Attachments

MASTER IN ENERGY EFFICIENT BUILDINGS

Curriculum - Academic Year 2017-18

Year/ Semester	Course Unit	ECTS credits	Lecturer(s)
I/1°	*Heat Transfer*	*6*	*Vincenzo Bianco*
I/1°	*Advanced Thermodynamics*	*6*	*Vladimir Alekhin*
I/1°	*Project Management*	*6*	*Angelo Musaio*
I/1°	*Computer Aided Design*	*6*	*Irina Maltseva*
I/1°	*Thermofluidynamic Measurements*	*6*	*Aleksander Noskov*
I/2°	*Finance for Engineers*	*6*	*Marina Shitikova*
I/2°	*Buildings Physics*	*10*	*Elena Mishenko*
I/2°	*HVAC Systems*	*8*	*Elena Rodina*
I/2°	*Buildings Simulation*	*6*	*Alina Minea*
II/1°	*Energy Economics*	*8*	*Alfredo Squarzoni*
II/1°	*Heat Pumps and Refrigeration Systems*	*8*	*Nickolai Vatin*
II/1°	*Renewable Energy Systems*	*8*	*Ruben Aghgashyan*
II/1°	*Energy Audit and Certification*	*6*	*Pavel Monastyrev*
II/2°	*Acoustics*	*6*	*Dmitrii Ulrikh*
II/2°	*Master Thesis*	*24*	*n.a.*

MASTER IN ENERGY EFFICIENT BUILDINGS

Curriculum - Academic Year 2017-18
Characteristics of the Course Units

Name	**Heat Transfer**
ECTS credits	6
Year / Semester	I /1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Demonstrate knowledge and understanding of the fundamentals of the heat transfer discipline and of the fundamental hypothesis of the one-dimensional calculation approach 2 – Recognize the different modes of heat transfer 3 – Calculate heat exchange in different unfamiliar configurations and under assigned boundary conditions, by choosing the most suitable numerical or analytical method 4 – Propose solutions to limit/enhance heat exchange in complex systems (e.g. heat exchangers, finned surfaces, etc.) 5 – Interpret technical diagrams for the estimation of relevant parameters (e.g. efficiency, friction factor, etc.) 6 – Illustrate the fundamentals of the heat transfer discipline and of the fundamental hypothesis of the one-dimensional calculation approach 7 – Participate in class discussions with colleagues and with teachers
Contents	Derivation of heat conduction equation; heat conduction in one dimensional systems; concept of thermal resistance; transient heat conduction with lumped system approach and model of the "semi-infinite" body; heat exchange from finned surfaces; forced convection on surfaces; theory of the boundary layer; laminar and turbulent flows; non dimensional parameters in forced convection; internal forced convection; natural convection over surfaces and in enclosures; non dimensional parameters in natural convection; fundamental laws of radiation heat transfer; radiative characteristics of a surface; concept of radiosity; view factors; radiation heat transfer among surfaces.
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 35 hours Practical classes, 25 hours
Assessment methods	Written and oral. A mid-term written test and a final-term written test are foreseen. The mid-term written test will be devoted to the assessment of the level of achievement of LOs 2 and 3 (ability of students to solve numerical problems related to heat exchange). The final term written test will be devoted to the assessment of the level of achievement of LOs 2, 3 and, mainly, 4 and 5. The oral test will be devoted to the assessment of the level of achievement of LOs 1, 3, 6 and 7 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the mid-term test students should demonstrate their ability to identify the heat transfer mode and to calculate heat exchange in a one

	-dimensional configuration and under assigned boundary conditions. The assessment will regard their capacity to correctly identify the heat transfer mode, to formulate the heat exchange equations and to solve them by using analytical methods. In the final term test students will be required to solve a problem related to a complex system (e.g. heat exchanger, finned surfaces, etc.). The problem will require also the interpretation of technical diagrams for the estimation of relevant parameters. The assessment will regard students' capacity to properly frame the problem, to identify the heat transfer mode and, in particular, to identify and correctly apply the best calculation process to the problem under consideration, to correctly interpret technical diagrams for the estimation of relevant parameters, and to obtain correct results. In the oral test students should demonstrate their knowledge and understanding of the fundamentals of the heat transfer discipline and of the fundamental hypothesis of the one-dimensional calculation approach. Also, their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Mid-term written test: 30% - Final term written test: 30% - Oral examination (including practical classes assessments): 40%
Preparatory course units	N.A.
Educational material of reference	Yunus A. Cengel "Heat Transfer", MARUEEB Lecture Notes

Name	**Advanced Thermodynamics**
ECTS credits	6
Year / Semester	I/1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Demonstrate knowledge and understanding of advanced aspects of thermodynamics, with specific reference to the second law 2 – Determine first and second law efficiencies of energy conversion and refrigeration devices 3 – Calculate thermodynamic properties of complex energy conversion and refrigeration cycles 4 – Propose solutions to enhance efficiency of complex systems (e.g. heat pumps, solar collectors, etc.) 5 – Interpret technical diagrams for the estimation of relevant parameters (e.g. pump/fan efficiency, pressure losses, etc.) 6 – Illustrate the fundamental concepts of applied thermodynamics and the main hypothesis of the calculation approaches 7 – Participate in class discussions with colleagues and with teachers
Contents	Second law of thermodynamics; entropy generation; entropy generation balance for devices; definition of exergy; the Guy-Stodola theorem; closed systems exergy balance; flow exergy; exergy rate balance for control volumes; exergy efficiency for devices; exergy efficiency in direct and inverse cycles; absorption refrigeration; heat pump systems; gas refrigeration systems; introduction to thermoeconomics.
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 35 hours Practical classes, 25 hours
Assessment methods	Written and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 2, 3, 4 and 5. The oral test will be devoted to the assessment of the level of achievement of LOs 1, 3, 6 and 7 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term test students will be required to solve a problem related to a complex system (e.g. heat pump, refrigeration cycle, etc.). The problem will require also the interpretation of technical diagrams for the estimation of relevant parameters. The assessment will regard students' capacity to properly frame the problem, to define the system efficiency and, in particular, to identify and correctly apply the best calculation process to the problem under consideration, to correctly interpret technical diagrams for the estimation of relevant parameters, and to obtain correct results. In the oral test students should demonstrate their knowledge and understanding of the fundamentals of the heat transfer discipline and of the fundamental hypothesis of the one dimensional calculation approach. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be

	assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term written test: 40% - Oral examination (including practical classes assessments): 60%
Preparatory course units	N.A.
Educational material of reference	M.J. Moran, H.N. Shapiro “Fundamentals of Engineering Thermodynamics”, MARUEEB Lecture Notes

Name	**Project Management**
ECTS credits	6
Year / Semester	I/1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Demonstrate knowledge and understanding of project management, with specific reference to buildings 2 – Identify the key variables in project management 3 – Estimate budget and execution time in the different phases of a project 4 – Propose solutions to minimize project risks 5 – Apply project planning methodologies, such as PERT and Gantt 6 – Summarise the fundamental concepts for managing a project team 7 – Evaluate project management strategies for different typologies of projects
Contents	Definitions and classifications of projects. Objectives in project management - time, costs, quality. Activity identification. Resources and resource management. Critical Path Method, Programme Evaluation and Review Technique, and resource scheduling. Performance measurement and costs. Project lifecycles and models. Project teams and leadership in project management. Managing risk in projects. Critical Chain Planning Method. Analysis of project success and failure.
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 40 hours Practical classes, 20 hours
Assessment methods	Written and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 1-3. The oral test will be devoted to the assessment of the level of achievement of LOs 1-7 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term test students will be required to analyse a case study focuses on a project related to a building. The assessment will regard students' capacity to identify the key variables, to estimate the budget and to prepare a time plan of the activities. In the oral test students should demonstrate their knowledge and understanding of the project management. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules:

grade	- Final term written test: 40% - Oral examination (including practical classes assessments): 60%
Preparatory course units	N.A.
Educational material of reference	R.K. Wysocki “Effective Project Management”, MARUEEB Lecture Notes

Name	**Computer Aided Design**
ECTS credits	6
Year / Semester	I/1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Operate effectively in different coordinate systems 2 – Construct three-dimensional wire frame model 3 – Construct three-dimensional surface and solid models 4 – Prepare a studio rendering of a model with surface qualities and lighting 5 – Illustrate and present building design information, using a range of advanced digital techniques 6 – Turn ideas into detailed designs by specifying the form and materials of designs 7 – Prepare models for CAE computations
Contents	Revision of the essential tools, model construction and comprehension, utilization of coordinate systems, wire frame modelling, derivation of 3D models from 2D draws, surfaces modelling, attachment of a material to a surface, lighting effects, solid modelling, Boolean operations, preparation of models for CAE tools, management of neutral formats
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 20 hours Computer classes, 40 hours
Assessment methods	Computer assignment and oral. A final-term computer based test is foreseen. The final term computer based test will be devoted to the assessment of the level of achievement of LOs 1-7. The oral test will be devoted to the assessment of the level of achievement of LOs 1-7 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term computer based test students will be required to develop a project of a building according to the indications provided. The assessment will regard students' to identify the main elements of the design and to reproduce them correctly by using CAD methodologies. In the oral test students should demonstrate their knowledge and understanding of the computer aided design. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term computer test: 60% - Oral examination (including practical classes assessments): 40%

Preparatory course units	N.A.
Educational material of reference	Autocad Reference Manual, MARUEEB Lecture Notes

Name	**Thermofluidynamic Measurements**
ECTS credits	6
Year / Semester	I/1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Present the main issues connected with execution of measurements 2 – Calculate the uncertainty linked to a set of measurements 3 – Determine the accuracy of a measured datum 4 – Investigate thermodynamic and fluid dynamic phenomena by performing experimental measurements 5 – Recommend the optimal technique for the measurement of temperature, pressure and mass flow rate 6 – Interpret the results of a measurement campaign
Contents	Introduction to theory of measurements, concept of measurement, definition of accuracy, uncertainty of measures, statistical analysis of data, thermal measurements, thermocouples, thermoresistance, thermometers, infra-red camera, pressure measurements, mass flow measurmenets, hot wire anemometers, data acquisition, data analysis.
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 30 hours Laboratory, 30 hours
Assessment methods	Laboratory assignment and oral. A final-term laboratory based test is foreseen. The final term laboratory based test will be devoted to the assessment of the level of achievement of LOs 2-4. The oral test will be devoted to the assessment of the level of achievement of LOs 1, 5 and 6 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term laboratory based test students will be required to perform a set of different measurements. The assessment will regard students' ability to analyse uncertainties and accuracy of the measurements for different kind of parameters (temperature, pressure and mass flow rate). In the oral test students should demonstrate their knowledge and understanding of the theory of measures. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term laboratory test: 40% - Oral examination (including practical classes assessments): 60%

Preparatory course units	N.A.
Educational material of reference	T.W. Lee “Thermal and flow measurments”, MARUEEB Lecture Notes

Name	**Finance for Engineers**
ECTS credits	6
Year / Semester	I/1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Solve problems utilising time value of money calculations 2 – Prepare simple financial planning models and determine external funds required 3 – Evaluate the strengths and weaknesses of a range of project evaluation techniques including payback, net present value, profitability index and internal rate of return 4 – Analyse financial statements 5 – Formulate a recommendation for a basic investment decision using a range of project evaluation techniques 6 – Appraise the risks connected with an investment decision
Contents	Time value of money, concept of compound and discount, inflation and cost price index, financial statement analysis, financial planning, cost of capital, investment analysis, risk and return, portfolio theory, business cases
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 30 hours Practical, 30 hours
Assessment methods	Final written test and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 1-3. The oral test will be devoted to the assessment of the level of achievement of LOs 4-6 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term written test students will be required to solve a complex problem related to the analysis of an investment. The assessment will regard students' ability to perform financial calculations and to formulate adequate hypothesis. In the oral test students should demonstrate their knowledge and understanding of basic financial concepts. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term written test: 40% - Oral examination (including practical classes assessments): 60%
Preparatory course units	N.A.

Educational material of reference	Brealey, Richard A., Myers, Stewart C., Marcus, Alan J. “Fundamentals of corporate finance”, MARUEEB Lecture Notes

Name	**Buildings Physics**
ECTS credits	10
Year / Semester	I/2°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Summarise relevant information regarding to the physics of a specific building 2 – Determine the level of thermal and moisture insulation 3 – Evaluate the degree of lighting and acoustic comfort of a building 4 – Design a building by respecting adequate standards regarding energy consumption, lighting and acoustic comfort 5 – Calculate energy consumption and environmental impact of a building 6 – Identify the most appropriate material to utilize in order to guarantee moist, thermal and acoustic insulation and to minimize the impact on the environment
Contents	Primary functions of buildings; code and user requirements; moisture and acoustics; diffusion, convection and capillary transport of moisture; design of thermal, moisture and sound insulation; light and lighting; thermal bridges; wind, air and rain tightness; choice of materials; ventilated roofs; calculation of thermal loads; basic principles and calculations in design of building assemblies and details.
Teaching and learning methods	Face to face, 100 hours
Teaching techniques	Lectures, 60 hours Practical, 40 hours
Assessment methods	Final written test and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 2-5. The oral test will be devoted to the assessment of the level of achievement of LOs 1 and 6 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term written test students will be required to solve a complex problem related to the preliminary design of a building. The assessment will regard students' ability to perform heat transfer, moist and acoustic calculations and to formulate adequate hypothesis. In the oral test students should demonstrate their knowledge and understanding of basic buildings physics. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term written test: 70%

	- Oral examination (including practical classes assessments): 30%
Preparatory course units	N.A.
Educational material of reference	Watson and Labs, “Climatic Building Design”, MARUEEB Lecture Notes

Name	**HVAC Systems**
ECTS credits	8
Year / Semester	I/2°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Summarise the technical design requirements for mechanical building services element 2 – Describe the safety and environmental requirements for mechanical building services elements 3 – Evaluate the environmental conditions to be maintained and correlate these to the best suited environmental system type 4 – Design the technical services necessary to guarantee the thermal and hygrometric comfort in a building 5 – Calculate the diameters of complex piping networks 6 – Select the correct devices to be used in a HVAC system
Contents	applied psychrometrics, air conditioning systems, design principles, comfort in the built environment, cooling load calculations, heating load calculations, introduction and use of computer-based load estimation packages software, air distribution, fans, ducts, air conditioning controls, advanced refrigeration cycles, evaporators, condensers, cooling towers, compressors, pumps, throttling devices, piping, refrigerants, control, refrigeration equipment, simulation of refrigeration systems, food refrigeration and industrial applications;
Teaching and learning methods	Face to face, 80 hours
Teaching techniques	Lectures, 40 hours Practical, 40 hours
Assessment methods	Final written test and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 2-6. The oral test will be devoted to the assessment of the level of achievement of LOs 1-6 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term written test students will be required to solve a complex problem related to the preliminary design of an HVAC plant. The assessment will regard students' ability to perform heat transfer and hydraulic calculations and to formulate adequate hypothesis. In the oral test students should demonstrate their knowledge and understanding HVAC plants. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To

attribution of the final grade	pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term written test: 50% - Oral examination (including practical classes assessments): 50%
Preparatory course units	N.A.
Educational material of reference	Fred Hall, Roger Greeno 2013, Building Services Handbook, MARUEEB Lecture Notes

Name	**Buildings Simulation**
ECTS credits	6
Year / Semester	I/2°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Illustrate the procedures used for assessing the energy efficiency of buildings 2 – Identify sustainable energy systems that are suitable for use in buildings 3 – Analyse energy and environmental performance of buildings 4 – Define the purpose of building simulations 5 – Produce building simulation models 6 – Perform simulation using computer software packages 7 – Analyze results and propose optimum solutions
Contents	Requirements for acceptable indoor environment; energy flow in buildings and its modelling; dynamic vs. static simulation; energy performance assessment methods; low energy buildings design; renewable energy as a source for heating, cooling and ventilating; energy efficient lighting systems; building energy management systems.
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 20 hours Computer class, 40 hours
Assessment methods	Final computer based test. A final-term computer test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 1-7.
Assessment criteria	In the final term computer based test students will be required to execute a full energy simulation of a building. The assessment will regard students' ability to build an energy model of a building, to use adequate software and to propose optimal solution with respect to energy efficiency and environmental protection.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term computer based test: 100%
Preparatory course units	N.A.
Educational material of reference	TRNSYS user guide, MARUEEB Lecture Notes

Name	**Energy Economics**
ECTS credits	8
Year / Semester	II/1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Summarise the main figures of a country energy balance 2 – Identify the components influencing the energy consumption 3 – Estimate future energy consumption by using top-down approaches 4 – Describe the working criteria of energy markets, including those linked to the emission trading 5 – Calculate KPIs of an electricity market 6 – Compare the main features of different energy markets 7 – Recognize the impact of energy policies on the energy markets
Contents	Analysis of energy balances; determinants of energy consumption; decomposition analysis of energy consumption; forecasting of energy demand; electricity sector; concept of merit order; variable cost of a power plant; KPIs of the power market; natural gas sector; energy policy in the natural gas sector; pricing of natural gas; EU emission trading scheme; coal market.
Teaching and learning methods	Face to face, 80 hours
Teaching techniques	Lectures, 40 hours Practical, 40 hours
Assessment methods	Final written test and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 3-5. The oral test will be devoted to the assessment of the level of achievement of LOs 1-7 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term written test students will be required to analyse an historical trend of energy consumption in relation to corresponding economic variables. The assessment will regard students' ability to apply decomposition analysis of energy consumption, calculation of KPIs and definition of simple forecasts. In the oral test students should demonstrate their knowledge and understanding of energy economics as a whole. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules:

grade	- Final term written test: 50% - Oral examination: 50%
Preparatory course units	N.A.
Educational material of reference	S.C. Bhattacharyya “Energy Economics”, MARUEEB Lecture Notes

Name	**Heat Pumps and Refrigeration Systems**
ECTS credits	8
Year / Semester	II/1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Analyse the performance of low carbon refrigeration systems 2 – Select and evaluate the optimum configuration of system components for a given application 3 – Analyse the environmental impact of alternative systems choices 4 – Describe the working criteria of refrigeration systems and heat pumps 5 – Conduct financial appraisals of low carbon energy systems 6 – Compare the main features of different refrigeration systems 7 – Design innovative systems for refrigeration and air conditioning
Contents	Absorption cycle refrigeration and trigeneration systems; Static cooling and displacement ventilation: Chilled beams; chilled ceilings; displacement ventilation design strategies; Geothermal heating and cooling: Geothermal design strategies; geothermal resource estimation; geothermal system design; system modelling
Teaching and learning methods	Face to face, 80 hours
Teaching techniques	Lectures, 40 hours Practical, 40 hours
Assessment methods	Final written test and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 1-5. The oral test will be devoted to the assessment of the level of achievement of LOs 1-7 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term written test students will be required to analyse different refrigeration cycles. The assessment will regard students' ability to determine the main thermodynamics parameters, as well as to provide an estimation of the performance of the system under investigation. In the oral test students should demonstrate their knowledge and understanding of Heat Pumps and Refrigeration Systems. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term written test: 50%

	- Oral examination: 50%
Preparatory course units	N.A.
Educational material of reference	I. Dincer “Refrigeration systems and applications”, MARUEEB Lecture Notes

Name	**Renewable Energy Systems**
ECTS credits	8
Year / Semester	II/1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Apply scientific concepts and principles underpinning renewable energy technologies 2 – Assess the contribution that renewable energy technologies can make to the overall sustainability of energy systems at different scales 3 – Describe the working criteria of energy generation of the main renewables technologies 4 – Conduct financial appraisals of renewable energy systems 5 – Compare the main features of different renewable energy systems 6 – Design innovative renewable energy systems
Contents	Overview of renewable energy; Resource scale and availability; Available technologies and challenges; Technical and economical assessment of renewable technologies; Detailed technical study of two major renewable energy technologies; Solar energy: solar thermal & solar PV, current technology and future potential; Wind energy: wind turbine configurations and power generating technologies; Broad study of technologies with less potential; Hydro power energy: Principles of hydro power technology; Ocean current, tidal & wave energy: technology, economics, challenges and R&D; Ground source and geothermal energy: principles, operation, future scope; Biomass and Bioenergy: resources, sustainability, processing, combustion, scope.
Teaching and learning methods	Face to face, 80 hours
Teaching techniques	Lectures, 40 hours Practical, 40 hours
Assessment methods	Final written test and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 1-4. The oral test will be devoted to the assessment of the level of achievement of LOs 1-6 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term written test students will be required to analyse different renewable energy systems. The assessment will regard students' ability to determine the main technical parameters, as well as to provide an estimation of the performance of the system under investigation. In the oral test students should demonstrate their knowledge and understanding of renewable energy systems. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment	Attribution of a final grade

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Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term written test: 50% - Oral examination: 50%
Preparatory course units	N.A.
Educational material of reference	V. Quaschning “Understanding Renewable Energy Systems”, MARUEEB Lecture Notes

Name	**Energy Audit and Certification**
ECTS credits	6
Year / Semester	II/1°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Outline the theoretical foundations of energy sustainability in the built environment 2 – Identify the role and the impact of the main parameters determining the energy performance of buildings 3 – Demonstrate knowledge of the legislative, regulatory and normative framework 4 – Implement solutions for the improvement of buildings' energy and environmental performance, both of new and of existing buildings 5 – Implement solutions for the upgrading of thermal comfort, habitability and sustainability of public and open spaces 6 – Determine costs related to an energy efficiency measures to implement
Contents	Codes & Standards & Indoor Air Quality; Utilities Procurement; Energy Audits and Instrumentation; Utility Bills Analysis, Baseline and Benchmarking; Energy Accounting and Economics; Green Buildings, LEED, and ENERGY STAR; Alternative Financing; Building Automation and Control Systems; Maintenance and Commissioning; Building Envelope; Lighting; Thermal Energy Storage Systems; Electrical Systems; Cogeneration and CHP Systems.
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 30 hours Practical, 30 hours
Assessment methods	Final written test and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 4-6. The oral test will be devoted to the assessment of the level of achievement of LOs 1-6 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term written test students will be required to develop an energy analysis of a buildings and to highlight the possible areas of improvement. The assessment will regard students' ability to determine the main technical parameters, as well as to provide an estimation of the corresponding costs. In the oral test students should demonstrate their knowledge and understanding of energy audit and certification procedures. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment	Attribution of a final grade

metrics	
Criteria of attribution of the final grade	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term written test: 50% - Oral examination: 50%
Preparatory course units	N.A.
Educational material of reference	MARUEEB Lecture Notes

Name	**Acoustics**
ECTS credits	6
Year / Semester	II/2°
Specific learning outcomes	On successful completion of this module students should be able to: 1 – Identify the parts of the outer, middle and inner ear explaining their role 2 – Explain the role of the two ears in distinguishing the direction of an acoustic source 3 – Convert noise levels into dB and linear levels, combining noise sources either coherent or incoherent 4 – Explain the meaning of common terms in wave mechanics, such as wavelength, wavenumber, wave speed, diffraction, reflection, dispersion etc 5 – Relate the speed of sound in a fluid to its physical properties 6 – Derive the one-dimensional wave equation for both a stretched string and a fluid-filled pipe and explain the assumptions necessary to do so
Contents	Sound Perception: 1. Introduction to Acosutics and Sound Perception; 2. The human auditory system and the functioning of the component parts; 3. Acoustic metrics and their uses for quantifying sound objectively and subjectively Physical Acoustics: 1. Introduction to Waves; 2. Sound Waves in Fluids; 3. Acoustic Plane Waves; 4. Sound propagation, reflection, transmission, refraction and absorption
Teaching and learning methods	Face to face, 60 hours
Teaching techniques	Lectures, 30 hours Practical, 30 hours
Assessment methods	Final written test and oral. A final-term written test is foreseen. The final term written test will be devoted to the assessment of the level of achievement of LOs 3-6. The oral test will be devoted to the assessment of the level of achievement of LOs 1-6 (theoretical comprehension of the subject and the capacity to understand and to express the related concepts).
Assessment criteria	In the final term written test students will be required to solve exercises related to acoustic problems. The assessment will regard students' ability to determine the main technical parameters and to solve relevant equations under specified boundary conditions. In the oral test students should demonstrate their knowledge and understanding of acoustics. Also their ability to illustrate their knowledge and understanding clearly (using appropriate wording), synthetically and correctly will be assessed. Finally, students' ability to participate in class discussions with teachers and colleagues will be assessed in practical classes.
Assessment metrics	Attribution of a final grade
Criteria of	The grade goes from 1 (minimum) up to 10 (maximum). The minimum threshold to pass is 6. To

attribution of the final grade	pass the exam students should obtain the minimum evaluation in all the assessments. The final grade will be determined according to the following rules: - Final term written test: 50% - Oral examination: 50%
Preparatory course units	N.A.
Educational material of reference	F. Fahy “Engineering Acoustics”, MARUEEB Lecture Notes

MASTER IN ENERGY EFFICIENT BUILDINGS

Characteristics of the Graduation Exam

Workload	*24 ECTS (600 hours)*
Requirements to be fulfilled by the final work	The graduation exam consists in the defence of a thesis work developed under the supervision of one of the professor of the Master Course in Energy Efficiency Buildings. All the disciplines are eligible for the development of the master thesis. A commission composed by five professors of the master course will examine the candidate, who presents its work in 20 minutes. Utilization of digital presentations, project prototypes, etc. is admitted. The commission asks question to the candidate after the presentation of its work.
Criteria for the attribution of the graduation grade	The final mark is attributed in the following way: - 70% on the basis of its previous carrier (i.e. based on the valuation obtained in each single module of the master course) - 30% on the basis of presentation and defence of the thesis work. The valuation focuses on: scientific quality of the thesis, capacity to present it and quality of the answers to the questions of the commission. The minimum mark to pass the graduation exam is 60 the maximum is 100.

MASTER IN ENERGY EFFICIENT BUILDINGS

Teaching Staff - Academic Year 2017-18

Lecturer	Qualification *	Course units of the SP	Course units of other SP
Vincenzo Bianco	*AP*	*Heat Transfer*	*Fundamental Thermodynamics*
Vladimir Alekhin	*FP*	*Advanced Thermodynamics*	*n.a.*
Angelo Musaio	*PR*	*Project Management*	*n.a.*
Irina Maltseva	*AP*	*Computer Aided Design*	*Architecture Design*
Aleksander Noskov	*CP*	*Thermofluidynamic Measurements*	*Fluid Mechanics*
Marina Shitikova	*FP*	*Finance for Engineers*	*n.a.*
Elena Mishenko	*L*	*Buildings Physics*	*n.a.*
Elena Rodina	*L*	*HVAC Systems*	*n.a.*
Alina Minea	*AP*	*Buildings Simulation*	*Fundamentals of Heat Tranfer*
Alfredo Squarzoni	*CP*	*Energy Economics*	*n.a.*
Nickolai Vatin	*FP*	*Heat Pumps and Refrigeration Systems*	*n.a.*
Ruben Aghgashyan	*FP*	*Renewable Energy Systems*	*n.a.*
Pavel Monastyrev	*AP*	*Energy Audit and Certification*	*n.a.*
Dmitrii Ulrikh	*AP*	*Acoustics*	*n.a.*

* FP: Full Professor; AP: Associate Professor; CP: Contract Professor; L: Lecturer; PR: Professional.

DEPARTMENT OF CIVIL ENGINEERING

Laboratories

Laboratory	Didactic Equipment	Work places / N. students per work place	Technical Staff
Thermodynamics and Heat Mass Transfer	*Infrared camera, thermocouples, viscometer, hygrometer, thermometers, anemometers, LabVIEW software, data acquisition systems*	*30 / 2*	*1 technician (9.00-13.00 14.00-18.00)*
Heating Systems	*Demonstration pilot of a thermosiphon, of a boiler, of a heating system, of a heat pump*	*6 / 4*	*1 technician (9.00-13.00 14.00-18.00)*
Buildings Simulation	*TRNSYS, EES, EnergyPLUS, Ansys-FLUENT, computer cluster*	*40/ 1*	*1 technician (9.00-13.00 14.00-18.00)*

DEPARTMENT OF CIVIL ENGINEERING

Library

Library of the Department of Civil Engineering	
Bibliographical material of interest for the didactic activities of the Master	*Yunus A. Cengel "Heat Transfer", M.J. Moran, H.N. Shapiro "Fundamentals of Engineering Thermodynamics", R.K. Wysocki "Effective Project Management", T.W. Lee "Thermal and flow measurments", Brealey, Richard A., Myers, Stewart C., Marcus, Alan J. "Fundamentals of corporate finance", Watson and Labs, "Climatic Building Design", etc.*
Web Connections	*Free wifi available*
Services offered	*Books consultation, books borrowing, Web of Science, Scopus*
Opening time and access rules	*9.00-13.00 and 14.00-18.00 Mon-Fri with the badge of the university*
Librarian staff available	*9.00-13.00 and 14.00-18.00*

MASTER IN ENERGY EFFICIENT BUILDINGS

Partnerships for carrying out training periods outside the University

Organization / Institution
ARUP and Partners
AMEC Foster & Wheelers
SAIPEM
Technip
Veolia

MASTER IN ENERGY EFFICIENT BUILDINGS

Partnerships for carrying out mobility periods

Institution
University of Genoa
Technical University of Kaunas
University of Campania “L. Vanvitelli”
Technical University of Iasi