**EEL 4732/5733 Advanced Systems Programming**

1. Catalog Description – (3 credits) Develop a deep understanding of operating system concepts and systems programming fundamentals and gain hands-on experience in systems programming by using Pthreads as well as implementing Linux device drivers and testing/verifying systems code for deadlock and race-freedom.
2. Pre-requisites:

   - C programming knowledge
   - COP 4600 (or equivalent) or EEL 5737 (for EEL 5733)
   - EEL 3701C and (EEL 3834 or COP 3503C or COP 3504C or COP 2274 or equivalent) and COP 4600 (or equivalent) (for EEL 4732)

3. Course Objectives – To learn the architecture and inner-workings of a real-world operating system and to learn how to write, test, and debug multi-threaded applications and device drivers in the face of a complicated concurrency model.
4. Contribution of course to meeting the professional component (ABET only – undergraduate courses) 3 credits of Engineering Science (for EEL 4930).
5. Relationship of course to program outcomes: Skills student will develop in this course (ABET only undergraduate courses) Outcomes a and k (for EEL 4930).
6. Instructor –Dr. Tuba Yavuz
   1. Office location: 4139 Malachowsky Hall
   2. Telephone: 352-846 0202
   3. E-mail address: tuba@ece.ufl.edu
   4. Class Web site: E-learning CANVAS.
   5. Office hours:

      Zoom Only Office Hours: Thursdays 3pm – 4pm & Fridays 3pm – 4pm (Zoom link will be available on ELearning)

      In-person & Zoom Office Hour: Tuesdays 10 am – 11 am, Room: 4139 Malachowsky Hall (Zoom link will be available on ELearning)

7. Teaching Assistant –TBA
8. Meeting times: MWF 3rd period (9:35 am – 10:25 am).
9. Class/laboratory schedule - 3 class periods consisting of 50 minutes each
10. Meeting Location – NEB 202 for on campus students and the lectures will be streamed over Zoom meetings for online students. Recordings will also be available.
11. Material and Supply Fees - None
12. Textbooks and Software Required – None.
13. Recommended Reading – (pdfs of these books will be provided on CANVAS)

    1. Title: Linux System Programming
    2. Author: Robert Love

3. Publication date and edition: 2013, 2<sup>nd</sup>
4. ISBN number: 978-1-449-33953-1

1. Title: The Linux Programming Interface
2. Author: Michael Kerrisk
3. Publication date and edition: 2010, 1st
4. ISBN number: 978-1593272203

1. Title: Linux Device Drivers
2. Author: Corbet, Rubini, & Kroah-Hartman
3. Publication date and edition: 2005, 3rd
4. ISBN number: 978-0-596-00590-0

14. Course Outline –

Week 1: Introduction to Operating Systems Concepts/Yavuz/Ch.1 of Linux System Programming

Week 2: Inter-process communication mechanisms/Yavuz/Ch.s 7 and 10 of Linux System Programming

Week 3: Pthreads Library/Yavuz/Tutorial at https://computing.llnl.gov/tutorials/pthreads/

Week 4: Solving classical IPC problems using Pthreads/Yavuz/ Tutorial at https://computing.llnl.gov/tutorials/pthreads/

Week 5: Virtual Memory Management/Yavuz/Online document at http://www.tldp.org/LDP/tlk/mm/memory.html

Week 6: Mapping Memory/Yavuz/Ch.9 of Linux System Programming

Week 7: File System Management/Yavuz/Ch 4. of Linux System Programming and http://www.tldp.org/LDP/tlk/fs/filesystem.html

Week 8: Introduction to Device Drivers/Yavuz/Ch.s 1 and 2 of Linux Device Drivers

Week 9: Char Drivers/Yavuz/Ch. 3 of Linux Device Drivers/Exam 1

Week 10:  Memory Mapping and DMA/Yavuz/Ch. 15 of Linux Device Drivers

Week 11: I/O Mechanisms/Yavuz/Ch.s 9 and 10 of Linux Device Drivers

Week 12: Concurrency and Race Conditions/Yavuz/Ch. 5 of Linux Device Drivers

Week 13: USB Device Drivers/Yavuz/Ch. 13 of Linux Device Drivers

Week 14: Testing a USB Keyboard Driver & Typical Device Driver Bugs/Yavuz/Representative bugs detected by Linux Driver Verification project  http://linuxtesting.org/project/ldv

Week 15: USB Block Drivers/Yavuz/Ch. 16 of Linux Device Drivers

Week 16: Some automated approaches to the detection of bugs in device drivers:
- Analyzing Device Drivers for Deadlocks and Race Conditions and Other Bugs & Wrap-up & Review/Yavuz/ Thorough Static Analysis of Device Drivers, Thomas Ball, Ella Bounimova, Vladimir Levin, Jakob Lichtenberg, Con McGarvey, Bohus Ondrusek, Sriram Rajamani, Byron Cook, Abdullah Ustuner, in EuroSys 2006, April 1, 2006.
- Tuba Yavuz:
  Detecting Callback Related Deep Vulnerabilities in Linux Device Drivers. SecDev 2019: 62-75
- Tuba Yavuz, Ken Yihang Bai:
  Analyzing system software components using API model guided symbolic execution. Autom. Softw. Eng. 27(3): 329-367 (2020)
- Tuba Yavuz. Verifying Absence of Hardware-Software Data Races using Counting Abstraction. MEMOCODE 2020.

15. Attendance and Expectations - Attendance is expected. Cell phones and other electronic devices are to be silenced. No text messaging during class or exams.

Requirements for class attendance and make-up exams, assignments, and other work are consistent with university policies that can be found at: https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx

16. Grading –

**Participation (5%):** Students are expected to participate by asking and answering questions during lectures. Students will be expected to keep a log on CANVAS and will be responsible for recording the details (wording of the question/answer along with the date). There may be several graded in-class group activities throughout the semester. Students can leverage these activities towards participation as well.

**Programming Assignments (30%):**
      Assignment1: Advanced User-Space Programming
      Assignment2: Multithreading I (Pthreads)
      Assignment3: Multithreading II (Pthreads)

Assignment4: File Systems
Assignment5: A simple char device driver
Assignment6: A thread-safe char device driver
Assignment7: Testing the USB keyboard driver/Simulating the USB keyboard device-driver interaction

**Exams (65%):** There will be 2 closed books and notes exams.

**Midterm Exam (30%):** Friday, March 1st (class time & place)

**Final Exam (35%):** Tuesday, April 30th (10 am – 12 pm)

**Students in the EDGE section will take the exams online at the same time with on campus students using Honorlock.** If they are not able to take the exam during that time for various reasons, they need to contact the instructor at least one week before the exam.

Note: This course is co-listed with the graduate class. The homework portion of the graduate section will involve additional work and more advanced concepts with respect to the undergraduate section. The exams will also involve more advanced concepts with respect to the undergraduate section.

17. Grading Scale –

| Percent | Grade | Grade Points |
|---------|-------|--------------|
| 93.4 - 100 | A | 4.00 |
| 90.0 - 93.3 | A- | 3.67 |
| 86.7 - 89.9 | B+ | 3.33 |
| 83.4 - 86.6 | B | 3.00 |
| 80.0 - 83.3 | B- | 2.67 |
| 76.7 - 79.9 | C+ | 2.33 |
| 73.4 - 76.6 | C | 2.00 |
| 70.0 - 73.3 | C- | 1.67 |
| 66.7 - 69.9 | D+ | 1.33 |
| 63.4 - 66.6 | D | 1.00 |
| 60.0 - 63.3 | D- | 0.67 |
| 0 - 59.9 | E | 0.00 |

More information on UF grading policy may be found at:
UF Graduate Catalog
Grades and Grading Policies


*Students Requiring Accommodations*

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

*Course Evaluation*
Students are expected 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.aa.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.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

**In-Class Recording**
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

*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://sccr.dso.ufl.edu/process/student-conduct-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 varied perspectives and lived experiences within our community and is committed to supporting the University's core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

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 Graduate Program Coordinator
• HWCOE Human Resources, 352-392-0904, student-support-hr@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@eng.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:** https://counseling.ufl.edu, 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 suppor**t, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

**Career Connections Center**, Reitz Union, 392-1601.  Career assistance and counseling; https://career.ufl.edu.

**Library Support**, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

**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://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

**On-Line Students Complaints***: https://distance.ufl.edu/getting-help/; https://distance.ufl.edu/state-authorization-status/#student-complaint.