NE 400/500  Nuclear Reactor Energy Conversion  Spring 2017

COURSE INFORMATION
1. **Instructor:** Dr. Igor A. Bolotnov
   2142 Burlington Engineering Laboratories
   e-mail (typical response within 12 hours): igor_bolotnov@ncsu.edu
   
   **Office hours (2142 BEL):** Thursday: 12:30pm – 2:30pm

   or by appointment

   EOL students’ call-in hour (518)542-8939: Tuesday: 3:30pm – 4:30pm (or arrange other time via e-mail)

2. **Teaching Assistants:**
   a. Course assistants:

   **Sandesh Bhaskar** (sbhaska2@ncsu.edu); Office hours: TBD in TBD BEL or by appointment.

   **Brayden Myers** (bgmyers3@ncsu.edu); Office hours: TBD in TBD or by appointment.

   b. Lab assistant:

   **Botros Hanna** (bnhannab@ncsu.edu); Office hours: Tue/Thu 1:30-2:30 pm in 2137 BEL or by appointment.

3. **Schedule:**
   a. Class: Monday, Wednesday 8:30am – 9:45am. Location: 327 Daniels
   b. Labs: by appointment with the Lab assistant
   c. Possible make-up classes: Friday 8:30am – 9:45am. Location: TBA
   d. Online **class evaluations** will be available for students to complete during the last 2 weeks of the semester then become unavailable at 8am on the first day of finals:

   8am April 17th, 2017 through 8am May 1st, 2017

   Students will receive an email message directing them to a website where they can login using their Unity ID and complete evaluations. All evaluations are confidential; instructors will not know how any one student responded to any question, and students will not know the ratings for any instructors.

   Evaluation website: [http://go.ncsu.edu/cesurvey](http://go.ncsu.edu/cesurvey)

4. **Prerequisites:**
   a. MAE 301 “Engineering Thermodynamics I”
   b. and a “C-” or better in NE 301 “Fundamentals of Nuclear Engineering”

   EOL students: contact the instructor if you don’t have the exact pre-req. courses to discuss your background

5. **Test Schedule** *(no lectures on the days of Tests)*

<table>
<thead>
<tr>
<th>Exam</th>
<th>On-campus students</th>
<th>EOL students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test #1</td>
<td>Wednesday, February 22, 2017: 6:00pm – 8:30pm (1202 BU)</td>
<td>02/22/17 – 02/23/17</td>
</tr>
<tr>
<td>Test #2</td>
<td>Wednesday, April 12, 2017: 6:00pm – 8:30pm (1202 BU)</td>
<td>04/12/17 – 04/13/17</td>
</tr>
<tr>
<td><strong>Final:</strong></td>
<td>Monday, May 8, 2017: 8am to 11am (327 Daniels)</td>
<td>05/08/17 – 05/09/17</td>
</tr>
</tbody>
</table>

   ([http://www.ncsu.edu/registrar/calendars/examsprg.html](http://www.ncsu.edu/registrar/calendars/examsprg.html)).

6. **Homework:** Homework will be assigned periodically throughout the semester. The last homework assignment may be due during the last week of classes. **EOL students:** please submit your homework to the EOL office.
**Late Assignments:** Unless stated otherwise, assignments are due at the beginning of class on the designated due date. Assignments turned in within 24 hours of this time are considered LATE and will be assessed a 25% penalty. Assignments turned in after 24 hours will be marked and returned to the student, but no credit will be assigned. To allow for unforeseen circumstances, students are granted a one time exemption if an assignment is turned in by 5:00 PM on the designated due date. Exceptions to this policy may be granted for documented medical or family emergencies.

7. **Attendance:** Required; Active class participation is strongly encouraged. University policy on definition of excused absences: [http://policies.ncsu.edu/regulation/reg-02-20-3](http://policies.ncsu.edu/regulation/reg-02-20-3)

8. **Text and Selected References**
   
   **Required text:**
   
   **Recommended texts:**
   
   
   **Other References:**
   4) Holman, *Heat Transfer*
   5) Hornbeck, *Numerical Methods*
   6) Carnahan, Luther and Wilkes; *Applied Numerical Methods*
   7) Tong and Weisman, *Thermal Analysis of Pressurized Water Reactors, 2nd Ed.*
   8) Lahey and Moody, *The Thermal-Hydraulics of a Boiling Water Nuclear Reactor*
   9) Rust, *Nuclear Power Plant Engineering*

9. **Grading:**

<table>
<thead>
<tr>
<th>NE-400</th>
<th>NE-500 (including EOL)</th>
<th>NE400/500 ABM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classwork</td>
<td>3 %</td>
<td>Classwork</td>
</tr>
<tr>
<td>Tests (2)</td>
<td>30 %</td>
<td>Tests (2)</td>
</tr>
<tr>
<td>Homework</td>
<td>18 %</td>
<td>Homework</td>
</tr>
<tr>
<td>Lab</td>
<td>25 %</td>
<td>Project</td>
</tr>
<tr>
<td>Final</td>
<td>24 %</td>
<td>Final</td>
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<td>3 %</td>
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<td>30 %</td>
<td>24 %</td>
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<td>20 %</td>
<td>14 %</td>
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<td>25 %</td>
<td>15 %</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 %</td>
</tr>
</tbody>
</table>

- A+ ≥ 96%
- A 92 – 95%
- A- 89 – 91%
- B+ 86 – 88%
- B 82 – 85%
- B- 79 – 81%
- C+ 76 – 78%
- C 72 – 75%
- C- 69 – 71%
- D+ 65 – 68%
- D 61 – 64%
- D- 56 – 60%
- F < 56%

* Must be top 5% student in the class as well to earn the “A+”.

10. **Academic Integrity:**
   a. University policy on academic integrity: [Code of Student Conduct Policy (POL11.35.1)](http://policies.ncsu.edu/policy/pol-11-35-1)
   b. By signing your name on either test or homework for this course every student implies the following statement: "I have neither given nor received unauthorized aid on this test or assignment"
c. Absolutely no collaboration is permitted during the tests. All the tests are closed book.
d. Each homework assignment must be completely your own. Zero grade will be assigned for particular homework for the first offence. Second offense will be reported to the Office of Student Conduct

11. **Students with Disabilities:** Reasonable accommodations will be made for students with verifiable disabilities. To take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 515-7653. For more information on NC State’s policy on working with students with disabilities, please see the [Academic Accommodations for Students with Disabilities Regulation (REG02.20.1)](http://policies.ncsu.edu/regulation/reg-02-20-1).

12. **No Electronic devices in class:** Cell phones are to be turned OFF prior to entering the class room. No exceptions. Use of laptops/other electronic devices during class is prohibited.

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**COURSE TOPICS**

1. **Thermodynamic Cycles (8 lectures)**
   - 1.1 Carnot cycle (L1)
   - 1.2 Rankine cycle (L2)
     - 1.2.1 Reheat cycle (L3)
     - 1.2.2 Regenerative cycle (L4)
   - 1.2.3. Actual vs. Ideal Cycles (L5)
   - 1.2.4. Advanced examples (L6)
   - 1.3 Brayton Cycle (L7)
     - 1.3.1. Modified Brayton Cycle (L8)
   - 1.4. Reactor systems examples (L8)

2. **Heat Conduction in Reactor Elements (4 lectures)**
   - 2.1 Fundamentals of conduction (L1)
   - 2.2 Heat conduction equations (L1)
   - 2.3 One-dimensional steady-state conduction (L2)
   - 2.4 Temperature distributions in fuel elements (L3)
     - 2.4.1. Effects of gap and variable conductivity (L4)

3. **Convective Heat Transfer in Reactor Systems (3 lectures)**
   - 3.1 Reactor coolant characteristics (L1)
   - 3.2 Axial fluid temperature profiles (L1)
   - 3.3 Forced convective heat transfer correlations (L2)
     - 3.3.1 Pipe and tube flow
     - 3.3.2 Non-circular passages
     - 3.3.3 Flow across tube banks
     - 3.3.4 Flow parallel to rod bundles
   - 3.4. Natural Convection (L3)
   - 3.5. Boiling heat transfer (L3)

4. **Heat Exchangers (3 lectures)**
   - 4.1 Overall heat transfer coefficient (L1)
   - 4.2 Log-Mean Temperature Difference (L2)
   - 4.3 Heat exchangers in reactor systems (L3)

5. **Reactor Heat Sources (7 lectures)**
   - 5.1 Heat generation in reactor fuel elements (L1)
   - 5.2 Heat generation in power reactors (L2)
   - 5.3 Reactor shutdown heat generation (L3,5)
   - 5.4. Heat generation in reactor structure (L4)
   - 5.5 Heat generation by radioisotopes (L4,5)
   - 5.6 Temperature distributions in fuel elements – Non-Uniform heat generation (L6)
   - 5.7 Temperature distributions in thermal shields and pressure vessels (L6)
   - 5.8 Lumped Parameter Models (L7)

6. **Numerical Solutions to the Heat Conduction Equation (2 lectures)**
   - 6.1 Steady-state, multi-dimensional problems (L1)
   - 6.2 Time Dependent Solutions (L2)
COURSE LABS

Lab schedule and workflow:
Each lab (except lab #1) consists of:
a. Before the lab: Students will bring pre-lab homework (answers to several questions posted on Moodle along with the lab handout) and submit them at the beginning of their lab session.
b. Experimental part performed in groups of 5-6 students under the supervision of the lab TA and/or course instructor.
c. Data analysis report which is due to the lab TA according to the schedule below.
d. The report will be graded and returned by the TA according to the schedule below.
e. Final lab report is due according to the schedule.
f. The graded final lab report will be returned to students within a month of lab day (or before the final exam for the last lab).

<table>
<thead>
<tr>
<th>Lab title/number</th>
<th>Lab date(s)</th>
<th>Data analysis due</th>
<th>Graded analysis returned</th>
<th>Final lab report due</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Propagation of errors</td>
<td>01/20/2017</td>
<td>01/25/2017</td>
<td>01/27/2017</td>
<td>n/a</td>
</tr>
</tbody>
</table>

*PULSTAR lab day: all NE400 students (and ABM) must show up at 8am outside the PULSTAR entrance (next to NE library).

- Doodle poll for the NE400/ABM lab times (due 01/13/2017): [http://doodle.com/poll/knh3dwc3fp8vnhyu](http://doodle.com/poll/knh3dwc3fp8vnhyu) (if you choose not to fill out the poll you will be assigned to a random group)
- Each lab (except #1) requires data analysis report (30% of total lab grade) and final report (70% of total lab grade).
- Absence of the pre-lab homework at the beginning of the lab session results in 10% penalty of the lab grade.
- Student absence (w/o prior arrangement) from the assigned lab session results in 50% penalty for the particular lab grade.

COURSE PROJECT (NE500 and ABM only)

- Project guidelines / options / details posted: January 18th.
- Specific topic assigned/chosen by February 15th.
- Progress report due March 20th.
- Final project report due April 26th.
- EOL students: please communicate with the instructor directly (via e-mail or phone) on the project related deliverables and questions.