Introduction to Discrete Applied Mathematics

We will discuss many areas of discrete mathematics in this course with emphasis on topics which have direct application in the real world. Each lecture will emphasize some particular technique or problem and often we will discuss an algorithm or procedure for efficiently realizing this technique. We begin with some mathematical analysis of some simply posed questions involving weighing of objects such as coins. Next we discuss a variety of algorithms that are used for sorting data. We then move to the subject of coding theory where we will study three different types of coding problems: Coding for efficiency of data storage, coding for error correction and coding for secrecy.

Later in the course will we will deal with an assortment of different algorithms and some problems in operations research. Among the topics covered will be the Fast Fourier Transform and how it can be used to multiply large numbers quickly, algorithms for linear programming and solution to network-flow problems, as well as some topics in game theory, mathematical economics and statistics.

Although many kinds of subjects are considered, there are common ideas that appear throughout. The mathematical content of this course involves some linear algebra, probability theory, algebra, and topics from a variety of other fields. It is hoped that the brief exposures we give to these topics will motivate you to want to learn more about them. We will from time to time digress to cover background material that will be used later in the course. We will try to go deeply enough into each area to reach significant and interesting results and not merely give definitions and easy consequences.

The requirements for this course include handing in weekly homework assignments, submitting a paper (which we will discuss below), and taking two (open book, open notebook) exams. The content of the exams will be made fairly precise before they take place. Your grade on the exam will reflect the degree to which you demonstrate an understanding of the material, so it pays to be honest; it's better to say "... This answer looks wrong for thus-and-such a reason, so if I had time I'd go back and check my work," rather than to bluff.

The homework will cover much of the material in detail and represents the most important part of the grade. The class will cover material quite rapidly, and it will be almost impossible to assimilate the material without reading these Notes and doing the homework. Hearing alone is only one exposure; hearing and reading also are not enough for most people.

Some of the assignments may involve writing programs. If you know a programming language and have access to a machine to run it, then write and run it. If you can write in a language but do not have access to a machine to run it then do what you can. If, on the other hand, you know no language, you may write in *pseudocode* which means you give an explicit logical description of your procedure in concise English. It's a good idea to learn enough about a real programming language to write code even if you do not run it. If you need help with this see the lecturer, the TA, or fellow students.

The paper, which should be on a topic related in some way to the course, can have several formats. One is the following: Imagine that you were to give a 90-minute lectures to the class on your selected topic. The topic paper could be a lucid and well organized set of notes on what you would say. The material for these lectures could be looked up in appropriate references. Another format for the paper is to write a program to do something related to the course. If you choose to do this you should explain what you are doing, give an overview including any comments on certain difficult points and present clear and well-documented code. If you choose this option you should learn a particular programming language. If you have a better idea for a term paper (for instance, if you think that one of the chapters in these Notes does a bad job of explaining things, and that you could do a better job!), then you may pursue it. The topic for the paper should be selected by midterm in general with an outline handed in no later than October 31. Students often choose to use the paper to fulfill the MIT writing requirement. We have prepared a handout listing some possible paper topics.

Consider it appropriate to discuss homework problems with classmates and friends (as well as the TA and the lecturer) after you've made an effort to think about them by yourself for a while. It is worthwhile for you to develop the habit and ability to discuss mathematics with others and discussions can be a valuable way to gain insight and familiarity. On the other hand, merely copying papers circumvents the learning process and is not allowed. A good way to proceed is to work out the *idea* of a solution with classmates, but then write it up alone, in your own words, without relying on detailed notes (you should have absorbed the key ideas and internalized them). If your final write-up looks too much like your collaborators', chances are you're leaning on the group too much in the writing-phase and thereby missing out on the valuable experience of writing up something on your own. (Employers of scientists and engineers regard communication skills as having as much importance as mathematical skills, so it literally pays to develop these skills.)

You should get into the habit of including in each assignment you hand in a list of the people you worked with on that problem. *This information will in no way be used in grading.* It is intended to help you get into the life-long habit of citing sources and avoiding plagiarism. (Remember, plagiarism isn't copying, it's copying without acknowledgment.)

The Notes that are being handed out are taken from lecture notes of Dan Kleitman's, revised and edited by him and his TAs over the past couple of years (Debbie Berkovitz, Mike Hawrlycz, Lenore Cowen, Richard Ehrenborg and Jennifer Huang), plus Jim Propp and his TAs (Wayne Goddard, David Gupta, Miklos Bona, Satomi Okazaki, and Esther Jesurum). Additional material is taken from presentations made by guest lecturers Joe Killian and Mark Haiman.

Some of the topics treated in these Notes will not be covered in Fall 1995; as the semester progresses, we will see how much material it is reasonable to try to do.

Every student who finds a new typo in the Notes (meaning one that someone else hasn't already pointed out to me) will get one "brownie point". The five students with the highest number of brownie points will each get a single grade-point added to their final grade for 18.310.