CSCI 5573/ECEN 5573: Advanced Operating Systems
Fall 2024

Instructor
- Name: Shivakant Mishra
- Office: ECCR 1B22
- Office Hours: W: 11 AM – 12 Noon; F: 3:30 – 4:30 PM
- Email: *mishras@colorado.edu*

Grader
tbd

Short Description
This is a graduate course in operating systems intended to create a foundation for operating systems research or advanced professional practice. Topics include Linux kernel programming, virtualization, light-weight virtualization, OS for small devices and current research directions.

Prerequisite
- CSCI 3753 and CSCI 4593 or equivalent undergraduate course work in operating systems and computer architecture. These are reasonably firm prerequisites. If you have not taken these courses, you should discuss your situation with me before you enroll in CSCI 5573.

Reading Material
Selected articles and other materials from the Internet.

Grading (*Weights assigned are tentative*)
- Homework and programming assignments: 40%
- Research paper presentation: 10%
- Course project: 20%
- Quizzes and Exams: 30%

Policies (See https://colorado.edu/academicaffairs/policies-customs-guidelines/required-syllabus-statements)

Classroom Behavior

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, marital status, political affiliation, or political philosophy.

For more information, see the underlined classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

If you have a temporary illness, injury or required medical isolation for which you require adjustment, please inform me as soon as you can. You do not need to state the nature of your illness when alerting me and do not need to provide "doctor's notes" for classes missed due to illness. Please note that campus health services no longer provide "doctor's notes" or appointment verifications.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include but are not limited to: plagiarism (including use of paper writing services or

technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. Understanding the course's syllabus is a vital part in adhering to the Honor Code.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct@colorado.edu. Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits protected-class discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner abuse (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu. Information about university policies, reporting options, and support resources including confidential services can be found on the OIEC website.

Please know that faculty and graduate instructors must inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive outreach from OIEC about resolution options and support resources. To learn more about reporting and support for a variety of concerns, visit the Don't Ignore It page.

Religious Accommodations

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, please notify the instructional faculty of any anticipated conflicts due to religious obligations as early in the semester as possible (at least two weeks before) so that there is adequate time to make alternate arrangements.

See the campus policy regarding religious observances for full details.

Mental Health and Wellness

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) located in C4C or call (303) 492-2277, 24/7.

Free and unlimited telehealth is also available through Academic Live Care. The Academic Live Care site also provides information about additional wellness services on campus that are available to students.

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Course Content

- Introduction: Review of fundamental concepts
  - Processor mode, system calls
  - Context switch: *schedule*( ) and *switch_to*( ) functions
  - Virtual memory layout
  - Symbol table: *System.map* file
  - System Boot
- Linux Internals
  - */proc* directory
  - *printk( )*, *dmsg*, *klogd*, kernel *oops* and *panic*
  - Loadable Kernel Modules: hello world, device drivers
  - Kernel probes: *kprobes*, *jprobes*, *kretprobes*
  - System call interception and manipulation
  - Linux hotplugging
  - USB Subsystem; USB device drivers
  - Interrupt handlers – Short IRQ, Long IRQ, *softirqs*, *tasklets*
  - Work queues
  - Keyboard interrupt handler
  - Scheduling tasks in kernel
- Virtualization
  - Virtual Machine Monitors
  - Machine Virtualization
  - Challenges with Virtualization
  - Full Virtualization: Binary Translation, Shadow Page Tables
  - Paravirtualization: Hypercalls
  - Hardware Assisted Virtualization – *VT-x*, *VMX*
  - Xen, VMWare, Denali, Terra
- Lightweight virtualization
  - *chroot*, *cgroups*, *namespaces*
  - Containers: LXC, Dockers
- Edge computing
  - Micro-service based architecture
  - EdgeX, Kura
  - Serverless computing
- Library OS
  - Microkernels vs Exokernels
  - Aegis, EXOS, SPIN
- OS for small devices
  - Android OS
- Current research topics

Note: *The course content will be updated over the semester based on class discussions and student interests.*