



ITP 485 Programming Game Engines

Units: 4

Spring 2023—MW—10:00 – 11:50am:

Location: OHE 540

Instructor: Matt Whiting

Office: RRB 221

Office Hours:

Office hours: M 9-10 am OHE-540

T 12-1 pm OHE-542

W 9-10 am OHE-540, 3:30-5:30 pm Online

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See Piazza for updated offices hours

Course Description

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.

Catalogue Description

Engine subsystems including rendering, audio, collision, physics, and game world models. Large-scale C++ software architecture in a video game context. Tools pipelines for modern games.

Learning Objectives

Our goals in the class are to:

- Develop a fundamental understanding of the nuts and bolts of game engine architecture
- Become a better game engineer
 - Engine, Gameplay, Tools, UI, whatever!
- Improve chance of getting a job as a game engineer

By the end of this semester, students will:

- Be familiar with the major components of a modern game engine
- Demonstrate confidence with C++ and HLSL
- Evaluate code performance from a machine-level point of view
- Creatively apply the techniques of shader programming to design shaders to create specific effects
- Efficiently and independently debug C++ code
- Research, analyze, and interpret online API documentation (specifically DirectX11)

Prerequisite(s): ITP-380

Co-Requisite(s):

Concurrent Enrollment:

Recommended Preparation:

Course Notes

Throughout the semester, students will work by themselves to build features in a simplified game engine. These assignments must be completed *individually*.

Each assignment builds upon the previous one, and late assignments cannot be accepted.

From time to time during the semester, we'll have in-class assignments. Each in-class assignment is to be completed individually during the time allotted during that class period and is "open-book". Any and all reference material is allowed, but collaboration is not. This is a chance to practice finding and using reference material.

There are two exams which are comprehensive of all topics covered. Unless otherwise stated, the exams are "closed-book".

Technological Proficiency and Hardware/Software Required

The course is taught exclusively in C++ using Windows DirectX 11 and Visual Studio.

Due to the nature of programming with the DirectX API, students should have access to a machine with Windows. If you are on an Intel Mac (not M1), you can download Windows from [USC Viterbi Dreamspark](#), and install it on your Mac via Bootcamp. Because we are using DirectX 11, Parallels or VMWare fusion do not work. You have to boot via bootcamp.

Students will have access to usable machines in the classroom, and acceptable laptops can be checked out from either the CS or ITP departments. There may also be the option of using an online virtual PC.

Required Readings and Supplementary Materials

Required:

Game Engine Architecture, Third Edition. Jason Gregory. ISBN-13: 978-1138035454.

Optional:

Real-Time Collision Detection. Christer Ericson. ISBN-13: 978-1-55860-732-3.

Effective C++ (3rd Edition). Scott Meyers. ISBN-13: 978-0321334879.

Description and Assessment of Assignments

There are 11 lab assignments. These are programs to be written individually. Some in-class time will be devoted to labs, but it is expected that students will spend about 8 hours per week working on these outside of class.

Each lab assignment will be given one of 4 grades:

- F Zero 0%
- C Revision Needed 60%
- B Meets expectations 80%
- A Exemplary 100%

Labs will be graded by the TAs. First, they will check that the lab functions correctly. Labs that are not turned in on time or do not function will be given a grade of F. Labs that partially function will be given a grade of C. If your lab functions reasonably well, the TAs will perform a “code review” where they inspect your source code for efficiency and readability. Based on this review, they may assign a grade of C, B, or A. In the case of an C or a B, the grader will provide specific notes for revisions to be made for a regrade.

You will have up to 1 week past the original due date to submit revisions for a regrade, and the final revision will be the grade awarded.

Late labs can be submitted up to the 1-week deadline for regrade but will incur a 20% late submission penalty.

In addition, there are several “In-Class” assignments intended to be performed during the class session.

There are also several “At-Home” assignments in the form of blackboard quizzes.

Grading Breakdown

Assignment	% of Grade
In-Class & At-Home	20
Lab Assignments	40
Midterm	15
Final Exam	25
TOTAL	100

Grading Scale (Example)

Course final grades will be determined using the following scale

A	93-100
A-	90-92
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
D	63-66
D-	60-62
F	59 and below

Half percentage points will be rounded up to the next whole percentage. For instance, 89.50% is an A-, but 89.49% is a B+.

Assignment Submission Policy

Lab assignments are to be pushed into our github classroom.

In-class assignments and exams are generally conducted on either gradescope or blackboard and will be turned in at the end of the course period.

Grading Timeline

All assignments are expected to be graded within 1 week of the due date.

Additional Policies

There is generally no curving. Students will receive the grade they earn.

Some assignments and exams will get a “do-over” as a take-home assignment. When offered, “do-over” assignments are weighted equally with the original assignment.

Extra credit is generally not offered.

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 and emergency circumstances.

Late Lab Assignments: There will be a 20% reduction for any lab assignments that did not get turned in on time, and no labs will be accepted for regrade more than 2 weeks past the original due date.

Course Schedule: A Weekly Breakdown

“Flipped” classes are in Green

	Topics/Daily Activities	Assignment	Read it Before Class
Class 1 1/9	Introduction	In Class: In-Class 01 (git repo)	
Class 2 1/11	Math Review Lab01_MathLibrary	Due @10am: At-Home 02 In Class: In-Class 02 (matrices)	§5.1 – §5.5 02_MathReview.pdf
No Class 1/16	Martin Luther King Day No Class		
Class 3 1/18	Assembly & SIMD	In Class: In-Class 03 (assembly1)	§3.4, §4.10
Class 4 1/23	Rendering 1 Lab02_Triangle	Due @10am: Lab01_MathLibrary Due @10am: At-Home 04	§11.1.0 – §11.1.2.4 04_Rendering1.pdf
Class 5 1/25	The C++ Compiler	In Class: In-Class 05 (assembly2)	§2.2
Class 6 1/30	Rendering 2 Lab03_Cube	Due @10am: Lab02_Triangle Due @10am: At-Home 06	§11.2.2, §11.2.4 06_Rendering2.pdf
Class 7 2/1	Cache	In Class: In-Class 07 (cache)	§3.3
Class 8 2/6	Texture Mapping Lab04_Texture	Due @10am: Lab03_Cube Due @10am: At-Home 08	§11.2.5 08_Texture.pdf
Class 9 2/8	Graphics Debugger		
Class 10 2/13	Lighting Lab05_Lighting	Due @10am: Lab04_Texture Due @10am: At-Home 10	§11.1.3 10_Lighting.pdf
Class 11 2/15	Memory Allocators	In Class: In-Class 11 (pool)	§6.2
No Class 2/20	Presidents' Day No Class		
Class 12 2/22	Serialization		§7.2
Class 13 2/27	Game Object Models Lab06_Models	Due @10am: Lab05_Lighting Due @10am: At-Home 13	§16.1 – §16.4 13_GameObjects.pdf
Class 14 3/1	Animation 1		§12.1 – §12.3
Class 15 3/6	Midterm Review		
Class 16 3/8	Midterm Exam		

No Class 3/13	Spring Recess No Class		
No Class 3/15			
Class 17 3/20	Animation 2 Lab07_Animation	Due @10am: Lab06_Models Due @10am: At-Home 17	§12.4 – §12.6 17_Animation2.pdf
Class 18 3/22	Hardware & 3D Math		§3.3, §5.4, §5.7
Class 19 3/27	Collision Detection Lab08_Collision	Due @10am: Lab07_Animation Due @10am: At-Home 19	§13.3; §13.5 19_Collision.pdf
Class 20 3/29	Multithreading	In Class: In-Class 20 (race conditions)	§4.5-§4.9; §16.6-§16.7
Class 21 4/3	Profiling Lab09_Jobs	Due @10am: Lab08_Collision Due @10am: At-Home 21	§2.3, §10.8 21_Profiling.pdf
Class 22 4/5	Scripting & Audio		§16.8-§16.9; §14.1-§14.4
Class 23 4/10	Normal Maps Lab10_NormalMap	Due @10am: Lab09_Jobs Due @10am: At-Home 23	§11.3.1 23_NormalMap.pdf
Class 24 4/12	GJK	In Class: In-Class 24 (GJK)	§13.3.5.5
Class 25 4/17	Post Effects Lab11_Bloom	Due @10am: Lab10_NormalMap Due @10am: At-Home 25	§11.2.7; §11.3.2-§11.3.4 25_PostEffects.pdf
Class 26 4/19	Networking		
Class 27 4/24	Instances & Compute	In Class: In-Class 27 (Toon)	
Class 28 4/26	Final Review	Due @10am: Lab11_Bloom	
	Final Exam	The final exam will be in-person in the classroom OHE-540	Monday May 8th 8am

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, “Behavior Violating University Standards” <https://policy.usc.edu/scampus-part-b/>. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct>.

Support Systems:

Student Counseling Services (SCS) - (213) 740-7711 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. <https://engemannshc.usc.edu/counseling/>

National Suicide Prevention Lifeline - 1-800-273-8255

Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. <http://www.suicidepreventionlifeline.org>

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender-based harm. <https://engemannshc.usc.edu/rsvp/>

Sexual Assault Resource Center

For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: <http://sarc.usc.edu/>

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086

Works with faculty, staff, visitors, applicants, and students around issues of protected class. <https://equity.usc.edu/>

Bias Assessment Response and Support

Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. <https://studentaffairs.usc.edu/bias-assessment-response-support/>

The Office of Disability Services and Programs

Provides certification for students with disabilities and helps arrange relevant accommodations. <http://dsp.usc.edu>

Student Support and Advocacy – (213) 821-4710

Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. <https://studentaffairs.usc.edu/ssa/>

Diversity at USC

Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. <https://diversity.usc.edu/>

USC Emergency Information

Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible, <http://emergency.usc.edu>

USC Department of Public Safety – 213-740-4321 (UPC) and 323-442-1000 (HSC) for 24-hour emergency assistance or to report a crime.

Provides overall safety to USC community. <http://dps.usc.edu>