Carleton University, Computer Science, Winter 2021
Comp 2501 (with Tutorial) Computer Game Design and Development

Class Times/Instructor: Wed/Fri 6-7:30 via Zoom, via Zoom, W.R. Lalonde
Contact: wilf.lalonde@gmail.com
Workshop (Preallocated slots, extra slot thurs): Mon 11:30-1pm, Thurs 6-7:30, Fri 1-2:30 via Zoom
No classes: Winter break week of Feb 14-20, Frid April 2.
Last day of classes: April 14 for slightly over 12 weeks of classes

Course Description: C++ Programming and math skills needed for developing 3D games. Classes needed to implement players, cameras, models, shaders, and sprites. Math needed for understanding position, directions, normals, and headings. Matrices for transformations and their inverses in both left-handed and right handed systems. Their uses in controlling objects, cameras, and texture manipulation. Facilities to support collision detection. Includes subsets of new first year course Comp 1008 Math for Game Programmers.

Prerequisite: Math 1104, COMP 1501, comp 2401.
Course Goals: The course has 2 goals: (a) to teach the 3D gaming math you will need in all subsequent courses and (b) to develop your C++ skill assuming you have taken or are currently taking a C++ course.

Course Work: Last year’s version of this course had 6 assignments, 1 project, 1 test and 1 exam for 9 submissions. Because of this year’s special circumstances, we will instead have roughly 1 assignment per week marked A/B/C (100%, 70%, 50%) with NO test and NO exams and with SIMPLER assignments. The emphasis is NOT on marks but on making sure that you develop your skills. So it is very important that YOU do the assignments and NOT LET A FRIEND do it for you.

Reference Book: Mathematics for 3D Game Programming & Computer Graphics (Third edition is the latest), Eric Lengyel, Charles River Media, Inc. This will be the book used by Comp 1008 Math for Game Programmers

Handing in: Via https://carleton.ca/culearn/ but all download materials will be available from Web: http://www.scs.carleton.ca/~lalonde (my page), and http://www.scs.carleton.ca/~lalonde/comp2501 (course page).

Course Outline

The rendering pipeline
- Generic overview
- Left versus right-handed systems
- Left-to-right versus right-to-left evaluation math
- Coordinates spaces (object, world, camera, and perspective)
Tuples

- The distinction between points, vectors, normal
- Two definitions of vector dot products
- Two definitions of vector cross product
- Intuitions behind dot products and cross products
- Many operations and related theorems on tuples, points, vectors, dot products and cross products.

Matrices

- Matrix multiply plus many other operations
- Matrix inverses and how to compute them
- Useful theorems involving transposes and inverses
- Matrix forms of dot and cross products

Transformations

- Translating, rotating, scaling transformations and their inverses
- Projection transformations
- Properties of rotations
- The general rotation transformation
- Fast inverses

Transformations for gaming

- Controlling placement
  - Object placement in worlds
  - Texture placement in objects
  - Camera placement in worlds
- Controlling and animating changes
  - Changes relative to an Object (pre-transformations)
  - Changes relative to a World (post-transformations)
  - Changes relative to a Parent
- Controlling changes when dealing with inverses
  - Changes from right to left-handed systems
- Articulated figures, poses, and skinning
  - Object and camera “look at” functions

Visibility determination

- Bounding boxes, planes, frustum, and visibility trees
- Octrees, quad trees, bounding box trees, and bsp trees.
- Distance to planes, plane transformations
- Building frustum, frustum transformations
- Determining if points, bounding boxes, and spheres are inside frustums
- Sprites and how to draw them without needing to rotate them
- Portal visibility
Collision detection and collision reacting

- Movement boxes and collision detection trees (similar to visibility trees)
- Basic algorithms for projections of points on a line, on a plane
- Basic algorithm for intersection of a line with a plane, with a sphere
- The concept of object sweeping,
- Point sweeps colliding with planes, spheres, bounding boxes, polygons, and polygon soup.
- Sphere sweeps colliding with planes, spheres, bounding boxes, polygons, and polygon soup.
- More general sweeps done efficiently

Quaternions

- Definitions and how they are used for rotations.

Undergraduate Academic Advisor

The Undergraduate Advisor for the School of Computer Science is available in Room 5302C HP; by telephone at 520-2600, ext. 4364; or by email at undergraduate_advisor@scs.carleton.ca. The undergraduate advisor can assist with information about prerequisites and preclusions, course substitutions/equivalencies, understanding your academic audit and the remaining requirements for graduation. The undergraduate advisor will also refer students to appropriate resources such as the Science Student Success Centre, Learning Support Services and Writing Tutorial Services.

SCS Computer Laboratory

SCS students can access one of the designated labs for your course. The lab schedule 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/technical-support/. Technical support is available in room HP5161 Monday to Friday from 9:00 until 17:00 or by emailing support@scs.carleton.ca.

University Policies

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. Some examples of offences are: plagiarism and unauthorized co-operation or collaboration. Information on this policy may be found in the Undergraduate Calendar.

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.

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.

Academic Accommodations for Students with Disabilities
The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and 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 me to ensure accommodation arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable) at http://www2.carleton.ca/pmc/new-and-current-students/dates-and-deadlines

**Religious Obligation**

Write to me 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 the Equity Services website: http://www2.carleton.ca/equity/

**Pregnancy Obligation**

Write to me 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 the Equity Services website: http://www2.carleton.ca/equity/

**Medical Certificate**

The following is a link to the official medical certificate accepted by Carleton University for the deferral of final examinations or assignments in undergraduate courses. To access the form, please go to http://www.carleton.ca/registrar/forms