

# Real-Time Software Development I

Spring 2023

SE 485

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**office hours:** In-Person: 4:30-5pm CDM 830 (Tues)  
REMOTE : 8-9 pm (Mon) Synchronous Zoom  
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**website:** <https://piazza.com/depaul/spring2023/gam475se485> (Preferred communication)  
**lecture:** In-Person: CDM 222 Tues 5:45-9:00pm  
REMOTE : Thursday 5:45-9:00pm Synchronous Zoom  
**Desired to Learn (D2L):** [d2l.depaul.edu](https://d2l.depaul.edu) (Grades, Viewing lectures, Announcements)  
**Version Control:** perforce: ***perforce.dpu.depaul.edu:1666***  
**All Communication:** Piazza for all communication, reply within 24 hrs during work week

## Description:

Real-time software development. Topics include runtime library construction, abstracting low-level systems, custom data containers, memory tracking, framework development, real-time design patterns, low-level drivers, graphics engine development. Design and implementation of multi-heap memory management system with aligned allocations with cross heap tracking. Exploration of real-time data driven messaging to allowing the run-time object data to control the behavior an application. Interface development to create a responsive optimized access to abstract data types. Students will design, develop and implement a real-time application (i.e. Graphics engine) that integrates multiple user-developed libraries with real-time constraints.

## Prerequisites:

- Required:
  - CSC 461 and (SE 456 or SE 450)

## Learning Goals:

- Students will design, develop and implement a large application with real-time constraints consisting of over 100K lines of code.
- Students will architect custom real-time components such as memory, file, object and math systems.
- Students will develop systems using test driven design process.
- Students will abstract, wrap and extend supplied real-time components to meet design and architectural constraints
- Students will develop large application using the iterative design process, incorporating layers, design patterns, libraries and restrictive access.
- Students will implement a real-time graphics engine marshalling and conditioning data to low-level graphics drivers.
- Students will explore data driven concepts and techniques

## Grading

50% - Milestone 1 Core Systems

- 10% - PA1 - PCS Tree (Object System)
- 20% - PA2
  - 10% - Memory System part A: Heaps/tracking
  - 10% - Memory System part B: Alignment/fixed block
- 10% - PA3 - Math System
- 5% - PA4 - File System
- 5% - PA5 – PCS Tree iterators

40% - Milestone 2 Graphics System

- 30% - Required features (Graphics, Shaders, Camera, Textures, Lighting, Scene Graph,...)
- 10% - Progression submission with video

10% - Final Essay

## Textbooks and printed resources

Additional course material will be many supplied through class notes, handouts or online links.

- 2 Required Books
  - **Game Engine Architecture**, 3<sup>rd</sup> edition, Gregory, A.K. Peters Ltd., 2018
    - ISBN: 978-1138035454
  - **OpenGL reference material**
    - Provided in class – links, books, material
- Recommended:
  - **Windows System Programming** (4th Edition), 2010, Johnson Hart,
    - ISBN: 978-0321657749
- Assumed you already have (please buy it if you don't have a copy):
  - **The C++ Programming Language**- Bjarne Stroustrup

### **Additional Material**

- Will be provided by the instructor
- Lectures, links, SDKs and other corresponding material

## Software

- **Microsoft Visual Studio 2019 Enterprise Edition (not Community)**
  - [MSDNAA Depaul – Visual Studio 2019 Enterprise](#)
    - C++ and C# install (future classes)
  - Any other variants are not used in this class
  - Students are responsible keeping their development tools working
- **Perforce Server**
  - Download and configuration instructions will be provided in class
  - **Perforce – Helix Visual Client (p4v)**
    - <https://www.perforce.com/downloads/helix-visual-client-p4v>
    - Server address: **perforce.dpu.depaul.edu:1666**

## Topics will include:

### Core Systems

- Memory System
- File System
- Object System
- Math System
- Libraries – Static and Dynamically linked

### Primitive Graphics Systems

- Transformations
- Camera
- Polygons / Strips
- Vertex Buffers
- Scene Graph
  - Bounding Volumes
  - Hierarchy of scene
  - Level of Detail

## Programming Assignments – 90%

Two distinctive milestones to this class. In the first milestone section, Core systems - we build individual components and libraries for the memory, file, object system, and math systems that will be used in the Graphics Engine. In the second milestone, we build a Graphics Engine from scratch, using the most primitives' components on top of OpenGL. All the work complete in this class is further extended in Gam 575 Game Engine II.

- **Milestone 1:** Core System - 50%
  - Composed of the following core systems:
    - 10% - PCS Tree (Object System)
    - 20% - Memory System
      - 10% - part A: Heaps/tracking
      - 10% - part B: Alignment/fixed block
    - 10% - Math System
    - 5% - File System
    - 5% - PCSTree iterators
- **Milestone 2:** Graphics Engine - 40%
  - Graphics Engine: 30%
    - Composed of the following base systems:
      - Transformations
      - Camera
      - Polygons / Strips
      - Vertex Buffers

- Texture
- Model management
- Composed of the following secondary systems:
  - Bounding Volumes
  - Hierarchy of scene
  - Level of Detail
- Demos using your new engine
- Progression submission: 10%
  - progression submissions
  - Showcase incremental development
  - Video and source drops weekly

## Final Essay – 10%

- Final essay covering the concepts and the material of the class (Take home exam).
  - Open book, Open notes, Open computer – Yes, I said it.
    - Essay format 5+ pages
  - Post-mortem of your design process and understanding of engine development

## Readings

Textbooks are used for references and learning new topics. It is suggested that you research and investigate material and ancillary topics covered in the class through these books as needed. High performance programming requires both breadth and depth knowledge in the C++ language, therefore everyone's needs and research will vary based on their own experience and evolving mastery of the material.

## Grading Scale:

93-100: A	87-89: B+	77-79: C+	67-69: D+	0-59: F
90-92: A-	83-86: B	73-76: C	60-66: D	
	80-82: B-	70-72: C-		

## Perforce Submissions

- Everyone is expected to submit several submissions to perforce a week.
  - Minimum of **five significant (real) submissions on two separate days**.
  - To promote incremental development and prevent last day rush.
  - Grade deduction will occur if not followed
- The biggest reason students get into trouble with software design:
  - Not starting the project early
  - Not working on the material frequently enough
  - Taking too large of a bite(byte) of the design
- Both are minimized with this Perforce RULE
- Even my simplest programs take 10-20 submissions.
  - For these project assignments, my average is 40-400 submissions, so five will be no problem.
- Detailed perforce changelist comments are expected

## Piazza Discussion forum

- Previous classes have highly participated in Piazza and did quite well
  - To promote this secondary learning approach
- Statistics show: students who participate more and help other students do better!
  - The correlation is ridiculous!
    - Poor understanding / poor participation.
    - Great understanding / Great participation
  - As you master the material, help others learn!
    - Want to be a Master programmer so master it!
- Everyone is **expected** and encouraged to participate on the Piazza discussion forum. All class-related discussion here this term.
- Everyone is expected to keep up with the material on Piazza and are responsible for its content. Critical class updates and directions will be presented there.
  - Not participating or reading the material on Piazza is **NOT** an **Excuse**.
- All correspondence that is not personal in nature should be vectored through Piazza
  - Sensitive material, use Piazza private note, not email.
- The quicker you begin asking questions on Piazza (rather than via emails), the quicker you will benefit from the collective knowledge of your classmates and instructors. I encourage you to ask questions when you are struggling to understand a concept.
- Keep the forum professional and positive, help each other out.
  - Karma really pays off here.
  - Help each other whenever you can.
    - There will be a time when you will need help from the class (trust me).

NOTE: Do **NOT** post until you have watched the entire lecture **FIRST** (in class or online)

This will prevent frustration on all sides (members asking or answering questions)

## Collaborating together on programming assignments

- You are encouraged to work together
  - Use the Piazza forums heavy
  - Even share your material with others in the common directory
    - Obviously not the answers
- Everyone is 100% responsible for the work they do.
  - If you get help with a section of code,
  - Please refactor the code the ***snot out of it***
    - Comment and understand that material
    - Transform the code to ***make it yours***
  - Be able to answer ***any*** question regarding the code you commit
- System for Detecting Software Plagiarism
  - We will be using MOSS - Measure of Software Similarity (Stanford University)
    - Indicates possible code infringements (plagiarism)

- MOSS - will detect the similarity independent of naming convention, indentation style or formatting, it compares abstract syntax tree of your code.
  - I will pursue any plagiarism/integrity violations aggressively, arguing for full expulsion from the university for the offenders.
    - Don't put me or you in this scenario
    - Any integrity violations will result in a failing grade for the course
- If you gain significant support / help from another student or website
  - Fully disclose the support / help you had in a Readme.txt file submitted with your assignments.
    - Disclosing the help, is **not permission** for copying the code.
    - Only there to clarify and acknowledge help you were given from a fellow student.
- Modifying any Unit Test or Project setting to alter the outcome results is also an **Academic Integrity Violation**
- If you are stuck and find yourself even tempted to plagiarize
  - Ask for help!!!!
    - Use on Piazza -> Visit during offices hours, make an appointment
    - **Don't ever compromise your integrity!**
- Material was uniquely created for this Class.
  - By the process of tuition, you "paid" for the contents and material of this class.
    - Do not share this **copyrighted** material in any form
    - It is design for your personal use, while enrolled in the Class.
  - Do **NOT** post any content or revealing material to any external website or forum outside of this class.
    - The Class Piazza forum is provided for this service, ask questions there, not on the internet (i.e. StackOverflow and other software forums)
- After you leave this class
  - You are expressly **FORBIDDEN** to provide or share the content with others.
  - Academic Integrity Violations can still be applied to students who provide material support to other students even after completion of the class.
- Just follow the golden rule:
  - **"I have neither given, nor received, nor have I tolerated others' use of unauthorized aid."**

## Miscellaneous

- **Late Policies**
  - Due dates and times are verified by the submission record on the Perforce Server
    - No extensions are allowed
  - All assignments need to compile without warnings
    - Failure to compile “as-is” results in a 0 for the grade
- **Memory Leaking**
  - For assignments that have memory tracking enabled
    - If an assignment is determined that its leaking memory
      - A deduction of 20% is applied to the grade of that assignment
  - Leaking status is provided during development
- **Crashing and Building**
  - All assignments are expected to build/compile “as-is”
    - Failure to build for any reason – grade of 0
  - Assignments are expected to work for a set duration  
*(long enough to demo all the features)*
    - A grade of 0 is given to any project that throws an exception, ends unexpectedly, crashes or hangs (not proceeding forward).
    - Crash – program locking up or quitting unexpectedly
- **Integrity Violation**
  - Any form of integrity violation will receive an “F” letter grade for the course, no exceptions
    - `const char *pGrade = “FAIL”;`
  - All material submitted is from this current offering of class, any material from the outside is considered a violation

## Tentative Class Schedule

Date	Lecture	Activity	Due
Week 1	Overview Architecture Design Object System	PA1 - Object system	
Week 2	Vector / Matrix Transformations Math Library	PA2 - Math system	PA1 - Object system
Week 3	Memory Overview Memory System	PA3 - Memory system Part A: Heaps/Track	PA2 - Math system
Week 4	Fixed Block Memory Data Alignment	PA3 - Memory system Part B: Align/Fixed Block	PA3 - Memory system Part A: Heaps/Track
Week 5	File System Load in Place Forward/Reverse Iterators	PA4 - File PA5 – PCSTree Iterators	PA3 - Memory system Part B: Align/Fixed Block
Week 6	Graphics Overview Refactoring Math Lib integration	Refactor Spinning Cube	PA4 – File PA5 – PCSTree Iterator Milestone I complete
Week 7	Game Loop Shader Manager Model Manager	Different models Different shaders	
Week 8	VAO/VBO Graphics Object Texture Manager	Rework models Add new model Changing textures	
Week 9	Camera Manager Culling Bounding Volumes Scene Graph	Camera movement Culling	Graphics Progress
Week 10	Loading from a File Attribute switching Camera transitions	Loading models from file Demo tweaking	
Week 11	Final Exam (take home)		Milestone II complete Final Exam due

University Dates (Drop, Withdrawal, Audit, Exam)

- <https://academics.depaul.edu/calendar/Pages/default.aspx>



## Course Policies

### Changes to Syllabus

This syllabus is subject to change as necessary during the quarter. If a change occurs, it will be thoroughly addressed during class, posted under Announcements in D2L and sent via email.

### COVID-19 Health and Safety Precautions

The health and safety of everyone at DePaul depend on the cooperation of all who come to campus. By taking care of yourself, you protect the entire community. DePaul's COVID-19 response plans are based on the latest guidance from the Centers for Disease Control and Prevention, the Chicago Department of Public Health and the university's medical advisor from AMITA Health.

Mandatory protocols must be followed by DePaul students, faculty and staff at all times on both campuses <https://resources.depaul.edu/coronavirus/guidance/health-safety-practices/Pages/default.aspx>.

### Respect for Diversity and Inclusion at DePaul University as aligned with our Vincentian Values

At DePaul, our mission calls us to explore “what must be done” in order to respect the inherent dignity and identity of each human person. We value diversity because it is part of our history, our traditions and our future. We see diversity as an asset and a strength that adds to the richness of classroom learning. In my course, I strive to include diverse authors, perspectives and teaching pedagogies. I also encourage open dialogue and spaces for students to express their unique identities and perspectives. I am open to having difficult conversations and I will strive to create an inclusive classroom that values all perspectives. If at any time, the classroom experience does not live up to this expectation, please feel free to contact me via email or during office hours.

### Online Course Evaluations

Evaluations are a way for students to provide valuable feedback regarding their instructor and the course. Detailed feedback will enable the instructor to continuously tailor teaching methods and course content to meet the learning goals of the course and the academic needs of the students. They are a requirement of the course and are key to continue to provide you with the highest quality of teaching. The evaluations are anonymous; the instructor and administration do not track who entered what responses. A program is used to check if the student completed the evaluations, but the evaluation is completely separate from the student's identity. Since 100% participation is our goal, students are sent periodic reminders over three weeks. Students do not receive reminders once they complete the evaluation. Please see <https://resources.depaul.edu/teaching-commons/teaching/Pages/online-teaching-evaluations.aspx> for additional information.

### Academic Integrity and Plagiarism

This course will be subject to the university's academic integrity policy. All students are expected to abide by the University's Academic Integrity Policy which prohibits cheating and other misconduct in student coursework. Publicly sharing or posting online any prior or current materials from this course (including exam questions or answers), is considered to be providing unauthorized assistance prohibited by the policy. Both students who share/post and students who access or use such materials are considered to be cheating under the Policy and will be subject to sanctions for violations of Academic Integrity.

More information can be found at <https://resources.depaul.edu/teaching-commons/teaching/academic-integrity/Pages/default.aspx>.

*Posting work on online sites, such as Hero*

All students are expected to abide by the University's Academic Integrity Policy which prohibits cheating and other misconduct in student coursework. Publicly sharing or posting online any prior or current materials from this course (including exam questions or answers), is considered to be providing unauthorized assistance prohibited by the policy. Both students who share/post and students who access or use such materials are considered to be cheating under the Policy and will be subject to sanctions for violations of Academic Integrity.

### **Academic Policies**

All students are required to manage their class schedules each term in accordance with the deadlines for enrolling and withdrawing as indicated in the [University Academic Calendar](#). Information on enrollment, withdrawal, grading and incompletes can be found at:

<http://www.cdm.depaul.edu/Current%20Students/Pages/PoliciesandProcedures.aspx>

### **Incomplete Grades**

An incomplete grade is a special, temporary grade that may be assigned by an instructor when unforeseeable circumstances prevent a student from completing course requirements by the end of the term and when otherwise the student had a record of satisfactory progress in the course. All incomplete requests must be approved by the instructor of the course and a CDM Associate Dean. Only exceptions cases will receive such approval. Information about the Incomplete Grades policy can be found at

<http://www.cdm.depaul.edu/Current%20Students/Pages/Grading-Policies.aspx>

### **Preferred Name & Gender Pronouns**

Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender variance, and nationalities. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the quarter so that I may make appropriate changes to my records. Please also note that students may choose to identify within the University community with a preferred first name that differs from their legal name and may also update their gender. The preferred first name will appear in University related systems and documents except where the use of the legal name is necessitated or required by University business or legal need. For more information and instructions on how to do so, please see the Student Preferred Name and Gender Policy at <http://policies.depaul.edu/policy/policy.aspx?pid=332>

### **Students with Disabilities**

Students seeking disability-related accommodations are required to register with DePaul's Center for Students with Disabilities (CSD) enabling them to access accommodations and support services to assist with their success. There are two office locations:

- Loop Campus (312) 362-8002
- Lincoln Park Campus (773) 325-1677
- Email: [csd@depaul.edu](mailto:csd@depaul.edu)

Students who register with the Center for Students with Disabilities are also invited to contact Dr. Gregory Moorhead, Director of the Center, privately to discuss how he may assist in facilitating the accommodations to be used in a course. This is best done early in the term. The conversation will remain confidential to the extent possible.

Please see <https://offices.depaul.edu/student-affairs/about/departments/Pages/csd.aspx> for Services and Contact Information.

### **Faculty Resources Available from the Dean of Students Office**

The online classroom [https://offices.depaul.edu/student-affairs/resources/faculty-staff/faculty-questions/Documents/Faculty\\_Resources\\_Online\\_Classroom.pdf](https://offices.depaul.edu/student-affairs/resources/faculty-staff/faculty-questions/Documents/Faculty_Resources_Online_Classroom.pdf)

### **Syllabus Resources Available from Teaching Commons**

<https://resources.depaul.edu/teaching-commons/teaching-guides/course-design/Pages/syllabuses.aspx#samples>