



UNIVERSITY OF SAN FRANCISCO  
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# Systems Foundations

CS 631 (4 units)

Spring 2024

TR 8:00am - 9:45am 01/22/24 - 05/09/24 LS 307 R 7:30am - 9:30am 05/16/24 - 05/16/24 LS 307

TR 2:40pm - 4:25pm 01/22/24 - 05/09/24 LS 307

Lecture

## Instructor Information

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Gregory Benson (Instructor)

benson@usfca.edu (Campuswire Preferred)

**Office Hours**

<https://cs631-s24.cs.usfca.edu/staff>

Quinn Brockmyre (TA)

qabrockmyre@dons.usfca.edu (Campuswire Preferred)

**Office Hours**

<https://cs631-s24.cs.usfca.edu/staff>

Max Weidmer

maweidmer@dons.usfca.edu (Campuswire Preferred)

**Office Hours**

<https://cs631-s24.cs.usfca.edu/staff>

## Course Description

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Study of the foundations of computer systems and the hardware/software interface. Topics span the design, implementation, and programming of processor architectures, networks, and operating systems. Computer architecture topics include instruction set design, cache design, hardware virtual memory, and virtualization. Network topics include network interfaces, protocol design, and network programming. Operating system topics include kernel design, the system call interface, resource

management, software virtual memory, and file systems. Programming projects required. Four hour lecture.

In this course we will study the foundations of computer systems and the hardware/software interface. The overall goal of this course is provide you with a solid foundation in how computer systems work at a low level. Even if you program primarily in high-level languages such as Java, JavaScript, and Python, it is important to understand how software interacts with computer processors, how languages are implemented, and how an OS kernel provides essential support to run programs. You will learn about language processing and compilers, assembly language programming, machine code, machine emulation, digital design, processor design, and OS kernel design. The course will consist of readings, lectures, and projects from each of the topic areas. Programming will be done in the C programming language and RISC-V assembly. Digital design will be done using the Digital schematic design tool. You will also gain experience in working with UNIX/Linux development tools and working from the command line.

## Course Learning Outcomes

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Upon completion of this course the students will have learned the following topics:

1. Work effectively at the UNIX command line / shell (All Projects)
2. Implement a scanner, parser, and interpreter for a simple language (Project01)
3. Construct and deconstruct binary-level data representations for integers, floats, strings, and machine instructions (Project01, Project03)
4. Translate C code snippets into RISC-V assembly language by hand (Project02)
5. Implement a RISC-V code generator for a simple language (Project02)
6. Implement an RISC-V processor emulator in C (Project03)
7. Understand and evaluate cache design and behavior (Project03)
8. Compose digital circuits into architectural components (Project04 and Project05)
9. Design and implement a working processor for a subset of the RISC-V instruction set (Project05)
10. Pipeline processor design and hazard mitigation (Project06)
11. Write programs using UNIX system calls and modify/add system calls in the kernel (Project07)
12. Understand OS kernel structure, process isolation, and virtual memory (Project08)

# Assignments

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In this class there will be two types of student work: labs and projects.

**Labs** consist of programming problems to help you learn the concepts discussed in class and prepare you for the upcoming projects. In some cases the code you write in the labs will be used in the projects. Your score for the labs will generally be determined by automated tests. Note that labs must be turned by the stated due date and time. Late labs will not be accepted. Submit what you have working to your GitHub lab repo before the due date and time.

**Projects** are one of the main assessment tools for the course and correspond to each learning outcome shown in parenthesis above. Projects will be graded for correctness (using the Autograder), repo/code quality, and comprehension using 1:1 interactive grading meetings with the instructor or a TA. Note, if a project meeting is required for a project, you must attend the meeting to earn credit for the project. If you do not finish a project by the due date and time, turn in what you have completed for partial credit. You will be allowed 1 week after scores have been submitted to Canvas to earn up to 50% back on any points missed. You can earn back 100% of any points missed for repo/code quality.

## Grading Breakdown and Grading Policies

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### Assignments

1. Labs 10%
2. Project01 - The NTLang Interpreter: 10%
3. Project02 - RISC-V Assembly and NTLang Code Generation: 10%
4. Project03 - RISC-V Emulator and Cache Simulator: 15%
5. Project04 - Digital Design 5%
6. Project05 - Single Cycle Processor: 15%
7. Project06 - Pipelined Processor Hazard Unit: 10%
8. Project07 - System Calls %10
9. Project08 - Processes and Virtual Memory %15

### Policies

1. Neatness counts, for both source code and circuit schematics
2. Original Work
  1. You may get explanatory help from the instructor, TAs, friends, tutors, Internet sites, and generative AI
  2. You must turn in only original work that you personally developed and can explain

3. You cannot turn in work created by generative AI, copied from the Internet, or copied from another student
4. You must not provide your original work to other students (giving your solutions can result in a 0)
5. No credit will be given for work which violates this policy
6. Repeated violations will result in a F in the course and will be reported to the CS Department Chair and the USF Academic Integrity Committee

### 3. Deadlines

1. If you are not done with an assignment by the deadline, you should turn in what you have working to get full credit for that work
2. Late work and corrections may be turned in for up to 50% credit, up to one week after grades are posted to Canvas
3. Extensions for full credit are not given except in extenuating circumstances, which you must discuss with the instructor in advance

### 4. Letter Grades are assigned according to the following table, without rounding or curving:

93.33% - 100%:	A
90.00% - 93.32%:	A-
86.67% - 89.99%:	B+
83.33% - 86.66%:	B
80.00% - 83.32%:	B-
76.67% - 79.99%:	C+
73.33% - 76.66%:	C
70.00% - 73.32%:	C-
66.67% - 69.99%:	D+
63.33% - 66.66%:	D
60.00% - 63.32%:	D-
Below 60%:	F

## Texts and Supplies

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### **The C Programming Language**

ISBN: ISBN-10 : 0131103628

Authors: Brian W. Kernighan and Dennis M. Ritchie

Publisher: Pearson

Edition: March 22, 1988

Where to purchase (URL): <https://www.amazon.com/Programming-Language-2nd-Brian-Kernighan/dp/0131103628?crd=3BML4RVG5428P&keywords=the+c+programming+language&qid=1706835688&sprefix=the+c+programming+languaug,aps,128&sr=8-1>

Required or recommended?: Optional

### Digital Design and Computer Architecture, RISC-V Edition

ISBN: ISBN-10 : 0128200642

Authors: Sarah Harris and David Harris

Publisher: Morgan Kaufman

Publication Date: October 22, 2021

Edition: 1st

Where to purchase (URL): <https://www.amazon.com/Digital-Design-Computer-Architecture-RISC-V/dp/0128200642?crd=34WRUY9JU01YE&keywords=Digital+design+and+computer+architecture+riscv&qid=1706835841&sprefix=digital+design+and+computer+architecture+riscv,aps,126&sr=8-1>

Required or recommended?: Optional

## Course Schedule

Day	Date	Event	Activities
Tuesday	1/23/2024		
Thursday	1/25/2024		
Tuesday	1/30/2024		
Thursday	2/1/2024		
Tuesday	2/6/2024		
Thursday	2/8/2024		
Tuesday	2/13/2024		
Thursday	2/15/2024		
Tuesday	2/20/2024		
Thursday	2/22/2024		
Tuesday	2/27/2024		
Thursday	2/29/2024		
Tuesday	3/5/2024		
Thursday	3/7/2024		
Tuesday	3/12/2024	Spring Break (No Class)	
Thursday	3/14/2024	Spring Break (No Class)	
Tuesday	3/19/2024		

Thursday	3/21/2024		
Tuesday	3/26/2024		
Thursday	3/28/2024	Easter Holiday begins at 4:00 P.M.	
Tuesday	4/2/2024		
Thursday	4/4/2024		
Tuesday	4/9/2024		
Thursday	4/11/2024		
Tuesday	4/16/2024		
Thursday	4/18/2024		
Tuesday	4/23/2024		
Thursday	4/25/2024		
Tuesday	4/30/2024		
Thursday	5/2/2024		
Tuesday	5/7/2024		
Thursday	5/9/2024	Last Day of Classes	

## Program Learning Outcomes

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**Theory:** explain and analyze standard computer science algorithms and describe and analyze theoretical aspects of various programming languages

**Application:** apply problem-solving skills to implement medium- and large- scale programs in a variety of programming languages

**Systems:** describe the interactions between low-level hardware, operating systems, and applications

**Project:** demonstrate effective communication and organization as part of a team of software developers or researchers collaborating on a large computer program

## Attendance Policy

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Attendance is strongly recommended but is not required.

## University Policies

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## **Credit-hour Policy**

One unit of credit in lecture, seminar, and discussion work approximates one hour of direct faculty instruction (or 50 minutes plus a break) and a minimum of two hours of out-of-class student work per week through one 15-week semester. For further details, see USF's [Credit Hour Policy](#).

The below resources and additional information can be found in the [Student Life Resource Toolkit](#).

## **Students with Disabilities**

If you are a student with a disability or disabling condition, or if you think you may have a disability, contact USF Student Disability Services (SDS) within the first week of class, or immediately upon onset of disability, to speak with a disability specialist.

If you are determined eligible for reasonable accommodations, please meet with your disability specialist so they can arrange to have your accommodation letter sent to me, and we will discuss your needs for this course. For more information, please visit [Student Disability Services](#), email: [sds@usfca.edu](mailto:sds@usfca.edu), or call (415) 422-2613.

## **Behavioral Expectations**

The University of San Francisco is committed to providing an environment consistent with the academic nature and core values of the institution in which students can participate in learning as a humanizing, social activity rather than a competitive exercise to support the full, integral development of each person and all persons, with the belief that no individual or group may rightfully prosper at the expense of others.

It is important you know what is expected of you academically and behaviorally through the published course syllabus, the [Student Conduct Code](#), and other instructions provided by the instructor. Therefore, you are expected to uphold the following:

- Behave in accordance with the Student Conduct Code and other USF policies
- Refrain from disrupting the ability of fellow students to learn or the instructor's ability to teach. Examples of disruption include:
  - Cell phone or computer use that significantly or repeatedly distracts others
  - Coming to class late, leaving early, or excessively physically relocating oneself in the classroom
  - Speaking frequently without being called on
  - Yelling, cursing, or engaging in aggressive behavior
- When interacting online, communicate in a respectful fashion. This includes, but is not limited to:

- Refraining from name calling, profanity, or typing in all capital letters
- Sending multiple emails with one sentence
- Avoiding rants or discussing non-relevant topics

Open discussion and disagreement are encouraged when done respectfully and in the spirit of academic discourse. There are also a variety of behaviors that, while not against a specific University policy, may create disruption in this course. Students whose behavior is disruptive or who fail to comply with the instructor may be dismissed from the class for the remainder of the class period and may need to meet with the instructor or Dean prior to returning to the next class period. If necessary, referrals may also be made to the Student Conduct process for violations of the Student Conduct Code.

### **Academic Integrity**

As a Jesuit institution committed to Cura Personalis—the care and education of the whole person — USF has an obligation to embody and foster the values of honesty and integrity. All members of the USF academic community are responsible for maintaining the standards of honesty and integrity. The [honor code](#) applies to all students (undergraduate and graduate) in the College of Arts and Sciences, the School of Education, the School of Management, and the School of Nursing and Health Professions. Faculty and students in the School of Law should review their own honor code for policies and procedures. Students enrolled in distance learning (online courses) are subject to these policies as well as supplemental policies set forth by their program. All students should review and familiarize themselves with the honor code, prohibited conduct, and procedures.

### **Counseling and Psychological Services**

Many college students experience mental health struggles. Counseling and Psychological Services (CAPS) is a great source of support for issues such as anxiety, loneliness, struggles with relationships, stress, identity development, racial/cultural concerns, and mild depression. However, CAPS does not prescribe medication and does not have a psychiatrist on staff, so students with more severe mental health concerns will be referred off-campus for treatment.

Counseling and Psychological Services (CAPS) offers remote individual and group teletherapy to students residing within California. Students seeking services are scheduled for a 15-20-minute phone triage to assess immediate risk, identify treatment needs, and provide initial recommendations. These may include a crisis intake session, brief, intermittent individual teletherapy (every 2-3 weeks), single session teletherapy, weekly individual teletherapy via UWill, weekly group therapy, or referrals to off-campus providers. There are no fees for services. To make an appointment, students must call 415.422.6352 or request an appointment via the [CAPS](#). CAPS does not accept walk-in appointments.

If you are concerned about a student and would like someone to follow up, please contact the Dean of Students Office at 415.422.5330. If you know someone who is an immediate risk of



harming themselves or others please contact Public Safety at 415.422.2911 in San Francisco, or out of state dial 911, or call the National Suicide & Crisis Lifeline by dialing 988. In addition, CAPS All Hours line can be reached 24/7 by calling 855.531.076. All students are encouraged to check out [CAPS](#) and access our extensive online resources, podcasts, mental health apps, videos, self-care strategies, and more.

## **Title IX**

The Title IX Office seeks to stop, remedy, and prevent occurrences of sex and gender-based discrimination, sexual harassment, and sexual violence. The University has a [Policy on Nondiscrimination based on Sex and Gender, Sexual Harassment and Sexual Misconduct](#). If you have experienced any of these behaviors, we encourage you to report the incident. If you report these behaviors to any staff or faculty member, they must notify the USF Title IX Coordinator.

Students who wish to report any sexual misconduct should use the [online mandatory reporting](#) form, or contact the Title IX Office directly. Other reporting options are available by visiting the Title IX [website](#). The Title IX Office is located in Lone Mountain Room 145.

As an employee at USF, and your Professor, I am a mandatory reporter, meaning I have to share any instances of sexual harassment or sexual violence shared with me or that become known to me. I will have to share this information, including names and any details known, to the Title IX Office to connect you with resources. If you would like more information about the resources available, you can ask me at any time this semester. You do not need to tell me why you are asking to get help for a friend, another student, or yourself.

## **Confidential Resources for Reporting Sexual Misconduct**

- Students may speak to someone confidentially which will not generate a report to the Title IX Office by contacting Counseling and Psychological Services at (415) 422-6352 during M-F 9-4pm, or speaking to a clergy member in University Ministry at (415) 422-4463.
- If you need to speak to a mental health clinician immediately, please **call the CAPS 24/7 All Hours Line at 855-531-0761** (available daily, including weekends and holidays, and accepts international calls), Public Safety (415-422-2911), 911, the Suicide Hotline (dial 988), or go to your nearest emergency room
- For off-campus resources, and local Bay Area organizations, view this [webpage](#).

## **Learning, Writing, and Speaking Centers**

The Learning, Writing, and Speaking Centers (LWSC ) at USF provide individualized support to assist students in better understanding course material and to aid them on their path to success.

Services are free and include tutoring, collaborative peer support services, academic skills coaching, writing, and speaking support. Services are available in-person and on Zoom. LWSC staff can be reached Monday through Thursday between 8:00am-8:00pm and Friday between 8:00am-5:00pm at [LWSC@usfca.edu](mailto:LWSC@usfca.edu) or through the chat box on our [myUSF webpage](#) or by phone at (415) 422-6713. To make an appointment for subject tutoring, academic skills coaching, the writing center, or the speaking center, students should visit the [Student Appointment Dashboard](#).

## **Communication**

All course communications, like all other USF communications, will be sent to your USF official email address. You are therefore strongly encouraged to monitor that email account.

## **Gleeson Library**

Looking for help with a research paper or project? Set up a consultation with a Librarian or get 24/7 research help [online](#).

## **Additional USF Resources**

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### **USF Food Pantry**

The USF Food Pantry is an intermediate, short-term solution for any registered USF student to receive food and toiletry resources. Students are invited to stop by the pantry located on the first floor of Gleeson Library in the Atrium, and take the items that they need. Items are available on a first-come, first-serve basis until our supply is depleted. You will be asked to check-in via QR code before entering the pantry. For more information and the current schedule, visit the [USF food pantry website](#). If you have further questions, please contact the Pantry Coordinator at [usfpantry@usfca.edu](mailto:usfpantry@usfca.edu) or 415-422-4099 (during business hours Monday thru Friday from 9:00am - 5:00pm). You can find out about additional food security resources through the [USF food insecurity resource page](#) and the [CalFresh resources site](#).