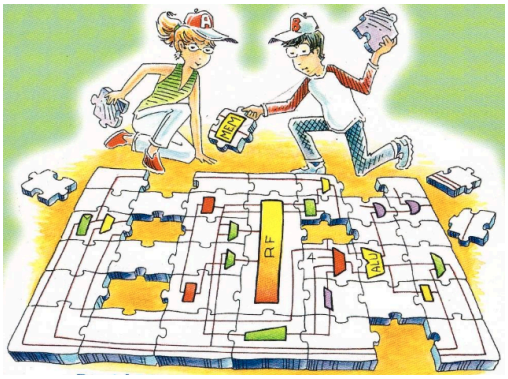
CSEE 3827: Fundamentals of Computer Systems



Semester: Spring 2025 | **Instructor:** Brian Plancher
Credit: 3 points | **Meeting time:** MW 11:40am-12:55pm & 1:10pm-2:25pm | **Room:** 501 NWC
Prerequisites: You should be familiar with the basics of imperative, sequential programming. This is typically provided by an introductory programming course such as COMS 1004 or another similar course. Contact the instructor if you have equivalent prior experience but do not have prerequisites.

Course Staff:

Instructor: Professor Brian Plancher bplancher@barnard.edu
Head TAs: Emma Li eql2002@columbia.edu & Madeline Skeel mgs2189@columbia.edu
For a full list of all TAs and their office hours please see the Courseworks!

Description:

This course explores the foundational principles of digital computing, bridging the gap between software and the physical hardware that executes it. Starting with binary representation and Boolean logic gates, students will progress through core topics in digital logic design and optimization, building towards the design of a processor and the assembly language with which it is programmed. By the end of the course, students will gain a comprehensive understanding of how software is translated into hardware operations, preparing them for future studies or careers in computer architecture, digital systems, and high performance computing.

Key topics include:

- Binary Information Representation
- Boolean Algebra & Canonical Forms
- Combinational & Sequential Logic
- Finite State Machines
- Memory & Addressing
- Assembly Language Programming
- Single-Cycle & Pipelined Processors
- Cache and Memory Systems

Grading:

- 60% In-Class Midterms (30% x2)
- 20% Take-Home Coding Midterm
- 20% Problem Sets

Note: requests for regrades can only be made for 1 week following the return of a grade.

Student Drop-Ins (Office Hours)

TA Office Hours are posted on the Courseworks.
See brianplancher.com/office_hours for Brian's most up-to-date OH schedule!

- These are scheduled time-slots for us to chat and I will also be available by appointment in case the scheduled slot doesn't work for you!
- I strongly encourage you to come to at least one student drop-in slot per semester.
- This is your time, so you can use it however you want! Stop by for a quick chat, ask questions about the course (or give feedback), ask questions about research, ask questions about getting jobs in finance/consulting/tech, tell me about a new hit TV show, any reason is a good reason!

Readings and Materials:

The course will involve the reading of technical papers, chapters of textbooks, and technical blog posts and the watching of technical videos. Specific readings and videos are listed in the detailed reading list and course scheduled below. Readings and videos can be accessed for free either as they are either open-source, through Barnard/Columbia Libraries, or will be posted to Courseworks. **Students will not need to purchase any textbooks or other materials for this course.**

Preliminary Detailed Reading List:

- Harris, S. and Harris, D. *Digital Design and Computer Architecture*. Morgan Kaufmann. 2015.
- Matthews, Suzanne J., Tia Newhall, and Kevin C. Webb. *Dive Into Systems: A Gentle Introduction to Computer Systems*. No Starch Press, 2022.

Email and Slack Policy:

I request that as much as possible you use Slack (instead of email) for all course-related questions. Please post liberally as if you have a question, another student likely has a similar question. There is also an anonymous bot if you would like to submit anonymously. I will try to respond to all Slack posts as soon as possible during working hours and at least within 1 business day during the weekdays and within 2 business days over the weekend. The course staff will also help respond to Slack posts and often will be more responsive than I can be, so please make sure to post publicly on channels if you'd like a fast response. **Click this link to sign up for our course Slack**. If you do need to reach me via email, please send the email to bplancher+courses@barnard.edu so that it is routed appropriately. I will try to respond to all emails within 2 business days.

Gradescope and Regrade Policy:

We will be using Gradescope for problem set submission and autograding. All coding assignments with autograders can be submitted an infinite amount of times until the deadline. Other assignments will be manually graded following submission. In general, Problem Sets will be graded on a 0/1/2 scale where 0 is incomplete, 1 is partially complete, and 2 is complete. As such, re-grades on all assignments will only be allowed in extenuating circumstances. All re-grade requests for such assignments must be submitted as a private message on Slack and will only be accepted for one week following the return of a grade. Do note that grades could go up or down following a re-grade.

Late Policy:

The late policy of this class follows a policy found in many Barnard/Columbia CS courses. Each day (24-hour period) or partial day late incurs a 33% penalty on the assignment. However, you are allowed a

total of **3 “flex” days**, to be used as you wish throughout the semester. Late hours round up the nearest day. To use a “flex” day, simply submit your work late and send a note to the course staff indicating how many “flex” days your late submission has incurred, and how many remaining “flex” days you have. When possible, advance notice is appreciated. If there is a situation that you feel should be exempt from this policy, you must reach out over email at least 48-hours prior to the due date. Note that weekdays, weekend days, holidays, etc. all count as one day. Also if an assignment is in multiple parts (e.g., coding and written), it simply counts as one late day if you turn in either or both parts one day late. Also, events that are known in advance do not constitute legitimate reasons for extensions, please make sure to plan ahead accordingly. **Finally, no flex days can be used for either in-class or take-home midterms.**

Assignment Descriptions:

In-Class Midterms (30% x2)
The midterms will be held in-class, closed-book, no notes. They will cover the course materials presented in the relevant module of the course. See the schedule for dates and topics covered. A review will be held preceding the exam. The exam will be designed to test knowledge useful for future work and validate your knowledge of both the core concepts explored in this course and their applications.

Take-Home Coding Midterm (20%)
Students will work through a take-home coding midterm. This will test and reinforce student knowledge of assembly programming and prepare students to leverage assembly to better understand processor design during the final course module.

Problem Sets (20%)
Students will work through a series of problems in order to develop fluency with the core topics and skills presented in the course. These problem sets will include both coding and theoretical components. Problem sets will be graded (0/1/2) where 0 is incomplete, 1 is partially complete, and 2 is complete.

Academic Integrity:

You are expected to hold yourself to the highest standard of academic integrity and honesty, as reflected in the Honor Codes of Barnard and Columbia.

The Barnard College Honor Code states:
“We, the students of Barnard College, resolve to uphold the honor of the College by engaging with integrity in all of our academic pursuits. We affirm that academic integrity is the honorable creation and presentation of our own work. We acknowledge that it is our responsibility to seek clarification of proper forms of collaboration and use of academic resources in all assignments or exams. We consider academic integrity to include the proper use and care for all print, electronic, or other academic resources. We will respect the rights of others to engage in pursuit of learning in order to uphold our commitment to honor. We pledge to do all that is in our power to create a spirit of honesty and honor for its own sake.”

The Columbia University Honor Code States:
“We, the undergraduate students of Columbia University, hereby pledge to value the integrity of our ideas and the ideas of others by honestly presenting our work, respecting authorship, and striving not simply for answers but for understanding in the pursuit of our common scholastic goals. In this way, we seek to build an academic community governed by our collective efforts, diligence, and Code of Honor.

I affirm that I will not plagiarize, use unauthorized materials, or give or receive illegitimate help on assignments, papers, or examinations. I will also uphold equity and honesty in the evaluation of my work and the work of others. I do so to sustain a community built around this Code of Honor.”

This course's policy on academic honesty builds on the honor code and is best stated as "be reasonable." We recognize that interactions with classmates and others can facilitate mastery of the course's material. As this course revolves mostly around team projects we expect students to collaborate heavily and work together on those assignments. Even on individual assignments students should feel encouraged to ask classmates and others for conceptual help. However, there remains a line between asking for help and submitting someone else's work. Especially on individual assignments, make sure this collaboration does not reduce to your classmate doing your work for you (e.g., writing your response, copy-pasting code, or making your slides). If in doubt as to whether some act is reasonable, ask first! The course staff would much rather have a conversation about extensions than about academic integrity! We hope you are reading these policies (or at least skimming them), so if you are, please send the course instructor an email with a (robotics) pun/joke/meme with the subject "academic integrity easter egg" and if you come by office hours I'll give you a prize (exact prize subject to availability)! Acts considered not reasonable will be referred to the Barnard Honor Board, and the course reserves the right to impose local sanctions on top of that outcome. **If you commit some act that is not reasonable but bring it to the attention of the course staff within 48 hours, the course may impose local sanctions, but the course will not refer the matter further except in cases of repeated acts.**

Diversity, Inclusion, and Accessibility:

In an ideal world, science would be objective. However, much of science is subjective and is historically built on a small subset of privileged voices. We acknowledge that it is possible that there may be both overt and covert biases in the material due to the lens with which it was written, even though the material is primarily of a scientific nature. Since integrating a diverse set of experiences is important for a more comprehensive understanding of science please contact the course staff (in person or electronically) or submit anonymous feedback if you have any suggestions to improve the quality of the course materials. We would like to create a learning environment that supports diversity of thoughts, perspectives, and experiences, and honors your identities. If you have a name and/or set of pronouns that differ from those that appear in your official records, please let us know! If you feel like your performance in the class is being impacted by your experiences outside of class, please don't hesitate to contact us. If you prefer to speak with someone outside of the course, the Center for Engaged Pedagogy (CEP) or the office of vice president for Inclusion and Engaged Learning are excellent resources.

If you believe you may encounter barriers to the academic environment due to a documented disability or emerging health challenges, please contact the course staff or the appropriate college/univerist support services. So that the course staff has enough time to implement accommodations, we request that any student with approved academic accommodations contacts the course staff within the first three weeks of the semester. If you have questions regarding registering a disability or receiving accommodations for the semester, please contact:

- The Barnard Center for Accessibility Resources & Disability Services (CARDS) at (212) 854-4634, cards@barnard.edu, barnard.edu/disabilityservices, or visit them on the third floor of the Diana Center in room 307.
- The Columbia University Disability Services at (212) 854-2388, disability@columbia.edu, health.columbia.edu/content/disability-services, or visit them at Wien Hall, Main Flr., Ste. 108A.

Wellness Statement:

It is important for undergraduates to recognize and identify the different pressures, burdens, and stressors you may be facing, whether personal, emotional, physical, financial, mental, or academic. We as a community urge you to make yourself– your own health, sanity, and wellness–your priority throughout this term and your career here. Sleep, exercise, and eating well can all be a part of a healthy regimen to cope

with stress. Resources exist to support you in several sectors of your life, and we encourage you to make use of them. Should you have any questions about navigating these resources, please visit these sites: barnard.edu/primarycare, barnard.edu/about-counseling, barnard.edu/wellwoman/about, health.columbia.edu/stressbuste

Affordable Access to Course Texts & Materials:

All students deserve to be able to study and make use of course texts and materials regardless of cost. Barnard and Columbia librarians have partnered with students, faculty, and staff to find ways to increase student access to textbooks. By the first day of advance registration for each term, faculty will have provided information about required texts for each course on CourseWorks (including ISBN or author, title, publisher, copyright date, and price), which can be viewed by students. A number of costfree or low-cost methods for accessing some types of course texts are detailed in the Barnard Library Textbook Affordability guide (https://library.barnard.edu/textbook-affordability). Undergraduate students who identify as first-generation and/or low income students may check out items from the FLIP lending libraries in the Barnard Library (library.barnard.edu/flip) and in Butler Library for an entire semester. Students may also consult with their professors, the Dean of Studies, and the Financial Aid Oce about additional affordable alternatives for having access to course texts. Visit the guide and talk to your professors and librarian for more details. **You will not need to purchase any textbooks for this course!**

Use of AI Content Generators:

I view AI tools as a powerful resource that you will likely leverage in the future. As such, the use of AI-based content generation tools, such as ChatGPT, is permitted in this course. However, you will be required to disclose any use of AI tools for each assignment. We will not mark you down for the use or non-use of AI tools. The course staff simply wants to understand the prevalence of AI tool use and methods of use to better adapt course policies and teaching practices for the future.

The goal of this policy is to help you develop your resilience to automation, as these tools will become increasingly prevalent in the future, and also to learn about their weaknesses. By incorporating these tools into your work process, you will be able to focus on skills that will remain relevant despite the rise of automation. However, **it is important to note that AI tools are susceptible to errors** (e.g., most citations are incorrect). As a student, it is your responsibility to ensure the quality and appropriateness of the work you submit in this course. As such please make sure to read carefully (and likely heavily edit) the output from such tools. Also, please be mindful of the data you provide to these systems, as your work may contain private information, not just your own but also that of others. For example, you should never enter the names of study participants into ChatGPT. Furthermore, there is a risk of inadvertently plagiarizing when using these tools as they often draw content without proper citation. Standard plagiarism policies will apply to all assignment submissions, and “AI did it!” is not a sufficient excuse. To prevent this, you can consider using more responsible tools that are designed to cite their data sources, and in either case you should make sure to add citations where appropriate yourself. Lastly, be aware of the dangers of becoming overly dependent on these tools. While they can be incredibly useful, relying on them too much can diminish your own critical thinking and writing skills.

If you do not wish to use these tools, that is a valid decision. The use of AI tools in education can be messy and unpredictable due to the risks mentioned earlier. You may have moral confusion or concerns about the uncertainty associated with using AI tools in their coursework. If you do not wish to use them, that is a valid decision. This policy aims to anticipate and mitigate any potential harms associated with AI tool usage, rather than promoting their use.

Preliminary Course Schedule:

Week	Day	Date	Topic	Description	Assignments	Readings	Module
0	W	Jan 22	Intro Class	Overview of the Course, Nuts and Bolts, Number Systems (Binary)	PS0 Released (W)	H&H Ch 1	Digital Design
1	M	Jan 27	From Analog to Digital	Digital Building Blocks, Transistors, Moore's Law			
1	W	Jan 29	Combinatorial Logic 101	Boolean Algebra, Basic Digital Logic Gates, Combinatorial Logic Design	PS0 Due (W) PS1 Released (W)	H&H Ch 2	
2	M	Feb 3	Combinatorial Logic 102				
2	W	Feb 5	Sequential Logic 101 **Pre-recorded Class**	Finite State Machines, Flip-Flops, Latches, Clocks, Logic Timing, Latency vs. Throughput		H&H Ch 3	
3	M	Feb 10	Sequential Logic 102		PS1 Due (M) PS2 Released (M)		
3	W	Feb 12	Digital Arithmetic Circuits 101	Adders, Subtractors, Multipliers, Dividers, Shifters, Fixed vs. Floating Point			
4	M	Feb 17	Digital Arithmetic Circuits 102			H&H 5.1-5.3	
4	W	Feb 19	Memory Circuits 101	Counters, Shifters, DRAM, SRAM	PS2 Due (W) PS3 Released (W)		
5	M	Feb 24	Memory Circuits 102			H&H 5.4-5.6	
5	W	Feb 26	**Midterm Review**		PS3 Due (W)		
6	M	Mar 3	**In-Class Midterm 1**				
6	W	Mar 5	Assembly Programming 101	Basic Usage & Design, RISC vs. CISC		H&H Ch 6	Assembly Programming
7	M	Mar 10	Assembly Programming 102	Arrays, Branches, Jumps, Conditionals, Functions & Call Stack	PS 4 Released (M)		
7	W	Mar 12	Assembly Programming 103	Continuing: Arrays, Branches, Jumps, Conditionals, Functions & Call Stack			

8	M	Mar 17	**No Class: Spring Break**				
8	W	Mar 19					
9	M	Mar 24	Advanced Assembly Topics	TBD		H&H Ch 6	
9	W	Mar 26	Advanced Assembly Topics	From MIPS to x86	PS 4 Due (W)		
10	M	Mar 31	**No Class: Take-Home Coding Midterm (Released M and Due Following M)**				
10	W	Apr 2	Microarchitecture 101	Building Blocks and Single Cycle Processor Design		H&H Ch 7	Processor Design
11	M	Apr 7	Microarchitecture 102	Building Blocks and Single Cycle Processor Design (Continued)	PS5 Released (M)		
11	W	Apr 9	Microarchitecture 103	Multi-Cycle and Pipelined Processors			
12	M	Apr 14	Microarchitecture 104				
12	W	Apr 16	Memory & I/O Systems 101	Memory Hierarchy, Caches, I/O Bus	PS5 Due (W) PS6 Released (W)	H&H 8.1-8.3	
13	M	Apr 21	Memory & I/O Systems 102				
13	W	Apr 23	Parallel Computing 101	SIMD, GPUs, and Thinking in Parallel		Dive Into Systems Ch 14, 15 (loose)	
14	M	Apr 28	Parallel Computing 102	FPGAs, Accelerators	PS 6 Due (M)		
14	W	Apr 30	**Midterm Review**				
15	M	May 5	**In-Class Midterm 2**				