

ECS 154A, Computer Architecture

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1 This Syllabus Is on Our Web Site

Important note: This syllabus, and lots of other important information, is available at <http://heather.cs.ucdavis.edu/~matloff/154a.html>

2 Consultation

2.1 Office and Office Hours

My office is in 3053 Kemper Hall, Ext. 2-1953. My office hours will be Monday 3:30-4:30 and Thursday, 2-3. **I enjoy my office hours very much, and look forward to interacting with you during them.**

I am also available at other times if you have short questions.

Our TA will announce office hours soon.

2.2 E-Mail

You are welcome and encouraged to send me your questions via e-mail. I read my mail every day, including evenings and weekends.

3 Adding or Staying Enrolled in the Class

3.1 Prerequisites Strictly Enforced

Please note that prerequisites are strictly enforced. If you are already enrolled but do not meet the requirements, please drop the class immediately, as otherwise you would be dropped by the Registrar, or get an E-NWS (“enrolled, no work submitted”) grade. The Homework Grader (Reader or TA) would not accept any homework from you, and your exam papers would not be graded.¹ Similarly, if you are on the waiting list, you will not be allowed to enroll.

3.2 Add Procedure

If you wish to add the course, see the department Web site, <http://www.cs.ucdavis.edu/>, for procedures. Roughly speaking, if there is limited space in the class, the priorities will be set by class level (though graduate students will not get higher priority). **Please note that no further adds will be allowed any time during the quarter, beyond those on this departmental list** (no further names will be added to the list itself).

¹If your work is mistakenly graded in spite of your ineligibility for the course, you will still receive an E-NWS grade at the end of the quarter. This has actually happened, with a student submitting all the work for the entire quarter and yet still not getting a grade.

4 Course Prerequisites

4.1 Importance

As explained in Section 3 above, the prerequisite material is strictly enforced.

Note also that the prerequisite material is likely to be used as foundation in various exam questions. So, it is quite important that you make sure you have reviewed the prerequisite material:

4.2 ECS 50 or EEC 70

You should be familiar with these and related terms:

bits; bytes; words; addresses; CPU; ALU; 2s complement storage; carry; ASCII; fetch/execute cycle; RAM; ROM; register; bus; op code; addressing mode; subroutine call; parameter passing; stack; bitwise mask; stack pointer; program counter (PC); difference between assembler and compiler; linker

4.3 ECS 110/C/C++/UNIX

You should be reasonably good at programming, and **HAVE A WORKING KNOWLEDGE** of basic UNIX concepts such as

files and directories; processes; C library and include files; **argc/argv** command-line variables; user-level windowing, e.g. creating and moving windows; modular program design; pointers; recursion; **fprintf()**, **fscanf()**, **fopen()**; **read()**, **write()**, **open()**; debugging aids such as **gdb**

Again, it will be assumed that you have a **working knowledge** of the UNIX tools mentioned above. If you are lacking some of them, please see my UNIX tutorial Web page, at <http://heather.cs.ucdavis.edu/~matloff/unix.html> If you do lack this background, be sure to take a look at these tutorials **NOW**, before it is too late to remedy any deficiencies. Remember, these are tools which you will be using every day in our course, and **they may arise in exam questions**.

It is also worth mentioning that Intel has complained that “UCD grads don’t know UNIX well enough.”

5 Workload

- Lots of digital circuit design work. This is intellectually similar to programming, in terms of both design and debugging, and thus makes similar demands on your time as do programming projects.

We will be using digital design simulators, mainly the public-domain Chipmunk package; see <http://heather.cs.ucdavis.edu/~matloff/chipmunk.html>. This is mainly a UNIX product, but a Windows version is available if you prefer.

- Some programming:

We will be doing some programming experiments to measure things like cache performance.

- Lots of reading:

Plan on spending 4 or 5 hours per week, every week, on the reading. Approximately 30-50% of the exam questions will come from the reading, so the reading is of vital importance, and must be done slowly, carefully and thoroughly.

6 Course Content and Goals

In ECS 50 or EEC 70, you got your first exposure to hardware, by studying the instruction set and addressing mode structure of one or more specific CPU types, e.g. Intel's Pentium. In ECS 154A, we go one more level down, seeing how electronic devices called **gates** are used to build CPUs, memories or other digital systems. We discuss only structures here, not the electronics-level material; there is no electronics content to this course.

The major topics to be covered are:

- digital design
- implementation of RAM/ROM/memory systems
- cache memory
- virtual memory

7 Course Materials

7.1 Dandamudi

Our bound text will be S. Dandamudi, *Fundamentals of Computer Organization and Design*, Springer-Verlag, ISBN 0-387-95211-X.

Our coverage will (subject to slight changes) be Chapters 2, 3, 4, 5, 16, 17, 18, 19, and 20.

Note that I have a required supplement on Dandamudi on our class Web page. I will update it throughout the quarter.

7.2 Printed Lecture Notes

The second text consists of my printed lecture notes (PLN). The first section of these is my introduction to digital design, and the rest consists of materials I use in ECS 50.² These are sold in the bookstore at the beginning of the quarter. Also, they are available as the PDF files in <http://heather.cs.ucdavis.edu/~matloff/154A/PLN> and <http://heather.cs.ucdavis.edu/~matloff/50/PLN>.

7.3 Each Student Must Have His/Her Own Course Materials

Note that exams are open-book, and there is no sharing of books or other materials (including calculators³) during exams. **Thus every student must have his/her own copy of Dandamudi, the PLN and other**

²Some of this has been updated, so you will need a new copy even if you took ECS 50 from me.

³Not that you need a calculator anyway; you don't.

course materials.

7.4 Bring the Course Materials with You to Class

Bring the PLN to lectures, discussion sections and exams.

8 Exams

8.1 Exam Schedule

There will be three exams, with Exam I approximately at the 3.5-week point, Exam II around the 6.5-week point, and the final exam, Exam III, on December 11.

There are no early or late exams. Provisions for oral makeup exams will be made if you have a documented medical excuse.

8.2 Open-Materials Policy

TESTS ARE TAKEN ON AN OPEN-MATERIALS BASIS. Bring Dandamudi and the PLN with you to each exam. You are also welcome to bring whatever other materials you wish, e.g. your ECS 50 texts, dictionaries,⁴ whatever you want. Whatever you bring, **make absolutely sure that you remember to bring all your course materials, as virtually all of the exam questions will refer to specific pages in them.**

8.3 How to Do Well on the Exams

8.3.1 Remember, This Is Not ECS 110

This course is primarily conceptual in nature, rather than being a programming course like ECS 110.

Yes, some of the exam questions will ask you to do some digital design (which, as noted earlier, is very much like programming) or programming, but most will not. Most will be “qualitative” questions which ask you about the nature of computer systems (albeit sometimes using programming as a vehicle to test your understanding).

8.3.2 Think, Not Memorize

Exam questions test insight, not memorization. They assume *active* reading and *thinking* about the material.

If for example you encounter a statement in the reading which puzzles you, don’t just skip it—ask me or the TA about it. An exam question may later ask you to explain it.

⁴For example, do you know what the words *relinquish* and *discrepancy* mean? These words have shown up in problem statements in exams. I will be happy to explain any such words if you like during the exams, but you may feel more comfortable with a dictionary.

8.3.3 Old Exams Yes, “Practice” Exams No

Please note carefully that I do not give practice exams. I do make all my old exams available on the Web, but they are not “practice exams.”

This is because I believe that learning does not consist of memorizing, and because this course (in the way I teach it) is not like a “calculus-style” course:

Calculus courses can have practice exams because the real exams have predictable, technique-oriented content. In a calculus class, you might have a lecture on integration by parts, then have a homework assignment of integration-by-parts problems, and then on the exam there would be a couple of such problems.

This would be impossible in ECS 154A—at least the way I teach it—because every exam problem is unique, and the problems test understanding of concepts, rather than techniques. Thus, it would be impossible to have practice exams.

I do make my old exams available on the Web, so you can get an idea of the general “flavor” of my exam philosophy. And I do sometimes state “focus areas” that I will feature in an upcoming exam. For instance, I may say, “I really want you to know this particular program example especially well,” and then the exam may contain a question (or even more than one question) on this program.

8.3.4 Homework-for-Learning Yes, Homework-as-Practice-for-Exams No

Similar to the point that I do not give practice exams, it is important to understand that the homework is not considered practice for exams either. The goal of the homework is to give you a chance to think more deeply about the material, and to give you a chance to nonpassively implement some of the course concepts. Sometimes a exam problem will indeed be similar to some homework problem, but many exam problems do not look like any homework problem. (Some exam problems are in the middle ground, meaning that homework problems play an indirect though important role in the exam.)

Again, the best way to prepare for exams is to constantly sift the material through your mind in a nonpassive manner, thinking about questions involving How?, Why/Why Not? What is the goal? and so on. The homework will really help you prepare for exams in this sense, because it will make you think thoroughly about the course material, but you should not expect problems to be explicitly similar to the homework.

8.3.5 Concentrate During Class

MAKE SURE TO LISTEN CAREFULLY IN CLASS.

Many exam problems will come from the answers I give to questions students ask during lecture, or maybe related to off-hand remarks I make during lecture when I suddenly get an inspiration.

Therefore, listen carefully to questions students ask in class, and to the answers I give. Make a note of seemingly-casual comments I make in lecture, and think about them carefully at home. These things may well pop up in exams. Such questions will still be answerable from if you miss class, but there is a definite advantage to paying close attention in class.

8.4 Please Note

An embarrassing subject which nevertheless must be mentioned is cheating on exams. **If a student is found to be cheating, it will be treated as a VERY SERIOUS matter, not a harmless prank; it will harm**

his/her standing at the university, and also possibly make it difficult for him/her to get a job when seeking employment after graduation. Please work as follows:

- Spread the desks out in the room before the exam.
- **ABSOLUTELY NO TALKING** to classmates at any time during the exam.
- Make sure you cover your exam paper at all times.
- Keep your exam paper covered when you are not actually writing, so that it will not be so exposed to view.
- **PLEASE USE THE RESTROOM BEFORE THE EXAM STARTS, RATHER THAN DURING THE EXAM.**

During a exam, if your paper is exposed, I will come to you and mention this to you. Thanks very much for your help.

9 Lecture Format

9.1 Bring the Materials to Lecture

Make sure you bring Dandamudi and the PLN to every lecture. They will play very active roles in the lectures.

I typically will ask you to open to a certain page, and then will call your attention to various sentences, examples and pictures on that page. The lectures will consist mainly of discussion and amplification of the examples in Dandamudi or the PLN, with additional examples and comments. I will seldom write on the blackboard.

A MAJOR GOAL OF THE USE OF PRINTED LECTURE NOTES IS TO GIVE STUDENTS A CHANCE TO ASK QUESTIONS AND TO ENGAGE IN CLASS DISCUSSION. You are very much encouraged to bring up any questions you might have. Please don't be shy about asking questions; there is no such thing as a "dumb" question. Similarly, listen carefully to the questions the other students ask; this can be a very valuable source of insight, to which you should pay special attention.

10 The Discussion Section

The discussion section is required, and will present material not covered in lecture (that material will appear on exams).

The TA will maintain a Web page, stating what has been covered and including any handouts.

11 The Class Newsgroup and Web Site

THE NEWSGROUP WILL PLAY A MAJOR ROLE IN OUR COURSE. IT IS REQUIRED THAT YOU READ THE NEWSGROUP EVERY DAY. Not only will announcements of homework assignments

be posted there, but also there may be later corrections, hints, etc. And of course, dates of exams and other related information will be announced on the newsgroup too.

You can read newsgroups using special-purpose programs such as **tin** or **slrn**; just type the program name, e.g. type `tin` when logged onto one of the CSIF machines. Or you can access newsgroup through general-purpose programs such as Web browsers. Or, click on the word *Newsgroup* on our ECS 154A home page, <http://heather.cs.ucdavis.edu/~matloff/154a.html>.

Note that the newsgroup can be accessed only from a UCD Internet address. You will have this if you are using a campus computer or have connected to the Internet via the campus modem bank. If you are not in this setting, you can still read the newsgroup by using **ssh** to log on to one of the CSIF machines. and then typing `tin` or `slrn` at the UNIX command line.

Please note that “.d” newsgroups are for discussion among students. This was the original intention when they were established some years ago; it seems that instructors of ECS 30 and 40 have abandoned that concept, but I feel it is important for the students to have a place of their own, without interference from the instructor.

Thus I usually do not read the .d groups. If there is a message you want me to see, please send me e-mail, instead of posting a message which you hope I will see on the .d group.

12 Grading

12.1 Weighting

The formula used is

$$\text{course grade} = 0.75 \times \text{Exams grade} + 0.25 \times \text{Homework grade}$$

where the Exams and Homework grades are each on the 4-point scale (4 for an A, 3 for a B, etc.).

12.2 + and - Grades

The threshold for a grade of n is (n-1).85; the threshold for an ‘n-’ grade is (n-1).6; the threshold for a ‘+’ grade is n.2. So, for example, if your weighted average from the above formula is between 2.6 and 2.84, your course grade is B-; if the average is between 2.85 and 3.19, your course grade is B; if the average is between 3.2 and 3.59, your grade is B+.

12.3 Exams Grade

Each exam grade will be used in letter grade form only (the numerical grades are recorded but not used).

IMPORTANT NOTE: If your first exam letter grade is lower than those of the other two exams, and if your Homework grade is at least B, that first exam grade will be thrown out completely. In that case, your exams grade will be the average of your second and third exams. **This, coupled with the fact that most of you will get a A’s as your Homework grade, typically makes an enormous difference in the course grade for many students.**

By the way, though, please note that **this policy of course does not imply that you should not try very hard on the first exam**, for many reasons:

- It might turn out that you do very well on the first exam, better than one of the other two, so you definitely would want to have the benefit of that first high grade.
- Even though Exam I is the only exam which I **guarantee** that I will throw out if the other two have higher letter grades, I also may throw out Exam II or III. If someone does quite well on Exams I and III, for instance, but poorly on Exam II, I may either greatly reduce the weight of Exam II for that person or even throw out Exam II entirely.
- When a student asks me for a recommendation to an employer, or asks me to write a letter for graduate school, I take ALL exams into account.

Exam grading is noncompetitive (there is no “curve”), so it is possible for everyone to do well.

12.4 Homework Grade

12.4.1 Assignment of Letter Grades

Your letter grade on this homework will be as follows, based on your average homework score: 90-100%, A; 85-89%, A-; 80-84%, B; 70-79%, C; 60-69%, D; under 60%, F.

12.4.2 You Must Turn in All Assignments to Pass the Course

Note that all homework assignments must be completed in order to get a passing grade in the course.

In order to be considered “completed” the basic work must be done, though there may be errors. In the case of a programming assignment, for example, if the program has sections obviously missing, or if the program does not even compile, it is not considered complete.

12.4.3 You Should Get an A on the Homework

I aim for the vast majority of the class to get an A on the homework. Lots of help is available, so this aim should be achievable. (And it is; I use this policy in every course I teach, and it always works out that most people get A homework grades.) Again, this is a real A, carrying as much weight as each exam (if no exam is thrown out).

12.4.4 Back Up Your Files Frequently!

Accidental deletion or destruction of your homework files will generally not be grounds for extending the due date.

12.5 Accuracy of Records

At the end of the quarter, it will be your responsibility to make sure that the Homework Grader’s records are correct as to your homework scores.

13 Machines

13.1 Linux PCs in CSIF

Our base machines will be the Linux PCs in the CS instructional labs (CSIF). If you pre-enrolled in this course, or if you took a CS course last quarter, you should already have an account. Your account name will be your surname, and if that is not unique, it will be your surname followed by your first initial. Your initial password will be the last eight digits of your student number; change it immediately, using `yppasswd`. Note that all the instructional machines share a common file system, so you can access the files from any machine.

13.2 Linux on Your Own PC at Home

I strongly encourage you to install Linux on your PC, if you have not already done so. I have a Linux installation tutorial at <http://heather.cs.ucdavis.edu/~matloff/linux.html>

14 Homework

14.1 Announcements

Homework assignments will be announced in the class newsgroup. The homework files themselves will be on the course Web site, so look there when an assignment is announced.

Occasionally there will be news about a current homework assignment, such as clarifications, hints and so on. These will be announced in the class newsgroup.

14.2 Partners

You may work on and submit the homework by yourself, but you are allowed and encouraged to do your homework together with one (not more than one) partner. In the latter case, the two of you submit the homework together; make sure to inform the Homework Grader of this.

In the material below, a “homework group” means either an individual or a pair of people working together.

If you do work with a partner, you must work TOGETHER, instead of simply having one partner do one problem and another partner doing another problem. **If the Homework Grader finds a pattern in which two partners are simply dividing the work among themselves rather than working together, he/she will not allow them to continue to work as partners.**

14.3 Analytical Work

Some of the homework questions may be non-programming in nature. Write these up in an ASCII text file with a name whose suffix is `.txt`.

14.4 Submitting the Homework

Since we use interactive grading (see below), you do not “turn in” your homework in the traditional way. However, you do have to send the Homework Grader an e-mail message of the following nature, to certify that you completed the work before the deadline.

14.4.1 Package Your Files

When you have finished all of a given homework assignment, first use the UNIX **tar** command to collect all your files for that assignment into one .tar file, say named Hwk2.tar. In the case of a program, this would be your files with suffixes such as .s, .c, .h and your Makefile.

14.4.2 Timestamp Your Package

Then run the UNIX **sum** command on the .tar file to produce a checksum. E-mail that checksum and file name (but not the file itself), to the Homework Grader. The date and time on your e-mail will verify that you sent the mail before the deadline, and then later during the grading, the fact that the checksum has not changed will show that you have not changed the file subsequent to sending the e-mail.

14.5 Grading

We will use interactive grading. The Homework Grader will announce homework grading times, and each homework group will sign up for a time slot. **In the case of group size of two, both members of the group must be present during the grading time. If a member misses that time, the other group member will be graded, but the one who misses the time must reschedule a time in order to receive credit for the assignment.**

During a group’s time slot, the group will log in to their account to access their files. They will then explain their homework solution, and in the case of a program demonstrate that it works. In the case of analytical homework, the group will explain the reasoning behind the work. The Homework Grader will ask each member of the group questions to confirm that he/she understood what they did. For example, such questions might ask why you wrote your program in a certain way, what the roles of the variables are, what numerical values the variables may have at times specified by the Homework Grader, why you did not choose certain alternative designs, and so on.

IMPORTANT NOTE: Each partner must be ready to answer questions about ALL the submitted work. If for example in a programming assignment, each partner wrote part of the program, both partners must still have thorough knowledge of both parts.

The Homework Grader will assign separate grades for each group member. Normally these grades will be identical, but if there is a substantial disparity in the levels of understanding the different group members have regarding the assignment, the Homework Grader will assign different scores to each member. As mentioned earlier, if this occurs repeatedly, the Homework Grader will not allow the partners to submit work jointly anymore.

14.6 If You Get Stuck

14.6.1 We Are Happy to Help If You Get Stuck

The work is expected to be challenging, and is designed to be thought-provoking. This thought-provoking nature of the assignments is the vehicle by which you get to really understand the concepts. You are not necessarily expected to see right away how to do an assignment. Instead, you are expected to spend a considerable amount of time pondering the assignment, gradually seeing more and more, until you finally see how to do the whole thing. It is that thought process which will develop insight into the course material.

The TA and I will be quite happy to help you, including giving you hints individually—but only if, after giving a matter considerable thought, you still don't see what to do. Once you have reached the point where you cannot go any further, we very much encourage you to seek help from us. We want you to do well on the homework!

14.6.2 When in Doubt, Check It Out!

A lot of questions are of such a nature that you can answer them on your own, just by trying it out on the computer. If for instance you are not sure how a certain gate works, devise a small test circuit involving that gate, and try it out.

14.6.3 Help by E-Mail

Again, you are welcomed and **strongly encouraged** to send me e-mail, at the address matloff@cs, for help on homework assignments. But you can help me if you keep the following in mind:

Please do NOT send me e-mail in HTML format. If you do, I will of course still answer it, but my answer will not be as clear. This is because when replying to e-mail, I like to quote parts of the original message, making the reply clearer. I cannot do this easily if your mail is in HTML.

14.6.4 Start Early!

Please make sure to start the homework soon after it is assigned. Don't wait until the last couple of days before the due date, because **when the due date approaches, I tend to be inundated with e-mail messages asking for help on the homework, and thus my answers at that time will necessarily be short and without details, since I won't have time to say more.**

14.7 Late Work

An assignment is late if it is completed (and the Homework Grader notified) after 11:59 p.m. of the due date.

If—this should never happen, but just if—you are late, you will be assessed a 5% penalty the first late day, and 10%-per-day penalty after that in your grade for that assignment. (Since e-mail is available every day, each of the seven days of the week counts as one day.) The maximum total penalty is 50%.

Each project group will be allowed a total of 2 late days over the quarter, time which is not penalized. You can use this as being late 2 days with no penalty on one assignment, or as being late 1 day with no penalty in each of two assignments.

In order to use this option, you must submit your work during the time you are using as your grace period. If for example you are 3 days late on an assignment, you will not be allowed to use your grace period time on that assignment; it will simply be counted as 3 days late.

The homework grader will keep the appropriate records.

14.8 Reading Homework

The reading—in Dandamudi, the PLN and handouts—is extremely important, and should be considered “homework.” As mentioned earlier, approximately 30-50% of the exam questions will come from the reading.

After each lecture, do the corresponding reading. **Do the reading PROMPTLY, that same day, rather than getting behind. This is the only way that you can get any insight from the reading; doing the reading the night before an exam will not work.** If you still have not done the reading as of the night before the exam, you actually will be better off not doing it, and getting more sleep instead, as cramming overnight won't be beneficial.

The official reading assignments will be listed on our class Web page. Note that some of the reading will be on material not covered in either lecture or discussion.

15 I Do Care!

I wish to emphasize that I care very much that you succeed in this course, and I look forward to getting to know all of you.