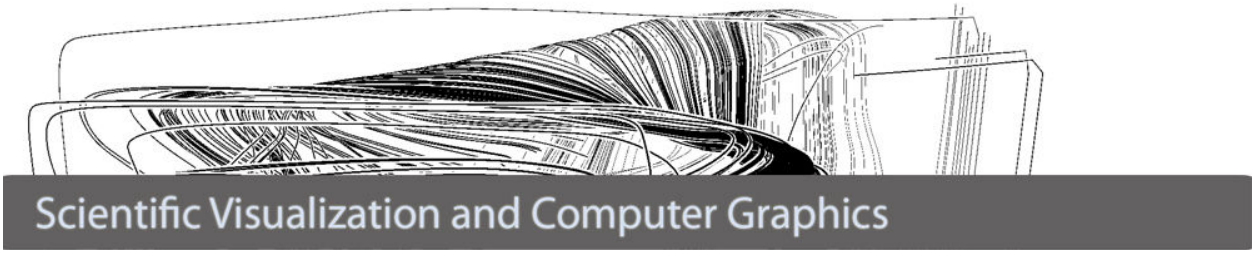


CSCI 3090 U
Winter 2014 Course Outline

Instructor

Dr. Christopher Collins
UA 4024, 905-721-8668 ex. 6581
Please contact me through Blackboard; urgent emails only to christopher.collins@uoit.ca

Laboratory Instructors (TAs)

Hrim Mehta
Email through Blackboard

Schedule

Lectures	**Labs**
Monday 11:10am-12:30pm, UA 2230	Wednesday 1:10pm-3:00pm, UA 2220
Thursday 12:40pm-2:00pm, UA 2230	Friday 11:10am-1:00pm, UA 2230

There are 8 lab activities. On weeks where there is no lab activity, the TA will be available in the lab room to assist with assignments and other questions, and may conduct supplemental tutorial lessons to clarify course material.

Important Dates

Classes start: January 6, 2014
Last day to withdraw from course without academic consequences: January 31, 2014
No lectures: February 17 & 20, 2014 (Midterm Break)
Classes end: April 11, 2014
Final exam period: April 14-25, 2014
Other important dates: www.uoit.ca > current students > Important Dates

Contact Hours

Dr. Collins
UA 4024, Tuesdays 1:00pm-2:00pm or by appointment
IM & Video chat during office hours: Skype: christopher.m.collins or Blackboard chat

Hrim Mehta
UA 4029, Mondays 2:00pm-3:00pm or by appointment

Academic Technology

Instruction for CSCI 3090 will be conducted in person and through Blackboard. Additional software required for the course will be provided as needed through Blackboard.

Students are invited to take advantage of *Twitter* to share links and tips related to course material. Please use the Twitter tag #UOIT3090. You can follow the instructor @ChrisNF.

Please be mindful of your use of technology in the classroom, including your UOIT-issued laptop and any other devices you bring. Activities which may be disruptive to others, such as playing games, are not acceptable and *you will be asked to stop or leave the classroom*.

Course Description

This course is about generating computer graphics — producing images with computers. The course covers the basics of basic principles and techniques used in computer graphics, an introduction to graphics programming, the mathematics of creating images from geometric models, and the specialized hardware used to render computer graphics. The course will cover both the theory of computer graphics and the programming techniques and algorithms used to create them. Building on the basics of graphics, the second part of the course will introduce visualization, with a focus on scientific visualization— a field of computer graphics concerned with producing images from scientific data. Visualization can provide insight into many types of scientific problems, from the outputs of physics simulations to the contents of a medical scan.

A Note on Teaching with OpenGL

OpenGL is a programming toolkit for 3D graphics, which will be used in this course. OpenGL has recently dramatically changed its architecture to rely heavily on *shaders* and deprecate *immediate mode* rendering. However, in this course (and many other graphics courses around the world) you will still learn first based on *immediate mode* as it provides a gentler introduction to the concepts of computer graphics programming. All graphics hardware continues to support immediate mode rendering. However, you should be aware that immediate mode rendering (using `glBegin()/glEnd()`) is officially deprecated. We will cover shader-based OpenGL later in the course. For more information on this pedagogical choice, please see:

Wolff, David *How do we teach OpenGL?*, Journal of Computing Science in Colleges, 28(1), pp. 185—191, Oct 2012.

Course Policies

Class attendance and participation in lectures is strongly recommended.

Attendance in labs is required. If you miss a lab due to illness or a death in the family, you must obtain the appropriate documentation (UOIT Medical Certificate, death certificate) and submit it to the course instructor within five business days of missing the lab. As space allows, and with a legitimate reason, it may be possible to attend a different lab section or complete a lab on your own time. Contact your TA in advance for approval.

Absence from more than two labs, regardless of any documented reasons, will result in a grade of F for the course (see http://www.science.uoit.ca/undergraduate/current-students/academic-policies.php).

If a holy day will conflict with scheduled labs, assignment deadlines, or the midterm test, you must inform the professor or TA at least seven business days before the scheduled time of the lab, assignment, or test.

The instructors will endeavour to provide timely responses to questions and be available during posted hours. However, students should not rely on a reply faster than 2 working days (i.e. questions sent 2 hours before assignment deadlines may not be answered). We will try to answer questions within 1 day.

This course is governed by the Faculty of Science academic policies (http://www.science.uoit.ca/undergraduate/current-students/academic-policies.php).

Computer Science Study Room

J 123A is available as a drop in study room for students registered in this course. Check the schedule on the door for details.

Course Outcomes

On the successful completion of CSCI 3090, students will be able to:

1. Explain the theory underlying the graphics pipeline.
2. Create basic OpenGL/GLUT programs.
3. Design matrix transformations to correctly position objects in a graphical scene.
4. Demonstrate an understanding of geometric modelling techniques.
5. Apply knowledge of rendering techniques such as lighting, back-face culling, view transformations, and texture mapping.
6. Describe the theory underlying ray tracing techniques and implement a simple ray tracer to render a scene.

7. Critique information and scientific visualizations using the theory of visual variables and knowledge of basic human visual perception.
8. Synthesize the graphical techniques and basic theories of visualization to design and implement simple visualization of scientific data using ParaView.
9. Implement graphics shaders to apply textures and other rendering effects.
10. Explain the most important advances in graphics hardware, including GPU programming, and relate them to the most challenging problems in the discipline.

Course Design

This is a lecture-based course which includes a series of programming assignments which will allow students to apply the concepts from the lectures to create computer graphics and visualizations. Basic knowledge of C/C++ is assumed. Source code will be distributed and supported for Windows, but students may use Linux. Classes will consist of lectures based on the course text, relevant videos, and discussions of late-breaking research. Laboratory sessions will review the programming techniques and algorithms needed to complete the assignments, as well as allow students time to work on assignments and practical lab activities with the assistance of the laboratory instructor. **Laboratory attendance is required. Attending a substitute lab is only allowed with instructor or TA permission.**

Outlines of lecture notes and supplementary materials will be placed on Blackboard. **Students are encouraged to take their own notes during lectures and discussions to supplement the instructor's material.**

Outline of Topics

1. Graphics Pipeline
    a. From model to pixels, overview of the basic process
2. Introduction to Graphics Programming
    a. GLUT
    b. Basic OpenGL Programming
    c. Transformations, lighting, simple animation

<Lab 1 & 2>

3. Modeling
    a. Polygons, face and vertex tables, normal vectors
    b. Transformations, matrices, composition of transformations
    c. Homogeneous coordinates
    d. Implicit representations
    e. Parametric representations, piecewise representation, continuity
    f. Cubic curves, canonical form, blending functions
    g. Hermite, natural spline, Cardinal spline, Bezier curve
    h. Hierarchical modeling, OpenGL examples, display lists

i. Subdivision algorithms

<Lab 3, Assignment 1>

4. Rendering
    a. Viewing transformations, projections
    b. Hidden surface, z-buffer, BSP trees
    c. Basic lighting, ambient, diffuse and specular reflection
    d. Texture mapping, Mipmaps, texture mapping in OpenGL

<Lab 4>

5. Ray Tracing
    a. Basic ray tracing technique, reflection, refraction, shadows
    b. Intersection calculations, sphere, plane, polygons
    c. Performance, bounding volumes, grids
    d. Distributed ray tracing, sampling patterns, path tracing

<Lab 5, Assignment 2>

<Midterm Exam>

<Lab 6>

6. Graphics Hardware
    a. Video, sync, frame buffers, bandwidth issues
    b. 3D acceleration, path to fixed function pipeline
    c. GPUs, geometry, vertex and fragment shaders,
    d. GPU architecture
    e. Programming GPUs, GLSL

<Lab 6, Lab 7, Assignment 3>

7. Introduction to Visualization
    a. Scientific and information visualization
    b. Visual variables and perception
    c. Interaction
    d. Scientific visualization rendering pipeline
    e. Introduction to ParaView, example visualizations
8. Datasets
    a. Standard datasets encountered in visualization
    b. Structure and attributes, topology and geometry, cell and point data
    c. Uniform rectilinear grid, non-uniform rectilinear grid, curvilinear grid
    d. VTK data formats

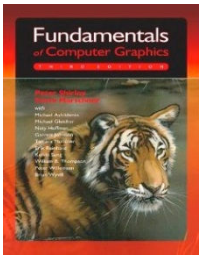
9. Visualization Techniques
    a. Scalar visualization techniques, colour maps, probes, contours

b. Marching squares and marching cubes, contours in ParaView
c. Vector visualization techniques, hedgehogs, glyphs, warps
d. Stream lines, stream ribbons, stream tubes
e. Volume rendering, transfer functions, volume traversal

<Lab 8, Assignment 4>

<Final exam>

Required Texts / Readings



Fundamentals of Computer Graphics, 3rd ed. by P. Shirley, AK Peters, 2009. Available at the UOIT bookstore.

Additional readings will be recommended or required as indicated on Blackboard under "Resources" and on the pages of specific lectures. ***Students are responsible for monitoring Blackboard for readings.***

Evaluation

Student progress in the course will be evaluated through lab activities, assignments, a mid-term exam, and a final exam. The marking breakdown is:

Labs	8 x 2% = 16%
Individual assignments	A1: 8%, A2: 10%, A3: 6%, A4: 6% = 30%
Mid-term test	24%
Final exam	30%
Total	100%

Assignments will primarily be evaluated based on the correctness of solutions, but credit may be allocated for documentation, discussion, and code quality as specified on the assignment handout.

Final course grades may be adjusted to conform to the Faculty of Science grade distribution profiles. Further information regarding grading can be found in Section 5 of the UOIT Academic Calendar.

Remarking

It is very important that all assessments are properly graded. If you believe there is an error in your assignment or exam grading, please submit an *explanation in writing* within 2 days of receiving the grade. No remarking requests will be accepted orally, and no re-grade requests will be accepted more than 7 days after return of the assignment.

Labs, Assignments and Tests

Lab activities will be completed during the lab time, and solutions should be posted to Blackboard *before leaving the lab*. Lab reports will be graded on a 1-4 scale based on the correctness of the solutions provided. No make-up labs will be offered, but students with documented excuses may complete missed lab activities on their own time.

Lab	Topic (Tentative)
1	OpenGL 1: Frustum and Cube
2	OpenGL 2: Facets and Lighting
3	Projection
4	Ray Tracing Basics
5	Texture Mapping
6	Shader Programming 1
7	Shader Programming 2
8	Paraview Visualization

Assignment	Topic
1	Modelling Techniques
2	Ray Tracing
3	Graphics Hardware
4	Visualization

Assignments will be distributed and handed in using Blackboard. Assignments are due at 11:59pm on the due date. Assignments should be submitted using Blackboard, and file names should follow the specifications given in the assignment handout.

Mid-term Test: March 10 (tentative). The midterm test will cover topics 1-5 of the outline.

If a scheduled midterm exam in a Science course will conflict with another test or a course you must contact the Science Academic Advising Office at least 7 days before the date of the exam. Special early exam arrangements may be made under these circumstances if the student applies by the deadline.

Collaboration: All assignments and tests are to be completed individually unless otherwise noted on the assignment handout. Laboratory and lecture activities may be collaborative as described by the instructor.

Lateness: Students are expected to complete the required assignments on time. Extensions will be granted on request and with an acceptable reason. 10% per day will be deducted from late assignments for a maximum of 3 *calendar* days, after which the assignment will not be accepted.

Missed assignments and tests: When a student has sufficient grounds for special consideration (such as documented illness or death in the family) the normal policy in the Faculty of Science for any

missed term work is to re-weight the remaining work in the course to account for the missing grade, in accordance with the regulations given at http://www.science.uoit.ca/undergraduate/current-students/academic-policies.php. Students who do not provide sufficient grounds, as determined by the course instructor, will receive a grade of zero for the missed work.

There are no make-up exams, tests, labs, or assignments.

Students who have legitimate grounds for missing a test/exam should not write the exam expecting to later decide whether or not the exam will count. If you choose to write an exam under any circumstances the decision is irreversible. If you are concerned about your ability to perform on the exam, you should speak to the Science Academic Advising Office about your options in advance of the exam.

Accessibility

Our goal is to offer this course using a *Universal Design for Learning* model, including providing electronic versions of all course materials. Feedback and suggestions from students on this issue are always welcome. To ensure that disability-related concerns are properly addressed during this course, students requiring accommodations to participate fully in this class are encouraged to speak with the instructor as soon as possible. In addition, students may provide the instructor with an official accommodation letter from the Centre for Students with Disabilities (CSD). Students who require alternative testing and examination arrangements or other academic accommodations must contact the Centre for Students with Disabilities (SW 116) as early as possible to ensure their needs can be met.

Academic Integrity

Students and faculty at UOIT share an important responsibility to maintain the integrity of the teaching and learning relationship. This relationship is characterized by honesty, fairness and mutual respect for the aim and principles of the pursuit of education.

Academic misconduct impedes the activities of the university community and is punishable by appropriate disciplinary action. Students are expected to be familiar with UOIT's regulations on Academic Conduct (Section 5.15 of the Academic Calendar) which sets out the kinds of actions that constitute academic misconduct, including plagiarism, copying or allowing one's own work to copied, use of unauthorized aids in examinations and tests, submitting work prepared in collaboration with another student when such collaboration has not been authorized, and other academic offenses. The regulations also describe the procedures for dealing with allegations, and the sanctions for any finding of academic misconduct, which can range from a written reprimand to permanent expulsion from the university. A lack of familiarity with UOIT's regulations on academic conduct does not constitute a defense against its application.

Further information on academic integrity is available at: http://goo.gl/GP5xa.

Final Examinations

The final exam will be **cumulative**, including all material in the course.

Final examinations are held during the final examination period at the end of the semester and may take place in a different room and on a different day from the regularly scheduled class. Check the published Examination Schedule on *MyCampus* for a complete list of days and times.

Students are advised to obtain their Student ID Card well in advance of the examination period as they will not be able to write their examinations without it. Student ID cards can be obtained at the Campus ID Services, in G1004 in the Campus Recreation and Wellness Centre.

Students, who through religious obligations are unable to write a final examination when scheduled, will be permitted to write a deferred examination. These students are required to give three weeks' notice to the faculty concerned and to document the religious obligations involved. Students who miss an exam for medical or compassionate grounds may submit a request for deferral, along with supporting documentation, to the Faculty within five (5) working days after the scheduled writing of the examination.

Further information on final examinations is available http://goo.gl/6u3Rt.

Course Evaluations

Student evaluation of teaching is a highly valued and helpful mechanism for monitoring the quality of UOIT's programs and instructional effectiveness. To that end, course evaluations are administered by an external company in an online, anonymous process during the last few weeks of classes. Students are encouraged to participate actively in this process and will be notified of the dates via *MyCampus*.

In addition to the formal evaluation process at the end of term, student feedback is encouraged and welcome through the semester. Students may contact the instructor to discuss any issues related to lectures or laboratories and to make suggestions throughout the term. Anonymous feedback forms and '1-minute essay' activities will take place throughout the term, and students are encouraged to use them fully.