

CS 552, Applied Complexity Theory, Spring 2005 Semester

Course Syllabus

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Introduction and Overview:

Algorithmics consists of the study of the design and analysis of algorithms. This discipline is based upon the application of mathematical techniques to the analysis of the efficiency of algorithms, and in particular to the effect upon the time to execute different algorithms of both the growth in the quantity of the input data to be acted upon and of the quality of the input data. The use of formal mathematical techniques goes back to the earliest times in the development of, and is probably the most important and certainly the most complex area of study within, the overall field of Computer Science. Algorithmics and related subject matter make extensive use of the mathematical discipline of complexity theory.

Summary Course Description:

The course consists of two phases. Phase 1 opens with an overview in which several alternative algorithms are examined for solving a relatively simple problem, and a qualitative appreciation will be conveyed for how different algorithmic approaches to solving a single problem can differ greatly in the amount of work entailed. Next, there will be a review of major mathematical concepts, and also a review of data structures. Then, the principles of the major analytical techniques used in the analysis of algorithms will be discussed in detail. In Phase 2, the principal classes of algorithmic design techniques will be addressed, including Brute-Force, Divide-and-Conquer, Transform-and-Conquer, Dynamic Programming, and the Greedy technique. A variety of well-studied computer science problems will be discussed, including algorithms for sorting (Selection Sort, Bubble Sort, Insertion Sort, Heapsort, Merge Sort, and Quick Sort), for searching, for string processing, for hashing, for handling graph problems, and for numeric problems. The tradeoff of space and time in algorithmic design, and the limitation of the power of algorithms will also be discussed, including *P*, *NP*, and *NP-complete* problems. *Prerequisites: Math/CS 228 and CS-240.*

Course Objectives:

By the end of the course, the student should be able to:

- a. Explain the principal criteria applicable to the evaluation of algorithms.
- b. Explain the concept of asymptotic order of algorithms (“Big-Oh”, “Big-Theta”, and “Big-Omega”).
- c. Identify the asymptotic order of common algorithms.
- d. Make use of recurrence relations in the analysis of recursive algorithms.
- e. Describe, both in ordinary English sentences and formally using pseudocode, several well-known algorithms that are used for sorting, for searching, for string processing, for hashing, for handling graph problems, and for numeric problems.
- f. Explain the significance of complexity classes ***P*** and ***NP***.

Textbooks and Other Source Materials:

Main Course Textbook (REQUIRED):

- (1) LEVITIN, ANANY (2003). *Introduction to the Design and Analysis of Algorithms*. Boston, MA: Addison Wesley. QA76.9.A43 L48 2003; 005.1—dc21; 2002027987; ISBN 0-201-74395-7.

RECOMMENDED (one of the following):

- (2) ROSEN, KENNETH H. (2003) *Student’s Solutions Guide for Use with Discrete Mathematics and its Applications. Fifth edition*. Boston, MA: McGraw-Hill. QA39.3.R67 2003; 511—dc21; ISBN 0-07247477-7.

- (3) GERSTING, JUDITH L. (2003). *Mathematical Structures for Computer Science. Fifth Edition.* New York, NY: W.H. Freeman and Company. QA39.3.G47 2002; 004'.01'51—dc21; 2002002589; ISBN 0-7167-4358-2.

or any other text on Discrete Mathematics

Instructor:

[Dr. Charles Abzug](#)

Course Practices:

Attendance Policy, and Relationship of Course Sessions to Readings: In class, announcements are sometimes made of new or changed course policies, requirements, modifications to assignments, etc. Information provided in such announcements may not appear anywhere in the course documentation. Furthermore, course sessions will cover *some* of the material in the readings, but will *also* include some material *not* covered by the readings. Therefore, students **must** not only do all of the readings, but must **also** attend **all** classes.

There are only three acceptable grounds for a student's missing a class: (1) grave medical or (2) serious personal problems affecting the student him/herself, or in some cases affecting a member of the student's immediate family. Immediate family is defined for the purpose of this policy as father/grandfather, mother/grandmother, sister, brother, spouse, or fiancé to whom you are formally engaged. (NOTE: I do **not** consider your girlfriend/boyfriend to be a member of your immediate family.) The other acceptable excuse for a student's missing a class is (3) *force majeure* (overpowering force due to an unexpected and uncontrollable event). An example of *force majeure* is the occurrence of a flat tire or of a motor vehicle accident involving your vehicle while you are traveling to class. If you want to claim exemption on one of these three grounds, be prepared to submit evidence (e.g., a note from a licensed physician on physician's stationery, or copy of police accident report).

I normally take attendance at every class. Attendance does not get factored directly into the grading process. Why, then, do I take attendance? The purpose is two-fold: (i) attendance data sometimes provide me with advance information that a student may be experiencing academic difficulty because of medical or personal problems, or for some other reason. In addition, I may also consult attendance records in deciding how much I am willing to extend myself in providing help should you get into academic difficulty during the semester. You are in a much better position to get a “break” if you have been conscientiously attending class.

Note that if you do miss out on a class, it is **your** responsibility to find out what we covered in class, as well as what announcements might have been made. It is also your responsibility to obtain the missed material. “I wasn’t in class when you made that announcement” is **not** an acceptable excuse for your failure to comply with any directives issued in class. Please see the companion to this section entitled, [“Policy on Classes Missed by Students”](#).

E-mail on Course-Related Matters: All E-mail messages related to the course must be identified by a Subject header of the form: *CS-xyz-n {additional subject identification}*, where *xyz* is the three-digit course number, *n* is the section number, and additional subject identification is appended following the course and section numbers. Thus, a submission of homework assignment 47 for course CS-789 Section 13 would have a Subject header: *CS-789-13-Assignment-47*.

Grading of Tests and Assignments, and the JMU Honor Code: You will eventually be assigned an overall course grade. The course grade will be based principally upon your performance on quizzes, exams, homework assignments, projects, etc. Integrity of the grading process requires that you be graded on the basis of **your own work** and not on someone else’s. Yet, sometimes a student may get stymied and not be able to complete an assignment on his/her own. ***If you find it necessary to obtain help from someone else in completing your assignment, you are required to indicate that by clearly marking it on your assignment.*** Thus, if one of your colleagues contributes a line of code to your computer program, you should plainly mark that via a comment inserted into the text of the program, as in the following example:

```
//Hieronymous Johnson kindly contributed the following line of code to my program:
for (int i=0, k=4-I; i<10; k=Math.abs(4-++I+(i>4?1:0)));1
```

Similarly, non-programming assignments should be clearly footnoted or annotated to indicate where someone else’s help contributed to the product. In the absence of a clear annotation in your

¹ I am indebted to Prof. David Brunner for contributing the coding example shown above.

submitted assignment, you will be assumed to be the sole author of all work that you submit. Should that turn out not to be the case, it will be accounted as an honor code violation and will be dealt with severely. Details of the JMU Honor Code are to be found at: <http://www.jmu.edu/honor/>

The JMU Honor Code specifies that every assignment, whether written or electronically submitted by a student, is submitted pursuant to the Honor Code, and **must contain a declaration** stating that “This work complies with the JMU Honor Code.”, together with your signature. I personally require that you place this signed declaration **on the first page** of your assignment. If the Honor Code declaration is not included *at the time that the assignment was submitted*, your grade for that assignment will be a zero.

Assignment and Homework Policy: Assignments of problems or exercises from the course text must be submitted in **legible** hard copy. Programming projects and major assignments, such as a term project or an essay (“paper”) must be machine-generated (i.e., not hand-written), and must be submitted **both** in hard- and in soft-form.

Format: Multiple pages of hard-copy must be **stapled** together², and **both** hard and soft copies must have, in the upper left corner of the first page:

- (a) your name
- (b) course number
- (c) section number
- (d) semester (e.g., Fall 2001)
- (e) date of submission, and
- (f) Honor Code declaration, with your signature.

Please note that I have no trouble remembering my own name. Therefore, you do not need to write my name on your homework assignments.

Content: All written work should be thoroughly professional in accordance with the highest standards. Your writing should be clear, should comply with the rules of grammar of the language in which it is written (for most of my courses, this will be English), as well as with good writing practice, and should be correctly spelled and punctuated and free of both slang and jargon.

² If you do not own a stapler, there is one available for student use in the Copy Center (HHS Room 1002).

Late Submissions Policy: All work is due at the designated date and time. Normally, I do not accept late submission of homework. Under some circumstances, I might be willing to accept a late submission, but if I should make an exception and accept a late homework, then acceptance is subjected to the following penalties:

| Date Received: | Penalty from Maximum Credit: |
|-----------------------|-------------------------------------|
| One day late | 10% |
| Two days late | 20% |
| Up to one week late | 40% |
| Up to two weeks late | 60% |
| Over two weeks late | 100% |

Grading Policy:

Overall Meaning/Definition of Grades: A grade of *A*, either on an individual assignment or for the entire semester, indicates work that is truly outstanding in the opinion of the instructor, demonstrating excellent understanding of the concepts covered. A grade of *B* indicates at the undergraduate level very good work, above the instructor's level of expectation for the class. Graduate students, however, are expected to perform at least at the B level. At the graduate level, a grade of *C* indicates a level of performance that is unsatisfactory, but nevertheless sufficient to merit receipt of credit for a graduate class, while a grade of *F* indicates work far below satisfactory, demonstrating insufficient achievement in the skills or level of knowledge required. Note that grades are based only on assignments given to every person in the class. Opportunities to earn extra credit may be announced to the entire class at various times during the semester, but extra-credit assignments will NOT be custom-crafted for individual students.

Extra-Credit Opportunities. Grades are based only on assignments given to every student in the class. Opportunities to earn extra credit may be announced to the entire class at various times during the semester, but extra-credit assignments will NOT be custom-crafted for the sake of an individual student. Your best strategy is to learn the course material by conscientiously studying and doing your assigned homeworks throughout the semester. If you wake up at the end of the semester and suddenly realize that you are in trouble, there may not be anything that you can do.

Extra Tutorial Assistance: I will be pleased to provide extra help in most instances to any student who requests it. However, the student who needs help must **both**: (i) take the initiative on his/her own to seek me out, **and** (ii) seek help in a timely manner and not wait until the last minute, when the examination or assignment due date is already imminent. You must also understand that I am willing to help when your own assiduous efforts to learn the material prove to be inadequate. I **cannot** provide tutorial assistance to a student who cannot find the time to do the assigned readings and homeworks.

Quizzes and Examinations: There will be one in-semester examination (mid-term), and a final examination. In addition, there will be several brief in-class quizzes given at irregular intervals throughout the semester, usually without warning. The quizzes, as well as the Mid-Term and Final Examinations, will be based **both** upon the reading assignments, regardless of whether or not the readings were covered in class, that were due up to **and including** the date of the quiz or examination, **and** also upon the material covered in class up to the moment of the quiz or examination, regardless of whether or not the assigned readings also cover the same material. *Occasionally* a student may have a bad day and will therefore not perform on a quiz up to his/her level of knowledge. Alternatively, circumstances may come up either that prevent him/her from covering the day's assignment on time, or that preclude his/her attendance on the particular day when a quiz is given. In either case, this will result in a quiz grade below the norm for that student, or in an automatic grade of zero if the quiz is not taken at all, regardless of reason. To avoid excessive anxiety on the part of a student who experiences a rare bad day, and to avoid having to take up students' and instructor's time with the giving and judging of explanations and excuses, as a matter of policy the lowest **two** quiz grades for each student will be dropped. Students are warned not to use up their two opportunities frivolously (e.g., don't miss class without grave cause). Preserve your allotment of excused low quiz grades for circumstances of real need.

Homework Assignments and Programming Projects: There will be several homework assignments (written homework), and several programming projects.

Class Participation: Vigorous student participation in class discussion makes for a much more lively and interesting class for all. To encourage participation in class discussion, the grading mechanism includes the opportunity for the student to earn a reward (details given below) for participating both **vigorously and constructively** in class. Note that your mere attendance can **not** be considered to be "class participation", and will **not** be rewarded with class participation points. Attendance is mandatory, and therefore rewards will not be meted out merely for attendance. However, your vigorous and constructive participation in class discussion will certainly make the class more interesting both for me and for your fellow students as well as for yourself, and this therefore can possibly result in an enhancement to your grade, as well.

Assignment of Grades: Makeup of overall grade for the semester will be as follows: First, a numeric score will be calculated based upon the student's performance on all the examinations, on the

quizzes and homeworks, and on the programming projects. The basis for calculating the numeric score is:

| | |
|--|---------|
| Collected Homeworks: | 10 pts |
| Programming Projects | 25 pts |
| In-class Quizzes: | 35 ptss |
| In-semester (mid-term) Examination | |
| Final Exam: | 30 pts |
| TOTAL: | 100 pts |
| Opportunities that may be announced, and participation in class discussion can earn extra points : | |
| | ≤10 pts |

After the numeric scores have been determined, letter grades will be assigned, based upon the distribution of the numeric scores. I make **no** commitment in advance regarding the letter-grade equivalent of specific numeric grades. The standard cutoff scores for grades are: 90 for **A**, 80 for **B**, 70 for **C**, and 60 for **D**. However, I reserve the right to lower the cutoff points in accordance with my judgment after studying the actual distribution of numeric scores.

Enhancement of Grades for Vigorous and Constructive Class Participation: An initial assignment of grades is made to all members of the class as described above. After the initial assignment of grades has been made, additional points will be dispensed to those students who participated vigorously and effectively in class discussion. This may result in the improvement of the grades for such students. Thus, non-participation will **not** lower anyone's grade, but high-quality participation may **possibly** raise it.

Legibility and Clarity-of-Communication Requirements for Quizzes, Examinations, Homeworks, and Term Papers: It is up to you, the student, to demonstrate to the satisfaction of your instructor that you have mastered the course material. We know that at the time of your birth you knew nothing about the subject matter of this course. If a change has occurred between then and now, then *you* must demonstrate that this has taken place. Therefore, your writing and drawing must be clear and unambiguous, and your answer should be obviously correct on its own, without benefit of any *post hoc* verbal explanation that you may provide of your answer. What this means is that:

- (i) your handwriting must be legible to the instructor;
- (ii) you must, yourself, bear the burden of choosing the correct words and technical terms that answer the question;
- (iii) your drawings must be neat, technically correct, and properly labeled;
- (iv) your sentences must be properly structured, and paragraphs must be correctly and logically organized;
- (v) you must thoroughly address **all** the specific issues raised by the question; and
- (vi) for multiple-choice, fill-in-the-blank and other short-answer type questions, you are responsible for marking the answer in the correct place on the answer sheet. The

grader will **not** be responsible for searching for the correct answer in other places, nor can credit be given after the fact for notations made on your question booklet that were not reflected in the answer marked on your answer sheet. Be careful, and check what you are doing. It can be very frustrating for student and instructor alike when a student who knows the material has to take a lower grade than he or she could have earned, because of the student's carelessness in marking the answer properly on the answer sheet. Nevertheless, Computer Science, like airline piloting, is notoriously unforgiving of mistakes, and minute attention to detail is one of the personal properties that the faculty tries to inculcate in our students.

Errors in Grading: Unclear answers will be marked **wrong**. Instructors are human and sometimes make mistakes, too. You are entitled to complain politely after class if you honestly feel that your answer is both clear and correct, but was misunderstood at grading time by the instructor. If the instructor agrees that a mistake was made, then your grade will be cheerfully corrected.

Rules for Examinations:

- (1) **No calculators** (except as may be announced), **no books, no notes**.
- (2) The JMU Honor Code must be scrupulously observed.
- (3) All work **must** be shown on your examination paper. You will certainly be given extra paper if you ask for it.
- (4) You must provide exactly ONE answer to each test question. In the event that you should provide more than one answer, the answer that is **wrong** is the one that will be graded.
- (5) All examinations **must** be taken at the scheduled time. If you miss the scheduled examination, you are responsible for providing **timely** documentation to support a medical or other *bona fide* emergency to avoid getting a grade of zero for the examination. Medical exemption requires certification from a licensed medical practitioner or facility. The documentation must be provided on the practitioner's letterhead and must be dated and signed by the practitioner, and must clearly certify the time range over which you were incapacitated. The practitioner's telephone number must also appear on the document.

Note that there is a deadline for submitting your documentation to support medical or other excused absence. The deadline is one calendar week after you return to class.

Homework Assignments:

Educational Philosophy: There are three ways for a student to learn complex technical subject matter, such as you will encounter in this course. First is by reading. Second is by coming to class and both watching and listening **interactively**. Third is by working selected problems and examples. This course has been carefully designed to integrate at least the first two, and perhaps all three modes of teaching and learning. There may be some material covered in the reading assignments that will **not** also be covered in the classroom, and there is other material **not** covered in the reading assignments that will be covered **only** in the classroom. Students will be held responsible **both** for the content of all assigned readings, ***whether or not covered in class, and*** also for all classroom material, ***whether or not covered in the assigned readings***. To assist you in reviewing both the readings and the classroom materials, and in preparation for the examinations, review questions covering the main points may be provided, and in some cases answers as well. Students are **well advised** to answer review questions in writing, and, where applicable, also to work out solutions to assigned problems in detail before peeking at the answers. The reason for this recommendation is that in first crafting your own answers or your own solutions you will be much more seriously stress-testing your own level of comprehension of the material. Then, when you compare your own answers with those provided to you, you will gain much better insight into any deficiencies in comprehension that you may have. If you look at the answers first, it will go much faster for you, but you will suffer in the depth of learning that you will attain. I treat you as adult by providing the answers up front in some cases and by trusting you to use good judgment in working through the problems before consulting the answers. Please don't disappoint me.

Types of Assignments: Details of homework assignments for this course are specified in a separate document. In general, a homework assignment for this course may have one or more of three components: readings, review questions, and practical exercises. Readings **must** be done on time, so that you will be properly prepared for, and get full benefit from the class. Review questions are also extremely important for you to answer prior to the class when they are due. In most cases, your answers to review questions will *not* be collected and graded, but these questions are excellent preparation both for a brief quiz that you may possibly encounter when you come to class and for the lengthier scheduled examinations. Readings, review questions, practical exercises, and reports must all be completed no later than the scheduled due date and must be ready for submission on the due date at the beginning of class. Some or all of the homeworks will be collected. These will be graded **not** on the basis of whether the answers are correct, but merely on the basis of whether the homework was done completely and conscientiously.

Policy Regarding Classes Missed by Students:

In the university environment, there is an implied contract between students and faculty. You (students) expect us (faculty) to come to class. I, as a faculty member, also expect all of my students to come to class. Occasionally, you may find it necessary to miss a class. If you must miss an occasional class, I trust you, as a responsible adult, to do so only for adequate reason. Therefore, you don't need to seek my permission before skipping a solitary class, nor do you need explain afterwards why you were absent. Please note, however, that I do look particularly askance at students who miss the last class prior to a vacation period and/or the first class after vacation. The university is very generous with scheduled vacations, and I expect you to make do with the allotted vacation days and **not** to take for yourself an extension of your vacation period beyond what the university has generously scheduled for all students and faculty. Airline tickets can usually be procured for travel *during* the scheduled vacation period, if they are purchased sufficiently in advance. In the event that you are unable to obtain a ticket without committing yourself to straying into the time scheduled for classes, then I invite you to make alternate plans and to spend your vacation closer to Harrisonburg.

If you have missed the class for good and valid reason, nevertheless you **are** responsible for making up the work you missed, as well as for complying with any announcements, directives, or instructions that might have been issued during the class that you missed. Therefore, it is up to **you** both to find out what was covered or announced, **and** to make up in a timely fashion any missed work.

You would be wise to prepare, as early as the very first day of the semester, for the possible occurrence of sudden brief acute illness (tummy ache, head ache, etc.), or of other, non-medical emergencies, such as a flat tire, traffic jam, family emergency, or the like. I suggest that you exchange phone numbers and E-mail addresses on the first day of class with several of your classmates. If at all possible, give notice to one of your colleagues prior to the class you will miss. Follow up as soon as possible after the missed class, so that you will be able to stay abreast of what is happening in class. Also, if you know in advance that you must miss a class, you should arrange to have someone hand in for you any assignments you may have done that are due that day. If you did not make advance arrangements, then it is even more important both that you follow up rapidly to find out what you missed and that you make up for missed work.

Do **not** send me E-mail, either asking in advance of the class you must miss what do I intend to cover, or querying me subsequently to the class on what did I cover. I teach many students each semester, and I just don't have the time to answer a blizzard of "What will I miss?" and "What did I miss?" E-mails. In the fortunately rare case that a student encounters a serious health problem or an issue in his/her personal or family life that spans several consecutive classes, it is my experience that I have almost always been able to make a special accommodation to try to help the student through the

crisis, and I will certainly make every effort to do so in the future, as well. But I must insist that you take care of the onesies and twosies on your own.

Class Meetings:

Classes meet during the Spring 2005 semester on Tuesdays and Thursdays from 1530 to 1645 hrs (section 1) and 1700-1815 hrs (section 2) in ISAT/CS Room 243.