CS371 Syllabus

1 Description

Lecture: TCL 206 MWF 12pm
Lab: TCL 206 Wed 1pm

Instructor: Prof. McGuire
Office Hours: TCL 308 M 10-11am
TCL 308 M 2:30-4pm
TCL 312 R 7-8pm

TA: Eric Muller
TA Hours: TCL 312 MT 10pm-12am
TCL 312 WR 9pm-12am

PhotoShop, medical MRIs, video games, and movie special effects all programmatically create and manipulate digital images. This course teaches the fundamental techniques behind these applications. We begin by building a mathematical model of the interaction of light with surfaces, lenses, and an imager. We then study the data structures and processor architectures that allow us to efficiently evaluate that physical model. Students will complete a series of programming assignments for both photorealistic image creation and real-time 3D rendering using C++, OpenGL, and GLSL. These assignments cumulate in a multi-week final project. Topics covered in the course include: projective geometry, ray tracing, bidirectional surface scattering functions, binary space partition trees, matting and compositing, shadow maps, cache management, and parallel processing on GPUs.

Format: Lecture, with optics laboratory exercises and programming projects. Fulfills the Quantitative Reasoning and CS Project Course requirements.

Prerequisites: Computer Science 136 or equivalent programming experience, and Mathematics 211 (may be taken concurrently) OR permission of the instructor.


I recommend Physically Based Rendering: From Theory to Implementation by Pharr and Humphreys and Mathematics for 3D Game Programming and Computer Graphics, 2nd Edition by Lengyel, depending on your choice of final project, but these are not assigned reading in the course.
2 Schedule Warning

Mrs. McGuire and I are expecting a baby at the end of the semester. Babies are born when they want to, not on schedule, so this could happen anywhere from before Thanksgiving out into the final exam period when it won’t affect you. I’ll suddenly be away for a few days when this happens, which means class is cancelled and nothing is due.

I scheduled the final projects to end (hopefully) before the birth so that I’ll be able to help you in lab with your projects as the deadline approaches. If the baby arrives between 11/24 and 11/26, I’ll extend the final project deadline a week (you’re welcome to still finish early if you want to!)

3 Content Warning

Computer graphics draws on mathematics, physics, and art as well as computer science. In this course, you will work with potentially hazardous materials and equipment in lab exercises, as you would in a physics lab. You will also view films and images that may contain adult themes, as you would in an art course. These materials are intended to increase your understanding and enjoyment of computer graphics. Your careful and appropriately academic conduct are required in both cases. In the event that you find a way to become injured or offended by pure mathematics I’ll add an extra warning next semester.

4 Evaluation

<table>
<thead>
<tr>
<th>Class/Lab Effort</th>
<th>15%</th>
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<tbody>
<tr>
<td>Homework</td>
<td>15%</td>
</tr>
<tr>
<td>Projects 0-5</td>
<td>30%</td>
</tr>
<tr>
<td>Exam (10/1)</td>
<td>20%</td>
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<tr>
<td>Project 6 (11/26)</td>
<td>20%</td>
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In-lab exercises and in-lecture effort are graded A/C/fail. A ‘C’ grade means that you were in the room and did something reasonable. An ‘A’ grade means you also made an earnest effort. Arriving late, leaving early, or not showing up earns an ‘F’. Arriving any time before 1:25 pm is considered on-time for lab.

Homework submitted late without permission will not be graded. I rarely grant extensions on homework because we’ll discuss the solutions in lecture on Monday.

Projects are collaborative and all group members will receive the same grade in normal circumstances. Projects submitted late without permission will be penalized one grade per 24 hours (e.g., from A -> B.) I tend to grant all reasonable extension requests, so long as they are made early.

Project 6 must be presented and submitted on 11/26 and will not be graded if submitted late. This means that you must be in class until 2:30pm the day before Thanksgiving break.

Students are responsible for all announcements that are posted here, made in class, or e-mailed to the class. For important changes I will use all three methods. Announcements supercede the printed syllabus.
5 Projects 0-5

Most weeks you will work on a project that is due at 6pm on Friday. On Mountain day, the project will be due that Saturday at 6pm (technically, the Mountain day ends at 4pm, which is before the deadline, but I'd like you to be able to take the entire day as a holiday.)

5.1 Group Work

The projects in this course are challenging. Working in a small team on them has many benefits. It teaches you how to design and develop software with others, gives you a support network for debugging, and divides the workload.

I will assign you to a group of 2 or 3 students for projects 0-5. All members of the group will receive the same grade for that project. You will probably not work with the same students on more than one project. If you would like to work alone on a project, let me know by Wednesday night before the assignment goes out. If you have a private reason to not work with a specific student, let me know at the beginning of the semester and I will arrange the groups accordingly. I intend group work to enhance your experience. If it is detracting, let me know so that we can fix the situation.

5.2 Resources

All of the projects use the G3D library as unified, well-tested support code base. Except where explicitly prohibited by the assignment, you can use any routine in the G3D library and look at any of its source code. You do not have to cite the library when used in your solutions.

For a project, you may also use any source code that you or any other student in the course has written for a previous project in the course. Some of the projects are cumulative, and this policy allows you to pick up from someone else's work if your solution had too many bugs to continue. When you use someone else's work you must first get their permission. When you use either your work or someone else's from a previous assignment, you must clearly cite that work at the location where it is used and in your index.html file.

6 Project 6

Project 6 is the highlight of the course. It is a four-week project where you will choose your own group and topic. To keep you on track, there are multiple intermediate deadlines, including a presentation of your proposal, a code review, and two status reports per week in the form of images. The project cumulates in a presentation of your work to the class on 11/26 (the day before Thanksgiving break).

For project 6 you may use libraries and routines from external sources (e.g., code posted online by graduate students). As in other cases, these must be cited in your work.

7 Labs

Most Wednesdays, I'll screen a short film after the break. These are important computer graphics shorts that use the techniques we're studying in class. They motivate our study of computer graphics. I recommend that you pack a lunch and eat during the screening. You can try and run out to buy lunch during the break, but might miss the beginning of the film.

Lab exercises are experiments using lenses, cameras, lasers, and other optical elements to study illumination phenomena in the real world. These will build your intuition and establish an
experimentalist approach that you should bring to your final project. Note that lab exercises graded only on attendance and participation. There's nothing to hand in.

The end of each lab period is reserved for programming time. This is a good opportunity to work on your weekly project and to get help from me. You must remain in lab until 3:50 pm unless we have made other arrangements.

We won't have a regular lab session every single week. Some exceptions will be: the exam, a field trip to the museum to see motivating artwork, a feature-length film, and project presentations.

8 Honor Code

I have never encountered an honor code violation in this course and expect you will keep that record clean. To avoid any confusion, the guidelines for collaboration in this course are as follows. Ask me if you are unsure of the correct conduct in a specific case. In the event that you accidentally violate the honor code or observe someone else violating the honor code, discuss it immediately with me and the department chairperson to avoid misunderstanding.

Homework must be your own work and may not be worked on collaboratively.

Projects 0-5 must contain only: code written solely by your group, code written by yourself or other CS371 students this semester for previous assignments, and code from the G3D library. Code from previous assignments must be clearly credited both where it is used and in your index.html file. It may be used only with permission of the students involved.

You are strongly encouraged to discuss design, debugging, and mathematics related to projects (except where they appear on homework) with other students. Note that using previously submitted work and discussing projects is a more liberal policy than the default CS department policy for programming projects. Coursework in this class reflects your maturity and is modeled on professional research and development: we tackle hard problems, and do so together.

Project 6 may contain code from any source so long as it is used with permission and is clearly credited where used and in your project report.

Exam work is of course to be performed independently and without the use of restricted aids.

Recall that in accordance with the CS department policies, looking at any other computer user's files without permission is unacceptable, regardless of whether those files are protected on the file system.
8.1 Suggested Weekly Schedule

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<thead>
<tr>
<th>Weekend</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
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<tbody>
<tr>
<td>Homework (1.5h)</td>
<td>10:00am Office Hours</td>
<td>12:00pm Lecture</td>
<td>12:00pm Lecture</td>
<td>Generate final results</td>
<td>12:00pm Lecture</td>
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<td>12:00pm Hwlrk due</td>
<td>12:50pm Break</td>
<td>12:50pm Break</td>
<td>+ polish docs (1h)</td>
<td>(2:30pm Colloquium)</td>
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<td></td>
<td>2:30pm Office Hours</td>
<td>1:05pm Film</td>
<td>1:05pm Film</td>
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<td>6:00pm Project due</td>
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<tr>
<td>Project design + infrastructure (1.5h)</td>
<td>Project coding (2h)</td>
<td>Complete project code -- maybe not compiling (2h)</td>
<td>Project debugging (2h)</td>
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<td></td>
<td>10:00pm TA Hours</td>
<td>10:00pm TA Hours</td>
<td>9:00pm TA Hours</td>
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The projects involve significant mathematics, design, and programming. Plan to spend about 10 hours per week on the project outside of class\(^1\). In most courses, the major challenge for most students is not the work but time management. To help with that I've structured the projects as follows.

Projects are designed for you to start on the weekend. You should tackle the major math and programming structure at the beginning. Homework is mostly math related to the project. It is due Monday to make sure that you have thought through the problems and have an opportunity to ask questions in lecture.

By Wednesday, you should be well into the implementation of your project. I'm setting aside the last hour of lab session for you to ask me programming questions and to debug your code together. In other words, you want to be far enough into the project that if anything goes wrong it happens Wednesday afternoon when I can help you, not late Thursday night when you're alone in lab.

A portion of your project grade is based on not what you did but how well you present it. Thursday and Friday are for polishing your results. The difference between a good graphics project and a great one is presentation. Showcase your hard work by rendering complex scenes or animating your results. This requires no extra programming, but is an important part of learning to present your work to others.

I recommend that you complete your project Thursday evening. I'm giving you until Friday evening because, if something goes wrong late Thursday then I’d rather you go to sleep and ask me about it during lecture than pull an all-nighter. A special note to seniors: Please do not cut colloquium to work on projects, or I’ll just have to move the deadline earlier.

Programming is on your own time and not during scheduled lab sessions. You may use any computer that you wish. However, only the FreeBSD machines in the Unix lab will be officially supported. The TA will provide scheduled project lab coverage hours to help primarily with C++ syntax and compiler errors.

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\(^1\) Keep in mind that this is an average. Some projects spread the work over two weeks, you’ll have almost no workload the last two weeks of the semester, and there’s no final exam, so you won’t be putting in that much time every week---however there’s also no guarantee that you won’t need more than 10 hours for some assignments, since every person works and learns at a different rate.
9 Semester Schedule

I modified the assignments for this year based on feedback from previous students, and based on
your feedback I will adjust the project assignments and lecture topics during the semester. The
deadlines will remain fixed so that you can plan your semester early.

9.1 Important Dates

9/5 First lecture
10/1 Exam
10/3, 10, 17, or 24 Mountain day (no class)
10/13 Reading Period (no class)
10/27 Project 6 proposals due
10/31 Projects approved
11/5 Prototype presentations
11/26 Project 6 due; present in lab
11/27 Thanksgiving break
12/5 Last day of class

See the website for homework and project due dates.

9.2 Lecture Topics

1. Light
2. Geometry
3. C++
4. The Rendering Equation
5. Photon Mapping
6. Bidirectional Scattering Distribution Functions
7. Sampling Impulses
8. Importance Sampling
9. Texture Mapping
10. Transformation Matrices
11. Perspective Projection Matrix
12. The Graphics Pipeline
13. Direct Illumination
14. Shadow Maps
15. Cube Maps
16. Deferred Shading
17. Research Papers
18. Lens Camera Model
19. Matting
20. Computational Photography
[Project 5 Due; No more assigned projects]
21. Non-Photorealistic Rendering
22. Texture Synthesis
23. Splines
24. Deblurring
[Project 6 Due; No more graded work]
25. Physical Simulation
26. Advanced Topics