Cmp Sci 4760 – Operating Systems
Department of Computer Science
Fall 2023

Instructor	Sanjiv K. Bhatia
Office	317 ESH
Phone	(314) 516-6520
e-mail	sanjiv@umsl.edu
url	http://www.cs.umsl.edu/~sanjiv/classes/cs4760
Office Hrs	T Th 1pm – 2:30pm (via Zoom or in person)
	Any other time by appointment
Prerequisites	Cmp Sc 2750 and Cmp Sc 3130

Welcome This is a course about operating systems and system programming. You will learn the algorithms to manage the internals of operating systems, specifically interprocess communications, process scheduling, resource management, memory management, file systems, and I/O scheduling. The course will help you with the ability to explain the internals of operating systems and improve your programming skills through large projects. I use the lessons learned in operating systems in my research and consulting work to optimize the code that I write. I'll like for you to improve your understanding of programming in C for tasks involving interactions with the system. We'll do all programming in Linux using the Gnu C compiler on `opsys`.

This is one of the most difficult courses you will encounter in the curriculum. The projects are long and will require you to spend a lot of time designing and debugging. However, I emphasize that I'll like you to succeed and am here to help you in any possible way, short of doing your projects.

Teaching Philosophy I believe in learning by doing things. Thus, I'll be assigning a number of projects to simulate the algorithms you learn for operating systems. The tests will be created to assess your mastery of the concepts while the projects will assess your ability to apply the right procedure by analyzing a situation and create code to solve complex problems. I'll be happy to help any student who gets stuck while working on the project. You are welcome to get in touch with me via Zoom at any time, or send me a message to meet over zoom to discuss any issue related to class, or even related to your career.

Course Description This course covers the structure of a generic operating system, considering in detail the algorithms for interprocess communications, process scheduling, resource management, memory management, file systems, and device management. It presents examples from contemporary operating systems. This course also requires practical projects implemented within a modern operating system or simulator environment.

Texts

- Stallings. *Operating Systems: Internals and Design Principles*. Prentice-Hall, Englewood Cliffs, NJ. 2017. Required.

- Robbins/Robbins. *Unix Systems Programming – Communication, Concurrency, and Threads*. Prentice-Hall, 2003. Required.

- Bic. Operating Systems. zyBooks, 2023. Optional. It has good exercises that can help you prepare for tests. It also has some animations that can explain some points better. To get this book:

    - Sign in or create an account in learn.zybooks.com

- Enter zyBook code: `UMSLCMPSCI4760BhatiaFall2023`
- Subscribe

Goals of the course This course will deepen your understanding of system programming, building on the foundation acquired in CMP SCI 2750. You will use your programming skills to design and implement data structures and algorithms used in the innards of an operating system. The overall goals of the course are:

- Understand the internals of a generic operating system

- Improve your programming skills by working on non-trivial simulations

- Become an expert programmer, ready to tackle industrial strength projects

Topics We'll discuss the structure of a generic operating system, with an emphasis on the algorithms and data structures needed to perform various tasks to manage processes, resources, memory, files, and IO devices. We'll touch on the security aspects of the operating systems throughout the course. There will be *extensive* programming in C under Linux environment. The sequence of topics will be as follows (in that order):

- Function, Types, and Structure of Operating Systems.

- Concurrent Programming, Process Interaction and Synchronization.

- Process Management and Scheduling.

- Resource Management and Deadlock Problem.

- Memory Management.

- File System and I/O management.

Outcomes At the end of this course, you are expected to be able to proficiently perform system programming tasks. You should also be able to explain different operating systems topics outlined above. You should know the algorithms to achieve various tasks in operating systems and use the knowledge to improve the performance of your programs.

Online Learning and Time Requirements This is a fully online asynchronous course, meaning that there is no requirement for you to meet face-to-face or virtually. The course was designed this way to allow for maximum flexibility, so you can integrate learning course content into your busy lives. That said, this is not a self-paced course, meaning that you do have to turn in assignments and participate in discussions by specific due dates. These due dates will require good time management on your part. You will notice that with the magnitude of projects, you may get stuck on some point/bug and end up wasting a lot of time; so it is prudent to start on your projects early.

Overall, this is an active class with online instruction complemented with extensive programming projects. The course is a 3-credit hour course and requires 3 hours of your time each week to imbibe the online lectures in addition to the time it takes you to read the required materials, watch the videos, and complete the projects, with the programming projects taking up a lot of your time. That means that you need to plan to spend a minimum of 8 hours every week (possibly up to 10-12 hours a week) on activities related to this course.

If this is your first blended or online course, it is recommended that you log into Canvas and complete the Online Course Overview listed in your Canvas course list. If you have already completed the orientation, you do not have to retake it but you can refer to it for helpful videos and tutorials about the technologies used in this course.

How to Succeed in This Course I truly believe in your success as a student and adapting my instruction to ensure your success. Below you will find several different instructional methods to help me accomplish my goal:

- I'll like good participation in the course. Therefore, I am allowing 5% points for participation. To have objectivity, I'll expect you to give me a one-minute audio-visual report every week on what you learned that week. You can also say things about what is going well with the course and what needs improvement. You will submit the comment using a tool called *Voice Thread*. The use of web cam will allow me to put a face to your name. You will receive 1 point for submitting the voice thread every week. At the end of the semester, all of the points will be aggregated towards 5% of your grade. For each week, I can reasonably expect the comment by Sunday midnight. I will not accept any late submission on this and so, please submit this diligently. I will not give you the point if you do not use the camera.

- The lectures cover theoretical aspects of the course. You'll need to figure out the use of system calls and library functions from the Unix textbook and by reading the man pages online. I'll be happy to guide you to whatever you need to read if you get stuck.

- The lecture notes will be available to you in the form of PDF documents. You can print those and annotate on them during lectures.

- It will be nice to see some discussions on Canvas regarding the material discussed in class, or even on new technology that you come across. I'll also provide you with a forum on Microsoft Teams to discuss your projects and help you prepare for the tests.

Email Requirements All correspondence should be made through your UMSL-provided email. Any unsigned email will go unanswered by me. *Please do not send me any attachments, like screenshots or code segments, without talking to me first.*

Attendance Presence in class for the online component of our course is determined by participation in an "academically related activity," i.e. submission of an assignment, assessment or discussion forum posting. The last day of attendance is the last day a student is academically participating in the online course.

Documentation that a student has logged into the Canvas course site alone is not sufficient by itself to demonstrate academic attendance.

Projects You will be given programming assignments, typically a programming project every two weeks. Assignments will be due at 11:59pm on the due date. Assignments should be submitted on opsys and must execute properly on opsys for proper credit. You should start working on the project as soon as it gets assigned as some of them may get tricky. If you do not know how to work on a project, see me as soon as possible for help. In the past, the students who have asked a lot of questions have scored better grades. Do not hesitate to ask a question in Teams, in my office hours, or over email, especially if you do not have an idea on how to start working on the project.

Grading The grade will be based on programming and homework assignments and three tests. All tests will be given online and will be open book and open notes. Tests will not be proctored but you will have to take them online during the day it is announced (you can do it from home). Each assignment must be meticulously documented and clearly identify its purpose, author, and date. I will like to *read* your submitted code; I should *not have to figure it out*. It will do you good if you peruse the Gnu coding standards. When you come to me for help with the code, or when you submit the code, make sure that you follow good indentation practices. If you miss any test or assignment without making prior arrangements, you will have a zero. I will not give any make up tests. The distribution of grades will be as follows:

Participation	5%
Programming Projects	50%
Three Tests	15% each

Students taking the course in graduate standing will be required to show a greater mastery of the material. This can be shown by additional work and additional mastery shown in exams.

Failure to hand in any assignment will result in an automatic zero for that assignment. If some student is unable to hand in an assignment by the deadline, he/she must discuss it with me *before* the deadline. I'll encourage you to talk to other students regarding homework but you should not collaborate to the extent that two submissions are copies of each other. If you are found copying an assignment (from another student or internet), or if your submission has *unreasonable similarity* to another submission, you get a zero for that assignment automatically. A second offense will be reported to the university officials and students involved will face serious consequences. I may ask you to explain your code to me, possibly in a zoom call; in case you are not able to explain the code to my satisfaction, I'll assign you a zero in that project. I'll allow you to submit up to two projects over the semester that are seven days beyond the deadline for no penalty. However, you must let me know before the deadline that you are going to be late with submission.

Feedback and Grading Timeline: I expect that you will have feedback and grade on your submitted projects within two weeks of submission. I'll try my best to return the graded tests to you within a week after the test. Under normal circumstances, I'll update your participation grade within 48 hours of the due date. You can find your grade in the Grades button on Canvas. However, the overall grade on Canvas is normally incorrect and does not account for different weights for participation, projects, and tests.

Miscellaneous If you have any disability that requires an accommodation (as per UMSL policy), you must notify me in advance. If you cannot attend the class due to a religious holiday or a university-sanctioned event, please let me know in advance as well. For a religious holiday, please also fill in the form available on the class web site.

You will have an account on the Linux machine opsys.cs.umsl.edu in the CS department and you should use it for all assignments. All programs must be done in C. Any assignment that fails to run on opsys automatically gets a zero. You can access opsys from home by signing on to campus VPN, or by logging on to delmar and then, ssh'ing from there.

Exam Dates

Test 1	Sep 21, 2023
Test 2	Oct 26, 2023
Test 3	Dec 07, 2023

Tests will be non-comprehensive but there may be a slight overlap from one test to next. There is no final exam.

Other important dates

Aug 27, 2023	Last day to enroll in the course
Sep 18, 2023	Last day to drop without receiving a grade
Oct 16, 2023	Last day to drop the course without instructor approval
Oct 19-22, 2023	Fall break
Nov 13, 2023	Last day to drop the course with instructor approval
Nov 18-26, 2023	Thanksgiving break

Anyone desiring an EXC grade after October 31, 2023 must be passing the course at that point to get EXC.

Tentative Calendar

Week 1	Overview of operating systems and concepts
Week 2	Overview of operating systems and concepts; Interprocess Communications
Week 3	Interprocess Communications
Week 4	Interprocess Communications
Week 5	Interprocess Communications; Test 1
Week 6	Process Management
Week 7	Process Management
Week 8	Process Management
Week 9	Resource Management
Week 10	Resource Management; Test 2
Week 11	Memory Management
Week 12	Memory Management
Week 13	File Systems
Week 14	File Systems; I/O Management
Week 15	I/O Management; Test 3

Detailed course outline

1. Introduction

    - Basic elements of a computer system: processor, memory, I/O modules
    - Evolution of a microprocessor
    - Instruction execution
    - Interrupts
    - Processor registers
    - Memory hierarchy
    - Multiprocessor and multicore organization
    - Classification of operating systems
    - Process execution modes in Unix/Linux
    - Overview of operating systems structuring methods like monolithic, layered, and object-oriented
    - I/O communication
    - Multiprogramming and multitasking

2. Process Coordination and Synchronization

    - Process concept
    - Overview of multitasking and role of interrupts
    - Concurrent execution and precedence graphs (process flow diagrams)
    - Race conditions, Sharing access
    - Critical Section Problem
        - Models for two processes, including Dekker's Algorithm
        - Models for multiple processes, including Bakery Algorithm
        - Semaphores, mutex locks, and monitors

3. Process Scheduling and Dispatch

    - Preemptive and non-preemptive scheduling strategies
    - Short term, medium-term, and long-term scheduling

4. Deadlocks – Causes, conditions, avoidance, prevention, and resolution

5. Physical and Virtual Memory Organization

    - Offset registers, partitions, pages, segments, swapping, overlays
    - Caching and associative buffers
    - Fetch, placement, and replacement policies
    - Thrashing and working sets

6. Device and File Management

    - File systems

- File types
- File access and directory management
- Distributed file systems
- Equivalence of files and devices
- Organization of I/O subsystems, free space management, and file layout
- Disk scheduling algorithms

Appendix A

Technology Requirements: As a computer science major and a student in an online course, you are expected to have reliable internet access almost every day. Please reach out to your academic advisor or student success network if you need hardware or access to the Internet. If you have computing problems, it is your responsibility to address these through the ITS Helpdesk (`helpdesk@umsl.edu`) or to use campus computing labs. Problems with your computer or other technology issues are not an excuse for delays in meeting expectations and missed deadlines for the course. If you have a problem, get help in solving it immediately from helpdesk. At a minimum, you will need the following software/hardware to participate in this course:

1. Computer with an updated operating system (e.g. Windows, Mac, Linux)

2. Updated Internet browsers (Google Chrome or Mozilla Firefox)

3. A pseudo terminal application to connect to server, for example PuTTy

4. Ability to navigate Canvas (Learning Management System)

5. Minimum Processor Speed of 1 GHz or higher recommended.

6. Reliable and stable internet connection.

7. Adobe Reader or alternative PDF reader (free)

8. A webcam and/or microphone is ***highly recommended***.

Course Plan for the Unexpected Please stay informed about university policies, instructions and resources as they relate to the COVID-19 pandemic. It is important to me that you stay on track toward your degree completion. This section presents our course continuity plans for how we will handle situations to avoid disruption to your learning.

- All the lecture material will be available to you as PDF documents on the class web page.

- I'll record and post all the lectures in Canvas.

- All the assignments will be available online. I'll ask you to explain your code to me for some of the projects via zoom.

- If I am unable to lecture due to sickness or emergency, I'll inform you before the beginning of class.Please keep a watch on your email and pay attention to announcements on Canvas.

Online Class Netiquette/Behavior

- Be self-reflective before you post an emotional response and reread what you have written to be sure it is positive. Think of your comments as printed in the newspaper. Your online comments will be seen, heard and remembered by others in the class.

- Use effective communication.

  - Avoid the use of all caps or multiple punctuation elements, such as !!! and ???.
  - Be polite, understate rather than overstate your point, and use positive language.
  - If you are using acronyms, jargon or uncommon terms, be sure to explain them so everyone can understand and participate in the discussion.

- Ask for clarification to a point if you feel emotional from a classmates post. It is likely that you misunderstood their point. This strategy will also help you step away from the intensity of the moment to allow for more reflection.

- Sign your name. It is easier to build a classroom community when you know to whom you are responding.

- Foster community. Share your great ideas and contribute to ongoing discussions. Consider each comment you make as one that is adding to, or detracting from, a positive learning environment for you and your classmates.

- Be constructive. You can challenge ideas and the course content, but avoid becoming negative online. When you disagree politely, you stimulate and encourage great discussion. You also maintain positive relationships with others with whom you may disagree on a certain point.

- Keep the conversation on topic by responding to questions, adding thoughtful comments about the topics at hand. Online dialogue is like conversation. If there is a certain dialogue going on, please add to it, but if you have something new to say, please post it in another thread.

- Define your terms. When using acronyms or terms that are particular to your field (or new to our course), please define them for others.

UMSL Course Policies

1. Participation (expectations)

   If you are unable to participate in the scheduled class activity or discussions, you must notify the instructor within the week of that class module or discussion. The instructor reserves the right to make judgment to accept and/or makeup assignments missed because of failed participation in the course activities.

   - It is vitally important that our classroom environment promote the respectful exchange of ideas. This entails being sensitive to the views and beliefs expressed during discussions whether in class or online. Please speak with me before recording any class activity. It is a violation of University of Missouri policy to distribute such recordings without my authorization and the permission of others who are recorded.

   - I will not respond to each post but will be monitoring each discussion. I'll correct if I find something that is incorrect.

   - Your success in this course will heavily depend on your ability to communicate, engage and participate in all course activities. Successful completion of this course requires that a student keep up with all assignments, coursework and discussions. Timely participation in in-class and online discussions is a very important part of this course and participation in these discussions, and other activities as assigned, is not optional. You are expected to prepare and post to discussions in a timely manner consistent with the requirements contained within the course syllabus.

   - **Online Discussion Guidelines**
     - Participation in the course should maintain a positive work and learning environment, as outlined in the UM Collected Rules & Regulations, 330.080
     - Postings should be evenly distributed during the discussion week.
     - Postings should be a minimum of three sentences, or one short paragraph, and a maximum of two paragraphs. Or you can give a one-minute recorded presentation.
     - Responses should be well written with proper punctuation, spelling and grammar.
     - Avoid short one-word postings, for instance, "I agree," unless accompanied by supporting statements from the readings or prior knowledge (work and life experience).

- Stay focused on the topic.
- Ask questions; challenge other postings that lack supporting evidence or present incorrect information.
- Encourage further discussion by building on current threads.
- Check your postings for responses from others and respond in kind.
- Use proper "netiquette".

- Turn off sound on beepers, cell phones, and other devices during class. Adherence to the Student Conduct Code is expected.

- I am committed to ensuring a positive learning environment by respecting that University policy.

- Your success in this course will heavily depend on your ability to communicate, engage and participate in all course activities. Successful completion of this course requires that a student keep up with all assignments, quizzes, projects and tests.

- If you are unable to participate in the scheduled class activities, you must notify the instructor within the week of that class module. **An unexcused failure to engage or participate with the class will be counted as an absence; unexcused absences may result in failure.** The instructor reserves the right to make judgment to accept and/or makeup assignments missed because of failed participation in the course activities.

2. **Academic Integrity/Plagiarism**: We want our learning environment to be honest and fair. The assessments in our course provide you with an opportunity to showcase what you know and learn from what you may not yet have mastered. When you submit work with your name on it, this is a written statement that credit for the work belongs to you alone. If the work was a product of collaboration (such as a group project), each student is expected to clearly acknowledge in writing all persons who contributed to its completion.

Each assignment and exam in our course will include clear guidelines about the rules around each assessment including what materials are appropriate to use. It is always required that the work you submit is your own, uses proper citation, avoids collusion or falsification.

If you have a question about an assignment, do not hesitate to contact me for clarification. You are responsible for being attentive to and observant of University policies about academic honesty as stated in the University's Campus Policies and Code of Student Conduct found in the UMSL Bulletin.

- **Plagiarism, collusion, cheating, and falsification are not acceptable** and will result in failure of an assignment and possible administrative sanctions such as dismissal from the university.

   Plagiarism. Representing the ideas or work of another as your own, intentionally or unwittingly, without proper, clear, explicit acknowledgement.

   Facilitation/Collusion. Supporting malpractice by another student, for example, allowing your work to be copied.

   Duplication of Work. Presenting the same work for a different assessment.

   Cheating. Using any unauthorized sources of information (such as previous or existing exams for this course) and providing or receiving unauthorized assistance on any form of academic work or engaging in any behavior specifically prohibited by the faculty member (e.g., uploading or using test or online homework questions on study sites such as Chegg.com, copying someone elses answers on tests and quizzes, copying/pasting exam or online homework questions from this semester for your peers or publicly in online forums).

   Falsification. Any untruth, either verbal or written, in ones academic work including presenting fabricated/made up data or presenting someone elses work as your own. Unless the instructor explicitly

states otherwise, it is dishonest to collaborate with others when completing any assignment or test, performing laboratory experiments, writing and/or documenting computer programs, writing papers or reports and completing problem sets.

- Academic dishonesty is a serious offense that may lead to probation, suspension, or dismissal from the University. Academic dishonesty can take a number of forms described above: plagiarism, cheating, unauthorized possession or distribution of academic materials including the unauthorized use, selling or purchasing of examinations or other academic work, using or stealing another students work, unauthorized entry or use of material in a computer file, and using information from or possessing exams that an instructor did not authorize for release to students.

- All instances of academic dishonesty will be reported to the Office of Academic Affairs who will determine whether you will appear before the Student Conduct Committee for possible administrative sanctions such as dismissal from the university. The instructor will make an academic judgment about the students grade on that work in this course. The campus process regarding academic dishonesty is described in the "Policies" section of the Academic Affairs website

3. **Title IX Policies**

Mandatory Reporting: Under Title IX, all UMSL faculty, staff, and administrators (with limited exception) are obligated to report any incidents of sexual harassment, sexual misconduct, sexual assault, or gender discrimination to the Student Affairs office and/or other University officials. This ensures that all parties are protected from further abuses and that victim(s) are supported by trained counselors and professionals. Note: There are several offices at UMSL (e.g., Counseling Services, Health Services, Community Psychological Service, Center for Trauma Recovery, and Student Social Services) whose staff are exempt from Title IX mandated reporting, when the information is learned in the course of a confidential communication.

Student Resources Your academic success is important to me. We all learn differently and bring different strengths and needs to the class. If there are aspects of the course that prevent you from learning or make you feel excluded, please let me know as soon as possible. Together well develop strategies to meet both your needs and the requirements of the course.

Access, Disability and Communication If you have a documented disability that may have an impact upon your work in this class, please contact Disability Access Services (DAS) immediately. Students must provide documentation of their disability to the office of Disability Access Services in order to receive official University services and accommodations. The staff is available to answer questions regarding accommodations or assist you in your pursuit of accommodations. Information about your disability is confidential. Once DAS information and steps to inform me about the accommodations to which you are entitled. Your accommodations will begin as soon as we discuss your approved accommodations.

- 131 Millennium Student Center
- Phone: (314) 516-5671
- Email: `das@umsl.edu`

Office of International Students and Scholar Services If you have difficulty communicating in English with the instructor of this course, contact ISSS.

- 362 Social Sciences & Business Building (SSB)
- Phone: (314) 516-5229
- Email: `global@umsl.edu`

Student Enrichment and Achievement SEA provides comprehensive support and intervention strategies that support your road to graduation!

- 107 Lucas Hall
- Phone: (314) 516-5300
- Email: `umslsea@umsl.edu`

Office of Multicultural Student Services (MSS) **and the University Tutoring Center** (UTC) MSS provides comprehensive student retention services to diverse student populations; through their tutoring center, the MSS offers comprehensive tutoring services free to students at UMSL.

- 225 Millennium Student Center (MSC)
- Phone: (314) 516-6807
- Email: `multicultural@umsl.edu`

Technical Support Please consult UMSL's Keep Learning web resource for technology tips and help with learning in Canvas.

Canvas If you have problems logging into your online course, or an issue within the course site, please contact the Technology Support Center.

- Phone: (314) 516-6034
- Email: `helpdesk@umsl.edu`

If you are having difficulty with a technology tool in Canvas, consider visiting the Canvas Student Guides, which has overviews of each tool and tutorials on how to use them.

If you continue to experience problems or just have questions, you can also contact the Learning Resource Lab.

- Phone: (314) 516-6704
- Email: `lrl@umsl.edu`

VoiceThread

- Online Contact Form
- Website

Departmental Tutoring The department offers tutoring for up to Cmp Sci 3130, and occasionally for other courses. Please check Canvas for information.