UNIVERSITY OF NEW BRUNSWICK

DEPARTMENT OF CHEMICAL ENGINEERING

UNENE COURSE

UN 702

POWER PLANT THERMODYNAMICS

2009

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POWER PLANT THERMODYNAMICS

COURSE OUTLINE

MODULE 1: *THERMODYNAMIC CYCLES*

Nuclear versus Conventional Steam Cycles
Regenerative Feedwater Heating
Moisture Separation and Reheating
Turbine Expansion Lines
Heat Balance Diagrams
Available Energy
Cycle Efficiency and Exergy Analysis

MODULE 2: *NUCLEAR HEAT REMOVAL*

Heat Conduction and Convection in Fuel Rods and Heat Exchanger Tubes
Heat Transfer in Boilers and Condensers
Boiler Influence on Heat Transport System
Boiler Swelling and Shrinking
Boiler Level Control
Condenser Performance

MODULE 3: *STEAM TURBINE OPERATION*

Turbine Configuration
Impulse and Reaction Blading
Blade Velocity Diagrams
Turbine Seals and Sealing Systems
Moisture in Turbines
Part Load Operation
Back Pressure Effects
Thermal Effects and Turbine Governing

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GRADING GUIDELINES

EVALUATION

FIRST ASSIGNMENT	20%	
SECOND ASSIGNMENT	20%	
FINAL EXAMINATION	60%	(3 hours)

The final examination is closed book with selected notes and tables supplied.

GRADING

A+	**above 90%**
A	**above 85%**
A-	**above 80%**
B+	**above 75%**
B	**above 70%**

Students must meet minimum standards as required by the institution at which they are registered.

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SCHEDULE

MODULE 1: THERMODYNAMIC CYCLES

4 April 2009 Plant Efficiency
5 April 2009 Exergy Analysis

MODULE 2: NUCLEAR HEAT REMOVAL

25 April 2009 Heat Transfer
26 April 2009 Boiler and Condensers

MODULE 3: STEAM TURBINE OPERATION

9 May 2009 Velocity Diagrams
10 May 2009 Turbine Operation

FINAL EXAMINATION

23 May 2005 Whole Course

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ASSIGNED WORK

There will be two blocks of assigned work following and based on Module 1 and Module 2. The assigned work will be to obtain real plant data from one of the plants for a particular component, to develop a new question (similar to a full 15 mark questions in the question bank) and to provide a complete solution to the question.

MODULE 1 ASSIGNMENT: EXERGY ANALYSIS

For a specified heat exchange component in the steam cycle (boiler, reheater, condenser, feedheater, etc.) list all specified data, determine flow rates, calculate thermal efficiency, determine effectiveness of available energy transfer and comment on the results. Complete solutions and explanations of method and assumptions made must be submitted. Due 24 April 2009.

MODULE 2 ASSIGNMENT: HEAT TRANSFER

For a specified heat exchanger component in the steam cycle (boiler, reheater, condenser, feedheater, etc.) list all specified data, determine flow rates, calculate heat transfer coefficients and determine the rate of heat exchange. Compare the calculated rate of heat exchange with the specified value and comment on and explain any discrepancies. Complete solutions and explanations of method and assumptions made must be submitted. Due 8 May 2009.

Note: All work must be entirely independent. Students may not use the same component in a particular plant for their analysis as any other student nor may they use a

component known to have been previously analysed in this course.

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FINAL EXAMINATION

The final examination will be based on the Question Bank, that is, the same or very similar questions will be set. The Question Bank sets the standard for the course with regard to breadth and depth of material. However, since the Question Bank is an evolving document, new questions are possible particularly with regard to descriptive material from the Course Notes.

The final examination will be structured as follows:

Descriptive Section: Three Questions of 15 marks each. Do any Two Questions (30 marks)

Calculative Section: Three Questions of 15 marks each. Do any Two Questions (30 marks)

The total is thus Four Questions (60 marks) and the nominal time allowed is three hours though some extra time is usually permitted.

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QUESTION BANK

The Questions Bank contains problems similar to those that will be set in the final examination. New problems are created each year and some modified for examination purposes. Past examination questions are identified by a date and the mark value for these questions is given. Generally a full hand written page of a descriptive answer or a full page of detailed calculations is worth 5 marks. Hence three pages are required for 15 marks. This is a senior course and students are expected to have developed the required direction and motivation to be able to work on their own. Students are expected to work from the Question Bank on an ongoing basis. Where possible answers will be given to the problems and students are required to work on their own, using the printed notes as reference, towards these answers.

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COURSE NOTES

The course notes consist of selected Articles from the UNESCO sponsored Encyclopedia of Life Support Systems (EOLSS). These articles were based on the instructor's course material for parts of senior level courses at UNB so are uniquely relevant for this course. Some material came originally from the operators and shift supervisor training course for CANDU nuclear operators.

MODULE 1 THERMODYNAMIC CYCLES

Article 3.10.1.4 Thermodynamic Theory
Article 3.10.1.5 Power Plant Steam Cycle Theory
Article 3.10.1.6 Exergy Analysis

MODULE 2 NUCLEAR HEAT REMOVAL

Article 3.10.1.3 Thermal Fluid Theory
Article 3.10.2.9 Nuclear Reactor Heat Removal
Article 3.10.2.10 Nuclear Reactor Steam Generation

MODULE 3 STEAM TURBINE OPERATION

Article 3.10.3.2 Steam Turbine Impulse and Reaction Blading
Article 3.10.3.3 Steam Turbine Components and Systems
Article 3.10.3.4 Steam Turbine Steam System
Article 3.10.3.5 Steam Turbine Operational Aspects

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COURSE PREREQUISITES

The course is based on the practical applications (with respect to nuclear power plants) of the following engineering disciplines:

- **Thermodynamics (Module 1)**
- **Heat Transfer (Module 2)**
- **Fluid Mechanics (Module 3)**

Students therefore must have a good knowledge of thermodynamic principles (heat and energy, steam tables, T-s and h-s diagrams) a basic knowledge of fluid mechanics (energy and momentum) and some understanding of heat transfer (conduction and convection).

The Thermo Primer provides the required background for this course and a sound working knowledge of the material in it is necessary for success in this course.