NORTHERN ARIZONA UNIVERSITY

School of Informatics, Computing, and Cyber Systems

# CS 480 **Operating Systems** Syllabus

| Term | Class No. | Section | Units | Days & Times | Room | Mode |
|---|---|---|---|---|---|---|
| Spring 2023 | 3901 | 001 | 3 | M/W 4:00 – 5:15 PM | 69-101 | In person |

## Enrollment Requirements

Prerequisite: CS 249 with a grade of C or better

## Course Website

http://bblearn.nau.edu

## Instructor

Dr. Michael Leverington
Email: Use BBLearn “Course Email” exclusively
Office Hours: Online, Office Hours specified in BBLearn
Physical Office Hours: TBD, depending on covid conditions
Office Location: EGR (69) #243

## Catalog Description

Theory behind operating systems; scheduling, memory management, I/O and concurrency. Letter grade only.

## Course Purpose

This course provides advanced Computer Science students with a foundational grounding in the development, design, and use of Operating Systems (OS) in general. While OS have significantly evolved over the past few decades, the foundational components are still an important part of understanding and modeling OS operations. In addition to understanding OS software specifically, students are engaged with non-trivial and large-scale programming challenges, which include creating a software product that simulates a working OS.

## Course Student Learning Outcomes

Upon successful completion of this course, students will be able to demonstrate the following competencies:

- **LO1**: Students will be able to describe the use and implementation of Operating System (OS) founding core principles related to OS structures, process management, CPU Scheduling, memory and data storage management, safety and security
- **LO2**: Students will be able to describe and analyze hardware, software, environmental, and user conditions and requirements in Operating Systems that have evolved to this point, and are steadily evolving beyond the current state of Operating Systems
- **LO3**: Students will be able to analyze and explain the algorithms and strategies used to implement OS operations
- **LO4**: Students will be able analyze and synthesize software that conducts the actions of selected Operating System components

## Assignments / Assessments of Course Student Learning Outcomes

Learning outcomes are assessed through a variety of means:

- Students will demonstrate the learning outcomes, including LO1, LO2, LO3, and LO4, by creating written artifacts that represent their knowledge, analysis, and synthesis of OS components, specifically through brief in-class quizzes and examinations
- Students will demonstrate knowledge and understanding of the design, development, and implementation of OS operations, including LO1, LO3, and LO4, by developing software products that represent selected OS components

## Grading System

A weighted sum of assessment components is used to determine your final grade in the course:

- Class activities, including written quizzes: **30%**
- Programming assignments: **30%**
- Mid Term Examination: **20%**
- Final Exam Examination: **20%**

Grades will be assigned using the weighted sum described above using this scale:
**A** ≥ 90%, **B** ≥ 80%, **C** ≥ 70%, **D** ≥ 60%, **F** < 60%.

Each graded item will be scored on a simple rubric, scores will be added and normalized to a percentage, and then multiplied by the appropriate weight specified above. Letter grades are earned as follows: A: 90% and above, B: 80% and above, C: 70% and above, D: 60% and above, F: below 60%. Per NAU policy, there are no plusses or minuses awarded, and grades are not normally rounded up or down.

Grading will be conducted, and grades posted as expeditiously as possible so students can be regularly updated on their current score. Students are expected to contact the Instructor if any grades do not seem correct; identified and legitimate grading issues will be corrected as soon as possible. However, grades posted and not challenged for three weeks after they are posted will be considered correct, and are unlikely to be subject to change.

## Readings and Materials

**Textbook Required**: The textbook *Operating System Concepts* (10th ed), by Abraham Silberschatz, et. al. However, the book will be delivered via ZyBooks. Go to learn.zybooks.com and enter **NAUCS480LeveringtonSpring2023**. The text is better quality than the original publisher and there may be some additions to the text as the semester proceeds. Since there may be circumstances where credit is earned through this media, the subscription is required.

**Class Outline and Tentative Schedule**

The course topics and a tentative schedule serve as an outline for the class:

| | | Monday | | Wednesday | Reading |
|---|---|---|---|---|---|
| **Week 1** | **1/16** | Course Introduction, first programming assignment | **8/31** | continued... | n/a |
| **Week 2** | **1/23** | OS history and development | **9/7** | continued… | Chapters 1, 2, Appendix A |
| **Week 3** | **1/30** | Processes | **9/14** | continued… | Chapter 3 |
| **Week 4** | **2/6** | Threads | **9/21** | continued… | Chapter 4 |
| **Week 5** | **2/13** | CPU scheduling | **9/28** | continued... | Chapter 5 |
| **Week 6** | **2/20** | Main memory | **10/5** | continued... | Chapter 9 |
| **Week 7** | **2/27** | Mid-Term examination | **10/12** | Virtual memory | Chapters 1,2,3,4,5,9, Appdx A |
| **Week 8** | **3/6** | Virtual memory | **10/19** | continued… | Chapter 10 |
| **Week 9** | **3/20** | Synchronization and Concurrency | **10/26** | continued… | Chapter 6, 7 |
| **Week 10** | **3/27** | Deadlocks | **11/2** | continued… | Chapter 8 |
| **Week 11** | **4/3** | File I/O | **11/9** | continued... | Chapters 11, 13, 14, 15 |
| **Week 12** | **4/10** | I/O systems, and their interaction with the OS | **11/16** | continued… | Chapter 12 |
| **Week 13** | **4/17** | OS system security, law and ethics | **11/23** | continued… | Chapter 16 |
| **Week 14** | **4/24** | OS system protection, law and ethics | **11/30** | continued… | Chapter 17 |
| **Week 15** | **4/31** | Law and ethics | **12/7** | continued… | n/a |
| **Week 16** | **12/14** | Final Exam<br>Monday, 8 May, 3:00p – 5:00p<br>Chapters: 6,7,8,11,12,13,14,15,16,17<br>Location: classroom | | | |

## Program Accreditation

The BSCS and BSE programs in the School of Informatics, Computing, and Cyber Systems are both accredited by ABET, which is “a not-for-profit, non-governmental accrediting agency for programs in applied science, computing, engineering, and engineering technology. ABET accreditation provides assurance that a college or university program meets the quality standards of the profession for which that program prepares graduates.” from the ABET website, 2017/01/03.

There are eleven assessed outcomes in the NAU BSCS program. While this course is not specifically assessed for ABET, several ABET components are supported, including:

b. An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution

c. An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs

e. An understanding of professional, ethical, legal, security, and social issues and responsibilities

Samples of the course assignments, and your responses to them, will be made available to a team representing a variety of outside institutions who will review the education our program provides to our students, and provide feedback to us so that we may maintain and continue to improve our Computer Science and Engineering standards as members of this international accreditation system.

**Course Policies**

The following policies will apply to this course:

**Attendance.** Students are expected to attend and be on time for every class. There will be class interaction every day, and possible clicker/quizzes almost every day. Miss a day, miss a lot!

**Class Interaction**. As stated previously in this document, there will be class activities almost every day. There will be weekly programming project assignments focused on the topic and objectives given the previous week. Students must attend to all activities since most or all of them will likely be graded.

**Late work submission.** As a general rule, late work will not be accepted. However, if the Instructor is advised ahead of time that a student will miss some course component for a legitimate and verifiable reason, consideration will be given to extending a deadline for the individual student.

**Electronic Devices.** It is expected that all students will silence their phones or other noise-making devices during class time. During the examination components, no electronic devices may be visible to the Instructor or used by the student. Students may keep a mobile phone or other device in their pocket but may not use any electronic device while in the testing environment. **Note that failure to follow this requirement is likely to result in a zero on the examination.**

**Blackboard Learn.** It is expected that all students have access to Blackboard Learn on the first day of class. All students are expected to check on Blackboard Learn for news or updates, posted grades, emails, announcements, and so on, every week day. It is a really good idea to check it once or twice on weekends as well.

**Working with Others.** Unless otherwise instructed, students may work together as needed for any and all classroom assignments. For the programming projects, students may work together on any part of the design and development phases up to the point of writing code. No one other than the Instructor, a course identified TA, or a tutor who is not currently taking this course may view your code. Note that in the Academic Integrity references below, your code must be unique; once you have worked out some programming solutions, you must go to your own editor and write the code your own way. Students may also ask questions or share information on the Blackboard Learn Discussion Board within reason.

**Academic Integrity (Course Level).** All rights, regulations, and conditions concerning academic honesty and plagiarism, as they appear in the current University catalog and later in this document, will be upheld in this course. In addition to the stated University standards, any student-contributed artifact found to have more in common with any other source including, but not limited to, one or more fellow students, any online reference, any exams, programs, or materials provided or used in previous classes or semesters, etc. than is considered reasonable or acceptable by the course Instructor(s) will be deemed to be academic dishonesty. Note that, like the University policy, this definition includes the person who provided the material(s) in question. Any student who has demonstrated academic dishonesty in this course will receive a minimum academic penalty of: 1) failure of the assignment or assessment artifact (i.e., assigned grade will be zero), and 2) an Academic Integrity Violation Form indicating the academic integrity breach and the associated sanction will be forwarded to the College of Engineering, Informatics, and Applied Sciences to be placed in the student's permanent file. **Note that with consideration for this being an upper level course, and assuming that students are well aware of, and experienced with, NAU's Academic Integrity policy, the most likely recommendation in the Academic Integrity Violation Form will be for the student to be dropped from the course with a grade of F.**

Spring 2020 Note: The new academic integrity rules include a component related to being in possession of previous examinations: "Possessing, using, or circulating previously administered examinations, unless authorized by the appropriate faculty member". For purposes of this course, this means that if you are found to be in possession of ANY examination other than 1) your own, and 2) from this semester's course, you will be found in violation of NAU's Academic Integrity policy (and get a letter written to the Dean).

**NAU Athletics.** If you are involved with any university-sponsored athletic activities that will have an impact on your course continuity, you must provide your Instructor with a letter from your coach and/or the NAU Athletic Department as soon as possible, but no later than the end of the second week of classes. This should include the official schedule of your activities which will impact your attendance throughout the semester. You must also advise your Instructor at least one week in advance of any absences related to the athletic activities

**Illness.** If you are sick or have a health-related reason for not continuing with course activities, let your Instructor know as soon as you are aware of the problem. You can do this via Blackboard Learn Course Email to the Instructor. As stated previously in this document, as long as the issue is legitimate and verifiable, advance notice to the Instructor may lead to extension of a homework, laboratory, or other deadline.

**Course/Policy Modification.** The Instructor reserves the right to add to, and/or modify any of the policies previously specified in this document as needed to maintain an appropriate and effective educational atmosphere in the classroom. In the case that this occurs, all students will be notified in advance of implementation of the new and/or modified policy.

**Resources for Student Success.** Successful university students take advantage of services and resources designed to boost learning and achievement.

- Jack's Care – immediate access to mental health support
- ResourceConnect - your online central navigation point for all NAU student resources
- University College Services – a full listing University College services
- Student Learning Centers - free drop-in, online, and individual tutoring appointments for math, writing, and over 100 courses; available Monday through Friday
- Action Center - messages to keep you academically on track – when you get a message take action!

**Personal Safety and Security.** The NAU Police Department offers safety and security information at this website. In addition, here are some brief tips to maintaining your own safety and security:

- Make personal safety your number one priority. Awareness, Avoidance and Risk Reduction are the best ways to avoid bad situations.
- Travel in groups of two or more and always travel in well-lit, heavily traveled areas. Advocate for, and protect your friends who are having difficulties. Don't look away.
- Tell someone where you are going and when you will return. You may also mention the path or transportation you will be using.
- Carry a whistle or noise maker. This can serve as a reminder to exercise caution, and can alert someone in the area that you need help. Your noisemaker and your car keys should always be in your hand as you walk to your car or facility access door.
- Be alert! Look around you; be aware of who is on the street and in the area. Make it difficult for anyone to take you by surprise. If listening to music, keep the volume low so you can hear what is going on around you.
- Never walk alone on campus at night. If you know you are going to be working late, plan ahead as to how you will get to your vehicle or residence safely.
- Use the campus shuttles to get around but again remember to travel in groups if you are getting off the shuttles in isolated locations.

# COVID-19 REQUIREMENTS AND INFORMATION

Additional information about the University's response to COVID-19 is available from the **Jacks are Back!** web page located at https://nau.edu/jacks-are-back.

## UNIVERSITY SYLLABUS POLICY STATEMENTS

**ACADEMIC INTEGRITY**
NAU expects every student to firmly adhere to a strong ethical code of academic integrity in all their scholarly pursuits. The primary attributes of academic integrity are honesty, trustworthiness, fairness, and responsibility. As a student, you are expected to submit original work while giving proper credit to other people's ideas or contributions. Acting with academic integrity means completing your assignments independently while truthfully acknowledging all sources of information, or collaboration with others when appropriate. When you submit your work, you are implicitly declaring that the work is your own. Academic integrity is expected not only during formal coursework, but in all your relationships or interactions that are connected to the educational enterprise. All forms of academic deceit such as plagiarism, cheating, collusion, falsification or fabrication of results or records, permitting your work to be submitted by another, or inappropriately recycling your own work from one class to another, constitute academic misconduct that may result in serious disciplinary consequences. All students and faculty members are responsible for reporting suspected instances of academic misconduct. All students are encouraged to complete NAU's online academic integrity workshop available in the E-Learning Center and should review the full *Academic Integrity* policy available at https://policy.nau.edu/policy/policy.aspx?num=100601.

**COPYRIGHT INFRINGEMENT**
All lectures and course materials, including but not limited to exams, quizzes, study outlines, and similar materials are protected by copyright. These materials may not be shared, uploaded, distributed, reproduced, or publicly displayed without the express written permission of NAU. Sharing materials on websites such as Course Hero, Chegg, or related websites is considered copyright infringement subject to United States Copyright Law and a violation of NAU Student Code of Conduct. For additional information on ABOR policies relating to course materials, please refer to ABOR Policy 6-908 A(2)(5).

**COURSE TIME COMMITMENT**
Pursuant to Arizona Board of Regents guidance (ABOR Policy 2-224, *Academic Credit*), each unit of credit requires a minimum of 45 hours of work by students, including but not limited to, class time, preparation, homework, and studying. For example, for a 3-credit course a student should expect to work at least 8.5 hours each week in a 16-week session and a minimum of 33 hours per week for a 3-credit course in a 4-week session.

**DISRUPTIVE BEHAVIOR**
Membership in NAU's academic community entails a special obligation to maintain class environments that are conductive to learning, whether instruction is taking place in the classroom, a laboratory or clinical setting, during course-related fieldwork, or online. Students have the obligation to engage in the educational process in a manner that does not interfere with normal class activities or violate the rights of others. Instructors have the authority and responsibility to address disruptive behavior that interferes with student learning, which can include the involuntary withdrawal of a student from a course with a grade of "W". For additional information, see NAU's *Disruptive Behavior in an Instructional Setting* policy at https://nau.edu/university-policy-library/disruptive-behavior.

**NONDISCRIMINATION AND ANTI-HARASSMENT**
NAU prohibits discrimination and harassment based on sex, gender, gender identity, race, color, age, national origin, religion, sexual orientation, disability, veteran status and genetic information. Certain consensual amorous or sexual relationships between faculty and students are also prohibited as set forth in the *Consensual Romantic and Sexual Relationships* policy. The Equity and Access Office (EAO) responds to complaints regarding discrimination and harassment that fall under NAU's *Nondiscrimination and Anti- Harassment* policy. EAO also assists with religious accommodations. For additional information about nondiscrimination or anti-harassment or to file a complaint, contact EAO located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011, or by phone at 928-523-3312 (TTY: 928-523-1006), fax at 928-523-9977, email at equityandaccess@nau.edu, or visit the EAO website at https://nau.edu/equity-and-access.

**TITLE IX**
Title IX of the Education Amendments of 1972, as amended, protects individuals from discrimination based on sex in any educational program or activity operated by recipients of federal financial assistance. In accordance with Title IX, Northern Arizona University prohibits discrimination based on sex or gender in all its programs or activities. Sex discrimination includes sexual harassment, sexual assault, relationship violence, and stalking. NAU does not discriminate on the basis of sex in the education programs or activities that it operates, including in admission and employment. NAU is committed to providing an environment free from discrimination based on sex or gender and provides a number of supportive measures that assist students, faculty, and staff.

One may direct inquiries concerning the application of Title IX to either or both the Title IX Coordinator or the U.S. Department of Education, Assistant Secretary, Office of Civil Rights. You may contact the Title IX Coordinator in the Office for the Resolution of Sexual Misconduct by phone at 928-523-5434, by fax at 928-523-0640, or by email at titleix@nau.edu. In furtherance of its Title IX obligations, NAU promptly will investigate or equitably resolve all reports of sex or gender-based discrimination, harassment, or sexual misconduct and will eliminate any hostile environment as defined by law. The Office for the Resolution of Sexual Misconduct (ORSM): Title IX Institutional Compliance, Prevention & Response addresses matters that fall under the university's Sexual Misconduct policy. Additional important information and related resources, including how to request immediate help or confidential support following an act of sexual violence, is available at https://in.nau.edu/title-ix.

**ACCESSIBILITY**
Professional disability specialists are available at Disability Resources to facilitate a range of academic support services and accommodations for students with disabilities. If you have a documented disability, you can request assistance by contacting Disability Resources at 928-523-8773 (voice), ,928-523-8747 (fax), or dr@nau.edu (e-mail). Once eligibility has been determined, students register with Disability Resources every semester to activate their approved accommodations. Although a student may request an accommodation at any time, it is best to initiate the application process at least four weeks before a student wishes to receive an accommodation. Students may begin the accommodation process by submitting a self-identification form online at https://nau.edu/disability-resources/student-eligibility-process or by contacting Disability Resources. The Director of Disability Resources, Jamie Axelrod, serves as NAU's Americans with Disabilities Act Coordinator and Section 504 Compliance Officer. He can be reached at jamie.axelrod@nau.edu.

**RESPONSIBLE CONDUCT OF RESEARCH**
Students who engage in research at NAU must receive appropriate Responsible Conduct of Research (RCR) training. This instruction is designed to help ensure proper awareness and application of well-established professional norms and ethical principles related to the performance of all scientific research activities. More information regarding RCR training is available at https://nau.edu/research/compliance/research-integrity.

**MISCONDUCT IN RESEARCH**

As noted, NAU expects every student to firmly adhere to a strong code of academic integrity in all their scholarly pursuits. This includes avoiding fabrication, falsification, or plagiarism when conducting research or reporting research results. Engaging in research misconduct may result in serious disciplinary consequences. Students must also report any suspected or actual instances of research misconduct of which they become aware. Allegations of research misconduct should be reported to your instructor or the University's Research Integrity Officer, Dr. David Faguy, who can be reached at david.faguy@nau.edu or 928-523-6117. More information about misconduct in research is available at https://nau.edu/university-policy-library/misconduct-in-research.

**SENSITIVE COURSE MATERIALS**

University education aims to expand student understanding and awareness. Thus, it necessarily involves engagement with a wide range of information, ideas, and creative representations. In their college studies, students can expect to encounter and to critically appraise materials that may differ from and perhaps challenge familiar understandings, ideas, and beliefs. Students are encouraged to discuss these matters with faculty.

Last revised August 4, 2022

## Epilogue

Operating Systems are the ultimate evidence of human command of computing machinery. They can also demonstrate evidence that humans have still not achieved complete command over computing machinery. The dynamic between these two conditions is what we will be studying. We will be looking at operating systems from several levels of abstraction, and you are expected to leave the course capable of understanding and discussing operating system components with other knowledgeable people. This can only happen if you engage in the learning and the materials aggressively and systematically. The topics are interesting and interested students can make them even more so.

Updated 07/08/2022