

Nuclear Power Plant Reactor Systems 1

ENU 4930, Sections PAF2 and PAF4, and ENU 6937, Sections FRC1 and FRC2, Spring 2021

T 1500-1655 (UF “Periods” 8-9), R 1605-1655 (UF “Period” 9)

4930-Synch: 100% Online (Synchronous)

4930-Synch-99: 80-99% Online (Synchronous)

6937-Synch: 100% Online (Synchronous)

6937-Synch-99: 80-99% Online (Synchronous)

Final Exam: none

Instructor

DuWayne Schubring, Associate Engineer

315 Materials Engineering Building (MAE). (All office hours will be via e-mail/Zoom.)

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

Weeks 4, 8, and 12: TBD

Other Weeks: TBD

Beginning and end times of office hours will be enforced strictly. If you cannot meet during office hours, appointments are available, though appointments on weekends and days in which no office hours are held are reserved for genuinely exceptional circumstances.

Description

This course will cover modern concepts for nuclear fission reactor systems, including advanced light-water reactors, gas-cooled reactors, and liquid-metal reactors. Topics covered for each type of reactor system will include thermal modeling, reactor safety, licensing, reactor physics, materials selection, and fuel cycles. (3 credits)

Prerequisites

A course in nuclear thermal hydraulics and a course in reactor physics.

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

Course Objectives

- Students will learn of the advances in light-water reactor (LWR) technology seen in Generation III/III+ (Year 2000 and beyond) systems and demonstrate ability to discuss and analyze the improvements to reactor safety in these systems

- Students will learn of relevant phenomena (thermal, material, neutronic) for novel reactor systems (gas-cooled reactors, liquid-metal reactors, etc.) and demonstrate the ability to make relevant comparisons both among these novel concepts and with existing LWR systems
- Students will develop a sufficient background to undertake research in the areas of advanced nuclear fission reactor design

ABET Professional Component – 4930 only

3 credits Engineering Topics

Student Outcomes Supported by Course

n/a – elective course

Required Textbooks and Software

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No required textbook. Instructor-produced notes available on Canvas.

Software: Engineering Equation Solver (provided at no charge via UFApps)

Recommended Materials

Thermodynamics, fluid mechanics, heat transfer, and nuclear thermal hydraulic texts (such as from ENU 4134 and 6135). Neutronics texts (such as from ENU 4103, 4104, or 6106).

Course Outline and Schedule

The day-by-day outline of lecture coverage is to be taken as a draft. Deadlines will not be moved earlier, but may be moved later.

Wk	Day	Date	Due	Material
1	T	12 Jan		Syllabus and Course Policies Introduction to Advanced LWRs
1	R	14 Jan		AP 1000,
2	T	19 Jan		AP 1000 and EPR
2	R	21 Jan		EPR
3	T	26 Jan		ABWR and ESBWR
3	R	28 Jan	Project 1	ESBWR
4	T	2 Feb		PHWR (focusing on CANDU, especially ACR)
4	R	4 Feb	Project 2	SCWR
5	T	9 Feb		SCWR
5	R	11 Feb		Introduction to Gas-Cooled Reactors
6	T	16 Feb	Project 3	Introduction to GCRs and GCR Materials
6	R	18 Feb		GCRs – Materials
7	T	23 Feb		GCRs – TRISO and Related Fuels
7	R	25 Feb		GCRs – Core Layout (Focus on Prismatic Cores)
8	T	2 Mar	Project 4	GCRs – Core Layout (Pebble Bed Cores)
8	R	4 Mar		GCRs – Neutronic Methods
9	T	9 Mar	Project 5	GCRs – Thermal Hydraulics
9	R	11 Mar		GCRs – Thermal Hydraulics
10	T	16 Mar	Project 6	Introduction to Fast-Spectrum Reactors
10	R	18 Mar		Introduction to Fast-Spectrum Reactors
11	T	23 Mar	Project 7	FSRs – Materials
11	R	25 Mar		FSRs – Materials and/or Core Layout
12	T	30 Mar		FSRs – Core Layout and Neutronics Methodst
12	R	1 Apr	Project 8	FSRs – Neutronics Methods
13	T	6 Apr		FSRs – Thermal Hydraulics of Liquid Metals
13	R	8 Apr	Report 9	FSRs – Thermal Hydraulics of Liquid Metals
14	T	13 Apr		FSRs – Comparison of Coolants (Including non-TH effects)
14	R	15 Apr	Project 10	FSRs – Comparison of Coolants (Including non-TH effects)
15	T	20 Apr	Project 0	Literature Review Presentations
15	W	21 Apr	Project 11	No Class (11:59 pm Deadline Only)

Grading

Grades are based on the average project score. Students in ENU 4930 must complete 10 of the Projects numbered 1 through 11. Students in ENU 6937 must complete Project 0 (Literature Review) as well as 9 of the Projects numbered 1 through 11. Students (in either course) may not complete additional projects and drop their lowest score(s).

The final grades will be assigned based on:

- A: 8.70+
- A-: 8.50-8.69

- B+: 8.30-8.49
- B: 7.50-8.29
- C: 6.70-7.49
- E: < 6.70

Please note the following:

1. I reserve the right to grant higher grades at the end of the course at my sole discretion, including the use of B- and C+. Under no circumstances will grades of C- or any flavor of D be used.
2. All project grades are out of 10 and will be independently rounded to 0.1 precision.
3. Grading in this course is plus-based. That is, I award you points based on correct steps, rather than deducting points for errors. As a result, a question such as, “Dr. Schubring, why did you take off 2 points here?” is both presumptuous and nonsensical, since you never had the points.
4. There is no general protection against double jeopardy. Points are often allocated to each specific step and to obtaining the final, correct answer in each problem – a single error will prevent you from earning points at that step and for the final answer.
5. Per UF policy, grades are entered into Canvas to enable you to look up grades quickly. These grades are manually copied from other documents. I reserve the right to correct data-entry errors, as well as other errors, until finalization of grades with the registrar.

More information on UF grading policy may be found at:

(For ENU 4930): <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

(For ENU 6937): <http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

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 near the end of the term. I will announce this via e-mail as needed.) Appeals will be considered for clerical errors and addition errors. Appeals will also be considered with regard to inconsistent scoring.

Grade appeals must be provided in the following format:

- Provide, in PDF format only, a written summary of which line-item(s) you believe were graded inaccurately. Be as specific as possible. In particular, be clear about page numbers – PDF vs. bottom-of-page page numbers.
- Send your appeal in the form of an e-mail with “ENU 4930/6937” and “Grade Appeal” in the subject line.

You will be informed of the result of your appeal via e-mail reply.

If I believe you are not acting in a good faith belief that more points are deserved, I will deem the appeal frivolous. Requests to change a line-item by only one point will also be considered frivolous. 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.

All Things COVID

Technology Requirements and Zoom Decorum

All class sessions will occur online, synchronously, via Zoom meetings. To participate fully in the course, you will need a computer or other device with a microphone and the ability to use the Chat and Share Screen features on Zoom.

You should mute yourself unless actively speaking/conversing. You are not required to turn on your video. If you are (1) using a busy internet connection, (2) are further than 300-350 miles from Gainesville (that is, beyond Miami or Atlanta or Pensacola), (3) multitasking in a way that may distract, or (4) likely to be interrupted, please leave it off. If you choose to use a profile image, please ensure that it is in good taste.

Required COVID Statement for All Sections

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the “chat” feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

Only those sessions for which a significant fraction of the class will be unable to attend due to UF/professional/career-related activities will be recorded. Due to the Spring 2021 “Recharge Days” policy, the class session on February 25 will either be recorded or replaced with pre-recorded video(s).

Required COVID Statement for 4930-Synch99 and 6937-Synch 99

*The following statement applies only to this section. Our only face-to-face session will be literature review presentations on April 20. Contrary to the following required statement, a classroom **has not** been assigned. If this section runs, I presume some appropriate space will be found.*

We will have face-to-face instructional sessions to accomplish the student learning objectives of this course. In response to COVID-19, the following policies and requirements are in place to maintain your learning environment and to enhance the safety of our in-classroom interactions.

- You are required to wear approved face coverings at all times during class and within buildings. Following and enforcing these policies and requirements are all of our responsibility. Failure to do so will lead to a report to the Office of Student Conduct and Conflict Resolution.
- This course has been assigned a physical classroom with enough capacity to maintain physical distancing (6 feet between individuals) requirements. Please utilize designated seats and maintain appropriate spacing between students. Please do not move desks or stations.
- Sanitizing supplies are available in the classroom if you wish to wipe down your desks prior to sitting down and at the end of the class.

- Follow your instructor's guidance on how to enter and exit the classroom. Practice physical distancing to the extent possible when entering and exiting the classroom.

- If you are experiencing COVID-19 symptoms:

<https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html>

please use the UF Health screening system and follow the instructions on whether you are able to attend class.

<https://coronavirus.ufhealth.org/screen-test-protect/covid-19-exposure-and-symptoms-who-do-i-call-if/>

Attendance & 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 notes provided online – only in class. Students are responsible for these materials. I reserve the right to take attendance to prioritize e-mail assistance.

Pursuant to HWCOE policy, the following statements are required:

(For ENU 4930): 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.

(For ENU 6937): Excused absences must be in compliance with university policies in the Graduate Catalog

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

and require appropriate documentation.

Make-Up Work Policies

Late-work excuses (extensions) 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. Most requests are granted, excluding those that provide a student or group of students an unfair advantage, 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 issues 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 generally 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.

I reserve the right to grant extensions for other personal reasons as *rare exceptions to the rule* at my sole discretion – advance notice gives you the best chance at a favorable decision. The approval

of an extension does not establish precedent for that student (notably, there are some scenarios that I may accommodate only once) or for other students with similar circumstances.

All requests for excused absence or extension must be submitted in writing, preferably via e-mail.

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.

For the purposes of this course, in the above-referenced list of approved absence (extension) 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 (a cousin, your spouse’s sibling’s spouse, 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 reasons for extensions. This includes activities related to nuclear engineering or nuclear power. Exceptions: (1) A student who is pursuing nuclear-related (whether pro- or anti-) politics as a career path may be granted extensions, 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 and (2) activities that are connected to the 2021 ANS Student Conference *that do not conflict with a presentation* will be taken as related to that professional activity and potentially grounds for extensions.

Further, be advised that any approved reasons for extensions do not reduce the amount of work you are expected to complete, but merely rearranges the timing. For those issues that are predictable (interview, holidays, etc.), you should work ahead to avoid disruption.

Projects

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

Projects (which could just as accurately be called homework) must be submitted electronically (via Canvas). 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, and .txt. For some projects, a zip archive may also be required or permitted.
- If multiple students in a group independently submit electronically, the submission by the student whose name is listed first on the assignment that I post to Canvas will take precedence. (One student must submit the entire project – different students submitting the main narrative and supporting zip archive is not allowed.)

Planned Project Topics for Projects 1-11 are at listed. Project 0 is for ENU 6937 only and is a Literature Review assignment.

1. Generation III/III+ PWRs
2. Generation III/III+ BWRs
3. PHWR (CANDU, ACR) and/or SCWR

4. GCR Materials
5. Unique Issues/Features for Pebble Bed Reactors
6. GCR Neutronics
7. GCR Thermal Hydraulics
8. FSR Materials
9. FSR Neutronics
10. FSR Thermal Hydraulics
11. Comparison of FSR Coolant Options

Collaboration

A small number of projects may be designed to be done in groups (either self-selected or instructor-assigned), though you may work alone if you prefer.

The ground rules for collaboration should be decided by each group through compromise and consensus. However, regardless of the preferences of the group as a whole, each student retains the individual right to privacy and to maintain good mental and physical health. To this end, no student shall be compelled:

- To join a real-name social networking site or modify their existing use of such a site, or
- To accept a 24/7 or other onerous on-call policy.

That is: each member holds a unilateral veto on using Facebook (or some such) for your group's work or for being contacted at all hours of the day and night.

Inter-personal issues within your group stemming from deciding group rules must be brought to me *promptly* for arbitration. This arbitration will focus on the guidelines above and in forming an equitable compromise (essentially, equal marginal/new inconvenience) among group members and not on determining whose activities outside this course (including personal pursuits, situations, and choices) are more meritorious.

No collaboration between groups is permitted.

Other Course Policies

Electronic Communication

The primary means of communication with the class outside of class time will be e-mail listservs. There is one listserv for each section of the class; except for those e-mails that relate only to face-to-face students, all messages will be sent to both listservs (unless the enrollment of one section or the other drops to zero). 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 listservs (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 listservs, 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 listservs, not indicating who caused me to send it.

When sending questions via e-mail, please make sure you provide all the information needed for me to produce an answer or solution. This includes any files on which you are working. (Note: I will not open files from students in the following formats: .ppt, .pptx, .doc, .docx; make a PDF and send that if needed.)

The Canvas platform will be used for file storage, assignment posting, and posting grades. I take no responsibility for downtime of this service, nor for actions of University of Florida staff that affect the website (including Canvas upgrades).

Letters of Recommendation/Evaluation Policy

To request a letter of recommendation/evaluation (for graduate school or otherwise), you must provide (all in a single e-mail):

- A copy of your UF transcript.
- A copy of a résumé (or CV).
- A copy of the following form with all four circles checked (requests with three or fewer circles checked will be denied):
<http://www.registrar.ufl.edu/pdf/ferparelease.pdf>.

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.

Syllabus Boilerplate

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.

Course Evaluations

The University of Florida expects students to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at: <https://gatorevals.ua.ufl.edu/students/>

Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluer.com/ufl/>

Summaries of course evaluation results are available to students at: <https://gatorevals.a.ufl.edu/public-results/>

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.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Undergraduate/Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@ufl.edu

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.

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:

<https://registrar.ufl.edu/ferpa.html>

Campus Resources

Health and Wellness

U Matter, We Care

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center:

<http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the Office of Title IX Compliance, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

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/>

Academic Resources

E-learning technical support, 352-392-4357 (select option 2) or e-mail to 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

On-Line Students Complaints:

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