

**ECE 595 / CS 491 / CS591**  
**Real-time Rendering and Graphics Hardware**  
**Spring 2007**

**Instructor:**

Pradeep Sen  
E-mail: [psen@ece.unm.edu](mailto:psen@ece.unm.edu)  
Website: <http://www.ece.unm.edu/~psen>  
Office: ECE Building, Room 225C  
Office Hours: Tuesday 2:00 – 4:00pm

There is no TA for this class.

**Class Location:**

ECE Building, Room 210  
Monday & Wednesday's 4:00 – 5:15pm

**Course Webpage:**

<http://www.ece.unm.edu/ECE595>

Important announcements, corrections and slides will be posted there. Get used to checking it often.

**Course Description:**

This course covers advanced topics in real-time rendering and graphics hardware. It is intended to bring students up to speed with the state-of-the-art in real-time graphics. After successful completion of this class, students should be able to get a job working on rendering engines or on graphics hardware, use GPU hardware to accelerate non-graphics applications, or begin to do research in real-time computer graphics.

**Textbooks:**

The following text is required for the course:

Tomas Akenine-Moller and Eric Haines. *Real-Time Rendering*, 2<sup>nd</sup> Edition. AK Peters, Ltd, 2002.

This book should be available at the UNM bookstore. Readings will be assigned from this text as well as from class handouts and papers referenced from the web. I also recommend students get the OpenGL “red book”:

J. Neider, T. Davis, M. Woo, *The OpenGL Programming Guide*, Addison-Wesley

There will be times where I will not hand out the reading in class, but rather refer you to the paper on the web. Often papers available on the web are of better quality than what we can print out and distribute in class.

**Pre-requisites:**

Students are expected to have taken at least one course in computer graphics and be familiar with the terms and concepts presented in the introductory class. The students are also expected to be reasonably comfortable in programming in C or C++ and have had some exposure to assembly programming. Knowledge of linear algebra will be useful. Please ask me if you have questions about whether your background is suitable for this course.

**Grading:**

The best way to learn a subject like real-time rendering is through a combination of homework assignments, projects, and exams that exercise and test different knowledge. In this class, we shall have 10 homework assignments, two projects (an introductory and final project), two exams (mid-term and final) and several un-announced pop-quizzes to determine the final grade of each student. The weight of each as it contributes to the final grade is given below:

Homework (10)	25%
Intro project	18.75%
Final project	18.75%
Mid-Term	12.5%
Final	18.75%
<u>Pop-quizzes</u>	<u>6.25%</u>
TOTAL:	100%

As far as is possible, the final letter grade will be assigned on a curve. Since this class is offered at the undergraduate and graduate level, I will make the distinction between the two by scoring the two curves separately. Since the size of this class will be small, it is difficult to get all the statistics necessary for an accurate grading curve. However, I will do my best at the end of the semester to assign a fair letter grade to each student by comparing their final score compared to that of their peers.

**Homework**

There will be ten homework assignments, all of equal worth, to total 25% of the final grade. Some of these assignments will involve written homework problems involving calculations or explanations, others will require programming. Written homework assignments must be submitted in person at the beginning of class on the day they are due. Programming assignments must be submitted electronically by midnight on the day that it is due. Any homework submitted after it has been collected it will be considered late. There is more discussion on the subject of late days in a later section of this syllabus.

**Projects**

There will be two projects assigned in this course. They are classified differently than homework assignments because they will probably take more time and effort. The first introductory project will be assigned during the first weeks of the course and will help lay the foundation for the student to understand the course. The final project, on the other hand, will be the culmination of many of the topics covered through out the semester. In addition to writing code, these projects might also involve short in-class presentations and written reports. An exact description of the deliverables and grading criteria for each project will be

given in the project handouts the day they are assigned. Projects and their associated deliverables cannot be submitted late.

### **Homework Submission and Late Days**

As mentioned earlier, homework submitted after the deadline (beginning of class for written assignments, midnight for electronic assignments) will be considered late. For every day that the homework is late, 25% will be taken off the homework. The first “late day” is counted from the deadline to midnight of the next day, and from then on from midnight to midnight. For example, say a written homework assignment is due at the beginning of class on Wednesday. From that time to midnight on Thursday is late day #1, from 12:01 to midnight on Friday is late day#2, etc. So if the homework is submitted on Saturday, it is the third late day and 75% will be taken off. After four late days, the homework does not need to be submitted as it is now worth zero (no negative points).

I understand that things get busy during the semester and sometimes it is difficult to get everything done on time due to unforeseen circumstances. For this reason, each of you will be provided with 5 “late days” to use at your discretion. These late days push back your submission deadline without penalty. To use them, let me know before the deadline how many late days you plan on using. I ask that when you submit a written homework assignment late you slip it under my office door (225C) and send me an email at the same time so that I know you have submitted it. Use your late days wisely!

As noted earlier, your late days cannot be used for the two projects. Also, “incomplete” grades will not be issued for the course, so please get all your work done by the end of the semester.

### **Exams**

There will be two exams: a mid-term and a final. The mid-term exam will be in class on March 7 and test the material that is covered in the first half of the course. The final exam will be held on May 7 from 5:30 – 7:30 pm and cover the entire course. Both exams will be paper and pencil only (no books, calculators, etc).

### **Pop-quizzes**

The pop-quizzes will be unannounced and there will be at least 5 during the course. The are two main reasons for doing these quizzes. First, they will test students to see if they are keeping up with the material and the reading, and therefore help me judge how the class is progressing as a whole. Second, the pop-quizzes will help ensure attendance is relatively constant throughout the semester. Pop quizzes can be given on any material previously covered in the class including the assigned reading for that day.

The pop-quiz will be held in the first five minutes of class, so students who miss the first five minutes will receive a zero for that pop-quiz. Therefore, please e-mail me at least 3 hours before class time if you are going to be late or miss class. You can do this 3 times. If you miss a pop-quiz but you have informed me in advance, the pop-quiz will not be counted when computing your final score.

**Extra credit**

On certain occasions, students will have the option to do additional work for extra credit. This will not be added to the student's final grade until after the grading curve has been computed. Therefore, the student's grade cannot get hurt by failure to complete the extra credit work; it can only help their grade. Extra credit can take the form of optional work on a homework or project, an extra credit question on an exam, or an extra-credit pop-quiz.

**Collaboration**

You may discuss problems with friends, but working in groups is not allowed. Do all your assignments and projects independently of others. If you discuss ideas with others, cite that in your work. Otherwise, working with others on an assignment is considered cheating.

**Cheating**

Cheating will not be tolerated in this class. If I suspect that you have cheated, you will receive an automatic 0 for the assignment and you will possibly also fail the course. Examples of cheating involve using somebody else's code or algorithm, artwork, etc without proper citation. Although I am not going to specifically look for this, I might occasionally compare people's code, so don't take the risk! Any case of cheating will be dealt with severely.

If you have questions about what constitutes cheating, please ask me. It is ok to look on the web for ideas on how to implement an algorithm, as long as you cite where you found that information. However, it is not ok to copy the algorithm! If you cannot get something to work and need to use somebody else's help, please cite that in both the code and in your writeup. It is important to know who contributed to what so that I can assign grades fairly.

**Computer Lab**

The Windows-based computers in ECE 211 are available for use by students in this class. They are fitted with NVIDIA GeForce FX5200 graphics cards. You are welcome to use these computers for your projects and assignments or if you want you can develop your code on any machine you wish (however, the final code must be able to run on these computers). I will often provide some skeleton code for the assignments for you to start with. This will be provided in Visual Studio, which is available on these machines. Of course, you can use other compilers and development systems, as long as your final source code can be compiled and run in Visual Studio.

**Friendly Advice**

Assignments in computer graphics can often take a lot of time. Don't get caught off guard and start well in advance. Come to my office hours to ask questions.

**Questions/concerns?**

Talk to me. We have a small class, so I want to hear your feedback through out the course. This will allow me to fine-tune the lectures to fill in things along the way.

## Course syllabus

Week	Date	Material	Assignments
1	1/17	<ul style="list-style-type: none"> <li>Introduction, overview of course, intro to real-time graphics pipeline</li> </ul>	
2	1/22 1/24	<ul style="list-style-type: none"> <li>Graphics pipeline I (vertex transformation and rasterization)</li> <li>Graphics pipeline II (fragment ops, framebuffer and display)</li> </ul>	Intro Project assigned 1/22
3	1/29 1/31	<ul style="list-style-type: none"> <li>Application-side optimizations for accelerating rendering such as view-frustum culling, portals</li> <li>Introduction to rendering engines, architectures, scene representations</li> </ul>	
4	2/5 2/7	<ul style="list-style-type: none"> <li>Intro to APIs (OpenGL and DirectX)</li> <li>Implementation considerations, performance and benchmarking</li> </ul>	Intro Project due 2/5 HW 1 assigned 2/5
5	2/12 2/14	<ul style="list-style-type: none"> <li>Real-time shading languages</li> <li>Real-time shaders</li> </ul>	HW 1 due 2/12 HW 2 assigned 2/12
6	2/19 2/21	<ul style="list-style-type: none"> <li>Fur, hair and other effects</li> <li>Real-time NPR (Guest lecture)</li> </ul>	HW 2 due 2/19 HW 3 assigned 2/19
7	2/26 2/28	<ul style="list-style-type: none"> <li>Texture I</li> <li>Texture II</li> </ul> <p>Topics to be covered: General texturing, texture hardware, texture antialiasing, mipmapping, anisotropic filtering, texture compression, discontinuities</p>	HW 3 due 2/26 HW 4 assigned 2/26
8	3/5 3/7	<ul style="list-style-type: none"> <li>Shadows I: hard shadows</li> <li>MIDTERM EXAM</li> </ul>	HW 4 due 3/5 HW 5 assigned 3/5
<b>Spring Break</b>			
9	3/19 3/21	<ul style="list-style-type: none"> <li>Shadows II: soft shadows</li> <li>Shadows III: soft shadows</li> </ul>	HW 5 due 3/19 HW 6 assigned 3/19
10	3/26 3/28	<ul style="list-style-type: none"> <li>Introduction to real-time illumination</li> <li>Spherical harmonics, theory of reflection, efficient representation of irradiance maps</li> </ul>	HW 6 due 3/26 HW 7 assigned 3/26
11	4/2 4/4	<ul style="list-style-type: none"> <li>Precomputed radiance transfer I</li> <li>Precomputed radiance transfer II</li> </ul>	HW 7 due 4/2 HW 8 assigned 4/2
12	4/9 4/11	<ul style="list-style-type: none"> <li>Geometry I: Level-of-detail representations</li> <li>Geometry II: Procedural geometry, terrain</li> </ul>	PROJECT ASSIGNED
13	4/16 4/18	<ul style="list-style-type: none"> <li>Physics and particle systems</li> <li>GPGPU</li> </ul>	HW 8 due 4/16 HW 9 assigned 4/16
14	4/23 4/25	<ul style="list-style-type: none"> <li>Real-time Ray tracing</li> <li>Rendering engines revisited, advanced rendering Engine techniques</li> </ul>	HW 9 due 4/23
15	4/30 5/2	<ul style="list-style-type: none"> <li>Guest Lecture</li> <li>Guest Lecture</li> </ul>	
16	5/7	<ul style="list-style-type: none"> <li>FINAL EXAM 5:30 – 7:30PM</li> </ul>	FINAL EXAM