IE170/171: Algorithms in Systems Engineering
Syllabus

Dr. Ted Ralphs

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1 Miscellaneous Course Information

Instructor:	Dr. Ted Ralphs
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Office Hours:	MWF 12:00-1:00
Web page:	http://www.lehigh.edu/~tkr2
Course web page:	http://www.lehigh.edu/~tkr2/teaching/ie170/
Course meeting time:	IE170 MWF 11:10-12:00
	IE171 M 1:10-4:00
Teaching Assistant:	Shantanu Chakraborty

2 Description of Course

This course will introduce students to the principles involved in designing, analyzing, and implementing basic algorithms common in systems engineering applications. The course will be divided into five units by topic area (see detailed syllabus below). Course meetings will consist of three 50 minute lectures and one three hour laboratory each week. The laboratory exercises will consist of case studies in which the students will have to apply the principles discussed during the week's lectures to solve a given systems engineering problem. This will be accomplished mainly through implementing various algorithms and data structures in C++. Weekly homework based on the laboratory case studies will further reinforce student learning.

3 Course Objectives

The goals of this course are for each student to:

1. Continue to sharpen basic computing and programming skills needed for future coursework, as well as reinforce material learned in previous courses;
2. Understand the basic principles of algorithm design, especially for applications in systems engineering;

3. Develop an appreciation for the importance of implementing algorithms efficiently and the skills necessary for doing so;
4. Understand basic techniques for analyzing the performance of algorithms;
5. Develop an ability to solve systems engineering problems by designing and implementing an appropriate algorithm.

4 General Course Requirements

4.1 Prerequisites

Students are expected to have basic computing skills, including familiarity with the C++ programming language. They should also have completed ENG 1 and CSc 17.

4.2 Required Text

Thomas H. Cormen (Editor), Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, *Introduction to Algorithms* (Second Edition).

4.3 Reading

Students will be expected to complete the readings associated with each lecture. Most readings will be from the course text, but students are encouraged to seek supplementary material. Links to supplementary reading material available over the Web will be available from the course page.

4.4 Lectures

Students will be expected to attend and participate in lectures. Lecture slides will be provided ahead of time on the course Web site and should be printed out and brought to lecture. Students will be graded on all aspects of class participation.

4.5 Laboratories

Students will be required to attend laboratories each week and compose a laboratory report due one week after the laboratory occurs. Details on the structure of the laboratories is given in Section 6.

4.6 Homework

Students will be required to complete weekly homework assignments related to the laboratories. The homework assignments will be submitted in conjunction with the laboratory reports each week.

4.7 Exams

The emphasis of the course will be on the laboratories. However, there will be a mid-term exam and a final exam to gauge each student's retention of the course material.

5 Course Outline

5.1 Blocks

Block 1: Introduction. In this block, the students will get a basic introduction to the principles of algorithm design and analysis.

Block 2: Sorting. Sorting algorithms are one of the most fundamental building blocks for more complex algorithms. The wide variety of sorting algorithms available also serves to effectively illustrate the effect of algorithm design on efficiency.

Block 3: Searching. Another fundamental technique is that of looking up entries in a database or searching for the occurrence of a string in a database. This block will examine techniques for performing these operations.

Block 4: Networks and Graphs. Networks and graphs are data structures widely used for representing connectivity and precedence relations in a wide variety of systems. This block will examine basic algorithms involving these data structures.

Block 5: Numerical Algorithms. In the final block, we will examine important numerical algorithms such as those for solving systems of equations and those used in cryptography.

5.2 Tentative Schedule of Topics and Laboratories

Week	Block	Topic	Reading	Laboratory
1	Introduction	Intro and C++ Review	Chapters 1-2	Eclipse
2		Analyzing Algorithms	Chapters 3	Search
3		Recursion and Recurrences	Chapter 4	Selection
4	Sorting	Heaps and Quicksort	Chapters 6-7	Stacks and Queues
5	Searching	Binary Search Trees	Chapter 12	Sorting
6		Hash Tables	Chapter 11	Binary Search Trees
7	Review	Review		Hash Tables
8	Networks	Graph Algorithms	Chapter 22	Review
9		Shortest Paths	Chapter 24	Mid-term Exam
10		Minimum Spanning Trees	Chapter 23	Graph Search
11	Numerical	String Matching	Chapter 32	Shortest Paths
13		Cryptography	Chapter 31	String Matching
14		Matrix Operations	Chapter 28	Cryptography
12		Systems of Equations	Chapter 28	Review

6 Laboratory Procedures

The laboratories will be the main focus of the course. In general, the labs will be case-based and will consist of a three part assignment. The first part of the assignment will be to implement a specified algorithm, the second part will be to analyze the algorithm, both theoretically and empirically, and the third part will be to complete supplementary written problems to be submitted along with the laboratory report. All programs will be written in C++ using the Eclipse C++ Integrated Development Environment (IDE).

During the lab itself, you will have a chance to work on your program with the help of the instructor or a teaching assistant. You should take advantage of this time to lay out the structure of your program and get as far as possible in implementing it. During the lab period, you should not access the Internet for help. At the end of the lab period, you will turn in what you have accomplished so far and finish the rest at home. Your partially completed lab work should be e-mailed to the instructor at the end of lab using the procedure outlined in Section 6.2, except that the subject of the e-mail should be "IE170 Laboratory *".

6.1 Lab write-ups

Materials submitted as part of the laboratory should consist of `well-commented` source code for the programming portion of the assignment and written answers to the remaining portions of the assignment. When conducting computational experiments, always conduct all experiments on identical hardware. When reporting on the results of the experiments, document the conditions under which your experiments were conducted, including a detailed description of the hardware.

6.2 Procedure for Turning in Labs

All laboratory reports and source code should be submitted electronically by e-mailing a ZIP file to the instructor by the next laboratory period. The ZIP file should have the name `<Network ID>-HW*.zip` where the "*" is replaced by the laboratory number and the subject of the e-mail should be "IE170 Homework *," where "*" is replaced by the laboratory number. If the report is a group assignment, then the mail ID of the last names of all the group participants should be listed in the file name separated by hyphens. Written reports should be in either Microsoft Word or PDF format and use the same naming convention. Source code should be included in the ZIP archive (no project files or other auxiliary files needed). A printed copy of your source code should also be submitted (no need to submit a printed copy of the rest of the lab. Please pay attention to these procedures in order to avoid needless penalties.

6.3 Grading

The number of points allocated to each part of the assignment will be specified in the description of the laboratory. Approximately 50% of the credit for the programming portion of the assignment will be determined by whether the source code compiles "out of the box" and runs according to specifications. The other 50% of the credit will be for efficiency and good design.

7 Overall Grading Scheme

50% Homework and Laboratory Write-ups
20% Mid-term
20% Final
10% Class Participation

8 Class Policies

8.1 Group Work

You are encouraged to share ideas with each other on class assignments **orally**. However, you must ultimately demonstrate your understanding of the material by writing up your own solutions without the help of other students or their written work, including source code. **AT NO TIME ARE YOU ALLOWED TO OBTAIN, LOOK AT, OR CUT AND PASTE FROM THE SOURCE CODE OR LABORATORY WRITE-UP OF ANY OTHER INDIVIDUAL, WHETHER THEY ARE IN THE CLASS THIS SEMESTER OR NOT. THIS INCLUDES GETTING SOURCE CODE FROM THE INTERNET. YOU ARE EXPRESSLY FORBIDDEN FROM SHARING ELECTRONIC FILES OF ANY TYPE BY ANY MEANS WITH ANYONE.**

8.2 Use of External Sources

Extensive materials related to the topics we will be covering in this class are available on the Internet. This may include, at times, source code for algorithms we will be studying. **WITH THE EXCEPTION OF SOURCE CODE**, you may use supplementary material to enhance your understanding of the course material. However, you should not look at other people's source code and you should not cut and paste from any source on the Internet. You will learn a great deal more if you complete the assignments on your own before consulting external references. If you don't understand how to solve the laboratory assignments, you will not do well on the exams.

If you use external references of any kind, even if they are not quoted verbatim, **YOU MUST CITE THEM**! This rule will be strictly enforced and violations will be dealt with harshly. Again, I encourage you to seek outside sources, but **you must acknowledge the source of any ideas that are not your own**.

8.3 The Standard Template Library

Many of the data structures we will consider are implemented in the STL. Unless otherwise specified, you should implement your own versions of these data structures for the laboratories. If you're unsure, please ask.

8.4 Licensing and Intellectual Property

When it comes to either writing your own source code or using programs or text written by others, you must be aware of the licensing issues involved with intellectual property on the Internet. Many people assume that anything that can be downloaded from the Internet is theirs to use freely,

but this is not true. Unless otherwise stated, all material available on the Internet is someone's intellectual property and you can only use it with a proper license. You must be aware of what the license under which you obtained intellectual property allows you to do and what it does not allow you to do. If you download and use someone else's program or other intellectual property, **you must ensure that the license allows you to do so**. Violations of this law will also be dealt with harshly. The intellectual property generated by you for this class, including source code and written assignments, will become the property of Lehigh University.

9 Lateness

I will allow a total of 7 days of lateness on laboratory assignments throughout the semester. These 7 days can be split up in any way you choose. In other words, you can have one assignment late by 7 days or 7 assignments each late by one day. After that, there is a penalty of 10% off per late-day on each assignment. No laboratory assignment will be accepted more than 7 days late. Exceptions to this rule will be made on a case-by-case basis. Please let me know if you will be turning in an assignment late.

10 Teaching Philosophy

I believe your grade should reflect the actual learning that took place in the course and not be simply the result of a simple formula. The way to maximize your grade in this course is to learn and understand the material. Most formulaic grading systems allow you (even encourage you) to maximize your grade without necessarily maximizing your learning. I want to discourage you from disconnecting these two goals.

Higher learning involves not just acquiring knowledge, but developing the ability to "know what you don't know." I call this ability self-assessment of knowledge. One of the goals of every course I teach is to cultivate the students' ability to perform accurate self-assessment of their work. Hence, you are encouraged to think about and state accurately not only the parts that you do understand from each assignment, but also the parts that you do not. You will get additional credit for an accurate self-assessment of your answer or approach. Hence, if you have gotten most of the way through an exercise and just cannot complete the last step or even if you are missing a step in the middle but know how to do the rest, just try to write down what you have done so far and what it is that you don't know how to do. This will help me to better gauge where your understanding is incomplete so that we can review these areas in class. It will also demonstrate your understanding of your own work.

Effective learning also involves knowing where to go to get help when you realize that your knowledge or understanding of a topic is incomplete. This could mean asking a classmate some questions, consulting external references, or coming to office hours. It can also mean asking a question in class when you don't understand part of the lecture. Chances are, other people don't understand it either. This is all an important part of class participation.

Another area in which you will be evaluated is by the level of detail and rigor in your written work. In general, you should err on the side of giving too much detail in your written work. The more explicit you are, the easier it will be for me to grade and the more you will demonstrate your understanding. If you spend significant time coming up with the answer to a problem, don't

short-change yourself by not spending enough time writing it down. Take some time to think about how best to present your thoughts. Otherwise, you may be throwing your hard work away.

You will be graded as much as possible according to my overall assessment of your learning in the course and your understanding of the course material. This includes your ability to perform self-assessment, your ability to ask questions to increase your understanding, and your ability to express your ideas in written form rigorously and with an appropriate level of detail.

10.1 Learning Styles

There are many different styles of learning. Some people gain better understanding from listening to something being explained orally. Some get better understanding from written material. Some like a combination of both. I do my best to accommodate various styles of learning. However, feel free to let me know what your learning style is so that I can take that into account when determining the future direction of the course.

10.2 Feedback

I very much appreciate and enjoy getting as much feedback from my students as possible, even if it is not all positive. Please don't be afraid to tell me what you think. And if you want to just stop by to chat, feel free. My door is almost always open, but if you could utilize office hours as much as possible, I would appreciate it. If you would like to make an appointment outside office hours, just call or send an e-mail.