Cornell College

# CSC 311: System Software

## Fall 2023 (Block 1)


### Instructor:

- **Name:** Ajit Chavan
- **Email:** achavan@cornellcollege.edu
- **Office:** West Hall 210


### Classes:

- Monday – Friday, 9:00 – 11:00 AM (West Hall 201)
- Monday – Friday, 1:15 – 3:00 PM (West Hall 201)

### Office Hours:

- Monday, Thursday, Friday, 11:00 AM – 12:00 PM (West Hall 201)
- Monday, Tuesday, Thursday, Friday, 3:00 – 4:00 PM (West Hall 201)
- By appointment

### Textbook:

*"Operating System Concepts," by Abraham Silberschatz, Greg Gagne, Peter Galvin, 10th Edition.*

### Resources:

1. **Moodle:** Moodle will be the primary platform for sharing class material, creation and submission of assignments, and posting grades. If you have any questions regarding the use of Moodle, please contact me and I will be happy to walk you through the process.
2. **Piazza:** Piazza will be primarily used as a discussion forum. You are allowed to discuss the questions/problems you encounter during your assignment on the Piazza. I highly encourage you all to use Piazza to connect with your classmates, to post your questions and participate in the discussion.

### Course Objectives:

This course focuses on how to design a system, and it takes an operating system as an example of a complex multifaceted software. It is important to note that the assessment will be based on both the operating system concepts as well as your understanding/experience in design principles of system design. As usual, I will discuss, in detail, assessment criteria as well as topics covered in this course during the first lecture. We will study the roles and responsibilities of each component of the Unix operating system. We will then investigate the different design issues we need to address to design an efficient operating system and evaluate the trade-offs of the solutions. In the second part of the course, we will see how to design scalable and efficient systems. We will also spend significant amount of the course (especially assignments) on programming in groups. My goal for this course is for you to **write at least 1000 lines of code during this block**.

After finishing this course, you will:

- Be able to understand roles and responsibilities of any operating system.
- Be able to understand different algorithms and protocols used by the OS to schedule processes.
- Be able to understand how the OS executes application on users' behalf and provide different services to the applications.
- Be able to conceptually understand how the file system works.
- Be able to figure out different requirements of a given system.
- Be able to design moderately complex software systems.

Some of the important topics that we will cover in this course:

- OS basics
- Process Management
- CPU Scheduling
- Synchronization and deadlocks
- Main Memory/Virtual Memory
- File System Basics
- Software System Design Principles

We will give special attention to the following education priorities and outcomes:

1. **Knowledge:** We will develop an overall understanding of Operating systems, methodology to design system software as well as how to leverage existing OS utilities to develop user applications.
2. **Inquiry:** We will discuss a lot of design problems and understand the different trade-offs we have to deal with while developing software systems. Rather than just knowing the best possible solutions, we will take a look at multiple solutions and figure out why (or in which cases) one solution is better than the other.
3. **Communication:** We will get more experience about how to engage with others in productive dialogue. We will present a number of concepts and then will have discussions about the different performance and security implications of these design choices. We will also work in teams to divide a large problem into different small problems and work together to solve these problems. Finally, we will integrate these solutions into one larger solution for the given problem.
4. **Ethical Behavior:** We will recognize personal, academic, and professional standards and act with integrity.

## Assessment:

For this course, the majority of emphasis will be on the three group projects/assignments. Apart from the weekly assignments, we will have two exams and daily quizzes. As usual, a chunk of grades will be reserved for your class-participation and your involvement in the group assignments. Although the syllabus provides the categorical weightage for assessment, the final grades will also be impacted by 1) the depth of your

knowledge about covered concepts, and 2) the amount of improvement accomplished during the block. I will talk about this is greater details during the first session. Following is the weightage for each assessment category:

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| Quizzes | 10% |
| Assignments | 45% |
| Exams | 25% |
| Class Participation | 20% |
| **Total** | **100%** |

| | - | | + |
|---|---|---|---|
| **A** | 90-92.99 | 93-100 | N/A |
| **B** | 80-82.99 | 83-86.99 | 87-89.99 |
| **C** | 70-72.99 | 73-76.99 | 77-79.99 |
| **D** | 60-62.99 | 63-66.99 | 67-69.99 |
| **F** | N/A | 0-59.99 | N/A |

## Assignments:

We will have group assignments in this course. All assignments will have two deliverables: 1) Code or paper submission that you will submit via Moodle, and 2) Class presentations. I will talk more about the weightage for each component and requirements/expectation for each component will be discussed on per assignment basis in the class. We will have one assignment each week. The final assignment will be for week 3 and 4 and will be a little bit larger than the remaining two assignments.

## Exams:

We will have two exams. The first exam will be a written exam on the second Wednesday. It will be for 10% of your final grades. Second exam will start on fourth Tuesday and will be individual 45 minutes interview. Second exam will be a comprehensive exam and will count for 15% of your final grades.

## Quizzes:

There will be around 10 in class quizzes (may be more if necessary). Usually, quizzes are closed book and closed notes. Each quiz will be for 10 points and will last for 15 minutes. Quizzes are designed to serve two purposes:

1. To help me assess your understanding of the material covered in the class. Help me understand if I need to go over some concepts again in the class.
2. To demonstrate you the loopholes in your understanding. Sometimes, you may think that you have understood some concepts, but quiz will help you understand if your assumption is correct or not.

## Class Participation:

This is one of the most important aspect of your overall assessment in the course. This category is divided into two parts: attendance (5%) and class participation (15%). It is also important to note that if you are not present in the class you cannot participate in the class, but just by attending the class, you will not get whole class participation points either. I will update the class participation grades daily.

## Course Policies:

This includes participation, integrity, credit hour discussion, and technology policies:

## Participation Policy:

We have mentioned that the class participation counts as 15% of your final grades. Class participation includes:

1. Adhering to the course policies while attending a class session.
2. Speaking up in whole-group discussion in a respectful manner. Talking frequently does not automatically mean you do well in this category—it is important that you also let others speak and contribute in meaningful ways.
3. Participating and contributing to the conversations and activities in small group setting.
4. Engaging with the course learning in a meaningful manner.
5. Completing assigned readings in a timely manner and following up with me if you have any questions.

## Academic Integrity and Honest:

Cornell College expects all members of the Cornell community to act with academic integrity. An important aspect of academic integrity is respecting the work of others. A student is expected to explicitly acknowledge ideas, claims, observations, or data of others, unless generally known. When a piece of work is submitted for credit, a student is asserting that the submission is her or his work unless there is a citation of a specific source. If there is no appropriate acknowledgment of sources, whether intended or not, this may constitute a violation of the College's requirement for honesty in academic work and may be treated as a case of academic dishonesty. The procedures regarding how the College deals with cases of academic dishonesty appear in The Catalogue, under the heading “Academic Honesty."

## Mental Health

As a college student, you may sometimes experience stress, anxiety, or other mental health challenges that affect your mood, energy level, concentration, and mental ability. Cornell recognizes that you may experience these challenges and provides resources to help you take charge of your mental health and overall well-being. If you, a classmate, or a friend experience mental health challenges at Cornell, please check out the Counseling Center’s website (www.cornellcollege.edu/counseling) for many resources on and off campus, and you can call the Counseling Center at 319-895-4292 for more information or to make an

appointment. Visit the Student Gateway and the Cornell Well-being Network websites for additional student re- sources.

## Resilience

Each day you have an invitation to learn in this course, and you attendance and participation are an integral part of what keeps our learning community strong. Sometimes we slip up. We forget to set an alarm. We don't expect a wave of depression to take over our day. And we miss class of have a moment where we aren't certain we can finish class. I encourage you to find what I know is within you to breathe through this and keep going. If you are in class, take a break and come back. If you miss class, come back to the next class period. Whatever you do, please don't give up. Communicate with me about what happened and we will create a plan for your success in the course. Building up resilience to the things that challenge us is a part of the human experience. It takes practice and I am here with you to help you practice.

## Disability and Accommodations

Cornell College makes reasonable accommodations for persons with disabilities. Students should notify the Office of Academic Support and Advising and their course instructor of any disability related accommodations within the first three days of the term for which the accommodations are required, due to the fast pace of the block format. For more information on the documentation required to establish the need for accommodations and the process of requesting the accommodations, visit Student Success Center's Website.

## Lesson Plan

| Week 1 | | | | |
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| **Day of Course** | **Date** | **Day of Week** | **Topics** | **Reading** |
| Day 1 | Aug, 28 | Monday | **Introduction and Overview**<br>- Course Introduction<br>- OS overview<br>- System Organization<br>- Resource Management | 1.1 What Operating System Do (4-7)<br>1.2.1.1 Interrupts (8)<br>1.2.1.2 Storage (11- 14)<br>1.2.1.3 I/O (14-15)<br>1.5 Resource Management (27-32) |
| Day 2 | Aug, 29 | Tuesday | **Process Management**<br>- Memory Layout<br>- Process State<br>- Process Control Block<br>- Scheduling Queues<br>- CPU Scheduling<br>- Context Switch | 3.1 Process Concepts (106-110)<br>3.2 Process Scheduling (112-115) |
| Day 3 | Aug, 30 | Wednesday | **Memory Management**<br>- Basics<br>- Address Binding<br>- Logical Vs Physical addr<br>- Memory Allocation<br>- Fragmentation<br>- Virtual Memory (Very Basic) | 9.1 Background (349-355)<br>9.2 Contiguous Memory Allocation (356-360)<br>10.1 Virtual Memory Background (389-392)" |
| Day 4 | Aug, 31 | Thursday | **Storage**<br>- Mass Storage structure<br>- HDDs<br>- Address Mapping<br>- NAND storage | 11. 1 Overview |
| Day 5 | Sept, 01 | Friday | **File System:**<br>- File attribute<br>- File Operations<br>- File Types<br>- File Structure | 13.1 File Concepts<br>14.1 File System Structure<br>14.2 File System Operations |
| **Week 2** | | | | |
| **Day of Course** | **Date** | **Day of Week** | **Topics** | **Reading** |
| Day 6 | Sept, 04 | Monday | **CPU Scheduling:**<br>- CPU-I/O Burst<br>- Preemptive Scheduling<br>- Scheduling Criteria<br>**Algorithms:**<br>- FCFS<br>- Shortest Job First<br>- Round Robin<br>- Priority Scheduling | 5.1 Basic concepts<br>5.2 Shcduling Criteria<br>5.3 Scheduling Algorithms |

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| Day 7 | Sept, 05 | Tuesday | **Continued from the previous day**<br>- Load Balancing<br>- Processor Affinity | 5.5 Multi-Processor Scheduling |
| Day 8 | Sept, 06 | Wednesday | **Exam 1** | |
| Day 9 | Sept, 07 | Thursday | **Synchronization:**<br>- Critical-Section<br>- Peterson's Solution<br>- Mutex<br>- Semaphores | 6.1 Background<br>6.2 The Critical-section Problem<br>6.3 Peterson's Solution<br>6.5 Mutex<br>6.6 Semaphores |
| Day 10 | Sept, 08 | Friday | **Deadlocks:**<br>- Deadlock<br>- Livelock<br>- Deadlock Characterization<br>- Resource Allocation Graph<br>- Deadlock handling<br>- (deadlock prevention) | 8.1 System Model<br>8.2 Deadlock in Multithreaded Application<br>8.3 Deadlock Characterization<br>8.4 Methods for Handling Deadlocks<br>8.5 Deadlock Prevention |
| **Week 3** | | | | |
| **Day of Course** | **Date** | **Day of Week** | **Topics** | **Reading** |
| Day 11 | Sept, 11 | Monday | **Memory Allocation:**<br>- Basic methods<br>- Translation Look Aside<br>- Hierarchical Page Table<br>- Hashed Page Table | 9.3 Paging<br>9.4 Page Table Structure<br>9.5 Swapping |
| Day 12 | Sept, 12 | Tuesday | **Caching:**<br>- Caching<br>- Address Mapping | Instructor-provided handout |
| Day 13 | Sept, 13 | Wednesday | **Assignment 2: Presentation** | |
| Day 14 | Sept, 14 | Thursday | **Virtual Memory:**<br>- Page Table<br>- Demand Paging<br>- Copy-On-Write<br>- Page Replacement Policies | 10.1 Basics<br>10.2 Demand Paging<br>10.3 Copy-on-Write<br>10.4 Page Replacement |
| Day 15 | Sept, 15 | Friday | **Storage Attachments:**<br>- Host-Attached Storage<br>- Network-Attached Storage<br>- Cloud Storage<br>- SAN<br>- RAID | 11.1 Mass Storage<br>11.5 Storage Device Management<br>1.7 Storage Attachment |
| **Week 4** | | | | |
| **Day of Course** | **Date** | **Day of Week** | **Topics** | **Reading** |
| Day 16 | Sept. 18 | Monday | Assignment 3 Presentation | |
| Day 17 | Sept, 19 | Tuesday | Exam 2 | |
| Day 18 | Sept, 20 | Wednesday | Exam 2 | |