UN 0502
Nuclear Power Plant Systems and Operation

NOTE: Course delivery specific information such as course time, location, etc. can be found on the UNENE website www.unene.ca

Instructor

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Study Materials

A coursepack is available for the course which includes the course material and the CANDU-9 simulator used in the class. The coursepack will be given out at the first class, without cost, to students who are *formally registered* in the course. Students who later drop the course by the drop-and-add date will be required to return the coursepack or pay for it.

Coursepack Information:

Title: Introduction to CANDU Systems and Operation (with CANDU-9 simulator on DVD)

Author: George Bereznai

Additional reading (Reference Books and Information Resources):

- Resource book & reference text are on the DVD.
- Additional materials: Presentations and discussions during lectures.

Lecture/Course Delivery

Usually the course is taught over weekends either out of the Durham College Whitby or Ontario Tech campus locations. Live attendance is normally expected. For the 2021 delivery, given the pandemic situation, we shall be offering this course virtually using Webex software. The lecture delivery shall be synchronous with the dates selected for the course. The lectures will include presentations by the instructors and time for performance of the simulator exercises. The midterm and final exam will also be conducted through Webex.

For formally registered students, the following requirements are expected for conducting the course:

- All students shall attend and participate in at least 75% of the lectures and will write both the midterm and final exam. Missing more than 25% of the course requires approval of the instructor for successful completion based on justification of the absence.

- Synchronous learning and participation is expected.
- Participation includes open discussion during the class time about the simulator exercises and the topics under discussion.
- Difficulty attending a class will be communicated to the professor at least 3 days in advance of the class that kay be missed.
- Assignments/simulation exercises will be completed as per schedule to keep all students at the same level in the class
- Students will have acceptable internet connection with a good microphone and speaker/headset and make the effort to be familiar with the communication software.

Note: If class size is insufficient such that the course is delivered in a reading course mode, then the expectations for course delivery become:

- Students will attend orientation sessions of the course to achieve direction for completion the simulations and conducting the reading.
- Simulations and reading of course material will be conducted on the students own time.
- Students will attend scheduled review sessions to ensure the simulation exercises have been absorbed properly and that the material is correctly understood.
- Students will attend scheduled exam preparation meeting.
- Students will attend the midterm and final exam.
- Students may send messages to the instructor between meeting dates requesting guidance but may have to wait for the next scheduled meeting for feedback. As such students will be encouraged to work ahead of the class schedule and use the review sessions as part of a collaborative study.

Course Evaluation

Every lecture, assignments will be scheduled. Some will be performed in class, others assigned to be completed before the next lecture. It is possible to perform the assignments ahead of time as they involve the use of the simulator. Assignments handed in late may be penalized.

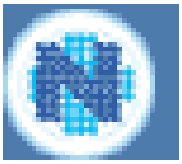
Student discussions and active participation during lectures are important and very much encouraged.

Marking Scheme – for registered students

Category	
Assignment	25%
Midterm (1)	30%
Final	45%

Course Description

The course is organized into chapters and modules. Each chapter encompasses a major portion of a CANDU Nuclear Power Plant, and each module covers a system or a group of functionally related systems. Note, other technologies may be discussed throughout the course.



The role and relation of the systems discussed in a module to the overall generating unit is introduced and related to the rest of the course with the aid of the "Course Map" shown on the diagram.

In Chapter 1 we look at the Overall Nuclear Electric Generating Unit as an entity. I am using the yellow background in the diagram to illustrate what is meant by the term Overall Unit: it is the complete physical plant that is involved in having the energy in the nuclear fuel converted through various processes to electrical energy. This chapter concentrates on the main building blocks that make up an operating unit and the interactions between these blocks.

Each of the subsequent chapters will look at the main systems and groups of systems of the overall unit.

In the second chapter we look at the main components of the reactor and of the moderator systems. We will see in some detail how the natural uranium fuel is held in the fuel channels and how it is cooled by the heavy water of the heat transport system. We will also look at the types of devices used to control the nuclear reaction.

Chapter 2 also has a module on the moderator heavy water system, and we will see the importance and safety benefits of having a moderator system that is separate from the reactor coolant system.

Chapter 3 deals with the Reactor Regulating System. The first module deals with the instruments and techniques used to measure the power produced by the reactor. The second module explains the control algorithms that compare the power measurements with the desired power level, and alter the neutron absorption characteristics of the control devices to change the power output of the reactor.

Using the simulator, you will perform several reactor operations under both normal and malfunction conditions, and gain a good appreciation of the rate and magnitude of power level changes, and the mechanisms through which the regulating system control reactor power.

Chapter 4 is about the Heat Transport System, which in CANDUs uses heavy water to transfer the energy released by the nuclear fuel in the reactor to generate steam to drive the turbine and generator. One module describes the key features of the Main Circuit, including the steam generators and the circulating pumps. The second module is about how the pressure and inventory of heavy water is controlled in the heat transport system. It is quite a complex system, and it is shown is sufficient detail on the simulator to let you do some interesting exercises under normal as well as several malfunction conditions.

Chapter 5 is about the systems that are often referred to collectively as the Balance of Plant: the steam, turbine and feedwater systems. Important control systems are associated with these, including the steam generator pressure and level control systems and the turbine control system. On the simulator a variety of malfunction involving each of the above systems will be dealt with.

The concluding section of the course covers a representative set of malfunctions that impact on the overall unit operation of a CANDU 9 Simulator. Students will be expected to be able identify the malfunction and perform corrective Actions to ensure safety criteria.

Learning Outcomes

At the successful completion of this course the participants will be able to:

- Identify and describe the key criteria for the safe operation of a nuclear power plant

- Describe and explain the overall control schemes used in nuclear power plants
- Describe and explain the design and main functions of Reactor Structures and the Moderator System
- Describe and explain the design and operation of the Primary Heat Transport System and Associated Controls
- Describe and explain the design and operation of the Steam Systems, the Turbine and Feed-Water System and Associated Controls
- With the aid of a nuclear plant simulator, perform Major Transient Operations and explain the significance to design
- With the aid of a nuclear plant simulator correctly diagnose malfunctions, identify and describe corrective operator actions and impact on design

Academic Integrity

Please see the UNENE website (https://unene.ca/education/academic-policy) regarding Academic Integrity for more details.

Academic misconduct includes, but is not limited to: Cheating on examinations, assignments, reports, or other work used to evaluate student performance. Cheating includes copying from another student's work or allowing one's own work to be copied, submitting another person's work as one's own, fabrication of data, consultation with an unauthorized person during an examination, or use of unauthorized aids. Penalties for academic misconduct include failing the course and/or ejection from the UNENE GDip or UNENE M.Eng.