

COMP 4482A/9511A, Fall 2020

Game Programming

Syllabus

Course Information

Overview

This course will provide a high-level look at the design, implementation, and usage of video game engines. The primary goal of this course is to offer a basic understanding of the systems required to create a usable and reusable foundation for game development. Extra time will be spent examining and working in existing game engines in order to demonstrate the effectiveness of good engine design (or perhaps bad design).

Some focus will be given to the graphical nature of game engines and will therefore include an introduction to shaders (expanding on CS 3388), animation techniques, and optimization algorithms. Depth will be given in selected areas, but the student will be expected to do a reasonable amount of independent reading and learning outside of the lecture hours.

Calendar Description

Core concepts and techniques of real-time rendering and physical simulation as applied to the development of interactive game and simulation software. Topics from: real-time programming, indoor and outdoor rendering algorithms, character animation, vertex and pixel shaders, shading models, real-time shadows, procedural methods, simulation of classical mechanics, numerical integration, threaded programming.

Prerequisite Requirements

- CS 3307 (Basic Software Engineering), or equivalent.
- CS 3305 (Operating Systems), or equivalent.
- CS 3340 (Algorithms I), or equivalent.
- Math 1600 (Linear Algebra I), or equivalent.

Useful Background Knowledge

- Working knowledge of multivariate calculus and linear algebra.
- Ability to code well in the C-like languages (C#, C++, Java).
- Experience coding with graphics and/or the OpenGL graphics API.

Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Teaching Staff + Office Hours

Alex Brandt

abrandt5@uwo.ca

Virtual (see OWL for details)

Mondays, 15:30 - 17:00

Teaching Assistants

Mathias Babin

mbabin2@uwo.ca

Virtual (see OWL for details)

By appointment

Email Contact

Students must use their Western (@uwo.ca) email addresses when communicating with instructors and teaching assistants. Include “CS4482” in the subject line or else your email may be missed by the teaching staff.

Course Materials and Website

There is no required textbook for this course. Course notes, supplementary materials, and all other course content will be posted on OWL. Some interesting supplemental material:

- *Game Engine Architecture*, Second or Third Edition, by Jason Gregory.
- *GPUGems*, *GPUGems2*, *GPUGems3*: <https://developer.nvidia.com/gpugems/>.

Class Schedule

Mondays, 13:30 - 15:30

Thursdays, 13:30 - 14:30

There are 3 lectures hours per week. They are all “virtual” and “synchronous”. Thus, you should be prepared to attend *and participate* in the online lectures *live*. Part of your overall mark includes participation. See below.

Course Topics

This is a suggested a list of topics and we will likely cover a subset based on the interests of the class and time constraints. Topics will not necessarily be presented in the order listed here.

- History of Game Development
- Programming for the *Nintendo DS* console.
- Game Engine Development - Common Systems & Pitfalls
- Unity 3D - A Game Engine

- Real-time Rendering
 - The scene-graph model
 - Indoor real-time rendering: BSP, portal rendering
 - Outdoor real-time rendering: ROAM, Geomipmapping, GPU raycasting
 - Character Animation: Explicit and Implicit
 - Shading: Lighting models, NPR, Shadows, Full-screen effects, HDR, Spherical Harmonic Lighting
 - Physically based rendering
- Physics
 - Basic physical concepts.
 - Basic properties of bodies: mass, centre of mass, moment of inertia.
 - Newton's laws.
 - Kinematics and Kinetics for particles and rigid bodies.
 - Collision and conservation of momentum.
 - Pulling it all together in an engine.
 - Current Physics Engines

As there simply is not enough class time to teach the above topics in detail, the course will proceed in a “breadth-first” manner. For many of the topics, we will provide references to material you already know from your basic CS education, along with instruction on how to apply that knowledge to the domain of video games. The best we can do is provide a starting point and a helpful push; to get the most out of these topics, you will have to do much study on your own.

Student Evaluation

Most of a student’s mark comes from applying what is learned in and out of class to a progressive series of assignments. There are three primary ‘streams’ of assignments: *Game Programmer*, *Engine Developer* and *Tools Programmer*. Students may pick and choose which assignments they wish to complete according to their interests and career aspirations. The only constraint is that the student must have completed **and passed** all pre-requisite assignments before submitting another assignment (assignments may *not* be completed concurrently). A graphical representation of the pre-requisite structure is given in Figure 1; it’s a *skilltree*.

Each assignment has an “experience point value” (XP for short). Completing the assignment results in the student being awarded the associated amount of XP. *Note that there are no specific grades given for assignments, they are strictly pass/fail.* If you meet the specified requirements for the assignment, you pass, and are awarded the associated XP. In this case, a **“pass” corresponds to roughly an 80%** in a traditional marking scheme. Occasionally, a particularly awesome assignment may be awarded “bonus XP”.

If you do not meet the requirements of the assignment, you will be informed which requirements were not met and you will receive no XP. However, you may continue to modify and resubmit your assignment until you pass, or until the final deadline, whichever comes first. **The final deadline is Tuesday, December 8th, at 23:55** no re-submissions will be accepted after that time (see **Assignment Schedule** below). Any remaining failing submissions will be graded on a standard 0-100% scale for partial XP.

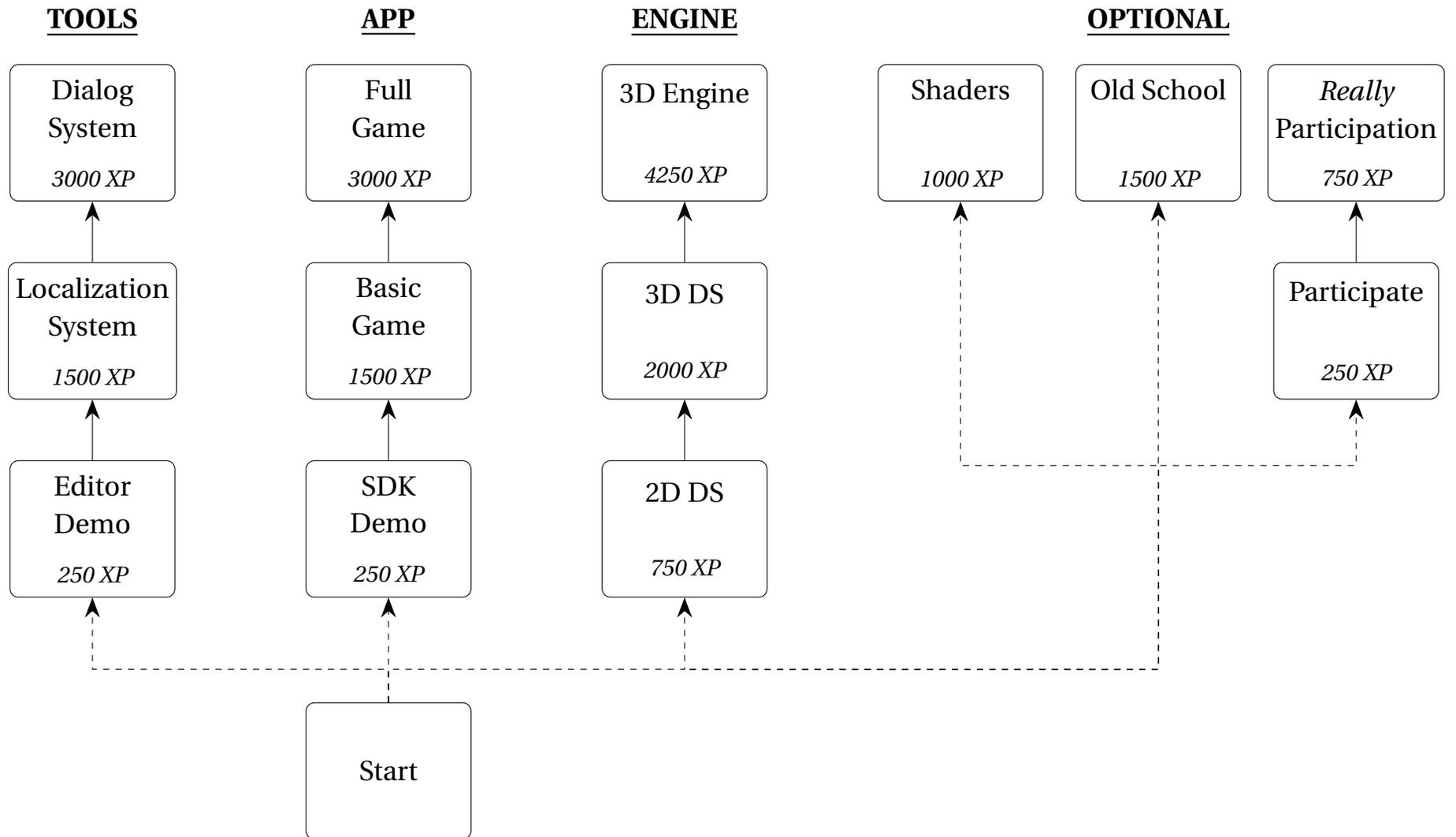


Figure 1: CS 4482 Skill Tree.

Computing your final grade

Every good RPG has an "XP curve" and this course is no different. We use here a very simple XP curve (to make computing your grade simple):

$$\text{Current Grade} = \sqrt{XP}.$$

That's it. That's your mark in the course. You add up the XP you've earned so far and take the square root. There is no final exam and the assignments are all pass/fail. This means there is *no* nondeterminism in your grade. You can decide, right now, which assignments you're going to do and, if you put in the work, you know *exactly* what your final grade will be.

WARNING: READ THIS

Note that because your grade is computed as the *square root* of accumulated XP, the accumulation of 100XP at the beginning of the course will increase your final grade much more than 100XP at the end. As your total XP grows, you need ever larger amounts of XP to increase your grade by a fixed amount. All of this should be completely familiar to anyone who has played an RPG in the past 20 years.

The important consequence is this: Make sure you plan to do one of the high-XP assignments at the end of a particular skill tree and proceed accordingly. The goal of the skill tree system is to provide flexibility for students with different interests. Under no circumstance should you plan to complete every assignment in the skill tree... unless you are independently wealthy, don't work and have absolutely no other classes.

This non-traditional grading scheme is frightening to me. What can I do?

Ignore everything above and come see me. We can decide together which assignments are best for your interests and which will give you an overall great mark in the course.

Assignment Schedule

There is a great deal of flexibility in assignment choice in this course and with that flexibility comes great responsibility. Much like the real world, you must manage your time accordingly for the different tasks involved in completing your projects.

Due to the mix-and-match aspect of this evaluation approach there are no firm due dates... However, it is expected that you submit some assignments throughout the term to show progression and engagement with the assignments. In particular, you must meet the following deadlines:

- Submit at least one “Tier 1” assignment (Editor Demo, SDK Demo, or 2D DS) by October 2, 2020, at 23:55. Additional Tier 1 assignments may be submitted after this date without late penalty.
- Submit at least one “Tier 2” assignment (Localization System, Basic Game, 3D DS) by October 30, 2020 at 23:55. Additional Tier 2 assignments may be submitted after this date without late penalty.
- **All first-time assignment submissions must be made by Friday, December 4th, 2020 at 23:55.** Any *new* submission after this date *will* receive late penalties as described below. Submissions made after this date may not be eligible for re-submission.
- **All re-submissions must be made by Tuesday, December 8th, 2020 at 23:55.** No re-submissions or modifications will be permitted following this date.

Late Assignments

Based on the above schedule, late submissions will be penalized 20% of their potential XP for each day late. That is, 0-23 hours late: -20%, 24-47 hours late: -40%, 48-71 hours late: -60%, etc. Given the flexible nature of this course and evaluation scheme, accommodations for missing these deadlines must be requested sufficiently early. For example, it is *not* feasible to complain about an illness on October 2, 11:52pm, and ask for an extension. Contact the instructor **48 hours** before any deadline, except in truly exceptional circumstances, to discuss your options for extensions or otherwise.

Note that due to the time required in the marking process, *re-submissions* will not be penalized as late (except after December 8th, 23:55, when **no submissions will be accepted**), provided that the original submission shows a reasonable attempt. "Place-holder" submissions will not be accepted. That is, making an empty or near-empty submission before the deadline to avoid a late penalty is unacceptable. Such a place-holder submissions will be considered void and late penalties will continue to be applied until a true submission is made.

Academic Consideration for Student Absence

Students will have up to two (2) opportunities during the regular academic year to use an on-line portal to self-report an absence during the semester, provided the following conditions are met: the absence is no more than 48 hours in duration, and the assessment for which consideration is being sought is worth 30% or less of the student's final grade. Students are expected to contact their instructors within 24 hours of the end of the period of the self-reported absence, unless noted on the syllabus. Students are not able to use the self-reporting option in the following circumstances:

- for exams scheduled by the Office of the Registrar (e.g., December and April exams)
- absence of a duration greater than 48 hours,
- assessments worth more than 30% of the student's final grade,
- if a student has already used the self-reporting portal twice during the academic year

If the conditions for a Self-Reported Absence are not met, students will need to provide a Student Medical Certificate if the absence is medical, or provide appropriate documentation if there are compassionate grounds for the absence in question. Students are encouraged to contact their Faculty academic counselling office to obtain more information about the relevant documentation.

Students should also note that individual instructors are not permitted to receive documentation directly from a student, whether in support of an application for consideration on medical grounds, or for other reasons. All documentation required for absences that are not covered by the Self-Reported Absence Policy must be submitted to the Academic Counselling office of a student's Home Faculty

For policy on Academic Consideration for Student Absences - Undergraduate Students in First Entry Programs, see: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Consideration_for_absences.pdf and for the Student Medical Certificate (SMC), see: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf

Religious Accommodation

Students should consult the University's list of recognized religious holidays, and should give reasonable notice in writing, prior to the holiday, to the Instructor and an Academic Counsellor if their course requirements will be affected by a religious observance. Additional information is given in the Western Multicultural Calendar: <https://multiculturalcalendar.com/ecal/index.php?s=c-univwo>

Policies, Accommodation, Accessibility

Mental Health

Mental and emotional well-being is highly important and should not be treated lightly. Students who are in emotional/mental distress should refer to Mental Health@Western at <http://www.uwo.ca/uwocom/mentalhealth/> for a complete list of options about how to obtain help.

Accessibility

Please contact the course instructor if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Student Accessibility Services (SAS) at 661-2147 if you have any questions regarding accommodations. More information can be found in Western University's Policy on Academic Accommodation for Students with Disabilities

Online Learning, Recording

All of the remote learning sessions for this course will be recorded. The data captured during these recordings may include your image, voice recordings, chat logs and personal identifiers (name displayed on the screen). The recordings will be used for educational purposes related to this course, including evaluations. The recordings may be disclosed to other individuals participating in the course for their private or group study purposes. Please contact the instructor if you have any concerns related to session recordings.

Participants in this course are not permitted to record the sessions, except where recording is an approved accommodation, or the participant has the prior written permission of the instructor. Completion of this course will require you to have a reliable internet connection and a device that meets the system requirements for Zoom. Information about the system requirements are available at the following link: <https://support.zoom.us/hc/en-us>

Online Etiquette

Some components of this course will involve online interactions. To ensure the best experience for both you and your classmates, please honour the following rules of etiquette:

- please "arrive" to class on time
- please use your computer and/or laptop if possible (as opposed to a cell phone or tablet)
- ensure that you are in a private location to protect the confidentiality of discussions in the event that a class discussion deals with sensitive or personal material
- to minimize background noise, kindly mute your microphone for the entire class until you are invited to speak, unless directed otherwise
- in order to give us optimum bandwidth and web quality, please turn off your video camera for the entire class unless you are invited to speak
- unless invited by your instructor, do not share your screen in the meeting

The course instructor will act as moderator for the class and will deal with any questions from participants. To participate please consider the following:

- if you wish to speak, use the “raise hand” function and wait for the instructor to acknowledge you before beginning your comment or question
- remember to unmute your microphone and turn on your video camera before speaking
- self-identify when speaking.
- remember to mute your mic and turn off your video camera after speaking (unless directed otherwise)

General considerations of “netiquette”:

- keep in mind the different cultural and linguistic backgrounds of other students.
- be courteous toward the instructor, your colleagues, and authors whose work you are discussing.
- be respectful of the diversity of viewpoints that you will encounter in the class and in your readings. The exchange of diverse ideas and opinions is part of the scholarly environment. “Flaming” is never appropriate.
- be professional and scholarly in all online postings. Cite the ideas of others appropriately.

Disruptive behaviour of any type during online classes, including inappropriate use of the chat function, is unacceptable. Students found guilty of Zoom-bombing a class or of other serious online offenses may be subject to disciplinary measures under the Code of Student Conduct.

Ethical Conduct

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at this web site.

All required papers may be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com

Source code submissions may be subject to similarity review by software that will check for unusual coincidences and patterns that may indicate cheating.

Student Support

The Student Development Centre provides learning skills services for students. Other services are also provided by the University Students’ Council

Registration Services

Refer to the Registrar’s website for information and services involving registration.