CS-350, Fall 2017

Fundamentals of Computing Systems

Tuesday & Thursday, 3.30 pm - 4.45 pm, CAS 224

Renato Mancuso

rmancuso@bu.edu
MCS-201A, 111 Cummington Mall,
Boston, MA
Office Hours: Wed, 5 pm - 6.30 pm
(617) 358-8537

Azer Bestavros

best@bu.edu
MCS-175, 111 Cummington Mall,
Boston, MA
Office Hours: Tue, 5 pm - 6.30 pm
(617) 353-9726

This syllabus represents a guideline on the intended pace of the course. As such it is subject to unpredictable yet moderate changes throughout the semester.

# 1 Course Description

This course is intended to provide students with a baggage of fundamental notions in "systems". In this context, the concept of system is willfully generic as one of the main objectives of this course is to cover reasoning approaches, mathematical tools, and modeling techniques that can be applied to a multitude of system instances.

As such, by the end of the course, students who take CS-350 will develop the ability to map new problems onto existing solutions, or at the very least onto existing approaches towards a solution. In fact, this course will help the careful student realize that many system instances have a common denominator of challenges and issues that can be approached using well established techniques and abstractions.

**Prerequisite(s):**

1. CAS CS-210: Programming and basic software/hardware interface concepts.

2. CAS CS-237 or CAS MA-381: Elements of discrete and continuous probabilistic analysis.

3. Please contact the instructor(s) ahead of time if you do not satisfy any of these prerequisites.

**Credit Hours:** 4

**Course Material:** *Lecture Notes on Fundamentals of Computing Systems.* The content of these notes is subject to change, and they constitute THE required readings for the class.
**Author(s):** Azer Bestavros, Renato Mancuso

**Course Objectives:** The typical know-how that students are expected to acquire with this course should allow them to:

1. abstract a system into fundamental sub-components;
2. identify performance metrics and tradeoffs to evaluate the behavior of a system;
3. measure dependence and correlation between metrics and events;
4. model and analyze queuing schemes;
5. evaluate resource management policies;
6. employ mutual exclusion and atomicity;
7. perform multi-agent synchronization and communication;
8. and employ models of computation for massively parallel processing systems.

## 2   Grading

Grading (except for the final exam) is done by a number of class graders, under the direct supervision of the Teaching Fellow(s). If you have an issue with a grade (homework or exam), please contact the Teaching Fellow(s). If your issue is not resolved, then (and only then) please contact me. In doing so, please note that (to ensure fairness and grading consistency) it is seldom the case that I will overrule a Teaching Fellow.

This class is not graded on a curve, i.e., there is no prescribed proportions for specific grades. This means that if everybody's performance in the class deserves an A, then everybody will get an A. The converse is also true! Therefore, don't be satisfied with an "average" grade because that average could well be less than what you expect. Being a "gateway" to all other (more advanced) CS "systems" classes, you should expect this class to be competitive. Thus, make sure you work hard from the very beginning.

In previous years, the average grade for this class was around B/B-. The minimum grade for this course to count towards the CS concentration is C.

An instructor is not allowed to give W (withdrawal) grades. One can get such a grade only by dropping this class by the deadline specified by the registrar office for withdrawals with or without a W grade (check the registrar's office calendar for the exact date). Also, an instructor is not allowed to give an I (incomplete) grade except if a student misses completing assignments and/or misses taking tests due to circumstances beyond their control.

**Grade Distribution:**

| | |
|---|---|
| Class/Piazza Participation | 10% |
| Assignments | 30% |
| Interim Exams #1 | 15% |
| Interim Exams #2 | 15% |
| Final Exam | 30% |

## 3   Course Policies

The following is a summary of the main course policies.

- **General**

  - Attending lectures is mandatory and will account for 10% of the final class grade.

- Students are responsible for all missed work, regardless of the reason for absence. It is also the absentee's responsibility to get all missing notes or materials.

- Quizzes and exams are closed book, closed notes.

- **No makeup quizzes or exams will be given.**

- Conflict exams can be scheduled as needed, but it is up to the student to schedule the exam at least 2 weeks before the date of the conflicting exam.

- **Grades**

  - As mentioned above, grading does not follow a curve. You will earn the grade that is directly proportional to your performance.

  - Grade corrections should be requested no later than 3 weeks after the corresponding assignment due date or exam date.

- **Homework Assignments**

  - Students are expected to work individually. Students involved in plagiarism will be heavily penalized according to the Academic Code of Conduct. Please carefully review the Academic Code of Conduct below. Discussion amongst students is encouraged, but when in doubt, direct your questions to the professor, or to a Teaching Fellow.

  - **No homework will be accepted if late by more than one class**. The only exception to this policy are certified medical excuses.

  - Homework assignments will be posted online at the end of each week, typically on Fridays.

  - Completed homework assignments in electronic form should be submitted online via Gsubmit. Solutions to homework assignments that are handwritten should be scanned and uploaded electronically.

# 4 Interaction with Instructors and TFs

In the context of this course, there are four main ways to interact with instructors and Teaching Fellow(s):

1. Lectures;

2. Discussion Sections;

3. Office Hours;

4. Piazza Online Platform.

## 4.1 Lectures

As mentioned above, attendance to lectures is mandatory and overall in-class participation contributes to 10% of the final grade. Attendance will be sampled via random quizzes announced in class. These quizzes will consist in straightforward questions related to the material presented in class.

Each student is responsible for **any** material covered in class, regardless of whether or not it is covered in the lecture notes or in any supporting material provided by the instructors. A good rule of thumb is: if it was mentioned in class, you are supposed to know it.

The length of each class is about 1 hour and 15 minutes. The first 10 minutes of each class will be used to answer questions about the material presented in previous lectures. As an instructor/TF is wrapping-up after the class is officially over, you are welcome to hang around and ask additional questions about the course material or about administrative matters.

## 4.2 Discussion Sections

Signing up for this course is a two-step process. You should have signed up for the main lectures, as well as for a one-hour weekly discussion section. The schedule of the discussion sections is reported below, but it may be subject to change due to unforeseen circumstances.

Discussion sections will be held directly by TFs. Discussion sections can be used to: (i) provide additional details about material covered in the main lectures; (ii) provide background information to better understand the next topic covered in the main lectures; (iii) discuss and provide clarifications about the homework assignments; and (iv) interactively solve exercises in preparation for an exam.

If (for some reason) you miss (or cannot make) the discussion section for which you are signed up, then please make sure to attend another one in the same week.

**Schedule:**

- Section A2: Wed, 9:05 am - 9.55 am, CAS 227

- Section A3: Wed, 1:25 pm - 2.15 pm, CAS 229

- Section A4: Wed, 11:15 am - 12.05 pm, CAS 222

- Section A5: Wed, 12:20 pm - 1.10 pm, MCS B23

## 4.3 Office Hours

Office hours are meant to answer specific questions about the material and/or the homework assignments. In order to efficiently use the (limited) time of TFs and instructors, please try to narrow the scope of your question down to the troubling concept/formula/exercise. For specific questions about the covered material, please make sure to show up during office hours and ask your question to the instructor or the TF. Conversely, if you have a generic concern about your understanding of the material, an in-class discussion or approaching the instructor after lecture may be the best option.

## 4.4 Piazza

In the context of this course, we will use Piazza as the official platform to extend the in-class interaction outside the scheduled lectures/discussion sections/office hours. Students are welcome to establish other ways to interact with each other online outside of Piazza. However, they should expect instructors and TFs to interact only on Piazza posts.

Piazza will be used to communicate important announcements, post supplemental material, post lengthy answers to questions that were not completely addressed in class, and the like. As such, every student is strongly encouraged to regularly check the official CS-350 Piazza page.

Although constructive opinions about the lectures and the material are welcomed, everyone should make an effort in keeping the discussion on a professional tone and to the point.

## 4.5 Interaction

During lectures, discussion sections, and office hours you are expected to be actively part of the course. A part of this active attitude consists in metabolizing the covered material, not just listening to it. Unfortunately, there is no such thing as a material delivery by the instructor that can be perfectly received by everyone in the class. As such, you are expected to have **questions**.

If you believe that your question is silly, ask! You will be surprised to know how many other students were wondering about the same thing; if you think that your question has a trivial answer, *ask!* You will be amazed by the depth of the answer; if you think that your question will require a lengthy response, *ask!* The instructors and TFs will do their best to provide a sketch of the answer and will use Piazza to answer more in detail; if you think that there is a typo in the presented material, *ask!* You will contribute to improve the material for years to come. Basically, if you have a question, *ask!*

# 5 Homework Assignments

Homework assignments constitute an important part of this course. They are designed to help you understand the materials covered in lectures and in assigned readings. It is only by doing the homework that you really learn the material.

## 5.1 Short-Term and Long-Term Assignments

This course includes two types of homework assignments: short-term (ST) and long-term (LT) assignments.

Long-term assignments will involve programming. Two LT assignments will be given: one at the beginning and one halfway during the course. Each LT will be composed by a set of objectives/tasks to accomplish by the due date. You are free to dictate you own pace in progressing through the objectives. However: (1) rushing right away to complete the assignment may not be a good idea, since the theoretical foundations to perform some of the implementation may be given in a lecture later on; (2) waiting until the last minute to complete an assignment designed to be completed in roughly 1 month is not a bright idea either. In general, you want to keep the objectives of the assignment in mind, and identify what part of the covered material can be used to progress in your implementation.

Short-term assignments are handed out regularly throughout the semester and serve the purpose of consolidating with exercises the material covered in class. These assignment will typically not require programming, although in some cases writing some code to test your answers could be a good idea. If this is the case, you are welcome to include the code in your submission to justify your answer. On average, each ST assignment will take 2-3 hours to complete, with large variations in this estimation on a student-by-student, assignment-by-assignment base. A good golden rule is: always account for *double that amount of time* to make sure you can complete your assignment on time.

## 5.2   Grade Distribution

Homework assignments account for 30% of the final grade. LT assignments compose 14% of the total, and ST assignments are worth 16% of the final grade. As such, each LT assignment will account for about 7% of the grade. Out of the 9 ST assignments, only 8 of them will count toward the final grade, so that each graded ST assignment corresponds to 2% of the final grade. Note that the grade distribution among ST assignments may be adjusted to account for slight differences in their length and difficulty.

## 5.3   Assignment Submission

Homework assignments will be posted on-line at the end of the week, typically on Fridays. Completed homework assignments are to be handed in electronically, typically using Gsubmit. More info about Gsubmit can be retrieved here: `http://www.cs.bu.edu/teaching/hw/gsubmit/`. Typically, homework assignments will be due before lecture on Tuesdays, i.e. 12 days after being handed out. It is strongly recommended to double-check the class schedule at the end of this document for homework assignments handout and due dates.

If your submission is composed in part by handwritten answers, you will need to scan all your answer sheets and submit them electronically. If you do not have a personal scanner, scanning capabilities are available at various university libraries and also through the main CS office on the first floor of MCS – keep in mind that they have well defined business hours. Alternatively, you can use mobile apps (e.g. CamScanner) to scan documents using your phone camera. When doing so, please make sure that the resulting PDF file is readable. Once you have an electronic copy of your answers, use Gsubmit to complete the submission process.

## 5.4   Late Policy

For full credit, your homework must be submitted electronically by the deadline. There will be a hefty penalty of 25% for a homework submitted one class late. You may submit part of the homework by the deadline to avoid the penalty on that part. No homework will be accepted if late by more than one class. There will be no exceptions to this policy, except for certified medical excuses. In such cases, extensions will be granted unless (and until) the homework solutions are posted (hopefully, about 1 week after the original due date).

# 6   Exams and Quizzes

This course includes three exams: two interim exams and a final exam. Quizzes and challenges can also be given through the semester to probe attendance, to give an opportunity for extra credits, or both.

## 6.1   Interim Exams

There will be two in-class exams. These exams (combined) will be worth 30% of the final grade, and will cover the material presented from the beginning of the semester (or from the previous in-class exam) and up to the last lecture before the exam. Please check the class schedule for the specific dates of these exams.

## 6.2 Final Exam

The course final exam is worth 30% of the final grade, and will cover the material offered throughout the semester. Please check the class schedule for date and time. The place for the final exam is typically the same as that of the lecture (and will be announced in due time, if different).

## 6.3 Missed and Conflict Exams

Please mark the exam dates on your calendar (and remember them when you make your recess and end-of-semester travel plans!) There will be absolutely no make-up exams, except for medical emergencies. For medical emergencies, you must provide a letter from a doctor, specifying the period of time during which you were unable to attend an exam.
Conflict exams can be arranged, as long as the student who has the conflict can communicate the need and arrange the exam at least 2 weeks before the date of the troubling exam. A conflict exam can be scheduled up to two days after the original date of the exam, and needs to be properly motivated. Once arranged, it is severely forbidden to obtain any detail from other students about the content of the original exam before taking the conflict exam.

# 7 Academic Code of Conduct

It is expected that each and every student complies with the directives and regulations provided in the Academic Code of Conduct. The full body of the code is available online at `https://www.bu.edu/academics/policies/academic-conduct-code/`. Hereafter we highlight those portions of the code of which the students should be particularly aware.

## 7.1 Academic Misconduct

Academic misconduct is conduct by which a student misrepresents his or her academic accomplishments, or impedes other students opportunities of being judged fairly for their academic work. Knowingly allowing others to represent your work as their own is as serious an offense as submitting anothers work as your own.

## 7.2 Violations of The Code

Violations include, but are not limited to:

- Cheating on examination;

- Plagiarism;

- Misrepresentation or falsification of data presented for surveys, experiments, reports, etc.;

- Theft of an examination;

- Unauthorized communication during examinations;

- Knowingly allowing another student to represent your work as his or her own;

- Forgery, alteration, or knowing misuse of graded examinations, quizzes, grade lists, or official records of documents;

- Theft or destruction of examinations or papers after submission;

- Submitting the same work in more than one course without the consent of instructors;

- Altering or destroying another students work or records, or altering records of any kind;

- Violation of the rules governing teamwork; Unless specifically authorized, the following rules apply to teamwork:

  1. No team member shall intentionally restrict or inhibit another team members access to team meetings, team work-in-progress, or other team activities without the express authorization of the instructor;
  2. All team members shall be held responsible for the content of all teamwork submitted for evaluation as if each team member had individually submitted the entire work product of their team as their own work.

- Failure to sit in a specifically assigned seat during examinations.

- Attempting improperly to influence the award of any credit, grade, or honor.

- Intentionally making false statements to the Academic Conduct Committee or intentionally presenting false information to the committee.

- Failure to comply with the sanctions imposed under the authority of this code.

## 7.3 Authorship

The student must clearly establish authorship of a work. Referenced work must be clearly documented, cited, and attributed, regardless of media or distribution. Even in the case of work licensed as public domain or Copyleft, (See: http://creativecommons.org/) the student must provide attribution of that work in order to uphold the standards of intent and authorship.

## 7.4 Declaration

Online submission of, or placing one's name on an exam, assignment, or any course document is a statement of academic honor that the student has not received or given inappropriate assistance in completing it and that the student has complied with the Academic Honesty Policy in that work.

## 7.5 Consequences

According to the Academic Code of Conduct, sanctions may be imposed on the student that has been deemed in violation of the code. Sanctions may vary depending upon the gravity of the misconduct. For minor violations, any of the instructors may require to: (i) redo a homework assignment; (ii) complete a different assignment than what originally given; assign a grade of zero or "F" for a single assignment or for the course. Major and/or repeated violations can result in official reprimands, disciplinary probation, suspension, or expulsion in agreement with the official code of conduct.

## 7.6 Personal Takeout

The whole point is: do your best to be a good student. You are here to learn, but in the meantime also to become a better citizen of the world.

# 8    Tentative Course Outline

The weekly coverage and assignments might change to adapt to the progress of the class, and to react to unforeseen circumstances. In the table, **ST** and **LT** stand for short-term and long-term assignment, respectively.

| Week | Unit | Content | Instructor | Assignments |
|---|---|---|---|---|
| Tue 9/05 | Background | System Abstractions and Performance Metrics | Azer | |
| Thu 9/07 | Background | Elementary Probability Analysis | Azer | LT #1 – Due 10/24<br>ST #1 – Due 9/19 |
| Tue 9/12 | Background | Probability Distributions and Expectations | Azer | |
| Thu 9/14 | Performance Evaluation | M/M/1 Queuing Model and Analysis | Azer | ST #2 – Due 9/26 |
| Tue 9/19 | Performance Evaluation | Discrete Event Simulation | Azer | |
| Thu 9/21 | Performance Evaluation | Measurement & Confidence Intervals | Azer | ST #3 – Due 10/03 |
| Tue 9/26 | Performance Evaluation | M/M/1 Variations & Queuing Nets | Azer | |
| Thu 9/28 | Performance Evaluation | Use Cases | Azer | ST #4 – Due 10/17 |
| Tue 10/03 | Resource Management | From M/M/1 to GPS | Renato | |
| Thu 10/05 | Resource Management | Basic CPU Scheduling | Renato | |
| Thu 10/12 | **Exams** | **Exam #1** | | |
| Tue 10/17 | Resource Management | Job-length Aware Scheduling | Renato | |
| Thu 10/19 | Resource Management | State-Sensitive (I/O) Scheduling | Renato | ST #5 – Due 10/31 |
| Tue 10/24 | Resource Management | Real-Time and Priority Scheduling | Renato | LT #2 – Due 12/12 |
| Thu 10/26 | Resource Management | Resource Co-Scheduling | Renato | ST #6 – Due 11/07 |
| Tue 10/31 | Communication & Concurrency | Mutual Exclusion | Azer | |
| Thu 11/02 | Communication & Concurrency | N-Party Mutual Exclusion | Azer | ST #7 – Due 11/14 |
| Tue 11/07 | Communication & Concurrency | Locking Schemes: Semaphores, Spinlocks, RCUs | Azer + Renato | |
| Thu 11/09 | Communication & Concurrency | Deadlock Management | Renato | ST #8 – Due 11/28 |
| Tue 11/14 | Communication & Concurrency | Producer/Consumer & Publish/Subscribe | Renato | |
| Thu 11/16 | Communication & Concurrency | Transactional Semantics, Networking & RPC Abstractions | Azer | |
| Tue 11/21 | **Exams** | **Exam #2** | | |
| Tue 11/28 | Distributed Systems | Global Snapshot and Lamport Clocks | Azer | ST #9 – Due 12/07 |
| Thu 11/30 | Distributed Systems | Hadoop & Cloud Computing Platforms | Renato | |
| Tue 12/05 | Distributed Systems | From Networks to On-Chip Networks | Renato | |
| Thu 12/07 | Distributed Systems | Advanced Topics | Azer | |
| Tue 12/12 | Distributed Systems | Wrap-Up | Azer + Renato | |
| Tue 12/19 | **Exams** | **Final Exam** | | |