Electrical & Computer ENGINEERING

Carnegie Mellon

Course Syllabus

18-600: *"Foundations of Computer Systems"*

Fall, 2016 **(2016/12/02)**

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Course Description: This course provides a broad view of how computer systems execute programs, store information, and communicate. It enables students to become more effective programmers, especially in dealing with issues of performance, portability and robustness. It also serves as a foundation for courses on computer architecture, compilers, operating systems, and computer networks, where a deeper understanding of systems-level issues is required. Topics covered include: machine-level code and its generation by optimizing compilers, performance evaluation and optimization, computer arithmetic, processor architecture, memory organization and management, networking technology and protocols, and supporting concurrent computation. 18-600 models after 15-213/18-213/15-513 with expanded contents. The course is presented at the graduate level and intended for ECE MS students. The expanded contents include: Processor Architecture and Design, and Techniques for Instruction Level and Thread Level Parallelisms.
Number of Units: 12

Class Schedule:

- **Lectures**:
  Lectures, Section A:
  MW, 8:00pm to 9:50pm (ET), DH A302
  Lectures, Section B:
  MW, 8:00pm to 9:50pm (ET), DH A302

  Lectures, Section SA:
  MW, 5:00pm to 6:50pm (PT), B23 118
  Lectures, Section SB:
  MW, 5:00pm to 6:50pm (PT), B23 109/110

  Lectures, Section GZ:
  TR, 8:00am to 9:50am (CST), JIE 214

- **Recitation**:
  Recitation, Section A:
  T, 8:00pm to 9:20pm (ET), HH 1107
  Recitation, Section B:
  T, 8:00pm to 9:20pm (ET), DH A302

  Recitation, Section SA:
  T, 4:30pm to 5:50pm (PT), B23 118
  Recitation, Section SB:
  T, 4:30pm to 5:50pm (PT), B23 109/110

  Recitation, Section GZ:
  W, 8:00am to 9:20am (CST), JIE 214

Required Textbooks:

1. Randal E. Bryant and David R. O'Hallaron, *Computer Systems: A Programmer's Perspective, Third Edition (CS:APP3e)*, Pearson, 2016.
2. Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language, Second Edition*, Prentice Hall, 1988.

Recommended Reference:

1. *Modern Processor Design: Fundamentals of Superscalar Processors,* by John Shen and Mikko Lipasti, 2005; reissued by Waveland Press Inc, 2013. ISBN 10: 1-4786-0783-1, ISBN 13: 978-1-4786-0783-0

Course Web Sites:

We will use Piazza in this course for communication: http://piazza.com/cmu/fall2016/18600/home
All 18-600 handout materials can be found at: http://ece.cmu.edu/~ece600/

Grading Algorithm:

50%	Lab assignments (7)
25%	Midterm exam
25%	Final exam
100%	TOTAL

Tentative Course Calendar (18-600 Fall 2016)

	Date	Day	Class Activity
	August/September		
Week 1	8/29	Mon	**Lecture 1: Course Introduction & Overview** [JS]
	8/30	Tues	Recitation 1: Course Tips, C/Linux Overview
	8/31	Wed	**Lecture 2: Computer Systems Big Picture** [JS] **9/1 (Thur): Lab 1 Out (Data Lab)**
Week 2	9/5	Mon	NO CLASS - LABOR DAY HOLIDAY
	9/6	Tues	Recitation 2: More C/Linux Overview (hands-on setup time)
	9/7	Wed	**Lecture 3: Information Representation I: Integers** [ZY]
Week 3	9/12	Mon	**Lecture 4: Information Representation II: Floating Point** [ZY]
	9/13	Tues	Recitation 3: GDB Overview & OH time for Data Lab Help
	9/14	Wed	**Lecture 5: Machine Programs I: Basics** [ZY] **9/15 (Thur): Lab 1 (Data Lab) Due; Lab 2 Out (Bomb Lab)**
Week 4	9/19	Mon	**Lecture 6: Machine Programs II: Control & Procedures** [ZY]
	9/20	Tues.	Recitation 4: Introduce Bomb Lab; Walk through Attack Lab (now optional)
	9/21	Wed.	**Lecture 7: Machine Programs III: Data & Programs** [ZY]
Week 5	9/26	Mon	**Lecture 8: Processor Architecture I: Processor Design** [JS]
	9/27	Tues	Recitation 5: Short In-class Activity
	9/28	Wed	**Lecture 9: Processor Architecture II: Pipelined Processors** [JS] **9/29 (Thur): Lab 2 (Bomb Lab) Due; Lab 3 Out (Arch Lab)**
	October		
Week 6	10/3	Mon	**Lecture 10: Processor Architecture III: Superscalar Processors** [JS]
	10/4	Tues	Recitation 6: Y86-64 Processor Simulator; Arch Lab Discussion
	10/5	Wed	**Lecture 11: Processor Architecture IV: Modern OoO Processors** [JS]
Week 7	10/10	Mon	**Lecture 12: Memory Hierarchy** [ZY]
	10/11	Tues	Recitation 7: Cache Lab overview
	10/12	Wed	**Lecture 13: Cache Memories** [ZY] **10/13 (Thur): Lab 3 (Arch Lab) Due; Lab 4 Out (Cache Lab)**
Week 8	10/17	Mon	**Lecture 14: Program Performance Optimizations** [JS]
	10/18	Tues	Recitation 8: Linking Overview (Ch. 7)
	10/19	Wed	**Lecture 15: Exceptional Control Flow I: Exceptions & Processes** [JS] **10/20 (Thur): Lab 4 (Cache Lab) Due; Lab 5 Out (Shell Lab)**

Week 9	10/24	Mon	**Lecture 16: Exceptional Control Flow II: Signals & Nonlocal Jumps** [JS]
	10/25	Tues	Recitation 9: Review for Mid-Term Exam
	10/26	Wed	**MID-TERM EXAM (110 min.)**
November			
Week 10	10/31	Mon	**Lecture 17: System Level I/O** [CI] (Guest lecturer: Chris Inacio from SEI)
	11/1	Tues	Recitation 10: Shell Lab Discussion
	11/2	Wed	**Lecture 18: Virtual Memory Concepts and Systems** [ZY]
Week 11	11/7	Mon	**Lecture 19: Dynamic Memory Allocation** [ZY] **Lab 5 (Shell Lab) Due; Lab 6 Out (Malloc Lab)**
	11/8	Tues	Recitation 11: Malloc Lab Discussion
	11/9	Wed	**Lecture 20: Parallel Arch. I: Overview of Parallel Architectures** [JS]
Week 12	11/14	Mon	**Lecture 21: Parallel Arch. II: Multi-core Cache Coherence** [JS]
	11/15	Tues	Recitation 12: OH time for Malloc Lab Help
	11/16	Wed	**Lecture 22: Parallel Arch. III: Performance and Power Iron Laws** [JS] **11/17 (Thur): Lab 6 (Malloc Lab) Checkpoint**
Week 13	11/21	Mon	**Lecture 23: Network Programming - Part I** [CI]
	11/22	Tues	NO CLASS - THANKSGIVING
	11/23	Wed	NO CLASS - THANKSGIVING
December			
Week 14	11/28	Mon	**Lecture 24: Network Programming - Part II** [CI] **Lab 6 (Malloc Lab) Due; Lab 7 Out (Proxy Lab)**
	11/29	Tues	Recitation 13: Proxy Lab Discussion
	11/30	Wed	**Lecture 25: Concurrent Programming** [JS]
Week 15	12/5	Mon	**Lecture 26: Parallel Programming** [JS]
	12/6	Tues	Recitation 14: Review for Final Exam
	12/7	Wed	**Lecture 27: Future of Computing Systems** [JS] **12/8 (Thur) Lab 7 (Proxy Lab) Due**
Week 16			
	12/15	**Thur**	**FINAL EXAM (180 min.)**

Education Objectives (Relationship of Course to Program Outcomes):

(a) an ability to apply knowledge of mathematics, science, and engineering: Labs and projects.

(b) an ability to design and conduct experiments, as well as to analyze and interpret data: Labs and projects.

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and
sustainability: Labs and projects, and special guest lectures by practicing computer architects from industry.

(d) an ability to function on multidisciplinary teams: Work in small teams on labs and projects.

(e) an ability to identify, formulate, and solve engineering problems: Extensive coverage of design tradeoffs.

(f) an understanding of professional and ethical responsibility:

(g) an ability to communicate effectively: Written reports and in-class presentations.

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context:

(i) a recognition of the need for, and an ability to engage in lifelong learning: Historical insights provided during lectures.

(j) a knowledge of contemporary issues: Industry guest lecturers will provide a good sense of these issues.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice: Labs and project works, and industry guest lecturers.

Academic Integrity Policy (http://www.ece.cmu.edu/student/integrity.html**):**

The Department of Electrical and Computer Engineering adheres to the academic integrity policies set forth by Carnegie Mellon University and by the College of Engineering. ECE students should review fully and carefully Carnegie Mellon University's policies regarding Cheating and Plagiarism; Undergraduate Academic Discipline; and Graduate Academic Discipline. ECE graduate student should further review the Penalties for Graduate Student Academic Integrity Violations in CIT outlined in the CIT Policy on Graduate Student Academic Integrity Violations. In addition to the above university and college-level policies, it is ECE's policy that an ECE graduate student may not drop a course in which a disciplinary action is assessed or pending without the course instructor's explicit approval. Further, an ECE course instructor may set his/her own course-specific academic integrity policies that do not conflict with university and college-level policies;

course-specific policies should be made available to the students in writing in the first week of class.

This policy applies, in all respects, to this course.

Carnegie Mellon University's Policy on Cheating and Plagiarism (http://www.cmu.edu/policies/documents/Cheating.html) states the following,

Students at Carnegie Mellon are engaged in preparation for professional activity of the highest standards. Each profession constrains its members with both ethical responsibilities and disciplinary limits. To assure the validity of the learning experience a university establishes clear standards for student work.

In any presentation, creative, artistic, or research, it is the ethical responsibility of each student to identify the conceptual sources of the work submitted. Failure to do so is dishonest and is the basis for a charge of cheating or plagiarism, which is subject to disciplinary action.

Cheating includes but is not necessarily limited to:
1. Plagiarism, explained below.
2. Submission of work that is not the student's own for papers, assignments or exams.
3. Submission or use of falsified data.
4. Theft of or unauthorized access to an exam.
5. Use of an alternate, stand-in or proxy during an examination.
6. Use of unauthorized material including textbooks, notes or computer programs in the preparation of an assignment or during an examination.
7. Supplying or communicating in any way unauthorized information to another student for the preparation of an assignment or during an examination.
8. Collaboration in the preparation of an assignment. Unless specifically permitted or required by the instructor, collaboration will usually be viewed by the university as cheating. Each student, therefore, is responsible for understanding the policies of the department offering any course as they refer to the amount of help and collaboration permitted in preparation of assignments.
9. Submission of the same work for credit in two courses without obtaining the permission of the instructors beforehand.

Plagiarism includes, but is not limited to, failure to indicate the source with quotation marks or footnotes where appropriate if any of the following are reproduced in the work submitted by a student:
1. A phrase, written or musical.
2. A graphic element.
3. A proof.
4. Specific language.
5. An idea derived from the work, published or unpublished, of another person.

This policy applies, in all respects, to 18-600

COURSE POLICY

Lab Assignments:

You will work on all lab assignments by yourself. All assignments are due at **11:59pm PT** on the **specified due date**. All hand-ins are done using the Autolab system. You may hand in as often as you like, with your most recent hand-in counting for credit.

The penalty for late assignments is **15% per day**. Each student will receive a total budget of **five grace days** for the entire course. Each grace day can be used to cover one day late without incurring the 15% penalty.

- Grace days are applied automatically until you run out. But, no more than two grace days can be used on any one assignment.
- Once you have spent your grace days, or exhausted the grace day limit for an assignment, then you will receive a penalty of 15% for each subsequent late day.
- Late assignments will only be accepted up to three days after the specified due date, or the **termination date**, i.e. each late assignment can only be late by up to three days.

Final Grade Assignment

Each student will receive a numeric score for the course, based on a weighted average of the following:

- Lab Assignments (50%): There are a total of seven lab assignments, which will count a combined total of 50% of your course score. Assignments have different weightings, based on the relative efforts required. See the class Web page for the assignment weightings.
- Exams (50%): There will a midterm exam counting 25% and a final exam counting 25%.

Grades for the course will be determined by a method that combines both a small amount of curving and absolute standards. The total score will be plotted as a histogram. Cutoff points are determined by examining the quality of work by students on the borderlines. Individual cases, especially those near the cutoff points may be adjusted upward or downward (by up to 5-10%) based on factors such as attendance, class participation (including contributions during lectures and recitations, and on Piazza), improvement throughout the course, and special circumstances.

Take care of yourself. *Do your best to maintain a healthy lifestyle this semester by eating well, exercising, avoiding drugs and alcohol, getting enough sleep and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone. There are helpful resources available on campus and an important part of the college experience is learning how to ask for help. Asking for support sooner rather than later is often helpful. If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support. Consider reaching out to a friend, faculty or family member you trust for help getting connected to the support that can help. Counseling and Psychological Services (CaPS) at the Pittsburgh campus can help you: call 412-268-2922 or visit their website http://www.cmu.edu/counseling/. For SV campus, please contact the Director of Student Affairs at 650-335-2846, Building 19, Room 1041 or student-services@sv.cmu.edu.*