Com S 327
Advanced Programming Techniques
Fall 2016

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Instructor

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Lecture	MWF 15:10–16:00pm in Carver 0101
Office Hours	Tuesdays 13:30-15:30 in the Software Engineering Learning Center (Atanasoff 125)

Teaching Assistants

Name	Email	Office Hours			Location
Sumon Biswas	sumon@iastate.edu	M	R	16:00–18:00	Pearson 145
Keegan Dahm	kcdahm@iastate.edu	T		18:00-20:00	Pearson 145
Nitesh Gupta	nkgupta@iastate.edu		W	17:00-19:00	Pearson 145
Zahra Khoshmanesh	zkh@iastate.edu	T	R	10:00-12:00	Pearson 145
Priyangika (Rumesh) Piyasinghe	rumesh@iastate.edu	M		12:00–14:00	Pearson 145
			W	13:00–15:00	Pearson 145

Course Summary (from the catalog)

Object-oriented programming experience using a language suitable for exploring advanced topics in programming. Topics include memory management, parameter passing, inheritance, compiling, debugging, and maintaining programs. Significant programming projects.

Course Summary (from the instructor)

We will cover the topics described above with two languages, C and C++, used as drivers. We will spend roughly half of the course on C and half on C++. We will also devote some time to programming environment, build tools, version control, and debugging; these are all concepts that you will need to understand and employ to be successful in this course and beyond.

Course Objectives

After successfully completing this course, students will:

- understand differences between managed languages (e.g., Java) and unmanaged languages (e.g., C and C++);
- understand and be able to use simple build systems (e.g., make);
- be able to design and build large programs from specification;
- be able to use third-party libraries in programs;
- be able to read, write, and modify C programs;
- understand memory management techniques for C;
- be able to read, write, and modify C++ programs;
- understand memory management techniques for C++;
- understand C++ templates and the standard template library.

Course Outcomes

This course has three major ABET outcomes:

1. By the end of this course, students will be able to produce efficient and correct C and C++ programs of significant lengths from specifications.
2. By the end of this course, students will be able to understand and use advanced C and C++ features in software development and maintenance.
3. By the end of this course, students will be able to write and debug large C and C++ programs based on English descriptions or pseudocode.

Prerequisites

Course prerequisites are Com S 228 and credit or enrollment in Math 166, or instructor permission. No exceptions. If you do not meet these prerequisites, it is the policy of the Computer Science department that your materials will not be graded.

Textbooks

There are no required texts for this course. All required material will be presented in lecture. Supplemental material may be found in the following excellent texts:

- Brian W. Kernighan and Dennis M. Ritchie, *The C Programming Language*.
- Bjarne Stroustrup, *The C++ Programming Language*.
- Erich Gamma, John Vlissides, Ralph Johnson, and Richard Helm, *Design Patterns: Elements of Reusable Object-Oriented Software*.

Recommended Software

In the past, I have recommended that students work directly on the Computer Science department's student server, `pyrite.cs.iastate.edu`. While this is still a good solution, there are some drawbacks, namely that it requires a constant network connection, which may get laggy, and that the server sometimes experiences heavy loads. In the Spring 2016 semester we did some experiments with virtual machines with some success. Using a Linux VM (or a native Linux computer) is now the recommended working solution.

Linux VMs

I have created two different Linux VM images. One is Slackware 14.1, which is the current version of the distribution of Linux that I run. The other is Fedora 23, which is the current version of the distribution of Linux that runs on `pyrite`. I have installed the drivers that allow Linux to interface with the host operating system through the VM, so you should be able to configure shared directories, cut-and-paste between host and client, and other, similar convenient things.

I have done a very small amount of configuration on these installations, including installing Valgrind (a memory debugging tool that you will want), Valkyrie (a GUI frontend to Valgrind), and Google Chrome.

I have created a user account, `student` with password `student` and did a small amount of configuration of that account in the `.bashrc` and `.bash_profile` files. The `root` (administrator) account uses the password `root`. **You will want to change both of these passwords with the** `passwd` **command!** In order to change the root password, you will first need to become root with the `su` command. You will need to become root if you want to, say, install software or configure system services, but you should not work as root; that would be asking for trouble. On my first Linux system, back in 1995, I worked as root. My second Linux system (same hardware, fresh install) became necessary less than 2 weeks after the first.

Both images are shared on Box with the following links:

Slackware: https://iastate.box.com/s/1vs4nx250a1jztqtbpoetg4k75z6e2as

Fedora: https://iastate.box.com/s/x30s67d6wdjz0o7bjbq85nwan8pj3eu7

Both images are large, slightly over 4 GB. They are *VirtualBox* images. You will need to install VirtualBox (https://www.virtualbox.org/wiki/Downloads) and import the image (File >> Import Appliance). Once you have successfully imported, you can delete the OVA files. Both systems are configured to use 4GB of memory. The virtual hard drives grow as needed up to a maximum of 32 GB. Much of the configuration can be changed, but only if the machine is not actually running.

Blackboard contains a pair of discussion forums, one for each image, where you can share your questions and comments about working with these machines.

Remote Server

It is always possible to complete the programming assignments by working directly on `pyrite.cs.iastate.edu` or on any of the Linux machines in the labs. Connect to `pyrite` using ssh. A nice, free Windows ssh client is PuTTY (http://www.putty.org/). To resolve `pyrite` from off campus, you will need to first connect to the Iowa State VPN (https://vpn.iastate.edu/).

Other Necessities

In a Linux environment, you can edit with Emacs, vi, or Pico (the first two are powerful and used by professional programmers all over the world, while the latter is simple and used by undergraduate computer science students with tunnel vision all over the world).

Regardless of your working environment, you will need a C and a C++ compiler, an editor, and a debugger. You may use whatever specific tools you like, so long as your submitted code compiles and runs on one of the VMs. In lecture, I will use GCC and G++ for compiling, Emacs for editing, and GDB for debugging, because these are what I use for real programming.

Be careful if you use Visual Studio! Visual Studio will often compile code that does not compile under GCC. If you are not developing on `pyrite` or one of the VMs, be sure to give yourself enough time for testing before you must submit.

The main project will use the ncurses library, which may be obtained in many different ways. Official site: http://www.gnu.org/software/ncurses/ncurses.html. The Slackware VM has the necessary ncurses development libraries; on the Fedora VM, you will need to issue the following command as root: `dnf install ncurses-devel`.

All submissions must compile with GNU Make for credit. Official site: http://www.gnu.org/software/make/

Helpful Extras

Version control software, such as `git` or `subversion`. Among other things, this allows you to keep your source code synchronized between your personal machine and the testing machine.

- Subversion book: http://svnbook.red-bean.com/
- Git book: http://git-scm.com/book

`Valgrind` (http://valgrind.org/) or some other memory profiling tool. This can save *hours* of work tracking down segmentation faults.

If you are running Linux, you probably have all of this already. Windows users can get everything by installing Cygwin (https://www.cygwin.com/), but it is easy to botch the installation; it is probably easier to install VirtualBox (https://www.virtualbox.org/wiki/Downloads) and then install a full Linux distribution on top of it. Mac OSX used to ship with GCC. My understanding is that it no longer does. Mac users: Google is your friend.

I cannot provide you with technical support on any platform save Linux. I have almost no experience with systems that are not either UNIX-based or embedded. My experience teaching this class in the past suggests that students who insist on working in Windows because they are more comfortable there struggle the entire semester, while those who commit to working in Linux struggle only at the beginning.

Lecture Attendance

We will not take attendance; however, you are expected to attend all lectures. You are responsible for all material presented in lecture, as well as for the content of any announcements made there. Many students believe that they can learn the material without attending lecture. Past experience, both in my and in other instructors' classes, shows that students who attend class tend to do well, and very few students who do not attend class even manage to pass.

BlackBoard

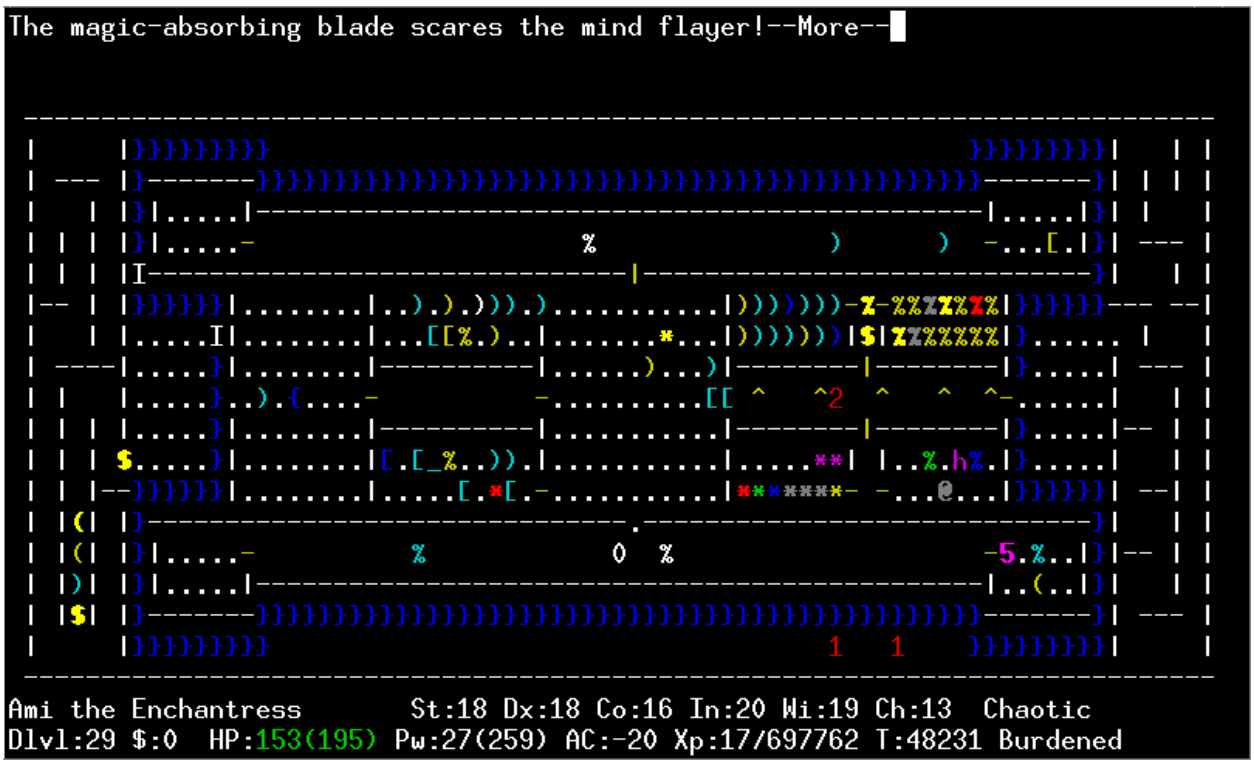
We will be using BlackBoard for this course. In particular,

- announcements about the course, such as assignments, due dates, and other logistics, will be made via Blackboard,
- clarifications and answers to common questions about homework will be announced through the BlackBoard discussion boards, and
- unless announced otherwise, all programming assignments must be submitted electronically via BlackBoard.

We expect you to check Blackboard regularly for announcements and homework or exam information. It is your responsibility to know how to log in, read announcements, use the discussion boards, and submit homework. You can log into Blackboard with your ISU NetID and password at:

https://bb.its.iastate.edu/

Choose Com S 327 after you log on.



Screenshot from a game of NetHack, showing a message on top (the player has attacked a mind flayer, a very dangerous monster that will suck out your brains), dungeon view in the middle, including the character (the '@'), the mind flayer (the 'h'), gold ('$'), various monsters that the character is aware of magically (the numbers, which denote their approximate strengths), a moat (the many '}'), many weapons, pieces of armor, gems, traps, doors, corridors, and items of food, and, on the bottom, the character's status.

Course Work

Projects (60%)

Over the course of the semester, we will be building a Roguelike game using ASCII graphics. Two iconic modern examples of such games are Angband and NetHack. The figure shows a screen shot of a typical NetHack game. Your games will probably not be nearly as extensive as these two examples—unless you want them to be!—but by the end of the semester, you will have developed a playable game with, at minimum, nice-looking, randomly-generated dungeon maps, items and monsters that are specified in files that your classmates' games will be able to read and use, turn-based play with keyboard input and terminal output, and the ability to save and restore. Many people write such games in a week as a part of a contest, for fun; some of them are even pretty good.

Certain functionality will be due, beginning the second week of classes, every week except for Spring Break and Dead Week at 10:00pm on Tuesday. Project requirements will be specified in advance, so that you may work ahead, but at any given time, you will only be graded on the functionality required by that date.

All assignments must be turned in with an ASCII readme file, named `README` and containing no more than 150 words, which describes your project's compliance with the specification to date including relevant function, data structures, and file names. Assignments must also contain an ASCII change log file named `CHANGELOG` that contains a cumulative list of dated updates from day 1 (e.g., "started project"). The change log will list every significant change you make to your project, including bug discoveries, bug fixes, functionality additions and changes, etc.

All projects must include a working makefile, named `Makefile`, which correctly builds a binary with debugging

symbols on `pyrite`. We will discuss these things in the first week of class.

All projects must be submitted via the appropriate assignment page on BlackBoard. Projects should be turned in as a *tarball* (a gzipped tar archive). Basic instructions, with an example, on how to create and extract acceptable tarballs follow. Tarballs are to be named

`<surname>_<forename>.assignment-<assignment number>.tar.gz`

and should extract to a directory named

`<surname>_<forename>.assignment-<assignment number>`

where `<surname>` is your family name, `<forename>` is your given name, `<assignment number>` is the submitted assignment number, and all other characters are literals. Thus, if *I* am submitting assignment 1.05, my tarball will be named

`sheaffer_jeremy.assignment-1.05.tar.gz`

and it will expand to the directory

`sheaffer_jeremy.assignment-1.05`

which will contain all of my source files, and `Makefile`, `README`, and `CHANGELOG` as defined above, but no generated files (run `make clean` first!).

Still using assignment 1.05 as the driving example, the simplest way to create a tarball follows. This is an actual session from my shell, saved with a program named `script`. I have added comments inline, preceding them with '`%%` ', which are not part of the actually shell I/O. Lines beginning with `sheaffer@sheaffer...` are input. Lines ending with a backslash ('\') are continued on the following line. I've indented continued lines by two spaces to make them stand out. All other lines are output.

```
Script started on Thu 08 Jan 2015 08:20:53 AM CST
%% Run 'make clean' to get rid of the binaries
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments/assignment1.05$ make clean
rm -f dungeon.o cds/heap.o rlg229
%% Move into the parent directory so that we can make a tarball of the
%% current directory
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments/assignment1.05$ cd ..
%% My directory isn't named as per the specification, so create a copy of it.
%% '-R' makes it copy recursively (a deep copy) so the 'cds' subdirectory is
%% copied, too, or you could rename it with 'mv'.
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments$ cp -R assignment1.05/ \
  sheaffer_jeremy.assignment-1.05
%% Create the tarball.  Four switches to tar.  'c' means create, 'v' means
%% verbose, 'f' means force, and 'z' means compress with gzip.  'v' and 'f'
%% aren't strictly needed, but 'v' does cause it to give the file list that
%% follows.
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments$ tar cvfz \
  sheaffer_jeremy.assignment-1.05.tar.gz sheaffer_jeremy.assignment-1.05/
sheaffer_jeremy.assignment-1.05/
sheaffer_jeremy.assignment-1.05/cds/
sheaffer_jeremy.assignment-1.05/cds/hash.h
sheaffer_jeremy.assignment-1.05/cds/tree.c
sheaffer_jeremy.assignment-1.05/cds/macros.h
sheaffer_jeremy.assignment-1.05/cds/neural_net.h
sheaffer_jeremy.assignment-1.05/cds/neural_net.c
sheaffer_jeremy.assignment-1.05/cds/list.c
sheaffer_jeremy.assignment-1.05/cds/heap.c
sheaffer_jeremy.assignment-1.05/cds/list.h
```

```
sheaffer_jeremy.assignment-1.05/cds/spinlock.h
sheaffer_jeremy.assignment-1.05/cds/heap.h
sheaffer_jeremy.assignment-1.05/cds/hash.c
sheaffer_jeremy.assignment-1.05/cds/heap.d
sheaffer_jeremy.assignment-1.05/cds/circular_queue.h
sheaffer_jeremy.assignment-1.05/cds/circular_queue.c
sheaffer_jeremy.assignment-1.05/cds/tree.h
sheaffer_jeremy.assignment-1.05/Makefile
sheaffer_jeremy.assignment-1.05/dungeon.h
sheaffer_jeremy.assignment-1.05/dungeon.c
sheaffer_jeremy.assignment-1.05/CHANGELOG
sheaffer_jeremy.assignment-1.05/README
%% At this point, I am done.  I could submit, however, I don't want to risk a
%% penalty to my grade, so I am going to test it out.  I can't really expand
%% the archive here, because the target directory exists.  Since that
%% directory is a copy, I could just delete it now, but if I made a mistake
%% and need to try again, I would rather not have to retype all that stuff, so
%% let's make a temporary directory to expand in, call it 'test'.
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments$ mkdir test
%% And move into it...
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments$ cd test
%% Now to open up the archive.  gzip compresses and decompresses.  The 'd'
%% switch tells it to decompress.  'c' tells it to concatenate the output to
%% the standard output, then we pipe ('|') that to tar, where 'x' means to
%% expand ('v' and 'f' are as above) and a file name of '-' means to read the
%% file from the standard input.  I can see in the output that follows that
%% the files are all there.  I can move in, do a build, some testing, etc.,
%% as I please.
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments/test$ gzip -dc \
  ../sheaffer_jeremy.assignment-1.05.tar.gz |tar xvf -
sheaffer_jeremy.assignment-1.05/
sheaffer_jeremy.assignment-1.05/cds/
sheaffer_jeremy.assignment-1.05/cds/hash.h
sheaffer_jeremy.assignment-1.05/cds/tree.c
sheaffer_jeremy.assignment-1.05/cds/macros.h
sheaffer_jeremy.assignment-1.05/cds/neural_net.h
sheaffer_jeremy.assignment-1.05/cds/neural_net.c
sheaffer_jeremy.assignment-1.05/cds/list.c
sheaffer_jeremy.assignment-1.05/cds/heap.c
sheaffer_jeremy.assignment-1.05/cds/list.h
sheaffer_jeremy.assignment-1.05/cds/spinlock.h
sheaffer_jeremy.assignment-1.05/cds/heap.h
sheaffer_jeremy.assignment-1.05/cds/hash.c
sheaffer_jeremy.assignment-1.05/cds/heap.d
sheaffer_jeremy.assignment-1.05/cds/circular_queue.h
sheaffer_jeremy.assignment-1.05/cds/circular_queue.c
sheaffer_jeremy.assignment-1.05/cds/tree.h
sheaffer_jeremy.assignment-1.05/Makefile
sheaffer_jeremy.assignment-1.05/dungeon.h
sheaffer_jeremy.assignment-1.05/dungeon.c
sheaffer_jeremy.assignment-1.05/CHANGELOG
sheaffer_jeremy.assignment-1.05/README
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments/test$ cd ..
%% Looks good!  I am ready to submit.  I don't need the temporary directory,
%% nor the renamed directory, so I am cleaning them up.
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments$ rm -rf test
```

```
sheaffer_jeremy.assignment-1.05
%% And exiting the 'script' program.
sheaffer@sheaffer-e7440:~/classes/semester/s2015/229/assignments$ exit

Script done on Thu 08 Jan 2015 08:22:54 AM CST
```

Given the cumulative nature of the assignments, we will attempt to return all assignments, except assignment 12, within 48 hours. **Assignments submitted with formats that do not match the above specification will receive a penalty of at least 20%. A assignment without an up-to-date readme, an up-to-date changelog, and a working Makefile will not be graded and will receive a grade of 0. A required feature which is not discussed in the readme will not be evaluated, and thus will not receive credit.** Since the assignment is cumulative, it will grow to such a size that searching your code for required features will become intractable to the graders. These rules are necessary to make grading possible.

Because the assignments are cumulative and we do not want students to fall behind with no reasonable chance of catching up, the instructor will periodically release code checkpoints to the class which may be used in part or in whole by any student in the class in subsequent submissions.

The first assignment is special, intended to get you acquainted with the development environment and to provide a gentle introduction to C, and it is not part of your game. For this reason, we will start numbering with 0.

Assignment submission schedule

Assignment	Due Date
Assignment 0	Wed Jan 18 22:00:00 CST 2016
Assignment 1.01	Wed Jan 25 22:00:00 CST 2016
Assignment 1.02	Wed Feb 1 22:00:00 CST 2016
Assignment 1.03	Wed Feb 8 22:00:00 CST 2016
Assignment 1.04	Wed Feb 15 22:00:00 CST 2016
Assignment 1.05	Wed Feb 22 22:00:00 CST 2016
Assignment 1.06	Wed Mar 1 22:00:00 CST 2016
Assignment 1.07	Wed Mar 8 22:00:00 CST 2016
Assignment 1.08	Wed Mar 22 22:00:00 CDT 2016
Assignment 1.09	Wed Mar 29 22:00:00 CDT 2016
Assignment 1.10	Wed Apr 5 22:00:00 CDT 2016
Assignment 1.11	Wed Apr 12 22:00:00 CDT 2016
Assignment 2	Wed Apr 19 22:00:00 CDT 2016

All assignments will be graded out of 10 points. Some assignments may be extended, reducing the total number of assignments; thus, the final weight of each assignment will be 60% divided by the final number of assignments.

Exams (40%)

There will be two exams, a midterm and a final. You must bring your university ID to all exams.

Exam schedule

Exam	Time	Location	Time	Weight
Midterm	Wed Mar 1 13:10:00 CST 2016	Carver 0101	50 minutes	20%
Final	Mon May 1 14:15:00 CDT 2016	Carver 0101	120 minutes	20%

You are responsible for providing at least 1 week advanced notice if you have an exam conflict. Students who give sufficient notice will be permitted to schedule an alternate exam time.

The class meeting before each exam will include review of a previous exam. The class meeting after each exam will include review of your exam. There will be a class meeting during the courses final exam period.

Lateness Policy

Late work will be accepted with no penalty until such time as the TAs begin grading, at which time submission will be closed and no further submissions will be accepted for the assignment. We cannot say when TAs will begin grading, but given that we intend to return work within 48 hours, it could be very soon after the deadline. Thus the optimal submission strategy to maximize your grade is to complete and submit the required functionality by the deadline. Except for projects 0 and 1.12, because it is cumulative, all work benefits the project as a whole, even if it occurs after its respective deadline, so work is never wasted. If you fail to have a complete, correct submission by the deadline, the optimal remaining strategy is to continue to develop, and submit regularly, until such time as you complete the assignment or you find submission closed. The TAs will always take the last submission that was available at the time that they download the projects.

Grading

Midterm and final grades will be curved. The curves will not be determined until grades are calculated, and will be designed to fairly rank your performance against that of your peers and reward you appropriately for your work. A traditional 10-point scale establishes a lower bound on your grade now. Any curve that is applied at the midterm will establish a new lower bound for the final grade, which may in turn be curved even more in your favor.

Bug Bounty

All solution code that is released by the instructor to BlackBoard is subject to a bug bounty. The bug bounty works as follows:

You must discover what you believe to be a bug in solution code. You must find an input that reproduces that bug. You must write a fix for the bug which is itself (apparently) bug free. You must post all of this to the respective solution thread on BlackBoard. If you are the first to post a correct bug fix, you will be rewarded with an increase of one grade level (that is, A- becomes A, C+ becomes B-, etc., but no change for an A) to your final course grade.

Just because something doesn't work the way you think it should doesn't make it a bug. I reserve the right to reject your submission if it "repairs" something that I consider not a bug. You may ask me before you work if I would consider X to be a bug; I will give you the best answer I can given the accuracy and detail of your question.

Be advised that if you post an incorrect bug report, input, or fix, the information immediately becomes available to your classmates, who may then beat you with the correction, so try to get it right the first time.

Academic Integrity

Academic integrity will be taken seriously in this course. We will use plagiarism-detection software to check all submissions. This is not because we believe that you will cheat, but because students have cheated in the past and the course is graded on a curve, placing us in a situation where cheaters actually hurt the rest of the class.

Exams and any and all required software functionality are to be your own work. We will take academic dishonesty seriously. We will report it to the Dean of Students. If you are found responsible for academic dishonesty in this class, you will receive a failing mark for the course. We believe that you are mature enough to understand "integrity" without a great deal of detail in the syllabus. Here we list some examples of things which you may and may not do in this class. If you are ever unsure, discuss it with the instructor.

The following examples should be taken in spirit, not as a complete list. For example, you may not edit another student's code, so it should be clear that you also may not write code on paper for another student to use. With respect to programming assignments, you may not:

- Share required elements of your project source code with anyone before the instructor clears those elements for sharing.
- Study required elements of another students source code.
- Submit another student's work as your own.
- Debug another student's source code.
- Edit another student's code.
- Use code from the Web or elsewhere to satisfy required functionality in your project before submission for that functionality is closed.
- Use third party code in your project without attribution.

You may:

- Discuss algorithms, data structures, and design with other students and on BlackBoard
- Directly use third-party code for non-required functionality with complete and correct attribution
- Directly use third-party code for required functionality, provided submission for that functionality has already been closed and you completely and correctly attribute the author.
- Implement algorithms learned from third-party sources in your code
- Share code that implements non-required functionality on BlackBoard.
- Share code that implements required functionality on BlackBoard after the instructor gives clearance to do so.
- Help another student debug, so long as that student "drives."

The University's policies on academic dishonesty are located online at:

http://catalog.iastate.edu/academiclife/regulations/#academicdishonestytext.

Please speak with the instructor directly if you have any questions or doubts.

Disabilities

Iowa State University complies with the Americans with Disabilities Act and Section 504 of the Rehabilitation Act. Any student who may require an accommodation under such provisions should contact the instructor as soon as possible and no later than the end of the first week of class or as soon as you become aware. Please obtain a SAAR form verifying your disability and specifying the accommodation you will need. No retrospective accommodations will be required in this class.

Harassment and Discrimination

Iowa State University strives to maintain our campus as a place of work and study for faculty, staff, and students that is free of all forms of prohibited discrimination and harassment based upon race, ethnicity, sex (including sexual assault), pregnancy, color, religion, national origin, physical or mental disability, age, marital status, sexual orientation, gender identity, genetic information, or status as a U.S. veteran. Any student who has concerns about such behavior should contact his or her instructor, Student Assistance at 515-294-1020 or email dso-sas@iastate.edu, or the Office of Equal Opportunity and Compliance at 515-294-7612.

Religious Accommodation

If an academic or work requirement conflicts with your religious practices or observances, you may request reasonable accommodations. Your request must be in writing, and your instructor or supervisor will review the request. You or your instructor may also seek assistance from the Dean of Students Office or the Office of Equal Opportunity and Compliance.