# EE 5340: PHYSICS OF COMPUTING: BASICS [SPRING 2017]

## 1 COURSE OVERVIEW

COORDINATES: Tue/Thu 8:15-9:30
Ackerman 319
https://ay16.moodle.umn.edu/course/view.php?id=13460

INSTRUCTOR:

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Office Hours: Tue 9:45-10:45

SYNOPSIS: Inspired by Richard Feynmans lectures in computation, Physics of Computation will explore how physical principles/limits have been shaping paradigms of computing. A key goal of this course is to understand how (and to what extent) a paradigm shift in computing can help with emerging energy problems.

Topics include but are not limited to: Physical limits of computing, coding and information theoretical foundations, computing with beyond-CMOS devices, reversible computing, quantum computing, stochastic computing. For each computing paradigm, we will cover (i) how information is represented, processed, stored, and communicated; (ii) to what extent shortcomings can be addressed; (iii) how the application domain looks like.

PREREQUISITES: Although some knowledge in computer architecture can be beneficial, basics will be covered in class.

REFERENCE MATERIAL: "Feynman Lectures on Computation", R. P. Feynman, Westview, June 2000; and "Quantum Computation and Quantum Information", M. Nielsen and E. Chung, Cambridge University Press, January 2011 represent the main texts. We will also cover classic and recent research papers on the subject matter.

| GRADING: | | |
|---|---|---|
| | Project | 30% |
| | Quiz $\times 2$ | 30% |
| | Assignment $\times 5$ | 40% |

PROJECT: We expect a small-scale research project. The scope should be computing paradigm - technology interaction. We encourage novelty, but students can also try to re-generate the results of an already published research paper. We will post a pool of ideas on the course website. Project teams of up to 2 students are allowed. **Project due date: Friday, May 05.**

ASSIGNMENTS: There will be 5 assignments. Assignments may include thought-provoking open-ended challenge questions, paper summaries/reviews, or very basic scripting/programming.

QUIZZES: Each quiz may be designated as an open book/notes/... take-home to be submitted 24 hours after the release of questions (the following exam dates are to be interpreted as release dates in this case).

**Quiz 1: Thu, March 9**
**Quiz 2: Thu, May 4**

MECHANICS:

- Regarding academic integrity and scholastic dishonesty, according to the Office for Student Conduct and Academic Integrity (OSCAI), "Academic integrity is essential to a positive teaching and learning environment. All students enrolled in University courses are expected to complete coursework responsibilities with fairness and honesty. Failure to do so by seeking unfair advantage over others or misrepresenting someone elses work as your own, can result in disciplinary action. The University Student Conduct Code defines scholastic dishonesty as follows: Scholastic Dishonesty: submission of false records of academic achievement; cheating on assignments or examinations; plagiarizing; altering, forging, or misusing a University

academic record; taking, acquiring, or using test materials without faculty permission; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement." applies. **Independent of the scope (be it a homework assignment, exam, ...), any conduct leads to F as the immediate final grade.**

- The students are expected to attend all class meetings. Office hours are not designated to serve as make-up lectures.
- **All assignments are due at the beginning of class, on the designated due date. Late assignments will receive a reduction of 20% for each day they are late, except for documented illnesses and family emergencies.**
- Any question or concern about grading must be communicated to the instructor within one week after the return of the exam or assignment concerned.
- You can work in groups to discuss assignments, as long as the submission reflects your own work.
- UNITE students should submit all assignments according to the UNITE procedures.
- **To obtain a passing grade, *all* assignments should be turned in, *all* quizzes should be taken, and the project should be submitted.**
- Any non-submitted or non-graded item will be processed with a grade of 0.
- Regarding incomplete grades, according to University Senate policy, "The I grade shall be assigned at the discretion of the instructor when, due to extraordinary circumstances, the student was prevented from completing the work of the course on time. The assignment of an I requires a written agreement between the instructor and student specifying the time and manner in which the student will complete the course requirements. In no event may any such written agreement allow a period of longer than one year to complete the course requirements." applies. An "I" will only be assigned if less than 15% of the course remains to be completed. In such a case, the "extraordinary circumstances" must be properly documented.
- Any student with disabilities to affect their ability to participate fully in class or to meet all course requirements is encouraged to notify the instructor so that appropriate accommodations can be timely arranged.

## 2 (TENTATIVE) SYLLABUS

| Week | Tue | Thu | Note |
|---|---|---|---|
| 1 | Introduction | Technology Scaling Artifacts | |
| 2 | Basic Computer Architecture | Theory of Computation | Assignment I out |
| 3 | Theory of Computation | Theory of Computation | Assignment I due<br>Assignment II out |
| 4 | Coding & Information Theory | Coding & Information Theory | Assignment II due |
| 5 | Coding & Information Theory | Coding & Information Theory | Project Proposal due |
| 6 | Coding & Information Theory | Reversible Computing | Assignment III out |
| 7 | Reversible Computing | Reversible Computing | Assignment III due |
| 8 | Reversible Computing | Reversible Computing | Quiz I out |
| 9 | Spring Break | Spring Break | |
| 10 | Reversible Computing | Quantum Computing | Project status report due |
| 11 | Quantum Computing | Quantum Computing | Assignment IV out |
| 12 | Quantum Computing | Quantum Computing | Assignment IV due |
| 13 | Physical Aspects of Computation: CMOS | Physical Aspects of Computation: Beyond CMOS | Assignment V out |
| 14 | Physical Aspects of Computation: Beyond CMOS | Physical Aspects of Computation: Beyond CMOS | Assignment V due |
| 15 | Emerging (Non-volatile) Memory Technologies | Emerging (Non-volatile) Memory Technologies | |
| 16 | Emerging (Non-volatile) Memory Technologies | Emerging (Non-volatile) Memory Technologies | Project (final) report due |