CS 0449–Intro to Systems Software
Fall Term: 2171

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<tr>
<th>Class</th>
<th>Recitation 1</th>
<th>Recitation 2</th>
<th>Recitation 3</th>
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<tbody>
<tr>
<td>Time:</td>
<td>11:00am – 12:15pm</td>
<td>10:00am – 10:50am</td>
<td>01:00pm – 01:50pm</td>
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<td>Days:</td>
<td>TH</td>
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<tr>
<td>Room:</td>
<td>G30 BENDM</td>
<td>5505 SENSQ</td>
<td>6110 SENSQ</td>
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<tr>
<td>Instructor:</td>
<td>Wonsun Ahn</td>
<td>Tazin Afrin</td>
<td>Yuyu Zhou</td>
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<th>Class</th>
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<tr>
<td>Time:</td>
<td>4:00pm – 5:15pm</td>
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<td>Days:</td>
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<tr>
<td>Room:</td>
<td>1501 WWPH</td>
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<tr>
<td>Instructor:</td>
<td>Wonsun Ahn</td>
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Contact Information

- **Instructor:** Wonsun Ahn
  - Office: 6115 SENSQ
  - Email: [wahn@pitt.edu](mailto:wahn@pitt.edu)
  - Office Hours: Thu 1:00-3:00pm
  - Grading TA: Xiangmin Fan
  - Office: 5808 SENSQ
  - Email: xiangmin@cs.pitt.edu
  - Office Hours: Tue 2:00-4:00pm

- **Recitation TA: Yuyu Zhou**
  - Office: 5412 SENSQ
  - Email: yuz69@pitt.edu
  - Office Hours: Mon 3:00-5:00pm
  - Grading TA: Henrique Potter
  - Office: 5082 SENSQ
  - Email: hap44@pitt.edu
  - Office Hours: Tue 9:00 - 12:00am

- **Recitation TA: Tazin Afrin**
  - Office: 6505 SENSQ
  - Email: tazinafrin@cs.pitt.edu
  - Office Hours: Wed 11:00 - 1:00pm
  - Grading TA: Yuhuan Jiang
  - Office: 5422 SENSQ
  - Email: yuhuan@cs.pitt.edu
  - Office Hours: Tue 10:00-12:00pm

Description

A *Computer System* is comprised of both hardware and software working in concert to accomplish useful work. In this course, we will explore the issues of programming a real computer system by examining the abstractions, interfaces, and design decisions that influence the way that software runs. This includes the role the Operating System has in communication and resource management.
The perspective we will take is one of the lifecycle of a program from implementation to execution. The simple act of compiling and running a program, a sequence of events we often take for granted, is a complex interaction of many different components that work together to manage the computer’s resources and perform the desired task. Together, these components form a working computer system.

**Prerequisites**
Before enrolling in this course, you need to have completed *CS 0445 – Data Structures* and have completed or be currently enrolled in *CS 0447 – Computer Organization and Assembly Language Programming*.

If you have any questions about the prerequisite material for the course, please ask at the beginning of the term.

**Course Purposes and Goals**
This course begins with the creation of executable programs in the C programming language. We will then explore the resultant program as it is stored on disk and as it is loaded for execution. Next, we will examine the interactions between our code and the code provided via libraries or the operating system to facilitate common, low-level tasks. Finally, we will look at the abstractions and resource management undertaken by the OS and its drivers to facilitate communication and hardware interaction.

The goals of the course are:

- Learning C programming. C is the most common language used for systems software.
- Exploring the layout of an executable program’s code and data both as stored on disk and loaded into memory.
- Interacting with the abstractions that libraries and the operating system provide.
- Implementing our own abstractions, and manage hardware resources through device drivers.

**Textbooks**

[**REQUIRED TEXT**]


*You may substitute instead (but you’re responsible for the appropriate readings):*


ISBN: 0-13110-362-8

[**ONLINE REQUIRED TEXTS**]
There are three additional textbooks that are available online in PDF form that we will refer to throughout the term. Links can be found on the course website.

Class Policies

Exams: There will be two midterms and a final. The exams will be closed book/notes. Cheating on exams will not be tolerated. Anyone caught cheating will be given a zero for the test and reported to the department following University procedures.

Projects: There will be 5 out-of-class assignments given. These are to be completed in the given time (no extensions will be given without a valid excuse. LATE WORK IS NOT ACCEPTED. Contact me before the deadline for clarifications.) These are meant to be your own work; anyone found to be collaborating will be disciplined in accordance to University policy. Cheating means (but is not limited to): using code from previous terms, other universities, your friends, finding it on the Internet, getting help from unapproved forums, or outsourcing it.

We will be using Moss, a tool from Stanford for determining inappropriate collaboration.

Labs and Quizzes: Attending recitation is an important part of this course. In recitation you will be able to work in a structured setting while completing small tasks (Labs). Concepts from class will be expanded upon and tested with unannounced quizzes.

Participation: Attendance will not be taken, but in a small class, any absence will be noticed. Several unexcused missed classes will adversely affect your grade.

Grading

Your grade will be based upon 3 exams, 5 projects, labs and quizzes (the lowest one of which will be dropped), and participation:

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<tr>
<td>First Midterm</td>
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<tr>
<td>Second Midterm</td>
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<td>Final Exam</td>
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<td>5 Projects</td>
<td>40% (8% each)</td>
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<td>Labs and Quizzes</td>
<td>10%</td>
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<td>Participation</td>
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<td><strong>Total</strong></td>
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The scale for the term will be:

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<th>100</th>
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<th>80</th>
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<td><strong>Letter</strong></td>
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<td>A</td>
<td>A-</td>
<td>B+</td>
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<td>B-</td>
<td>C+</td>
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<td>C-</td>
<td>D+</td>
<td>D</td>
<td>D-</td>
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Disability Resources and Services:
If you have a disability for which you are requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services, 216 William Pitt Union, (412) 648-7890, as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

Academic Integrity
Students are expected to comply with the University of Pittsburgh’s Policy on Academic Integrity. Any student suspected of violating this obligation for any reason during the semester will be required to participate in the procedural process as outlined in the University Guidelines on Academic Integrity. For further information see: http://www.pitt.edu/~provost/ai1.html

Term Schedule
The daily topics are subject to change depending on our pace. They are there to assist you in the readings so you can focus on those concepts prior to class.

The textbooks are indicated as follows:

• Practical C – Course text
• Misurda – CS 0449: Introduction to Systems Software (online)
• ALP – Advanced Linux Programming (online)
• LDD3 – Linux Device Drivers, 3rd edition (online)

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<thead>
<tr>
<th>Week 1: 8/30/2016 - 9/1/2016</th>
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<tbody>
<tr>
<td><strong>READINGS:</strong> Practical C, Chapters 1-4, 6, 8, 11</td>
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<tr>
<td><strong>TOPICS:</strong></td>
</tr>
<tr>
<td>• Intro to the Course</td>
</tr>
<tr>
<td>• C Programming</td>
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<tr>
<td>o Data Types and Representation</td>
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<td>o Operators &amp; Bitwise Manipulation</td>
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<td>o Control Flow</td>
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<tbody>
<tr>
<td><strong>READINGS:</strong> Practical C, Chapters 5, 7, 9</td>
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<tr>
<td><strong>TOPICS:</strong></td>
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<tr>
<td>• C Programming (continued)</td>
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<td>o Arrays</td>
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<td>o Strings</td>
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<td>Week</td>
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| 3    | 9/13/2016 - 9/15/2016 | Functions<br>
|      |             | **FRIDAY, SEPTEMBER 11, 2016:** Fall term add/drop period ends<br>
|      |             | **READINGS:** Practical C, Chapters 10, 12-14, 17; Misurda, Chapter 1<br>
|      |             | **TOPICS:**<br>
|      |             | • C Programming (continued)<br>
|      |             |   o Scope vs. Lifetime<br>
|      |             |   o Pointers<br>
|      |             |   o I/O<br>
|      |             |     ▪ Console<br>
|      |             |     ▪ Files<br>
| 4    | 9/20/2016 - 9/22/2016 | **TOPICS:**<br>
|      |             | • C Programming (continued)<br>
|      |             |   o Memory management<br>
|      |             |     ▪ malloc/free<br>
|      |             |   o Structures, and Unions<br>
| 5    | 9/27/2016 - 9/29/2016 | **THURSDAY, SEPTEMBER 29, 2016:** First Midterm Exam<br>
|      |             | **TOPICS:**<br>
|      |             | • Review for first midterm exam<br>
| 6    | 10/4/2016 - 10/6/2016 | **TOPICS:**<br>
|      |             | • Program Representation<br>
|      |             | • Linking<br>
|      |             |   o Static<br>
|      |             |   o Dynamic<br>
|      |             | • Libraries, archives, shared objects<br>
|      |             | • Executable file formats<br>
| 7    | 10/11/2016 - 10/13/2016 | **TOPICS:**<br>
|      |             | • X86 assembly & calling conventions<br>

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**Courses:**
- Practical C<br>
- Misurda
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<thead>
<tr>
<th>Week 8: 10/18/2016 - 10/20/2016</th>
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<tbody>
<tr>
<td><strong>READINGS:</strong> <em>Misurda</em>, Chapter 7; <em>ALP</em> Chapters 3, 8</td>
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<tr>
<td><strong>TUESDAY, OCTOBER 18, 2016:</strong> No class, follow your Monday schedule!</td>
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<tr>
<td><strong>TOPICS:</strong></td>
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<tr>
<td>• Processes and Memory Management</td>
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<tr>
<th>Week 9: 10/25/2016 - 10/27/2016</th>
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<tr>
<td><strong>FRIDAY, OCTOBER 30, 2016:</strong> <strong>Withdrawal Deadline (For “W” grade)</strong></td>
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<tr>
<td><strong>READINGS:</strong> <em>LDD3</em>, Chapters 1-2</td>
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<tr>
<td><strong>TOPICS:</strong></td>
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<tr>
<td>• Interaction with Operating System</td>
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<tr>
<td>• interrupts (int 0x80, int 3)</td>
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<tr>
<td>• calling convention/ABI</td>
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<td>• Syscalls</td>
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<tr>
<td>• Signal Handling</td>
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<tr>
<td><strong>THURSDAY, NOVEMBER 3, 2016:</strong> <strong>Second Midterm Exam</strong></td>
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<td><strong>TOPICS:</strong></td>
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<tr>
<td>• Fork System Call &amp; Processes</td>
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<tr>
<td>• Review for second midterm exam</td>
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<tbody>
<tr>
<td><strong>READINGS:</strong> <em>Practical C</em>, Chapters 7,10,18</td>
</tr>
<tr>
<td><strong>TOPICS:</strong></td>
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<tr>
<td>• Linux Device Drivers</td>
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<tr>
<td>• Multi-file Development</td>
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<tr>
<td>• Providing an interface/API</td>
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<td>• Header files</td>
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<td>• Makefiles</td>
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<tr>
<td><strong>READINGS:</strong> <em>Misurda</em>, Chapter 8; <em>ALP</em>, Chapter 3</td>
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### Week 13: 11/22/2016 - 11/24/2016

**TOPICS:**
- Finish up makefiles
- Communication and Networking
  - Berkley Sockets
  - Pipes
  - Shared Memory

**READINGS:** *Misurda*, Chapter 9

**THURSDAY, NOVEMBER 24, 2016: Thanksgiving Break, University Closed**

**TOPICS:**
- Finish up networking
- Threading
  - User vs. Kernel Threading
  - Scheduling/yield/sleep
  - pthreads

### Week 14: 11/29/2016 - 12/1/2016

**READINGS:** *Misurda*, Chapter 10

**TOPICS:**
- Finish up threading
- Deadlocks/Synchronization

### Week 15: 12/6/2016 - 12/8/2016

**READINGS:** Prepare for the final exam

**TOPICS:**
- Review for the final exam

### Finals Week

**Final Exam (TH 11:00am – 12:15pm Class):** Tuesday, December 13, 2016, from 12:00pm–1:50pm

**Final Exam (TH 04:00pm – 05:15pm Class):** Thursday, December 15, 2016, from 2:00pm–3:50pm