

COMP 4501A - Advanced Facilities for Real-Time Games

Winter 2023

Carleton University
School of Computer Science
Course Outline
Last update: December 20, 2022

Course Information

Instructor: Oliver van Kaick

Contact: Oliver.vanKaick at carleton.ca

Classroom: Please check the public class schedule

Lectures: Tuesdays and Thursdays, 11:35am – 12:55pm

Student hours: Information on student hours can be found in Brightspace

Course Website: <https://brightspace.carleton.ca/d2l/home/131313>

Teaching Assistants

A list of teaching assistants and their contact/office hours information will be posted to Brightspace once the course starts.

Course Summary

The course covers the use of game engines for the development of computer games, and advanced techniques relevant to games, such as 3D rendering, animation, and the simulation of physics. Assignments consist of programming/game development tasks.

Course Calendar Description

A practical course on the design and implementation of modern game engines and advanced facilities provided by these engines. Such facilities include systems for rendering 3D scenes; simulating physics; playing animations; game AI; and enabling multi-player games. Students will undertake a significant game development project.

Includes: Experiential Learning Activity

Prerequisite(s): COMP 3501.

Lectures three hours a week.

Topics Covered

- Architecture of games and game engines.
- Advanced rendering techniques: deferred rendering, global illumination heuristics, illumination models, programming of surface, vertex, and fragment shaders.
- Animation: key-frame animation, mesh animation, character animation, locomotion.
- Rigid-body physics: collision detection, animation based on physical simulation.

- Introduction to soft-body physics.
- Shape modeling and acquisition.
- Networking, AI, pathfinding.

Learning Outcomes

At the end of this course, students will be able to:

- Design the software architecture for a game of reasonable complexity, using a component-based architecture model.
- Summarize the main components that typically compose a game engine, explaining how these are integrated into a coherent software architecture, and how they can be used for game development.
- Explain the principles behind common techniques used for the creation of games, such as rendering, animation, and physical simulation. This includes the mathematical concepts and algorithms related to these techniques.
- Identify the most suitable techniques that can be used to add a specific functionality or effect to a computer game.
- Implement a game of reasonable complexity in the Unity engine, using 3D graphics.

Resources

We do not have an assigned textbook, as the course draws topics from a variety of areas. The following books are useful for the main topics discussed in the course:

- **Game engines:** Jason Gregory, "Game Engine Architecture", Second Edition, CRC Press, 2015.
- **Computer graphics:** Peter Shirley, Steve Marschner, "Fundamentals of Computer Graphics", Third Edition, CRC Press, 2009.
- **Real-time rendering, physically-based rendering:** Tomas Akenine-Möller, Eric Haines, and Naty Hoffman, "Real-time rendering", Third Edition, A. K. Peters, 2008.
- **Animation:** Rick Parent, "Computer Animation: Algorithms and Techniques", Third Edition, Morgan Kaufmann, 2012.

The programming assignments and course project will be based on the Unity Engine (<https://unity3d.com/>). There is a wealth of books and on-line tutorials specific to programming in Unity. I would advise to start by checking the tutorials provided in the Unity website.

You are free to make use of art assets found online provided that their license allows you to freely use the assets and you credit the source. Code fragments that are not of your own authorship are allowed under the following conditions: 1. The code should not be implementing the main tasks required for an assignment, but rather serve for adding additional features to the projects; 2. Provide credit to the original author of the code and make sure that you understand what the code is doing.

Computer Requirement

For the programming assignments, you will need a computer that has a GPU suitable to run computer games and powerful enough to run the Unity engine. Recent Windows computers with GPU support should work fine.

Assessment Scheme

Grading scheme (the specific deadlines can be found in Brightspace):

- Assignments + course project: 60%
- Final (take home) exam: 40%.

Note that you need to obtain a passing grade on the final to pass the course.

Late Assignment Policy

Assignment deadlines are strict. The following scheme is applied to late submissions (which includes assignments and the final course project):

- 3 hours late: no penalty
- 3 to 12 hours late: -10%
- 12 to 24 hours late: -20%
- More than one day late: assignment receives a grade of zero.

Assignment submissions are handled electronically (i.e., through Brightspace). Technical problems do not exempt you from submitting on time. So, if you wait until the last minute and then have issues with your connection, you will receive a deduction according to the scheme above. Consequently, you are advised to:

- Periodically upload your progress (e.g., upload your progress to Brightspace after each major change; we will only grade your last submission).
- Submit your final work at least one hour in advance of the due date and time.
- Store backups of your assignments in the cloud, e.g., OneDrive, Dropbox, a private GitHub repository. However, your assignment has to be submitted to Brightspace so that we have a timestamped submission. Urls to the cloud will not be accepted as assignment submission.

The assignments consist of programming/game development tasks. If a project does not run, it will receive a mark of zero. Consequently, after you upload your submission to Brightspace, you should re-download it immediately and ensure that the project runs fine.

You are expected to demonstrate good programming practices at all times and your code may be penalized if it is poorly written. You are also expected to do the necessary preparatory work (i.e., devising an algorithm) before you start coding.

Academic Integrity

If you are unsure about the expectations regarding academic integrity (how to use and cite references, how much collaboration with lab- or classmates is appropriate), ask your instructor. Sharing assignment specifications or posting them online (to sites like Chegg, CourseHero,

OneClass, etc.) is considered academic misconduct. You are never permitted to post, share, or upload course materials without explicit permission from your instructor. Academic integrity offences are reported to the office of the Dean of Science. Penalties for such offences can be found on the ODS webpage: <https://science.carleton.ca/academic-integrity/>.

Undergraduate Academic Advisors

The Undergraduate Advisors for the School of Computer Science are available in Room 5302HP; or by email at scs.ug.advisor@cunet.carleton.ca. The undergraduate advisors can assist with information about prerequisites and preclusions, course substitutions/equivalencies, understanding your academic audit and the remaining requirements for graduation. The undergraduate advisors will also refer students to appropriate resources such as the Science Student Success Centre, Learning Support Services and Writing Tutorial Services.

SCS Computer Laboratory

Students taking a COMP course can access the SCS computer labs. The lab schedule and location can be found at: <https://carleton.ca/scs/tech-support/computer-laboratories/>. All SCS computer lab and technical support information can be found at: <https://carleton.ca/scs/tech-support/>. Technical support staff may be contacted in-person or virtually, see this page for details: <https://carleton.ca/scs/tech-support/contact-it-support/>.

University Policies

For information about Carleton's academic year, including registration and withdrawal dates, see [Carleton's Academic Calendar](#).

Pregnancy Obligation. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit [Equity Services](#).

Religious Obligation. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, visit <https://carleton.ca/equity/focus/discrimination-harassment/religious-spiritual-observances/>.

Academic Accommodations for Students with Disabilities If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or pmc@carleton.ca for a formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure

accommodation arrangements are made. For more details, visit the [Paul Menton Centre](#) website.

Survivors of Sexual Violence. As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: carleton.ca/sexual-violence-support

Accommodation for Student Activities. Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact your instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see [the policy](#).

Student Academic Integrity Policy. Every student should be familiar with the Carleton University student academic integrity policy. A student found in violation of academic integrity standards may be awarded penalties which range from a reprimand to receiving a grade of *F* in the course or even being expelled from the program or University. Examples of punishable offences include: plagiarism and unauthorized co-operation or collaboration. Information on this policy may be found [here](#).

Plagiarism. As defined by Senate, "plagiarism is presenting, whether intentional or not, the ideas, expression of ideas or work of others as one's own". Such reported offences will be reviewed by the office of the Dean of Science. Standard penalty guidelines can be found [here](#).

Unauthorized Co-operation or Collaboration. Senate policy states that "to ensure fairness and equity in assessment of term work, students shall not co-operate or collaborate in the completion of an academic assignment, in whole or in part, when the instructor has indicated that the assignment is to be completed on an individual basis". Please refer to the course outline statement or the instructor concerning this issue.

Special Information

It is important to remember that COVID is still present in Ottawa. The situation can change at any time and the risks of new variants and outbreaks are very real. There are number of actions you can take to lower your risk and the risk you pose to those around you including being vaccinated, wearing a mask, staying home when you're sick, washing your hands and maintaining proper respiratory and cough etiquette.

Feeling sick? Remaining vigilant and not attending work or school when sick or with symptoms is critically important. If you feel ill or exhibit COVID-19 symptoms do not come to class or

campus. If you feel ill or exhibit symptoms while on campus or in class, please leave campus immediately. In all situations, you must follow Carleton's symptom reporting protocols.

Masks: Carleton has paused the COVID-19 Mask policy, but continues to strongly recommend masking when indoors, particularly if physical distancing cannot be maintained. It may become necessary to quickly reinstate the mask requirement if pandemic circumstances were to change.

Vaccines: While proof of vaccination is no longer required as of May 1 to attend campus or in-person activity, it may become necessary for the University to bring back proof of vaccination requirements on short notice if the situation and public health advice changes. Students are strongly encouraged to get a full course of vaccination, including booster doses as soon as they are eligible, and submit their booster dose information in cuScreen as soon as possible. Please note that Carleton cannot guarantee that it will be able to offer virtual or hybrid learning options for those who are unable to attend the campus.

All members of the Carleton community are required to follow requirements and guidelines regarding health and safety which may change from time to time. For the most recent information about Carleton's COVID-19 website and review the Frequently Asked Questions (FAQs). Should you have additional questions after reviewing, please contact covidinfo@carleton.ca.

Doctor's note or medical certificate: in effect for Fall 2022 term. In place of a doctor's note or medical certificate, students are advised to complete the [self-declaration form](#) available on the Registrar's Office website to request academic accommodation for missed course work including exams and assignments. Students should also discuss with the course instructor the required accommodations arising from the COVID-19 situation. Please check online for the latest policy in this regard for the Winter 2023 term.