CARLETON UNIVERSITY
Department of Mechanical and Aerospace Engineering

Course Outline, Fall 2016

Lecturs:	**MECH 4403: Power Generation Systems,**
	Tuesday & Thursday 4:05 PM to 5:25 PM, 446 TB
Labs:	**SREE 4001: Efficient Energy Conversion, 378 UC**
	Friday 8:35 AM to 11:25 AM

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Calendar Statement

Steam generators, solid, liquid, gaseous and biofuels and cycles. Geothermal, solar powerplants. Energy storage. Environmental aspects of power generation. Industrial use and auto-generation of energy. Energy intensity and efficiency of industrial processes and products. Comparative analysis of raw material, energy, or product transport. Life-cycle analysis of alternatives.
Prerequisite(s): SREE 3002 and SREE 3003. Lectures three hours per week, laboratories/problem analysis three hours per week.

Learning objectives
In this course, students will be expected to
• Identify power systems and their components
• Determine the necessary design requirements and constraints of a power system
• Develop and refine conceptual systems designs to satisfy a given design problem
• Analyze the design economics and value of a design
• Apply design methodologies for individual components of a power system
• Design and simulate a complete power system for a given location

Learning outcomes
By the end of this course, students will be able to
• Classify power systems and their individual components
• Formulate the design requirements and constraints of a power system
• Apply an appropriate set of assumptions with justification to produce conceptual designs
• Analyze a real power system to find its design economics and value
• Assess potential improvements to individual components of a power system
• Design a complete power system subject to realistic requirements and constraints

Additional notes to the course:

MECH 4403 / SREE 4001 is a compulsory course with a three hour lab section that has a primary focus on engineering design of power systems with the incorporation of various sources and storage technologies. Further, this course culminates the SREE sequence of courses by utilizing the knowledge and analysis techniques shown in ENVE 2001, MAAE 2400, MAAE 2300, SREE 3001, SREE 3002, SREE 3003, and MAAE 3400. The expectation is that students are familiar with the content in these courses, and any other preceding engineering course. If you are uncomfortable with past course content, it is highly recommended that you review your notes from the relevant courses.
The course examines the design approaches for efficient energy conversion in large scale power systems. This means that the entire energy conversion chain is examined and the corresponding technical implementations that are responsible for the energy conversion. We begin with the sources such as fluid flows and thermal sources through to conversion into electricity then the distribution of the electricity for end users. In previous courses you have seen some of the relevant technology in isolation, here you will see how this technology is actually used and the design requirements and constraints that exist. Given the focus on design, you will receive many case studies to consider with the last set of case studies appearing on the final exam.
Be aware, design case studies are inherently open-ended and have multiple correct answers. The justification of the answers is where engineering knowledge and judgment is demonstrated.

Outlines:

<u>Section 1 : Course introduction (1 lecture)</u>

- Review of current Ontario, Canadian, and World electric power generation options. Discussion of emerging alternatives. Overview of challenges and opportunities of each option.
- Review of operation and management of electric power system to place power generation options in context.

<u>Section 2 : Review of thermodynamic principles and analysis of cycles (~3 lectures)</u>

- Methods for analyzing Rankine cycles including multi-stage expansion, regeneration, reheat.
- Methods for analyzing simple Brayton cycles for combustion turbines using ideal air standard analysis, including inter-cooling, regeneration, multi-stage expansion.
- Combustion stoichiometry, heating values, efficiency, emissions, and environmental considerations.

Section 3 : Analysis and design of efficient Rankine power cycles for electric power production from fossil-fuel and nuclear sources (~4 lectures)

- Overview of boiler design and heat transfer analysis methods.
- Review of process models for realistic coal-fired, oil-fired, and nuclear power plants.
- Design considerations for supercritical steam cycles.
- Overview of carbon capture and storage options and energy implications.

Section 4 : Analysis and design of efficient natural-gas-fired combustion turbines and combined Brayton-Rankine cycles for electric power production (~3 lectures)

- Examine limitations of ideal air standard analysis method. Introduction of methods for analyzing Brayton cycles using real-gas properties.
- Review of process models for realistic simple cycle and combined cycle power plants.

Section 5 : Power generation from low-temperature sources (~8 lectures)

- Geothermal, solar thermal, and waste-heat thermal sources.
- Solar radiation and heat transfer and thermodynamic analysis of solar thermal collectors.
- Working fluid options and cycle options for organic Rankine cycles.
- Transient operation with non-dispatchable thermal sources and options for thermal storage.

Section 6 : Power generation with fuel cells (~6 lectures)

- Overview of fuel cell technologies, operational characteristics, and design of fuel cell power generation systems.
- Introduction to electrochemistry of fuel cells.
- Introduction to fuel cell thermodynamics.
- Performance characteristics and system efficiencies.
- Description of proton exchange membrane and solid-oxide fuel cells.
- Design and operation of fuel cell systems and applications.
- Thermodynamic analysis of stationary fuel-cell power plants.
- Thermodynamic analysis of combined heat and power fuel-cell power plants.

Labs:
There will experimental labs related to hydro power, thermal and solar energy. Students will work in groups of 4 students to complete the lab requirements.

Course Design Projects:

The purpose of the design projects are to apply the material covered in the lectures, discussions, and textbooks to design and build a small scale power plant. The project groups should be the same as the lab groups of 4 students.

Evaluations

The course evaluations and their percentage weight toward your final grade are: Lab reports 10%, Design reports 40%, Final exam 50%.