Programming Game Engines  
ITP 485 (4 Units)

| **Objective** | This course provides students with an in-depth exploration of 3D game engine architecture. Students will learn state-of-the-art software architecture principles in the context of game engine design, investigate subsystems typically found in a real game engine, survey engine architectures from actual shipped games, and explore how the differences between game genres can affect engine design. Students will participate in individual hands-on lab exercises to reinforce these concepts. |
| **Concepts** | Engine subsystems including rendering, audio, collision, physics, and game world models. Large-scale C++ software architecture in a games context. Tools pipelines for modern games. |
| **Prerequisites** | ITP 380 |
| **Instructor** | Joshua Glazer |
| **Contact** | Email: jglazer@usc.edu |
| **Office Hours** | TBD |
| **Lab Assistant** | Matthew Pohlmann (<pohlmann@usc.edu>) |
| **Lecture/Lab** | 4 hours/week |
| **Course Structure** | Throughout the semester, students will work by themselves to build out a skeleton game engine framework, which by the end of the semester will feature per-pixel lighting and animation, among other features. These assignments must be completed individually. There will periodically be “pop” quizzes. These quizzes will generally be 3-4 questions, and can occur during any class session. There are at least six quizzes, with the lowest quiz grade being dropped. There are two exams which are comprehensive of all topics covered. |
| **Textbooks** | **Required:**  
**Optional:**  
**Grading**  
The course is graded with the following weights:

- Lab Assignments (10% each) 50%
- Quizzes (6 total, lowest grade dropped) 10%
- Midterm Exam 20%
- Final Exam 20%

**TOTAL POSSIBLE** 100%

If a lab assignment receives a grade lower than 50%, the student(s) are required to resubmit it with a satisfactory amount of completion, or they will automatically receive an F in the course.

**Grading Scale**  
Letter grades will be assigned according to the following scale:

- 93%+ A
- 90-92% A-
- 87-89% B+
- 83-86% B
- 80-82% B-
- 77-79% C+
- 73-76% C
- 70-72% C-
- 69 D+
- 67-68 D
- 66 D-
- 65 and below F

Half percentage points will be rounded up to the next whole percentage. So for instance, 89.5% is an A-, but 89.4% is a B+.

There is no curving. Students will receive the grade they earn. Extra credit is generally not offered.

**Policies**  
*Make-up policy for exams:* To make up for a missed exam, the student must provide a satisfactory reason (as determined by the instructor) along with proper documentation. Make-up exams are only allowed under extraordinary circumstances. Note that quizzes cannot be made up.

*Late Assignments:* As there are only four due dates the entire semester, late projects will not be accepted unless the student(s) meet the same criteria for making up exams.

Before logging off a computer, students must ensure that they have emailed or saved projects created during the class or lab session. Any work saved to the computer will be erased after restarting the computer. ITP is not responsible for any work lost.

ITP offers Open Lab use for all students enrolled in ITP classes. These open labs are held beginning the second week of classes through the last week of classes. Hours are listed at: [http://itp.usc.edu/labs/](http://itp.usc.edu/labs/).
**Academic Integrity**  
USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, ([www.usc.edu/scampus](http://www.usc.edu/scampus) or [http://scampus.usc.edu](http://scampus.usc.edu)) contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A.

Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: [http://www.usc.edu/student-affairs/SJACS/](http://www.usc.edu/student-affairs/SJACS/). Information on intellectual property at USC is available at: [http://usc.edu/academe/acsen/issues/ipr/index.html](http://usc.edu/academe/acsen/issues/ipr/index.html).

In this class, all code submissions will be ran against current, previous, and future students using MOSS, which is a code plagiarism identification tool. If your code significantly matches another student’s submission, you will be reported to SJACS.

Generally, the rule of thumb is that it is acceptable to discuss solutions to problems with other students, but once you are looking at someone else’s code, it crosses over into the realm of cheating. It does not matter if this code is online or from a student you know, it is cheating in all situations. Do not share your code with anyone else in this or a future section of the course, as allowing someone else to copy off your code carries the same penalty as you copying the code yourself.

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**Students with Disabilities**  
Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. Website and contact information for DSP: [http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html](http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html), (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX) ability@usc.edu.

**Emergency Preparedness**  
In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.

Please activate your course in Blackboard with access to the course syllabus. Whether or not you use Blackboard regularly, these preparations will be crucial in an emergency. USC’s Blackboard learning management system and support information is available at [blackboard.usc.edu](http://blackboard.usc.edu).
## Course Outline

### Week 1 (8/24 and 8/26) – Introduction & CPP Refresher
- Course introduction
- shared_ptr
- STL

**Reading:** Gregory: §1.2 - §1.6, §3.1 - §3.2

**Lab:** Begin work on Lab 1: CPP Refresher

### Week 2 (8/31 and 9/2) – C++ Compiler
- Preprocessor, Compilation Phases
- Virtual functions
- sizeof

**Reading:**

**Lab:** Continue work on Lab 1

### Week 3 (9/9) – Cache and Performance
- Cache structure and usage
- Profiling
- Optimization

**Reading:** Gregory: §3.4, §2.3, §9.8

**Lab:** Finish work on Lab 1

**Lab 1 DUE 9/15 at 11:59 pm**

### Week 4 (9/14 and 9/16) – SIMD
- Efficient Math
- Memory Alignment

**Reading:** Blackboard: “SIMD Tutorial,” Gregory: §4.7

**Lab:** Begin work on Lab 2: SIMD and Pool Allocator

### Week 5 (9/21 and 9/23) – Custom Allocators, Utilities
- Efficient Memory Management: Pool, Stack allocators
- Error Handling

**Reading:** Gregory: §5.2, §3.3

**Lab:** Continue work on Lab 2

### Week 6 (9/28 and 9/30) – Game Object Model & Data Management
- Hierarchical vs. Component model
- Streaming
- Serialization

**Reading:** Gregory: §15.1-§15.4

**Lab:** Finish work on Lab 2

**Lab 2 DUE 10/6 at 11:59 pm**

### Week 7 (10/5 and 10/7) – Intro To Rendering
- Spaces
- Graphics Buffers
- Shading and Shaders

**Reading:** Gregory: §10.1 - §10.2

**Lab:** Begin work on Lab 3: Rendering Components
### Week 8 (10/12 and 10/14)- Intermediate Rendering
- Normal Maps,
- Z Buffer / Prepass
- Deferred shading
- Visibility Determination

**Lab:** Continue work on Lab 3

### Week 9 (10/19 and 10/21)- Midterm Exam
- In classroom, during class hours

**Lab:** Finish work on Lab 3

**Lab 3 DUE 10/27 at 11:59 pm**

### Week 10 (10/26 and 10/28)- Hardware Considerations and Advanced 3D Math
- Integer and IEEE floating-point formats
- Console hardware overview and writing cross-platform code
- Quaternions, Splines, and Pseudo-Random Number Generation

**Reading:** *Gregory: §4.1 - §4.6, §4.8*

**Lab:** Begin work on Lab 4: Texturing, Lighting and Shading

### Week 11 (11/2 and 11/4)- Collision Detection
- Quick review of physics basics
- Fast moving bodies and the bullet-through-paper problem
- GJK and AABB prune/sweep algorithms

**Reading:** *Gregory: §12.3*

**Lab:** Continue work on Lab 4

**Lab 4 DUE 11/17 at 11:59 pm**

### Week 12 (11/9 and 11/11)- MultiThreading
- Updating a multi-object simulation in real time
- Integrating rendering, physics, and animation into the game loop
- Multiprocessor game loops

**Reading:** *Gregory: §7.1 - 7.6; §15.6*

**Lab:** Finish work on Lab 4

**Lab 4 DUE 11/17 at 11:59 pm**

### Week 13 (11/16 and 11/18)- Animation System Architecture
- Animation basics
- Blending and compression techniques
- Animation system architecture and pipeline

**Reading:** *Gregory: §11.1 - §11.10*

**Lab:** Begin work on Lab 5: Skeletal Animation and More!

### Week 14 (11/23)- Multiplayer
- UDP, TCP/IP, ICMP, and the socket layer
- Client/Server, Peer-to-Peer, and other networking models

**Reading:** Multiplayer whitepaper on Blackboard

**Lab:** Continue work on Lab 5

**Lab 5 DUE 12/4 at 11:59 pm**

### Week 15 (11/30 and 12/2) Content/Engine Pipelines
- DCC pipelines & Build Tools

**Reading:** *Gregory: §14.4*

**Lab:** Finish work on Lab 5

**Lab 5 DUE 12/4 at 11:59 pm**

**Final Exam: TBD 7-9 pm in classroom (KAP 267)**