

Advanced Reactor Concepts

ENU 6937/4930, Section 2C93/2C79, Spring 2018

M 1250-1340 UF “Period” 6 and F 1250-1445, UF “Periods” 6-7

CBD 224

Final Exam: None

(Note: This course is currently taught as a special topics course (ENU 6937 and ENU 4930).

A permanent course number (ENU 6143) has been requested for the graduate-level course. I will use “ENU 6143” to refer to this course, in both sections.)

## 1 Instructor

DuWayne Schubring, Associate Engineer

172 Rhines Hall

352-294-7870

dlschubring@ufl.edu (This is the best way to reach me. The Canvas “conversations” feature *is not* e-mail. Messages sent via that system will not be acknowledged.)

Office hours: M 1415-1600, T 1315-1530, W 1245-1430, via e-mail, and by appointment.

## 2 Course Description

Advanced light-water reactors, gas-cooled reactors, liquid-metal reactors. Thermal modeling, reactor safety, licensing, reactor physics, materials selection, and fuel cycles.

## 3 Prerequisites

(ENU 4134 or ENU 6135) and (ENU 4103 or ENU 6106)

## 4 Course Objectives

1. Provide students with an understanding of advances in light-water reactor (LWR) technology seen in Generation III (Year 2000 and beyond) systems and the ability to discuss and analyze the improvements to reactor safety in these systems
2. Provide students with an understanding of relevant phenomena (thermal, material, neutronic) for novel reactor systems (gas-cooled reactors, liquid-metal reactors, etc.) to make relevant comparisons both among these novel concepts and with existing LWR systems
3. Prepare students to undertake research in the areas of advanced nuclear fission reactor design

## 5 Professional Component (ABET) – Undergraduates Only

n/a – elective course

## 6 Program Outcomes Supported by Course – Undergraduates Only

n/a – elective course

## 7 Textbook

None

## 8 Reference Materials

*Nuclear Systems I: Thermal Hydraulic Fundamentals*, N.E. Todreas and M.S. Kazimi, 2011 (2nd edition). (ISBN: 9781439808870)

*Nuclear Heat Transport*, M. M. El-Wakil, 1978 (1st edition). (ISBN: 0894480146).

*Nuclear Energy Conversion*, M. M. El-Wakil, 1982 (Revised Edition). (ISBN: 0894480154).

*Nuclear Reactor Analysis*, J. J. Duderstadt and L. J. Hamilton, 1976. (ISBN: 0471223638).

References from recent literature will be provided electronically.

## 9 Course Schedule

- Water-cooled Reactors
  - Generation III/III+ PWRs (emphasis on AP1000, secondary emphasis on EPR), focusing on improvements in safety relative to Generation II systems and including construction experience
  - Generation III/III+ BWRs (emphasis on ESBWR), focusing on improvements in safety relative to Generation II systems and including construction experience
  - Heavy water reactors (emphasis on CANDU series)
  - Supercritical water reactors, including thermal-, mixed-, and fast-spectrum designs
- Gas-cooled thermal-spectrum reactors
  - Materials selection and development, with an emphasis on TRISO fuel
  - Core layout, including behavior of pebble beds
  - Nuclear analysis (reactor physics), including burnup and breeding considerations
  - Thermal analysis, including in-core calculations and balance-of-plant (power cycles)
  - Fast-spectrum reactors (emphasis on sodium-cooled reactors)
    - \* Materials selection and development, focusing on fuel forms and cladding materials
    - \* Core layout and nuclear analysis (reactor physics), including burnup and breeding considerations
    - \* Thermal analysis, including in-core calculations and balance-of-plant (power cycles)
    - \* Comparison among coolant options (sodium, lead, LBE, NaK, gas, etc.)

There will be between 2 and 5 hours of lecture and 1 HW for each of the 12 second-level topics listed above. You must complete 9 of these 12 HW. (You may not do all and drop the three lowest.) Homework due dates will be on Wednesday, 1430 (end of office hours) each Wednesday

from January 24 through April 18, excluding March 7. Some HW may require access to export-controlled software. Appropriate accommodations, which may include restrictions on your choice of which HW to drop, will be made.

Your final HW (HW 13) will be a written report evaluating the relative merits of the reactors discussed. This HW will be due at the final class period and cannot be skipped.

## 10 Evaluation of Grades

Your grade is entirely based on the average of your homework scores, which are tabulated as scores out of 10. There are 13 homework assignments in the course. You must complete 10 of these assignments, including 9 of the first 12 and HW 13. You may not do more than 10 assignments and drop the lowest.

- A: 85%+
- A-: 83.5-84.99%
- B+: 82-83.49%
- B: 75-81.99%
- C: 67-74.99%
- E: < 67%

I reserve the right to grant grades more generous than this scale at my discretion at the end of the course, including B- and/or C+ grades. *Under no circumstances will grades of C- or any flavor of D be used.*

Canvas is used to enable you to look up grades quickly. Note that the Canvas gradebook is *not* official. I reserve the right to correct errors, including transcription errors, from the official (spreadsheet) gradebook, to which I alone have access, until finalization of grades with the registrar.

More information on UF grading policy may be found at:

Graduate Students: <http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

Undergraduates: <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

## 11 Attendance and Class Conduct

*Skip at your peril.* Attendance is not considered in the grade. However, some materials in the course will not be covered in the references or in the notes provided online – only in class. Some example problems and complex figures (hard to digitize, easy to make on chalkboard) fall into this category. Students are responsible for these materials.

If a student arrives late or leaves early, he/she is expected to do so with minimum level of disruption to the class in progress. There is no tolerance for mobile phones or other electronic disruptions. Such disruptions will lead to the student being told to leave the room for the duration of the class period. The same principle applies to office hours or appointments – if you stop by my office and your phone rings, you will be told to leave the room for the duration of that day’s office hours (or your appointment considered over).

I reserve the right to take attendance to prioritize e-mail assistance.

## 12 Recording Lectures, etc.

UF grants each student the right to record classes for which they enroll, on the condition that no disruptions are presented to other students or faculty. You are not required to inform me that you are recording these class sessions.

Failures of your recording equipment are *not my problem* – requests to delay the meeting or to repeat myself for the convenience of your recording will not be honored.

Further, you are permitted to record office hour or appointment conversation on ENU 6143 questions. If you wish to record during office hours or appointments, you must inform (not “ask”) me that you will be recording. In this case, note that our conversation must be restricted to the content of this course. If you wish to ask more general questions, such as those relating to academic planning or your future career goals, I will insist that you turn the recording off before I discuss those subjects.

### 13 Make-Up Work Policies

Late-work excuses can be grouped into the categories of *professional*, *medical*, and *personal*.

*Professional:* Reasonable extensions for job/internship interviews, technical conferences, or other professional/career development reasons should be requested. Requests are typically granted, at my discretion, unless they would grant a student or group of students an unfair advantage over their peers, cause significant disruption to the course or grading schedule, or violate some UF policy.

*Medical:* Extensions will also be granted for (your own) medical reasons – please do not come to class if you are ill. Per UF policy, in the case of medical absences that are frequent or suspiciously-timed (*e.g.*; you are repeatedly, suddenly ill at deadlines), I may request a signed note from a physician or similar professional practitioner.

*Personal:* In addition, UF policies require accommodation for several non-academic, non-medical reasons. *Extensions for these personal issues are strictly limited to those mandated by the letter of UF policies.* The list of UF-approved personal reasons changes from time to time. If you have a question regarding your personal issue and if it qualifies under one of the excused absence/late-work policies, contact me in advance.

The 12-day rule will be enforced strictly. Note that the count of days is based on a per-student, not per-approved-activity basis. All requests for excused absence or extension must be submitted in writing, preferably via e-mail.

Pursuant to HWCOE policy, the following statements are required:

1. (Pertains to undergraduate students only) Excused absences are consistent with university policies in the undergraduate catalog  
<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>  
 and require appropriate documentation.
2. (Pertains to graduate students only) Excused absences are consistent with university policies in the graduate catalog  
<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance>  
 and require appropriate documentation.

For the purposes of this course, in the above-referenced list of approved absence reasons, the word “family” shall be taken to mean your parents, grandparents, great-grandparents (etc.); children, grandchildren (etc.); siblings; aunts/uncles; nieces/nephews; your spouse and the spouse of any of the above; and half- or step- “versions” of the above categories. More distant relatives (cousins, etc.), partners (excluding spouses), and pets are not included. Minor illnesses (guideline: anything

meriting home care only or care at a walk-in clinic, as opposed to an ER) of family members, including minor children, do not count as serious family emergencies, nor do events such as birthdays, anniversaries, weddings, etc.

Political activities, including protests, demonstrations, and the like are considered personal matters and not generally permitted as excused absences. This includes activities related to nuclear engineering or nuclear power. Exceptions: A student who is pursuing nuclear-related (whether pro or anti-) politics as a career path may be granted excused absences, at my discretion, on condition of providing evidence of *bona fide* efforts to secure a full-time position or to secure admission to a relevant, non-STEM degree-granting graduate program.

## 14 Homework

*Excluding the make-up work policies, above, no late homework will be accepted.*

Homework may be submitted electronically (via Canvas) or as hard copy; some may have required electronic submissions indicated on the assignment sheets. The following restrictions apply for electronic submissions:

- Submissions may include multiple files, but only files with the following extensions will be accepted: pdf, xls, xlsx, ees, txt, and zip. This zip archive may not contain any ppt, pptx, doc, or docx files. Such files will be *ignored* for the purposes of grading.
- No hybrid submissions (some parts as hard copy, some electronically) will be accepted – exceptions *may* occur and will be discussed on that specific HW's assignment sheet.
- If a hard copy and electronic submission are provided, the hard copy will take precedence. (Only it will be read, reviewed, and graded.)

Some assignments require the use of fluid properties. Use only those properties from EES. *No points will be awarded on problems solved with any other set of properties.*

## 15 Grade Appeal

All appeals of grades, including those from clerical/grade-calculation errors, must be made within 1 week of return. (This may be modified for specific assignments. I will announce this via e-mail if needed.)

Grade appeals must be provided in the following format:

- Include your entire assignment *unmodified*.
- Attach (paper clip preferred) a written summary of which problem(s) or part(s) you believe were graded inaccurately. Be as specific as possible.
- Turn in your appeal to me at class time or during office hours.
- I will review your grade appeal, contact you via your ufl.edu e-mail address, and return the assignment in class. Fairly simple appeals provided to me during office hours may be decided upon while you wait, at my discretion.

Appeals will be considered for clerical errors, addition errors, and inconsistent scoring. Grade appeals will not be entertained if you simply do not like that (for example) Part 1 was worth only 20% Part 2 worth 50%.

Denied appeals may be deemed “frivolous”, if I believe the student is not acting in a good faith belief that more points are deserved. Following two frivolous appeals, your grade appeal privilege through this method will be *revoked*. Further appeals must be done through the petitions process, which requires formal paperwork and department/program level involvement.

## 16 File Formats

The electronic components of assignment submissions *must* be in the formats requested. If you do not know how to convert your files to these formats, contact me in advance of the deadline. Not knowing your software is not an excuse for late assignments. Accepted formats may include plain text, .pdf, .csv, and EES files, as well as other file formats at my discretion.

In particular, I will not open files from students in the following formats: .ppt, .pptx, .doc, .docx. Presentation and word processing documents are best converted to .pdf.

## 17 Electronic Communication and Course Website

The primary means of communication with the class outside of class time will be e-mail listserv. These listservs will send to your @ufl.edu address only. Any inquiries regarding grading will be directed towards your @ufl.edu address only, per FERPA .

Technical and procedural questions will be answered as a reply to whatever e-mail address you used to send them. If the entire class will benefit from the answer, I may send to the class list (either in lieu of or in addition to a direct reply to you, at my discretion). If you do not wish to have a specific e-mail to me regarding technical content or course procedures replied to through the class list, you must explicitly state this in that e-mail. In such a case, I will reply directly to you and send a general-purpose announcement to the class list, not indicating who caused me to send it.

The primary use of the Canvas website is for file storage, as all assignments, lecture notes, etc. will be provided there. I take no responsibility for downtime of this service, nor for actions of University of Florida staff that affect the website (including Canvas upgrades). The gradebook on Canvas is used to enable you to look up grades quickly. Note that this gradebook is *not* official. I reserve the right to correct errors, including transcription errors, from the official (spreadsheet) gradebook, to which I alone have access, until finalization of grades with the registrar.

## 18 Letters of Recommendation/Evaluation Policy

To request a letter of recommendation/evaluation (for graduate school or otherwise), you must provide:

- A hard copy of your UF transcript.
- A hard copy of a résumé (or CV).
- A hard copy of the following form: <http://www.registrar.ufl.edu/pdf/ferparelease.pdf>. You *must* check all four circles.

Letters are typically filed once per week. For students whom I know only through coursework, my letter typically focuses on an estimate of their rank-in-class and on their performance on projects and challenging problems.

I will only file *one batch* of letters per student during the term, for any student currently enrolled in a class with me. (This policy is designed to keep me from looking up slight changes in your rank/performance multiple times for multiple batches of letters.) I recommend that this batch occur as late as possible in the term to allow me sufficient information (sample size) on your performance to write a useful letter.

I reserve the right to refuse provide a letter for any student and am not obligated to provide a reason for such refusal.

## 19 Changes to Syllabus

Changes to this syllabus will be provided via the Canvas platform. Such changes may include those required by policy changes, my travel, changes in the speed of course coverage, university closure, errors in previous syllabus versions, and other reasons.

## 20 Syllabus Boilerplate

### 20.1 Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to me when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Please note that UF policy, clarified to faculty during the Fall 2016 term, states that no retroactive accommodations are available.

### 20.2 Course Evaluations

UF expects students to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at

<https://evaluations.ufl.edu/results/>.

### 20.3 University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code:

<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>

specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

## 20.4 Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

## 20.5 Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see:

<http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html>

## 20.6 Campus Resources

### 20.6.1 Health and Wellness

U Matter, We Care: If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) or 352-392-1575 so that a team member can reach out to the student.

Counseling and Wellness Center (392-1575) and

<http://www.counseling.ufl.edu/cwc>

University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>

### 20.6.2 Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu)

<https://lss.at.ufl.edu/help.shtml>

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling.

<https://www.crc.ufl.edu/>

Library Support, Various ways to receive assistance with respect to using the libraries or finding resources.

<http://cms.uflib.ufl.edu/ask>

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.

<https://teachingcenter.ufl.edu/>

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.

<https://writing.ufl.edu/writing-studio/>

Student Complaints Campus:

[https://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf)

On-Line Students Complaints:

<http://www.distance.ufl.edu/student-complaint-process>