Course Title	Analysis of power generation technologies				
Course Code	ME410				
Course Type	Compulsory				
Level	BSc (Level 1)				
Year / Semester	4th/Spring				
Teacher's Name	Dr. Charalambos Chasos				
ECTS	6	Lectures / week	3	Laboratories/week	0
Course Purpose	The course purpose is to educate students in the synthesis, operation and analysis of various power generation technologies. Furthermore, the course aims to teach the students how to calculate the thermodynamic and fluid properties of the working media in thermal engines and turbomachinery which compose conventional and alternative power generation technologies, in order to evaluate their performance. In addition, the course prepares the students in order to select state-of-the-art analysis methods for the assessment of large scale power plants and to investigate the effect of various operating conditions and technical parameters on the plant performance. The present course belongs in the BSc. in Mechanical Engineering programme and provides advanced theoretical and analytical knowledge for power generation technologies, which is required for mechanical engineers.				
Learning Outcomes	By the completion of the course, the students should be able to: 1. List the different types of thermal power plants, their main components and the fuel types which are used. 2. Describe the combustion processes and heat transfer phenomena taking place in combustion chambers and boilers, and the resulting gas emissions, and list emissions reduction technologies. 3. Apply equations for the calculation of thermodynamic and fluid flow properties for the basic processes in gas turbines, steam turbines, combined cycle power plants, and nuclear power plants. 4. Calculate thermodynamic data, construct graphs of thermodynamic cycles and carry out energy balance of various types of gas turbines, steam turbines, combined-cycle power plants and internal combustion engines for power generation. 5. Assess the performance characteristics of thermal power plants, nuclear power plants, hydrodynamic power plants and wind power plants. 6. Select methodologies for the analysis of thermal power plants and combined solar-thermal power plants and specify their basic components configuration requirements. 7. Name the distributed power generation systems and describe energy storage technologies.				

	8. Explain power plants specifications and requirements and select appropriate state-of-the-art power generation systems from known manufacturers.		
Prerequisites	ME200, ME202	Corequisites	None
Course Content	**Introductory aspects for power generation:** Thermodynamics principles and laws, combustion theory and emissions production, heat transfer phenomena. Fuel types (Heavy fuel oil, Diesel, Coal, Natural Gas). Renewable Energy Sources and technologies. **Thermal power plants:** Components and different types of gas turbines (closed circuit, open circuit). For different types, various flow processes phenomena. Flow processes in the gas turbine components. Components and different types of steam turbines (superheat, reheat, regenerative and supercritical cycles). For different types, various flow processes phenomena. Flow processes in the steam turbine components. Components and types of the combined-cycle power plants. For different types, various flow processes phenomena. Flow processes in the components of combined-cycle power plants. Different types of Internal Combustion Engines for power generation. For different types, various flow processes phenomena. Nuclear power plants, types of nuclear reactors, nuclear fusion and environmental considerations. **Power plants utilising renewable energy sources**: Different types of hydraulic machines and construction of the machinery, aspects of their operation, including head, discharge, power, efficiency and cavitation factors. Different types of wind turbines, wind sites, wind capacity and off-shore wind technology. Aspects of wind turbines performance and efficiency. Solar/thermal power plants including solar fields utilising parabolic trough and power tower technologies employed in gas turbine, steam turbine and combined-cycle hybrid power plants. Overall efficiency of plants, heat storage systems and direct steam generation technologies. **Thermodynamics analysis of thermal engines:** Thermodynamic cycles (Rankine Cycle, Brayton Cycle). Basic processes in gas turbines (atmospheric air characteristics, compression, combustion and expansion). Performance analysis of gas turbines, using simple analysis of an open-circuit gas turbine. Basic processes in boilers/steam generators and steam turbines (combustion, heat transfer, steam production, expansion and condensation), boilers types. Performance analysis of steam turbines, using simple analysis of superheat, reheat and regenerative steam turbine power plants. Basic processes in the combined-cycle power plants. Performance analysis of a combined-cycle plant, using an open-circuit gas turbine, an interconnecting heat exchanger and a superheat steam turbine. Basic processes in the reciprocating Internal Combustion Engines and performance analysis of a high power output Diesel engines and combined configuration with steam cycle. **Energy balance analysis and performance characteristics of thermal power plants:** Conservation of mass and energy for control volume. Steady state and transient state analyses of control volumes. Energy balance and calculation of the thermal efficiency of gas turbine, steam turbine and combined-cycle. Pressure drops in the various components of power plants and effects. Improvement of performance via technical		

	and operation modifications and quantify the associated effects on performance. Synthesis of modifications related with heat exchangers, reheat cycles and other developments. **Other aspects of power generation technologies:** Distributed power generation. Energy storage technologies. Environmental pollution, emissions reduction technologies, carbon dioxide capture and storage technologies. Environmental legislation and imposed penalties on pollutant emissions. **Assignment:** Individual assignment performed following the thermal power plant energy analysis and the various component selection and design/layout of plant, for a combined-cycle power plant of high power output.
Teaching Methodology	The course is delivered to the students by means of lectures, exercises solution on the whiteboard, conducted with the help of computer presentations, as well as demonstrations of various power generation systems and components from known manufacturers. Planned visits at local power plants for demonstration of different types of gas turbines, steam turbines, combined-cycle power plants and internal combustion engines. Lecture notes and presentations are available through the E-learn site of the course for students to use in combination with the textbooks and references.
Bibliography	**(a) <u>Textbooks:</u>** 1. Breeze, P. "Power Generation Technologies". Elsevier, 2005. 2. Rolf Kehlhofer, Rolf Bachmann, Henrik Nielsen. Combined Cycle Gas & Steam Turbine Power Plants. 2nd edition. Penn Well Publishers, USA,1999. **(b) <u>References:</u>** 1. H. I. H. Saravanamuttoo, G. F. C. Rogers, Henry Cohen. "Gas Turbine Theory". Prentice Hall, 5th edition, 2001. 2. Poullikkas, A. "Introduction to power generation technologies". Nova Science Publications. 2010. 3. Johansson, B. T., Kelly, H., Reddy A. K. N. and Williams, R. H. E. C "Renewable Energy: Sources for Fuels and Electricity". London: Earthscan Publications, 1993. 4. Lamarsh, J. R. and Baratta, A. J. "Introduction to nuclear engineering". Prentice Hall Publications. Third Edition, 2001. 5. Moran, M. J. and Shapiro, H. W. "Fundamentals of Engineering Thermodynamics". 6th Edition, John Wiley and Sons. 2008. 6. Turns S. R. "An introduction to combustion, concepts and applications". 3rd Edition, McGraw Hill, 2012.
Assessment	**<u>(a) Methods:</u>** • Assignment 20% • Mid-term examination 20% • Final Exam 60% **<u>(b) Criteria:</u>** • The assessment criteria are included in the edited document of the assignment. In particular, the clarity of the content and writing, the

	structure, the definition of specifications of plant, the quality of diagrams, graphs, tables illustration and data calculation and analysis, the discussion and conclusions are assessed. • The mid-term exam is done during the seventh week of the semester, which assesses the students' performance on the subject matter taught during the first six weeks of the semester. Two questions ask for system diagrams, thermodynamic graphs and calculations which are assessed on the correctness, clarity, results and units used. • The final exam includes four questions (theoretical and analytical) and assesses students on the subject matter of the course and their ability to describe power generation technologies, to draw diagrams and graphs, carry out calculations of performance data and compare and discuss the results.
Language	English