Crystalline polymers. Elastomers
- Polymer mixtures and copolymers
- *Colloids*
- Introduction
- Types of colloidal systems

- Colloidal Interaction, colloidal stabilization
- Colloid-polymer mixtures
- Dense suspensions and crystals
- Colloidal glasses and gels

Bibliography

- Course notes (G. Petekidis)
- R. J. Hunter, Foundations of Colloid Science, Oxford, University Press, New York, 2001
- W.B. Russel, D.A. Saville, W.R. Schowalter, Colloidal Dispersions, Cambridge University Press, 1989
- Panagiotou, Interfacial phenomena and Colloidal systems 1998.
- D. F. Evans, H. Wennerström, The Colloidal Domain, Where Physics, Chemistry, Biology and Technology meet, 2nd Edition, John Willey and Sons, New York, 1999.
- R. M. Fitch, "Polymer Colloids, A comprehensive introduction", Academic Press, London, 1997

480. Heterostructures, Nanostructures and Semiconductor Nanotechnology

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 242

8th Semester

https://www.materials.uoc.gr/el/grad/courses/ETY480/

Learning Outcomes

The course is an introduction to the Semiconductor Nanotechnology, focusing on the physics of nanostructured semiconductors, exemplified in the various applications they find in modern technology, revolving around the broader field of optoelectronics. Special emphasis is given in handling problems of practical interest that require the use of computer and of basic computational methods.

Syllabus

- Quantum Heterostructures

Introduction to quantum wells and superlattices. Characteristic lengths and times. Electronic States and quantum heterostructures. Shell method. Excitons in quantum wells. Heterojunctions for doping modulation. Valence band electronic structure. kp method. Kane model. Luttinger-Kohn model for quantum wells. Optical transitions and selection rules. Stark effect. Vertical transport in quantum heterostructures.

- Semiconductor nanostructures

Types of low dimensional semiconductors: quantum dots and quantum wires. Qualitative and quantitative description of physical properties. (a) spherical quantum dots, (b) core-shell quantum dots, (c) epitaxial quantum dots, (d) cylindrical quantum wires, (e) quantum wires with dots, (f) branched wires. Methods for spontaneous growth and assembly of low dimensional semiconductors. Quantum dot lasers.

- Semiconductor nanotechnology

Limitations of microelectronics and the role of nanotechnology. Cornerstones of nanotechnology. Fabrication of devices: Optical (nano-LASER and nano-LED), and Electrical (Nano-diodes). Assembly nanowires and quantum dots in two dimensions. Properties and Obstacles. Technological applications.

Bibliography

- S.L Chuang, Physics of Optoelectronic Devices, John Wiley &Sons, New York (1995)
- D. Bimberg, M. Grundmann, N.N. Ledentsov, Quantum Dot Heterostructures, John Wiley & Sons, Chichester (1998)

481. Elements of Semiconductor Physics

OE2

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: 242

7th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY481/

Learning Outcomes

The course includes the study of Semiconductor Physics as well as of the operating principles of basic optoelectronic devices. The learning goals that students should have achieved at the end of the course are the following:

- Enhanced basic understanding of semiconductor physics.
- Understanding important optoelectronic devices such as the semiconductor diode laser and solar cell.
- Preparation of the students for attending postgraduate level classes in the field of semiconductors and optoelectronics.

Syllabus

- Energy bands in semiconductors and carrier statistics
- Carrier transport and P-N diode
- Optical transitions in semiconductors
- Quantum wells
- Optical gain – Laser action
- Waveguides
- Solar cells

Bibliography

- J. Singh, "Optoelectronics, Edition Tziola, 2016
- S.O. Kasap, Principles of Electronic Materials and Devices, Papasotiriou 2004, Athens.
- B.G. Streetman and S. Banerjee, Solid State Electronic Devices, Prentice Hall, (2000)
- R. F. Pierret, Semiconductor Device Fundamentals, Pearson (1996)
- S. M. Sze, Physics of Semiconductor Devices, Wiley, New York (1981)
- D. Wood, Semiconductor Optoelectronic Devices, Prentice-Hall, UK (1994)

483. Elements of Magnetic Materials

OE2

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: 362

7th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY483/

Learning Outcomes

This course will provide students with the fundamental knowledge in the field of magnetism and magnetic materials. At the end of the course the student will be able to:

- Provide explanation for fundamental concepts and phenomena of magnetism.
- Apply those concepts to understand the nature of magnetic behavior of various materials.
- Propose methods for characterization of different magnetic materials
- Discuss various applications of magnetic materials in cutting edge technologies and devices

Syllabus

- Magnetostatics
- Classification of magnetic materials
- Magnetic measurements and characterization
- Magnetic order
- Magnetic domains
- Fine ferromagnetic particles
- Magnetic thin films
- Permanent magnets
- Magnetic recording
- Soft magnetic materials
- Giant magnetoresistance

Bibliography

Notes are provided by the lecturer (in the Greek language) on the course website that cover the course in its entirety. The following books can be used for reference to specific topics.

- J.M.D. Coey, "Magnetism and Magnetic Materials", Cambridge Univ. Press, Greek translation: Public City (2012).
- D. Jiles, "Introduction to Magnetism and Magnetic Materials", Chapman & Hall (1991).
- S. Chikajumi, "Physics of magnetism", Krieger (1978).
- C. Kittel, "Introduction to Solid State Physics", Wiley, Greek translation: Pnevmatikos Publishing (1976).

488. Special Chapters of Magnetic Materials

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 362

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY488/

Learning Outcomes

At the end of the course, students are expected:

- To familiarize themselves with the physics of applied magnetism
- to be able to apply this knowledge in understanding the behavior of various magnetic materials
- To be able to propose methods for characterization of different magnetic materials
- To have a good understanding of the applications of magnetic materials in cutting edge technologies and devices
- To know methods of collecting information on specialized topics in micro-magnetism in order to conduct independent research.

Syllabus

- Experimental methods for characterization of magnetic materials
- Magnetic order and critical phenomena
- Quantum theory of magnetism-itinerant electron ferromagnetism
- Magnetization dynamics
- Magnetoelectronic materials
- Magnetic recording materials
- Magnetoresistance- sensors
- Spintronics

Bibliography

Notes are provided by the lecturer (in the Greek language) on the course website that cover the course in its entirety. The following books can be used for reference to specific topics.

- J.M.D. Coey, "Magnetism and Magnetic Materials", Cambridge Univ. Press, Greek translation: Public City (2012).
- B.D. Cullity and C.D. Graham, "Introduction to Magnetic Materials", 2nd edition, Willey and IEEE.
- D. Jiles, "Introduction to Magnetism and Magnetic Materials", Chapman & Hall (1991).
- Stephen Blundell, "Magnetism in Condensed Matter", Oxford University Press (2001)
- S. Chikajumi, "Physics of magnetism", Krieger (1978).
- C. Kittel, "Introduction to Solid State Physics", Wiley, Greek translation: Pnevmatikos Publishing (1976).

490. Photonic Materials

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: -

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY490/

Learning Outcomes

Students at the end of the course:

- They will possess advanced knowledge and skills (critical understanding of theories and principles) in the field of modern Photonics, with emphasis on modern applications, like in telecommunications and nano-photonics.
- They will be able to use the knowledge they acquired in a way that shows a professional approach to their work.
- They will be able to gather and interpret elements of the subject to form scientifically documented opinion, both on scientific and social/ethical issues. (e.g. risks of new technologies to human health).
- They will be able to communicate information and solutions to the subject of the course (modern photonic materials) to both a specialized and non-specialized audience.
- They will have developed those knowledge-acquiring skills, which they need to pursue further studies with a high degree of autonomy.

Syllabus

- Light and matter, light waves, absorption and emission, optical properties of matter
- Modern lasers: operation principles, new technologies and applications
- Optics of short laser pulses: theory and applications
- Nonlinear optics: materials, systems and spatiotemporal phenomena
- Optical fibers – Telecommunications
- Photonic crystals
- Metamaterials

- Terahertz photonics

Bibliography

- Fundamentals of Photonics, B.E.A. Saleh and M.C. Teich, 2nd edition Wiley
- Photonics, A. Yariv and P. Yeh, 6th edition Oxford University Press

491. Biological materials and composite biomaterials

E

Teaching Hours: 3-0-0, ECTS: 6

Prerequisite Courses: 232

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY491/

Learning Outcomes

The course outline includes the study of biomaterials and composite biomaterials, their physicochemical and mechanical properties, their degradation mechanisms, their biocompatibility criteria and evaluation, the biological responses following an implantation. The learning goals that students should have achieved at the end of the lesson are the following:

- To become familiar with biomaterials and composite biomaterials
- To consolidate the notions of the structural mechanisms used by Nature to create materials with defined properties
- To use this knowledge towards the design of biocompatible materials
- To be conceptually prepared to perform a diploma thesis in a research laboratory in the area of biomaterials, tissue engineering and regenerative medicine

Syllabus

- Materials for Biomedical Applications
- Chemical Structure of Biomaterials
- Physical Properties of Biomaterials
- Mechanical Properties of Biomaterials
- Biomaterial Degradation
- Biomaterial Processing
- Surface Properties of Biomaterials
- Protein Interactions with Biomaterials
- Cell Interactions with Biomaterials
- Biomaterial Implantation and Acute Inflammation
- Wound Healing and the Presence of Biomaterials
- Immune Response to Biomaterials
- Biomaterials and Thrombosis
- Infection, Tumorigenesis and Calcification of Biomaterials

Bibliography

- Book "Biomaterials – The interface between Biology and Materials Science", J.S. Temenoff, A.G. Mikos, Edition Utopia, ISBN: 978-618-5173-27-2 (book translated in greek language)
  The text book covers 100% of the examination matter

494. Introduction to Biomedical Engineering

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 232 or 335

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY494/

Learning Outcomes

Upon completion of the course, students will:

- Get acquainted with the mammalian physiology from the engineering an physics perspective
- Get acquainted with the mechanical forces exerted on cells and tissues, and the mechanisms of transmission of the mechanical signal and its conversion into a biochemical signal.
- Get familiarized with examples of applications of Biomedical Engineering to various branches of Medicine.
- Obtain gain basic and advanced knowledge in biomedical engineering that entails a critical understanding of theories and principles of engineering, biology and medicine
- Obtain specialized problem-solving skills in biomedical engineering, which are required in research and / or innovation in order to develop new knowledge and processes and integrate knowledge from different fields.

Syllabus

- Basic concepts of vascular engineering and cardiovascular physiology
- Interaction of Mechanical and Genetic Factors in Atherosclerosis
- Bio-rheology. Viscosity and Viscoelastic Properties of Blood
- Cellular Engineering and Mechanotransduction
- Mechanical Properties of Cell Membrane
- Stem Cell Engineering and New Therapeutic Applications
- Viscoelastic Properties of the Extracellular Matrix of the Cell
- Artificial blood and polymer solutions that simulate the Rheological Properties of Blood
- Tissue engineering of joints
- Examples and Applications of Biomedical Engineering

Bibliography

- Fundamentals of Fluid Mechanics", by Munson, Okiishi, Huebsch, Rothmayer (7th Edition, Wiley)

500. Symmetry in Materials Science

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 116, 305

8th Semester

http://theory.materials.uoc.gr/courses/sms/

Learning Outcomes

By the end of the course, students are expected to

- Become familiar with the mathematical foundations of Materials Science as well as mathematical toolbox that is necessary for the theoretical study of materials, as well as for the design of characterization experiments.
- Know the key concepts of discrete group theory, the application of group theory to the symmetry of molecules and crystalline solids, as well as the effect of symmetry on the electronic and vibrational states in materials.
- Be albe to predict the effect of symmetry on the absorption spectra of materials and on the response

of materials to external fields.

Syllabus

- Group Theory: Point group, molecular symmetry. Representations and characters.
- Applications of point groups: Normal modes of vibrations, infrared- and Raman spectroscopy, molecular orbitals.
- Space groups and crystal symmetries. Applications: Wyckoff positions, diffraction, electron wave-functions in solids.
- Crystallography: Methods of crystal structure determination from X-ray diffraction data of powders and single-crystals.
- Symmetry and Response. Mechanical properties. Stress and strain tensors and elastic constants. Electrical properties. Thermoelectric and Piezoelectric effects.

Bibliography

- *J. D. Vergados, Group and Representaion Theory, World Scientific (2016).*
- P. Atkins and R. Friedman, Molecular Quantum Mechanics, 4th_Edition 2005
- A. S. Nowick, Crystal properties via group theory, Cambridge University Press 1995
- R. E. Newnham, Properties of Materials: Anisotropy|Symmetry|Structure, Oxford University Press 2005.
- M. S. Dresselhaus, S. Dresselhaus, A. Jorio, Group Theory, Springer, 2008.
- P. W. M. Jacobs, Group theory with applications in chemical physics, Cambridge University Press, Cambridge, 2005.
- M. A. Armstrong, Groups and Symmetry, Springer, 1997.
- P. W. Atkins, Physical Chemistry, chapter 15 ("Molecular Symmetry"), Oxford University Press, Oxford, 6th edition, 1999.
- L. D. Landau and E. M. Lifshitz, Theory of Elasticity, chapter 1, Butterworth-Heinemann, Oxford 1986.
- Chemical Applications of Group Theory, 3rd Ed. , F. Albert Cotton, Wiley 1990
- Infrared and Raman spectra of crystals, G. Turrell, Academic Press, 1972
- Infrared and Raman Spectra of Inorganic and Coordination Compounds 6th Ed, K. Nakamoto Wiley 2008
- X-Ray Structure Determination: A Practical Guide, 2nd Ed, G. H. Stout L. H. Jensen, Wiley 1989
- Richard C. Powell, Symmetry, Group Theory, and the Physical Properties of Crystals, Springer 2010.
- Molecular Symmetry and Group Theory, M. Sigalas, L. Antonoglou, N. Charistos, AUTH, 2015 (in greek).
- D.L. Rousseau, R.P. Bauman, S.P.S. Porto, (1981), Normal mode determination in crystals. *J. Raman Spectroscopy.*, 10: 253-290. doi:10.1002/jrs.1250100152

512. Computational Materials Science II: Electronic Structure

E

Teaching Hours: 2-0-3, ECTS: 5

Prerequisite Courses: 305 and of OE1

8th Semester

http://theory.materials.uoc.gr/courses/est/

Learning Outcomes

By the end of the course, students are expected to:

- Become familiar with the modern theory of electronic structure, and more specifically with DFT (Density Functional Theory), by employing large software packages.
- Know the basic principles of solving quantum mechanical problems in materials science as well as how to perform computational experiments in order to study properties of standard materials.
- Develop scientific computing and software related technical skills.

- Acquire hands-on experience in first principles calculations for solving challenging problems in materials science.

Syllabus

- Introduction to DFT.

  Schrödinger equation for polyelectronic systems and methods for its solution. Exchange and correlation potential. Calculation of molecules energy and reactions enthalpy.
- Crystalline solids.

  Density and bulk modulus calculation using Bloch theorem. Energy bands.
- Surfaces.

  Extension of theory to semi-periodic structures. The concept of surface tension. Influence of adsorbed molecules on surface properties. Adsorption enthalpy.
- Magnetic materials. The role of spin in the magnetic properties of materials, such as iron, as well as in the cohesion of nonmagnetic molecules, such as H_2O. The concept of density of states and its calculation. Oscillations of simple molecules.
- Experimental techniques.

  Basic principles of experiments for the depiction of the electronic structure, such as STM (Scanning Tunneling Microscope) and their simulation. Electronic band structure calculations in metals, insulators, and semiconductors.
- Reaction speeds.

TST (Transition State Theory) and nudged elastic band method for the calculation of the speed of a chemical reaction. Application to diffusion constants calculation.

Bibliography

- Antonios N. Andriotis, Computational Physics, Volume II, 1999.
- Frank Jensen, Introduction to Computational Chemistry, Wiley-VCH, 2nd edition 2006.
- Efthimios Kaxiras, Atomic and Electronic Structure of Solids, Cambridge University Press, 2003.
- Richard M. Martin, Electronic Structure: Basic Theory and Practical Methods, Cambridge University Press, 2004.
- Jos M. Thijssen, Computational Physics, Cambridge University Press, 1999.

570. Special Topics on Soft Matter

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 243

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY570/

Learning Outcomes

This course targets to delve into certain subjects related to soft materials, covering the spectrum from synthesis and characterization to structural and dynamical properties and soft matter processing.

The learning goals of the course are the following:

- Deepen the students' knowledge on specific, and more specialized, topics on soft matter, not covered by the other courses of the field.
- Ability to solve targeted problems and become familiar with soft matter data
- Understand the applications of soft matter in new technologies.
- Prepare the students for carrying out their diploma work and / or postgraduate studies in soft matter.

- Expose the students to a highly intellectual environment and teaching by distinguished visiting Professors.

Syllabus

For 2019, the course comprised a brief review of the main characteristics of soft matter (length, time and energy scales) followed by a discussion of some of the following topics, according to the students' interests:

- Modern methods of polymer synthesis and characterization
- Synthesis and characterization of colloids
- Mechanochemistry methods
- Supramolecular chemistry
- Microscopic thermal motion – mesoscopic polymer models
- Polymer melts and relation with other soft materials
- Semiflexible polymers and liquid crystals
- Polymer Blends and Polymer Mixtures
- Copolymers
- Branched Polymers
- Rheometry and non-linear response (Shear and Extensional Flow)
- Crystalline polymers
- Slow dynamics and heterogeneities
- Glass Transition
- Hard and soft spheres, interactions
- Colloidal crystallization and glass transition
- Colloidal gels and colloid-polymer mixtures
- Viscoelasticity and diffusion of colloids

Bibliography

- M. Rubinstein and R. H. Colby, *Polymer Physics*. Oxford University Press, 2003.
- J. D. Ferry, *Viscoelastic Properties of Polymers*, Wiley, 1980
- M. Doi, S.F. Edwards, *The theory of polymer dynamics*, Oxford University Press, 2007
- J. Mewis, N. J. Wagner, Colloidal suspension rheology, Cambridge, 2012

580. Optoelectronics & Laser

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 242

8th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY580/

Learning Outcomes

The course combines a general overview of the field of Optoelectronics with an in-depth introduction to the operating principles of perhaps the most characteristic and exciting optoelectronic device, which is the laser diode. Special emphasis is given in handling problems of practical interest that require the use of computer and of basic computational methods.

Syllabus

- Brief review of the optical properties of semiconductors, quantum wells and waveguides
- General presentation of diode lasers and other optoelectronic devices
- Conditions for lasing action

- Operating principles of diode lasers
- Special reflectors and cavities for diode lasers
- Optical gain in quantum wells
- Tunable semiconductor laser

Bibliography

- L. Coldren and S. Corzine, Diode lasers and photonic integrated circuits, Wiley Series in Microwave and Optical Engineering, John Wiley & Sons (1995)
- G. P. Agrawal and N. K. Dutta, Semiconductor Lasers, 2nd Edition, International Thomson Publishing (1993)
- J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill (1995)

598. Bioorganic Nanostructures- Supramolecular Chemistry

E

Teaching Hours: 3-0-0, ECTS: 5

Prerequisite Courses: 121, 122, 012

6th Semester

https://www.materials.uoc.gr/el/undergrad/courses/ETY598/

https://598bionano.wordpress.com

Learning Outcomes

This course will serve to introduce important notions and concepts in the field of supramolecular chemistry through examples that dictate supramolecular organization in Nature and their comparison with published works. The goals of this course are to familiarize students to the different types of chemical systems used for the assembly of complicated molecular architectures and functional molecules, to help students obtain the essential knowledge needed to critically examine modern scientific literature related to supramolecular chemistry, and show how the notions and tools of supramolecular chemistry are applied in other areas of chemistry and biology. Upon successful completion of the course, the students will be able to:

- Understand the basic definitions and principles of supramolecular chemistry, widely used for the construction of novel materials,
- Correlate nanostructure architecture with the chemical structure of its components,
- Identify non-covalent interactions employed in self-organization and use this knowledge to understand and design new molecules and nanostructures,
- Work in multidisciplinary environments requiring basic supramolecular chemistry understanding (within the framework of a diploma thesis or Erasmus).

Syllabus

The course details the basic principles of supramolecular chemistry leading to spontaneous and programmed formation of (bio)nanostructures. The course extends the basic concepts of the role of non-covalent interactions (studied in previous courses such as General Chemistry and Organic Chemistry) and explores the essential role they play in Nature and all areas of modern supramolecular materials and biomaterials chemistry. The main themes are:

- Nanotechnology: definitions, approaches, perspectives,
- Supramolecular Chemistry: Definition and basic principles,
- Non-covalent interactions/self-assembly,
- Molecular recognition – host-guest chemistry,
- Template-directed synthesis,
- Dynamic covalent chemistry,
- Self-organization: Amphiphiles, polymers, helical polymers, supramolecular polymers, peptides,

proteins, oligonucleotides,

- Mechanically-interlocked molecular architectures,
- Molecular Machines
- Presentation and analysis of research studies from current literature

Bibliography

1. Core Concepts in Supramolecular Chemistry and Nanochemistry, Jonathan W. Steed, David R. Turner and Karl J. Wallace. John Wiley & Sons, Ltd: Chichester, 2007.
2. Supramolecular chemistry: Concepts and perspectives, J.-M. Lehn, VCH, Weinheim 1995.
3. "Application of supramolecular chemistry", Schneider, H.J., CRC Press 2012.