CS-UY 2214, Computer Architecture and Organization

Syllabus – Fall 2021

Jeff Epstein and Ratan Dey

1 Basic information

1.1 Course description

The purpose of the course is to introduce and discuss the structure and operation of digital computers. Topics will include the logic of circuits, microarchitectures, microprogramming, conventional machine architectures, and an introduction to software/hardware interface issues. Assembly language and hardware design programming will be used to demonstrate some of the basic concepts.

1.2 Logistics

Meeting times are as follows:

Section	Time	Place	Instructor
ALEC	10:00 AM - 11:50 AM MW	DIBN LC400	Dey
BLEC, CLEC	8:00 AM - 9:50 AM MW	370J 202	Epstein
REC1	8:00 AM - 9:50 AM F	RGRS 615	Gamberini, Panchal
REC2	10:00 AM - 11:50 AM F	RGRS 601	Jung, Panchal
REC3	12:00 PM - 1:50 PM F	RGRS 200	Jung, Dheer
REC4	12:00 PM - 1:50 PM F	RGRS 205	Gamberini, Krieger
REC5	2:00 PM - 3:50 PM F	RGRS 200	Xu, Krieger
REC6	4:00 PM - 5:50 PM F	RGRS 200	Xu, Hall
~~REC7~~	~~8:00 AM - 9:50 AM F~~	~~RGRS 304~~	
REC8	2:00 PM - 3:50 PM F	RGRS 304	Dheer, Hall

Please attend only the lecture and recitation that you are registered for.

1.3 Contact

The best way to get in touch with your professor is by email. You are encouraged to contact us with any question, at any time.

Name	email	office hours
Jeff Epstein	jeff.epstein@nyu.edu	by appointment
Ratan Dey	ratan@nyu.edu	by appointment

Our teaching assistants are:

Name	email	office hours
Esther Jung	hej239@nyu.edu	Thu 11 AM - 12 PM
Aditya Dheer	ad4961@nyu.edu	Wed 4 PM - 5 PM
Vito Gamberini	nvg7278@nyu.edu	Mon 10 AM - 11 AM
Jiaze Xu	jx991@nyu.edu	Tue 5 PM - 6 PM
Rishyak Panchal	rishyak+TA@nyu.edu	Tue 4 PM - 6 PM, Thu 5 PM - 6 PM
Kayla Krieger	kdk314@nyu.edu	Tue 1 PM - 2 PM, Thu 1 - 2 PM
Connie Hall	kh2954@nyu.edu	Thu 2 PM - 3 PM

When contacting a member of the teaching staff by email, please use the course code ("CS-UY 2214") in the subject, so that we know the context.

1.4 Prerequisites

To enroll in this course, you must have passed CS-UY 2134 and CS-UY 2124, or CS-UY 2204, or equivalent courses. Prerequisite courses must be passed with a grade of C- or better. Students should be comfortable reading, writing, and debugging programs in an imperative programming language, such as C++ or Python.

1.5 Textbook

This textbook is optional. It may provide useful background information but is not required for this course. It is Computer Organization and Design: The Hardware/Software Interface, D. A. Patterson and J. L. Hennessy, 5th edition, Morgan Kaufman, 2014. ISBN : 978-0-12-407726-3

1.6 Topics

A tentative list of topics to be covered this semester:

- Binary arithmetic
- Adders and ALUs
- Verilog
- Cycles and timing
- E15 instruction set
- Intel x86 instruction set
- Functions, stack, recursion
- Syscalls
- Pipelining
- Caching
- NUMA
- Parallel architectures
- GPU architecture

2 Coursework

2.1 Grading rubric

Your final numeric grade for this class will be calculated as follows:

- Lecture participation: 10%
- Recitations: 10%
- Final exam: 20%
- Homework: 30%
- Projects: 30%

In order to pass this class, you must achieve an average of at least 50% in each of the categories of projects, homework, and exams. Getting less than 50% in any one of these categories will result in failing the course, regardless of your grades in other categories.

Your final numeric grade will be converted into a letter grade based on the standard cutoffs.

2.2 Assignments

Assignments will be distributed on NYU Brightspace and should be submitted on Gradescope. Only work submitted on Gradescope will be accepted.

- Homework — Credit is given for finding correct solutions to the problems posed in the homework assignment. Partial credit may be given for partially correct solutions. The cumulative homework represents a significant component of your final grade, and therefore students should complete the work carefully. You are encouraged to start the homework early, as it may be more time-consuming than you expect. Your submitted homework must represent purely your own work.

  The lowest homework grade will be dropped.

- Recitation work — Credit is given for a reasonable good-faith effort to complete the work. You are expected to consult with teaching staff and other students. The focus of recitation work is to practice the material, not to demonstrate mastery. All recitation work should be done during recitation sections. Students are encouraged to collaborate with each other in completing recitation work. In order to get credit for recitation work, you must (a) be present during recitation, (b) submit your work promptly, and (c) request a check from your recitation leader.

- Projects — These are larger programming assignments that require a deeper understanding of course material and more time to complete. They are accordingly each given more weight than homework. Your submitted projects must represent purely your own work.

After each assignment, a certain number of students will be randomly selected for a follow-up interview. You will have the opportunity to answer more in-depth questions about your submission with a member of the teaching staff.

2.3 Participation

Lectures are not intended to be an exercise in passive listening. Students should be engaged with the material, prepared to ask questions, and ready to respond to learning activities. With active learning, you'll feel more engaged, you'll remember the material better, and you'll be able to shape the direction of the discussion.

To help motivate student engagement, we'll be using a student response system (SRS), Poll Everywhere. This tool allows the instructor to present polls to students during lecture, giving each student a chance to

respond. Students can respond via their computer or smart phone. Responses to the poll can then form the basis of in-class discussions.

Participation with SRS contributes to your grade. In-class polls will typically be evaluated on the basis of good-faith effort: that is, if you demonstrate a sincere attempt to answer correctly, you will get credit, even if your answer is wrong. Some polls may be evaluated as "pop quizzes," i.e. your credit depends on getting the right answer, in which case you will be notified in advance.

2.4 Getting help

This is a challenging class. If you are struggling with the material, it is your responsibility to take action to improve your understanding. There are a variety of ways to get help:

- Review the slides. Although the slides are not a substitute for the lecture, they may provide clarifying details.
- Ask questions in class. A classroom discussion is the most direct way to understand the material thoroughly. You can ask questions during lecture or during recitation.
- Meet with a TA. The teaching assistants offer regular office hours, and can meet with you one-on-one or in small groups.
- Meet with the professor. The professor has regular office hours, as well as office hours by appointment.
- Send an email. You can contact your professor or a TA by email to ask questions about the homework or course material.
- Read the book. You may prefer the presentation of material in a textual format.

In case of any doubts, please discuss the situation with your professor. Your professor may be able to help you recover from bad grades if you take action in a timely manner.

3 Tools

3.1 Gradescope

We use Gradescope to submit assignments. You should receive an automatic email notifying you of your registration on Gradescope. If you don't already have an account, please create your Gradescope account according to the following guidelines:

- For your *name*, please give the customary name you use to mark your work. Give both first and last name.
- For your *student ID*, give your NYU NetID. Your NetID is the identifier based on your initials, followed by a number, such as `ab123`.
- For your *email address*, give your NYU email address. This is normally the address based on your NetID (for example, `ab123@nyu.edu`).

You may re-submit your work on Gradescope as many times as you like until the deadline. Submit early to ensure you don't miss the deadline. After the deadline, you will not be able to re-submit. Once you've submitted, please verify that you uploaded the correct file, as only those files that you've uploaded will be graded: it is your responsibility to check that the uploaded materials correspond to the work that you want evaluated. If you are submitting work on behalf of a group, make sure that you use the group submission option to include all members of your group. If you are using a Mac, please be aware that the operating

system creates invisible files named `__MACOSX` and `.DS_Store`; please do not upload these files to Gradescope: uploading them makes grading more difficult and may negatively impact your grade.

Your submitted homework will be evaluated and given a grade. The evaluation includes detailed feedback from the grader. Please be sure to read the comments provided to you in the evaluation, as they will help you understand your mistakes. Click on the question number in Gradescope to show the rubric items that were applied against that question, and view your submitted file in Gradescope to see additional comments provided by the grader. Students are encouraged to correct mistakes in their homework, so as to better learn the material. You should ask the professor or a TA for clarification about any past mistakes, if the reason for a point deduction is not clear to you.

If you feel that your assignment has been graded incorrectly, submit a regrade request on Gradescope. Be sure to submit your regrade request promptly, as regrade requests are typically accepted only within one week from the time that grades are published.

3.2 Programming environment

A substantial component of this class is programming work to be completed independently. You need to make sure that you are able to use the software tools necessary to accomplish this.

You should develop your programming assignments using tools as similar as possible to the environment under which they will be evaluated, to ensure that you don't lose points due to a difference in versions or different behaviors under different operating systems.

- A new service, Anubis, is available at `https://anubis.osiris.services/`. Logging into Anubis gives you access to a cloud-based text editor and a pre-configured Linux environment, which you can use to develop your assignments.

  After logging in to Anubis, select Join Class from the Courses menu. The Anubis course registration code for this class is `Uec3h` . Then, you should have access to the CS-UY 2214 VM: click Launch Session, then, when it's ready, click Go to IDE. Be sure to click Stop Session when you are longer using it.

  Please be aware that the Anubis service gets busy, especially around deadlines. Please plan accordingly. Anubis may crash or lose saved data: you are responsible for such cases, and therefore you should take steps to backup all your data to a secure location.

  Your professor is not an administrator of Anubis and is not responsible for its upkeep. If you have technical problems with Anubis, please contact Anubis tech support. When contacting Anubis tech support, be sure to include the course number and a precise description of the problem.

- NYU Vital, a cloud-based virtual machine service, is available at `https://vital.engineering.nyu.edu/`. With Vital, you will have access to virtual machines, accessible anywhere, pre-configured with all the tools you'll need for this class.

  Detailed instructions for using Vital are provided in the Vital user guide, available on Brightspace. The Vital course registration code for this class is `jYodC5RL` .

  Please be aware that the Vital service gets busy, especially around midterms and finals. Please plan accordingly. Vital may crash or lose saved data: you are responsible for such cases, and therefore you should take steps to backup all your data to a secure location.

  Your professor is not an administrator of Vital and is not responsible for its upkeep. If you have technical problems with Vital, please consult the Vital user guide or contact Vital tech support. When contacting Vital tech support, be sure to include your Vital registration email; the course number; and a precise description of the problem.

- You may install Linux into a virtual machine running on your own computer. This has the advantage that you won't need internet connectivity to use it, but on the other hand you are responsible for

configuring the machine and installing the necessary software. Fortunately, most of the software you'll need can be easily installed through the repositories.

Instructions for installing and configuring VirtualBox are provided on Brightspace.

- Windows supports the Windows Subsystem for Linux (WSL), which allows you to run a complete Ubuntu installation without a virtual machine.

  There are several online tutorials for installing WSL. Here's a good one.

- If you have Linux installed on your own computer, you may choose to develop software without the use of a virtual machine. Please make sure that you're using the right version of any necessary software.

3.3 Poll Everywhere

We use Poll Everywhere as a student response system (SRS).

- To use it on your mobile device, download the app at `https://www.polleverywhere.com/mobile`.
- To use it from your web browser, go to `https://pollev.com/`.

In either case, you will need to enter your professor's "presenter ID," which is `jeffepsteinnyu` or `ratandey` depending on your professor. When prompted, log in to the NYU SSO with your NYU NetID. You may be asked to confirm a registration for the NYU College of Nursing; that's okay, just go with it.

You can consult the Poll Everywhere student guide for help.

4 Additional policies

4.1 Class expectations

Attendance is in-person and mandatory, both for lectures and for recitations.

If you feel ill, do not come to class. Instead, report your symptoms to the NYU COVID-19 Prevention & Response Team and to Student Affairs. Staying home while sick prevents the spread of infections to other people and reduces the likelihood of additional absences or a class disruption. Excued absences due to illness or COVID-19 will not have any negative academic impact.

You are expected to take notes during lecture, based on our discussions and lectures. Please be prepared to do so.

Active participation in class discussions is strongly encouraged. This is the best time for students to ask questions or clarify any confusing concepts. In addition, you are responsible for any material covered in class, even if it isn't in the textbook. If you miss a class, you should contact a classmate to recover the missed content and assignments.

To participate in person, just raise your hand. To participate via Zoom, use the "raise hand" icon available on the Participants pane.

When attending in person, please disable or silence any device that may audibly disrupt the class.

While attending in person, you must obey the NYU COVID-19 policy, which requires a face covering over your nose and mouth at all times.

Please bring your phone or computer to lecture, so that you can participate in Poll Everywhere. Make sure that you are logged in to the app during lecture.

During class time, please do not use your phone or computer for activities unrelated to class. Please do not eat or drink during class.

Students are expected to arrive to every class promptly. You should be actively engaged in the learning process during the duration of the class time.

4.2 Communication

Your professor may occasionally use email to make class announcements. It is your responsibility to check your NYU email account regularly.

Assignments will typically be posted on NYU Brightspace. It is your responsibility to check NYU Brightspace for assignments, and to submit your work in a timely manner.

4.3 Office hours

All office hours are held on Zoom.

- TA office hours are scheduled at a regular time each week. You can find the schedule at the beginning of the syllabus. Connect through the Zoom tab on Brightspace.
- Professor office hours are made by appointment. Please email your professor to set up a time.

4.4 Late policy and make-up policy

All assignments should be submitted before the due date. Homework and projects may be submitted without penalty up to 24 hours after the due date. After that time, absolutely no submissions will be accepted.

In general, late assignments (except as indicated above) will not be accepted, and substitute exams will not be offered.

Consideration may be given in case of a documented special circumstance, such as a medical condition or a family emergency, in accordance with university policy. If that case applies to you and you need additional time to complete an assignment or need a rescheduled exam, your first point of contact should be Tandon's Student Affairs office. Please provide to them written documentation of your circumstance, and they will in turn make a recommendation to your professor about how to proceed.

4.5 Special pleading

A principle of fairness in evaluation is that all students receive the same opportunity to complete the same assignments. Therefore, it would be unethical to offer some students additional opportunities, when those opportunities are not made available to everyone. Therefore:

- Your professor will not offer a student an extra credit assignment, if that assignment is not offered to the whole class.
- Your professor will not offer a student the chance to repeat or revise an assignment, when such an opportunity is not offered to the whole class.
- Your professor will not offer a student the chance to submit an assignment beyond the scheduled deadline and grace period, except in cases supported by Student Affairs, as described above in the section discussing the late policy.

Please do not ask for such unfair opportunities.

4.6 Academic integrity

This class is bound by the Student Code of Conduct. We aim to ensure that your grade reflects your understanding of the material, and therefore we require that the work that you submit for grading be a result of your own effort. This applies to homework, projects, and exams for this class. This policy does *not* apply to recitation work, which is the only case where collaboration among students is encouraged.

Motivation Why do we take academic integrity seriously?

- If the work that you submit does not represent your own effort and understanding, you are doing yourself a grave disservice, by cheating yourself out of an opportunity to learn. Your grade has value only if it accurately represents what you've accomplished to get it. In the end, your diploma (should you achieve it) is worthless unless it is supported by personal growth and knowledge.
- Furthermore, by submitting work that does not represent your own effort and understanding, you are behaving dishonestly to the class's teaching staff. The professor and the TAs who work hard to create assignments, provide instruction, and evaluate students' work, do so in order to provide learning. Students who submit others' work as their own are therefore wasting the time of the teaching staff.
- Finally, misrepresenting yourself in your submitted work does real damage to your classmates. If you achieve a grade through dishonest work, students who complete the assignments honestly are at a disadvantage.

Policy We realize that it's not always clear what activities are acceptable in the context of working on your assignments. This is especially true in Computer Science, where the web can provide excellent learning resources (good!) as well as solutions to assignments (bad!). To help you understand the boundaries of what is and is not acceptable, we provide the following guidelines, which are based on the Stanford CS107 collaboration rules. We classify activities into three categories, according to a traffic light model: those activities that are always acceptable (green light), those that are acceptable but require a citation (yellow light), and those that are not acceptable (red light).

- These activities are always acceptable:
  - Green light **Discussion of general course topics.**

    You may freely discuss the course material, outside of the context of a specific assignment. This means you can ask and answer questions about the rules of the programming languages and tools that we use, as well as theoretical matters that were covered in lecture or in the textbook. However, the discussion may not refer to solutions for a specific assignment.

    For example: "What does the `elem` function do? What is the syntax for a function definition?"
  - Green light **Discussion of assignment requirements.**

    You may freely discuss the requirements for a specific assignment. However, the discussion may not refer to solutions.

    For example: "Are we allowed to use `reverse`? Is performance important?"
  - Green light **Use of public resources for background information.**

    Web sites, books, and other public resources provide lots of great information. You are expected and encouraged to refer to documentation for the languages and tools that we use, as long as they don't refer to the specific task for your assignment.

    For example, the official Python documentation is okay, but "How to write Space Invaders in Python" is not okay (assuming the assignment is Space Invaders).
  - Green light **Discussion with teaching staff.**

    This is the best way to get help! You can always turn to your professor and TAs with any questions. You can ask questions about any assignment during class, during office hours, or by email.
- These activities are acceptable but require a citation:
  - Yellow light **Re-using your own work.**

If you are submitting your own work, including code, that you originally completed before you took this class, you must provide a note stating this fact, including when you originally did the work and under what conditions.

If you want to submit work that you have previously completed for an earlier instance of this class, or for any other class, you should discuss the matter with your professor before proceeding.

- Yellow light **Discussion of testing.**

  If you aren't sure if your solution is correct, it can be helpful to develop a strategy to test it. You may propose and discuss tests collaboratively, as long as you provide a note describing the incident. For example, you may remind a friend that a particular function needs to work with empty lists. However, you may not see each other's code or discuss it in detail.

- Yellow light **Discussion of debugging.**

  You may discuss particular error messages and propose possible solutions, as long as you provide a note describing the incident. For example, if a friend says they are getting a "segmentation fault," you may suggest that they might be dereferencing a null pointer. However, you may not see each other's code or discuss it in detail.

What is a citation? If you participate in one of the activities in this section, you must state so in the assignment that it pertains to. If the assignment is a coding exercise, you must write a comment in your code describing the activity. If the assignment is non-code work, you must write a preface describing the activity.

Every citation must describe (a) the specific source of the information that you used (a person, a book, or a web site), and (b) how you used that information, and to what extent it influenced your work. Failing to provide a citation when participating in one of these activities renders the activity unacceptable, and therefore a violation of academic integrity.

- These activities are never acceptable, and always constitute a violation of academic integrity:

  - Red light **Copying code or answers from others.**

    The work you submit must be written entirely by you. This means not only that you physically wrote it, but that the ideas behind it are yours. You may not copy code, read code, or consult code from another person, directly or indirectly. If you are in an environment where you are able to see another person's solution, it is your responsibility to take yourself out of that environment and actively prevent the possibility of being influenced by their work.

  - Red light **Collaborative development.**

    You may not work together with another person, or "walk through" your code with another person. Even if you are not directly sharing code, any detailed sharing of design, pseudocode, structure, or substance, even in partial or incomplete form, is not acceptable. Solving bugs collaboratively or discussing particular code around debugging issues is prohibited. You must work on your assignments alone.

  - Red light **Using public resources for assignment-specific code.**

    Web sites, books, and other public resources can provide valuable information, but any resource that refers to the task that you are to complete for the assignment, or to a task that is substantially similar to it, is not allowed. The design and implementation of your solution may not be influenced by an external resource. Taking code, in any quantity, from a web site is prohibited. If you find yourself reading a web site that addresses the design or implementation of a program similar to the task at hand, you are required to stop using it.

    The boundary between "general background resources" and "assignment-specific resources" may be fuzzy. If you have any doubt that a resource you are using is acceptable, ask your professor first.

– Red light **Allowing others to use your code or answers.**

At no point should anyone else have access to your work. This means that you may not keep your work on a shared or public computer. You may not post your work on a public web site (including Github and similar sites). You may not show your work to others, even if they promise not to use it in their own work. Your work should remain private, and if at any time it isn't, then you have contributed to academic dishonesty.

You may use Github (and similar sites) as version control storage, but it is your responsibility to ensure that your repository is private. If your code is publicly visible at any time, it constitutes a violation of this policy.

The prohibition on sharing your work remains in effect even after you have submitted your work, after the due date has passed, and after the course has ended. Be aware that other students may attempt to submit your work as their own without your knowledge. Students in future semesters should not have access to your work.

If you are in doubt about whether a particular activity is acceptable, it's best to consult with your professor *before* doing it.

If you are struggling in the class, please discuss your situation with your professor. Plagiarism is not a solution.

Violations of academic integrity will be dealt with strictly. Typically, this means receiving a failing grade for the course and a referral to Student Affairs.

If you have committed plagiarism, your first step should be to reach out to your professor so we can work together to find a way for you to move forward with integrity. A timely request to retract a compromised work or apply an amended citation that properly credits authorship could rectify the misrepresentation that would have otherwise been the basis for a strict punishment.

Examples Here are some real-world examples of plagiarism, and their outcomes:

- Alice submits a homework before the deadline. Then, after the deadline, Bob asks to see Alice's solution, allegedly just for reference. Since the deadline has already elapsed, Alice obliges. Unbeknown to Alice, Bob has received, for medical reasons, a deadline extension. Bob then submits Alice's solution as his own. Consequence: both students fail.
- Cathy and Dave are roommates. In their apartment, they share a computer, which they can both log in to. Dave uses the computer to submit his homework. Later, Cathy finds Dave's homework on the computer, and uses it to complete her own homework. Consequence: both students fail.
- Emil is an experienced programmer who uses Github to store his assignments as part of his programming portfolio. His homework assignment is stored to a public repository, where Felicity finds it with a Google search. Felicity then downloads his homework and submits it as her own. Consequence: both students fail.
- Greta and Harry complete their homework together to save time. Greta does the odd-numbered questions, and Harry does the even-numbered questions, then they combine them. Consequence: both students fail.

4.7 Inclusivity statement

The NYU Tandon School values an inclusive and equitable environment for all our students. We hope to foster a sense of community in this class and consider it a place where individuals of all backgrounds, beliefs, ethnicities, national origins, gender identities, sexual orientations, religious and political affiliations, and abilities will be treated with respect. All students' learning needs should be addressed both in and out of class, and the diversity that students bring to this class should be viewed as a resource, strength, and benefit. If this standard is not being upheld, please feel free to speak with the professor.

4.8 Religious holiday observance

The instructor supports NYU's policy with regard to absence due to religious holidays. If you have a conflict due to observance of a religious holiday, please alert the instructor in advance so that a plan for makeup can be arranged.

4.9 Academic accommodations

New York University provides reasonable accommodations to qualified students who disclose their disability to the Moses Center. Reasonable accommodations are adjustments to policy, practice, and programs that level the playing field for students with disabilities and provide equal access to NYU's programs and activities. Accommodations and other related services are determined on a case-by-case basis, taking into consideration each student's disability-related needs and NYU program requirements.

If you are student with a disability who is requesting accommodations, please contact New York University's Moses Center for Students with Disabilities at 212-998-4980 or mosescsd@nyu.edu. You must be registered with CSD to receive accommodations. Information about the Moses Center can be found at `http://www.nyu.edu/csd`. The Moses Center is located at 726 Broadway on the 2nd floor.

If you are authorized to receive accommodation for an exam, it is your responsibility to schedule the exam with the Moses Center in advance. To receive other types of accommodation, please discuss with your professor in advance.

4.10 ABET learning goals

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies