

HELLENIC MEDITERRANEAN UNIVERSITY

School of Engineering

Department of Mechanical Engineering

COURSE OUTLINES

5 courses

BUILDINGS ENERGY PERFORMANCE SIMULATION

COURSE OUTLINE

1. GENERAL			
SCHOOL	School of Engineering		
ACADEMIC UNIT	Department of Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	8000.1.211.0	SEMESTER	1st
COURSE TITLE	BUILDINGS ENERGY PERFORMANCE SIMULATION		

INDEPENDENT TEACHING ACTIVITIES if credits are awarded for separate components of the course	WEEKLY TEACHING HOURS	CREDITS
Total		

COURSE TYPE general background, special background, specialised general knowledge, skills development	
PREREQUISITE COURSES	Heat and mass transfer, Fluid mechanics, Mechanical design, Numerical methods.
LANGUAGE OF INSTRUCTION and EXAMINATIONS	
OFFERED TO ERASMUS STUDENTS	Yes (in English)
COURSE WEBSITE (URL)	

2. LEARNING OUTCOMES
Learning outcomes
The aim of the course is for students to acquire comprehensive knowledge on buildings' energy performance simulation, specifically regarding established methods for dynamic and simple energy analysis, special focus on the zonal modelling method including building discretization into thermal zones, interpretation of energy-audits data to model input conditions, understanding of building-shell thermophysical and optical properties, calculation of heating and cooling systems efficiency ratio, simulation set-up, modelling procedure and assessment of results referring to state and impact Key Performance Indicators (KPIs). The course includes an energy analysis project concerning the parametric analysis of building-energy upgrading and techno-economic impact assessment.
General Competences
Upon successful completion of the course, students will be able to: • Understand the steps of a building energy audit • Discretize buildings into thermal zones • Compile energy-audit information to suitable modelling input conditions • Compute thermophysical and optical properties of building envelope • Calculate building heating and cooling systems efficiency ratios/performance coefficient • Familiarized with energy simulation through setting-up a case study using building energy simulation software • Analyse simulation results towards state and impact KPIs in the framework of techno-economic studies using building energy simulation techniques

3. SYLLABUS

Energy balance in buildings: Building-physics principles, heat transfer in buildings, energy breakdown in energy consumption per end-use and per energy vector, compilation of primary energy consumption, energy-induced emissions, buildings' energy-saving potential.

Energy audits: Energy-related data collection, recording of building use, systems and operation schedules, interpretation of architectural design, recording of structural elements, extraction of properties used as input conditions in energy modelling, Building energy benchmarking/rating.

Building thermal zones: Discretization into thermal zones, calculation of air infiltration, ventilation specifications, impact of shading in energy performance.

Building envelope thermophysical and optical properties: Calculation of thermal transmittance and the impact on energy performance, building thermal-insulation adequacy assessment, structural elements reflectivity and emissivity.

Building-systems' properties calculation: Estimation of heater-boiler efficiency, calculation of COP/EER of air-conditioning systems, efficiency of solar collector for hot water production purposes, lighting adequacy, etc.

Energy-performance simulation: Exhibition of building energy modelling set-up, thermal zoning, imposing suitable input conditions (based on previous knowledge on building envelope systems' properties affecting the energy balance), execute simulations, simulation data processing towards state and impact KPIs for various energy-upgrading scenarios.

Assessment of energy investments in buildings: Prediction of Net Present Value, Internal Rate of Return and other special indicators for assessing the viability of retrofit scenarios for various building uses.

Assignment: Techno-economic study for energy-upgrading of a building case study.

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY Face-to-face, Distance learning, etc.	Face to face	
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY Use of ICT in teaching, laboratory education, communication with students	Presentation of electronic slides	
TEACHING METHODS The manner and methods of teaching are described in detail.	Activity	Semester workload
	Course total	
STUDENT PERFORMANCE EVALUATION Description of the evaluation procedure	Students will conduct an assignment / case study involving building energy analysis. There will be a final exam. Student final grade will be the average of the grade of final exam and of the assignment.	

5. ATTACHED BIBLIOGRAPHY

Hensen, J., & Lamberts, R. (Eds.) (2019). Building performance simulation for design and operation. (2nd expanded ed.) Routledge Taylor & Francis Group.

Fundamentals of Building Performance Modeling Handbook, IESVE 2025.

Brackney, L., Parker, A., Macumber, D., & Benne, K. (2018). Building energy modeling with OpenStudio: A practical guide for students and professionals. Springer International Publishing.

INTRODUCTION TO MODERN PHYSICS - QUANTUM STRUCTURE OF MATTER

COURSE OUTLINE

1. GENERAL			
SCHOOL	School of Engineering		
ACADEMIC UNIT	Department of Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	0813.4.006.0	SEMESTER	2nd
COURSE TITLE	Introduction to Modern Physics - Quantum Structure of Matter		

INDEPENDENT TEACHING ACTIVITIES if credits are awarded for separate components of the course	WEEKLY TEACHING HOURS	CREDITS
	0	4
Total	0	4

COURSE TYPE general background, special background, specialised general knowledge, skills development	Undergraduate course
PREREQUISITE COURSES	Calculus of one variable Differential Equations Linear Algebra
LANGUAGE OF INSTRUCTION and EXAMINATIONS	English
OFFERED TO ERASMUS STUDENTS	Yes (in English)
COURSE WEBSITE (URL)	

2. LEARNING OUTCOMES
Learning outcomes
This course introduces students to elementary concepts of quantum physics. It begins with the end of classical physics and describes the evolution of quantum theory, its basic principles, as well as its consequences in the macrocosm. Starting with the Schrodinger equation, along with certain fundamental principles of quantum theory—such as the uncertainty principle and the Pauli exclusion principle—as well as the relevant formalism, the course concludes with (i) the explanation of the periodic table of elements and (ii) the consequences of quantum theory on well-known and elementary properties of matter. These include the typical density of matter, its compressibility, electrical conductivity, etc. Upon successful completion of the course, the student will be able to: Know the basic principles of quantum physics. Understand the concept of the wavefunction. Know how to solve simple quantum mechanics problems. Understand basic properties of matter.
General Competences
Independent work Working in an interdisciplinary environment Generation of new research ideas Promotion of free, creative, and inductive thinking

3. SYLLABUS

The End of Classical Physics – From Classical to Quantum Description

Black-body radiation and Planck's explanation

Photoelectric effect

Compton effect

The quantum view of matter

Old and New Quantum Theory

The planetary model of the atom and Bohr's theory

De Broglie matter waves

The foundation of quantum theory

The wavefunction and the Schrodinger equation

The statistical significance of the wavefunction and observable quantum mechanical quantities

The uncertainty principle

The harmonic oscillator

The Pauli exclusion principle

Two Important Problems of Fundamental Significance

The hydrogen atom and atomic orbitals

The periodic table of elements

From Atoms to Molecules and Condensed Matter

The quantum theory of the chemical bond

Solids: Conductors, Semiconductors, Insulators

The end of stars: White dwarfs, neutron stars, and black holes

The discovery of the transistor

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY Face-to-face, Distance learning, etc.	Lectures	
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY Use of ICT in teaching, laboratory education, communication with students		
TEACHING METHODS The manner and methods of teaching are described in detail.	Activity	Semester workload
	Course total	
STUDENT PERFORMANCE EVALUATION Description of the evaluation procedure	Quizzes Final written exam	

5. ATTACHED BIBLIOGRAPHY

<https://cup.gr/book/introduction-to-quantum-physics/>

SOLAR ENERGY & APPLICATIONS

COURSE OUTLINE

1. GENERAL			
SCHOOL	School of Engineering		
ACADEMIC UNIT	Department of Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	0813.8.022.0	SEMESTER	2nd
COURSE TITLE	Solar Energy & Applications		

INDEPENDENT TEACHING ACTIVITIES if credits are awarded for separate components of the course	WEEKLY TEACHING HOURS	CREDITS
	4	6
Total	4	6

COURSE TYPE general background, special background, specialised general knowledge, skills development	
PREREQUISITE COURSES	None
LANGUAGE OF INSTRUCTION and EXAMINATIONS	English
OFFERED TO ERASMUS STUDENTS	Yes (in English)
COURSE WEBSITE (URL)	

2. LEARNING OUTCOMES

Learning outcomes

This course presents concepts and technologies related to the production of electrical and thermal energy through the utilization of solar radiation. For this purpose, the course is divided into three sections, a) Solar Geometry and the Properties of Solar Radiation, b) Solar Radiation Utilization Technologies for Direct Electricity Generation, and c) Solar Radiation Utilization Technologies for Direct Heat Generation.

After successful completion of the course, students will have:

- understood basic properties of solar radiation, calculating basic angles of solar geometry and solar potential
- understood the basic operation & energy production of photovoltaics from different absorber materials
- learned to calculate efficiency & energy production of different technologies and geometries of solar collectors
- learned to compose photovoltaic and solar thermal energy production systems with storage and their dimensioning
- performed measurements for the evaluation of photovoltaic and solar thermal systems

General Competences

- Search, analysis and synthesis of data and information, using necessary technologies
- Decision making
- Independent work
- Teamwork
- Working in an interdisciplinary environment
- Generation of new research ideas
- Promoting free, creative and inductive thinking

3. SYLLABUS

The course is divided into three sections:

a) Solar Geometry and the Properties of Solar Radiation. The first section presents and analyzes the basic concepts governing Solar Geometry, such as the basic angles that determine and characterize the sun's path on the horizon, such as solar declination, hour angle, sunrise and sunset time, solar altitude, solar azimuth, the concepts of solar and civil time, the surface azimuth and finally calculates the angle of incidence of solar radiation on a surface. The basic relationships that characterize the quantity and spectrum of solar radiation are also given, such as its three basic components (direct, diffuse and reflected) and empirical methods for estimating the available radiation at a geographical location and the radiation incident on a surface are presented.

b) Solar Radiation Utilization Technologies for Direct Electricity Generation. In the section on the production of electricity directly from solar radiation, the various photovoltaic system technologies are presented. The photoelectric and photovoltaic phenomenon is analyzed, basic technological concepts of electrical power generation from photovoltaic collectors are given, the basic layout-structure and the process of composition of a photovoltaic station are analyzed and the mathematical background is presented, with its numerical-computational application, for calculating the electrical power generation from photovoltaic panels.

c) Solar Radiation Utilization Technologies for Direct Heat Generation. In the section on heat generation from solar radiation, the various available solar collector technologies are given, such as open type, flat selective, vacuum tubes and parabolic mirrors, and their basic technical characteristics are presented. The analytical mathematical background for calculating the efficiency and heat generation from solar collectors and the numerical methodology for its application are also given. Indicative applications of the available solar collector technologies for hot water production, space heating, industrial uses and electrical power generation through solar thermal steam & gas turbine power plants are presented.

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY Face-to-face, Distance learning, etc.	In person	
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY Use of ICT in teaching, laboratory education, communication with students	<i>The course is supported by computational tools and laboratory exercises on the above three distinct subjects.</i>	
TEACHING METHODS The manner and methods of teaching are described in detail.	Activity	Semester workload
	Course total	
STUDENT PERFORMANCE EVALUATION Description of the evaluation procedure		

5. ATTACHED BIBLIOGRAPHY

DIPLOMA THESIS COURSE OUTLINE

1. GENERAL			
SCHOOL	School of Engineering		
ACADEMIC UNIT	Department of Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	0813.9.014.0	SEMESTER	255th
COURSE TITLE	Diploma Thesis		
INDEPENDENT TEACHING ACTIVITIES if credits are awarded for separate components of the course	WEEKLY TEACHING HOURS		CREDITS
	0		30
Total	0		30
COURSE TYPE general background, special background, specialised general knowledge, skills development			
PREREQUISITE COURSES	None		
LANGUAGE OF INSTRUCTION and EXAMINATIONS			
OFFERED TO ERASMUS STUDENTS	Yes (in English)		
COURSE WEBSITE (URL)			
2. LEARNING OUTCOMES			
Learning outcomes			
After the successful preparation of the Thesis, students will be able to tackle a fairly complex engineering topic, that is: • to grasp its complexity • to identify the individual requirements (scientific, technical, organizational, economic) • to seek the best from a series of proven solutions • to design its implementation • to design, analyze and simulate its operation, if necessary • to construct or supervise and coordinate its construction • to evaluate its performance • to propose improvements			
General Competences			

Through the preparation of their thesis, and depending on its topic, students also will have the opportunity to develop the following general skills:

- communication skills through their communication with stakeholders from the technical, academic and administrative fields in the subject of their thesis and the promotion of their work through all available printed and electronic media
- the ability to research, search and exchange information or data through their work in an international academic environment
- to write comprehensive, technically and linguistically sound scientific-technical texts
- to present and support their work publicly and to large audiences
- to write and publish scientific articles in international journals and conferences in English
- to develop critical thinking, with the ultimate goal of contributing to the local and global development and prosperity

3. SYLLABUS

The Final Project Thesis is an extensive work – analytical, synthetic, experimental or related to a specific application – that is prepared by senior students in order to obtain the title of Graduate Mechanical Engineer. The Thesis has a fairly complex and multi-level scientific-technical subject that is generally related to the direction of studies chosen by the student.

It constitutes a concentrated culmination of the studies and its purpose is to give the student the opportunity to complete their knowledge and present their abilities in the elaboration of an independent topic of the Science of Engineering.

The subject of the work is determined either by a professor or upon the proposal of the student and in collaboration with the supervising professor.

The Final Project Thesis consists of a comprehensive review of literature that can be followed by either:

- modeling
- design
- fabrication
- characterization

of advanced engineering topics in one of the three sectors in the department:

- Energy
- Robotics
- Manufacturing

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY Face-to-face, Distance learning, etc.	In Person	
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY Use of ICT in teaching, laboratory education, communication with students		
TEACHING METHODS The manner and methods of teaching are described in detail.	Activity	Semester workload
	Course total	
STUDENT PERFORMANCE EVALUATION Description of the evaluation procedure		

5. ATTACHED BIBLIOGRAPHY

GEOTHERMAL - BIOENERGY - COGENERATION - SMART GRIDS

COURSE OUTLINE

1. GENERAL			
SCHOOL	School of Engineering		
ACADEMIC UNIT	Department of Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	0813.9.016.0	SEMESTER	1st
COURSE TITLE	Geothermal - Bioenergy - Cogeneration - Smart grids		
INDEPENDENT TEACHING ACTIVITIES if credits are awarded for separate components of the course	WEEKLY TEACHING HOURS	CREDITS	
	4	6	
Total	4	6	
COURSE TYPE general background, special background, specialised general knowledge, skills development			
PREREQUISITE COURSES	None		
LANGUAGE OF INSTRUCTION and EXAMINATIONS	English		
OFFERED TO ERASMUS STUDENTS	Yes (in English)		
COURSE WEBSITE (URL)			
2. LEARNING OUTCOMES			
Learning outcomes			
This course examines forms of Renewable Energy Sources, such as Geothermal Energy and Bioenergy from Biomass, Biofuel or Biogas. Advanced energy systems that contribute to rational energy use and the maximization of energy efficiency are also examined, such as Cogeneration systems and Smart energy networks, "Power to X" and hydrogen technologies. Upon successful completion of the course, students will be able to: • Understand the theoretical background and technologies for the utilization of geothermal fields. • Know the processes of woody biomass utilization and the aspects of biofuel production (composting, gasification, transesterification, pyrolysis, anaerobic digestion). • Know the basic cogeneration technologies and can develop operating algorithms depending on the priorities of each project. • Prepare dimensioning and energy calculations for cogeneration systems and district heating - district cooling networks. • Analyze and implement strategies for the optimal use of smart grids to propose targeted energy solutions to consumers. • Become familiar with the technologies that convert energy into fuels or chemical products (Power to Gas, Power to Liquids, Power to Heat) and understand their techno-economic feasibility • Know the technologies for the production and use of hydrogen and understand their role in the energy economy.			
General Competences			

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

- Search, analysis and synthesis of data and information, using the necessary technologies
- Adaptation to new conditions
- Independent work & Teamwork
- Working in an international environment and interdisciplinary environment
- Generating new research ideas
- Project design and management
- Respect for diversity and interculturality
- Respect for the natural environment
- Demonstrating social, professional and ethical responsibility & sensitivity to gender issues
- Decision-making & Exercising criticism and self-criticism

Promoting free, creative and inductive thinking

3. SYLLABUS

In Geothermal energy, the topic is initially presented as a renewable energy source, and the available geothermal fields are distinguished, while the methodologies for exploration and assessment of geothermal potential are analyzed. Basic geological - geotechnical concepts are presented. The basic technologies for the exploitation of geothermal fields in the production of electrical and thermal energy are presented, as well as the design, siting and dimensioning methods

Regarding Biomass, the basic raw materials in the production of biomass and biofuels are presented (wood, by-products of agricultural crops, energy crops, urban or livestock organic waste, waste from the food industry). Biofuels are distinguished into solid, liquid and gaseous and their basic characteristics are presented (density, moisture content, net calorific value). The basic biofuel production processes are presented (composting, gasification, transesterification, pyrolysis, anaerobic digestion). Characteristic quantities of the biomass production process are given, regarding the required raw material and the production cost per unit of final product.

The basic alternative technologies for cogeneration of electricity and heat are presented, including thermoelectric plants, decentralized systems and trigeneration units. The concept of district heating and district cooling systems is given. Their basic components are presented, including networks, heat exchangers, alternative connectivity, etc. and typical examples of dimensioning and design of cogeneration and district air-conditioning systems are presented.

Furthermore, the course introduces the concepts of smart grids, presenting the conceptual model of smart grids and analyzing:

- the functionalities of smart grids
- the concept of demand management from the consumer's perspective and the available implementation strategies
- the implementation programs of smart grid processes
- the required technologies (telecommunications, electrical networks, demand management technologies and applications, decentralized energy production and storage devices)
- the expected benefits and difficulties of developing smart grids.

In addition, the technologies that convert electrical energy into other forms of energy or chemical products (Power-to-X) are presented, with emphasis on the production of hydrogen through electrolysis (Power-to-Gas), the conversion to liquid fuels (Power-to-Liquids) and the use for thermal energy (Power-to-Heat). In addition, examples are given for the idea of storing excess renewable electricity for future use, increasing the flexibility and sustainability of energy systems.

Finally, an introduction is made to the technologies for the production and use of hydrogen, as well as its integration into the energy economy. The role of hydrogen as a clean energy solution and the challenges facing its wider adoption are analyzed.

4. TEACHING and LEARNING METHODS - EVALUATION

DELIVERY

Face-to-face, Distance learning, etc.

In person

USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY Use of ICT in teaching, laboratory education, communication with students		
TEACHING METHODS The manner and methods of teaching are described in detail.	Activity	Semester workload
	Course total	
STUDENT PERFORMANCE EVALUATION Description of the evaluation procedure		
5. ATTACHED BIBLIOGRAPHY		

DEPARTMENT OF MECHANICAL ENGINEERING, HELLENIC MEDITERRANEAN UNIVERSITY

