ECE 721: Advanced Microarchitecture
Spring 2024

Course instructor:

Dr. Eric Rotenberg
ericro@ncsu.edu

Panopto Channel:

All lectures are live-streamed (*i.e.*, webcast-ed) and recorded in the Panopto ECE 721 Channel   (<-- use this link). A link to the Panopto ECE 721 Channel is also available on the main Moodle page.

THE 40 SECOND DELAY: The live-stream is delayed by 40 seconds. This means when the class begins at 10:15:00, you'll start to see the live-stream at 10:15:40.

Scheduled class time and room:

10:15 – 11:30 AM, Monday and Wednesday, EB3 2124

Office hours:

Monday and Tuesday, 1:00 - 2:00 PM, in my office (EB2 2004D) and over Zoom (OH Zoom link   ).
Also by appointment as needed.

Prerequisites and restrictions:

Prerequisites: ECE 463/563 and strong C/C++ programming skills
~~Restrictions: Enrollment by permission of instructor.~~

Course description:

The course begins with contemporary superscalar microarchitecture, including instruction fetching, register renaming and instruction dispatch, out-of-order instruction issue, retirement, speculative execution, and memory disambiguation. Students build upon a detailed, execution-driven, execute-at-execute, cycle-level simulator ("721sim"), which is the basis for the final project (student-defined projects and/or predefined projects). Various topics in microarchitecture are covered through lectures and papers, for example: value prediction, trace cache, predication, control independence, multipath execution, branch pre-execution, large-window (latency-tolerant) processors, complexity-effective processors, simultaneous multithreading, and speculative multithreading.

Course textbook, materials, computing, and web page:

Required textbook:
None.

Computing environment:
General-purpose programming tools (compilers, debuggers, git, *etc*.) and EDA tools are available on ECE servers (grendel.ece.ncsu.edu).
Remotely login to grendel.ece.ncsu.edu using your Unity ID and password; see the "Remote Access" section in the User Guide to ECE Linux Environment .

Wolfware tools (Moodle, Panopto):
Materials (lecture notes, papers, quizzes, exams, project specifications, message boards, *etc*.) are posted on your ECE 721 Moodle site. To access your ECE 721 Moodle site and Panopto channel, login at: https://wolfware.ncsu.edu

Grading:

1. Projects (65%)
    - Project 1 - ILP Limit Study (5%)
    - Project 2 - Register file and renaming module (10%)
    - Project 3 - Working with full simulator, coding key parts of issue/execution pipeline (10%)
    - Project 4 - Final project (40%)
      Note: Projects 1, 2, and 3 are individual projects. Project 4 (research project) is carried out by teams of two students each, with exceptions (solo project or team of three) approved or disapproved in consultation with instructor.
2. Midterm exam (15%): See below regarding how the midterm exam will be administered.
3. Final exam (15%): See below regarding how the final exam will be administered.
4. Quizzes (5%): About 10-12 conference papers are assigned as required reading throughout the semester. There is a brief 5-10 minute quiz for each paper; please see the quiz methodology below. One to four basic questions on a given quiz aim to (1) confirm that you read the paper and (2) test understanding of some major concepts in the paper. Note: the lowest two quiz scores will be dropped from the overall quiz average that goes into calculating final grades. Note: some quizzes may be untimed and involve a simulation or other involved problem.

The +/- grading system will be used in this class. In the table below, "[" and "]" are the "inclusive" range operators and ")" is the "exclusive" range operator.

[97 - 100] A+
[93 - 97) A
[90 - 93) A-
[87 - 90) B+
[83 - 87) B
[80 - 83) B-
[77 - 80) C+
[73 - 77) C
[70 - 73) C-
[67 - 70) D+
[63 - 67) D
[60 - 63) D-
[0 - 60)   F

- The midterm and final exams will be:
  (1) Moodle-based and auto-graded (in some cases manually regraded for additional partial credit), and

(2) on-line, synchronous (*i.e.*, at the prescribed time, which is the class time for the midterm exam and the university-set time for the final exam), and proctored via Zoom.
If you are a student in the EOL section (601), please contact me about exam scheduling.
- Each quiz will be: (unless otherwise stated)
(1) closed notes/closed paper (you may NOT reference the paper, your notes from the paper, or any other reference materials),
(2) Moodle-based and auto-graded (in some cases manually regraded for additional partial credit),
(3) on-line, asynchronous, and unproctored, and
(4) timed (you can start the quiz any time within a fixed window, but once you start it, you have a short time to complete it as if it were an in-class quiz). The timed aspect enforces the requirement that you read and assimilate the full paper <u>before</u> taking the quiz.

Incomplete grades:

The IN grade is assigned in accordance with university policy, which states: "At the discretion of the instructor, students may be given an IN grade for work not completed because of a serious interruption in their work not caused by their own negligence." IN is only a temporary grade and must be converted to a letter grade by the end of the next regular semester, by completing the missed work. University policy for IN grades can be found at http://policies.ncsu.edu/regulation/reg-02-50-03.

Late assignment policy:

- Quizzes: Because of the way quizzes are administered and graded, <u>missing the deadline means your quiz is not submitted at all (0 for the quiz).</u> (Specifically, Moodle does not provide an automated method for applying a late penalty, so the TA would have to check timeliness of each student's quiz and manually adjust scores accordingly, negating the huge benefits of auto-grading.) Please also see the policy on excused/unexcused absences in this syllabus.
- Project 1: Project 1 is submitted as a Moodle quiz. Therefore, the same policy applies to Project 1 as other quizzes: failing to make the Project 1 quiz attempt (*i.e.*, not entering your ILP limit study results and analysis) will result in a 0 grade for Project 1, even if you did the work for Project 1.
- Projects 2-4: Projects 2-4 are submitted via Gradescope. Each project specification will indicate three things:
1. A deadline.
2. A late deadline, after which projects will no longer be accepted (grade of 0).
3. A late penalty that depends on the amount of time that the project is late within the late period (after the deadline and before the late deadline).

Attendance policy:

In accordance with the university's attendance policy (http://policies.ncsu.edu/regulation/reg-02-20-03):

- On-campus section (001): Full attendance at classes (in-person) and examinations (Zoom) is expected of all students. That said, you should attend the Panopto live-stream or watch the Panopto recording if you have symptoms associated with COVID-19, flu, *etc*.
- EOL section (601): Students in this section must either attend the Panopto live-stream or watch the Panopto recording in a timely manner for each lecture. Please contact me about exam scheduling.

Email the instructor if you need to be excused (see policy on excused/unexcused absences in this syllabus).

Policy on excused/unexcused absences and scheduling makeup work:

Excused absences are defined in accordance with the university's attendance policy (http://policies.ncsu.edu/regulation/reg-02-20-03).

1. Lectures: For both excused and unexcused absences, the student must watch the live-streamed or recorded lecture.
2. Quizzes and Project 1 (submitted as a Moodle quiz): If an excused absence prevents meeting the quiz attempt deadline, the instructor will arrange an extension. If an unexcused absence prevents meeting the quiz attempt deadline, the late assignment policy will be applied (*i.e.*, grade of 0, as explained above).
3. Projects 2-4: If an excused absence prevents timely completion of the project, the instructor will arrange an extension. If an unexcused absence prevents timely completion of the project, the late assignment policy will be applied (*i.e.*, a late-time dependent penalty and a 0 after the late deadline, as explained above).
4. Exams: A makeup exam will be arranged in the case of an excused absence. A grade of 0 will be given in the case of an unexcused absence.

Academic integrity:

Students are bound by the university policy on academic integrity found in the NCSU Code of Student Conduct, which can be accessed at http://policies.ncsu.edu/policy/pol-11-35-01.

Students are also bound by the NCSU Honor Pledge: "I have neither given nor received unauthorized aid on this exam, quiz, or project." The Honor Pledge must be electronically signed or confirmed on each exam, quiz, and project. It is the understanding and expectation of the instructor that the student's electronic signature or confirmation on any exam, quiz, or project, means that the student neither gave nor received unauthorized aid.

Each student is expected to only claim work which is his/her/their own.

Students with disabilities:

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office (DRO). More information about DRO can be found at https://dro.dasa.ncsu.edu . For more information on NC State's policy on working with students with disabilities, please see the "Academic Accommodations for Students with Disabilities Regulation (REG02.20.1)": http://policies.ncsu.edu/regulation/reg-02-20-01.

Laboratory safety:

Students may use NCSU computer labs for their work. Each student is expected to observe proper procedures as outlined in the Safety Plan for the NCSU computer labs.

In addition, you are required to follow COVID-19 related Community Standards to Protect the Pack .

Extra expenses:

None.

Transportation requirements:

None.

Audit requirements:

This course may be audited if there is sufficient justification (for example, if the student is doing a full-time co-op during the semester). To receive audit credit, a student must receive a C- weighted average on the quizzes (audit-only weight: 20%), midterm exam (audit-only weight: 40%), and final exam (audit-only weight: 40%).

Audit students are welcome to work on projects but the TAs and I are not obligated to provide any guidance and we won't include projects in the audit grading process.