# CSE 5542 (Approved): Real-Time Rendering

## Course Description

Comprehensive list of topics in real-time rendering using OpenGL and GLSL, including coordinate systems, transformations, viewing, illumination, texture mapping, and shader-based algorithms.

**Prior Course Number:** CSE 781
**Transcript Abbreviation:** RT Rendering
**Grading Plan:** Letter Grade
**Course Deliveries:** Classroom
**Course Levels:** Undergrad, Graduate
**Student Ranks:** Senior, Masters, Doctoral
**Course Offerings:** Autumn
**Flex Scheduled Course:** Never
**Course Frequency:** Every Year
**Course Length:** 14 Week
**Credits:** 3.0
**Repeatable:** No
**Time Distribution:** 3.0 hr Lec
**Expected out-of-class hours per week:** 6.0
**Graded Component:** Lecture
**Credit by Examination:** No
**Admission Condition:** No
**Off Campus:** Never
**Campus Locations:** Columbus
**Prerequisites and Co-requisites:** (CSE 3901 or CSE 3902 or CSE 4901 or CSE 4902 or CSE 560) and (Math 2568 or Math 568 or Math 571)
**Exclusions:** Not open to students with credit for CSE 781
**Cross-Listings:**

**The course is required for this unit's degrees, majors, and/or minors:** No
**The course is a GEC:** No
**The course is an elective (for this or other units) or is a service course for other units:** Yes

**Subject/CIP Code:** 14.0901
**Subsidy Level:** Doctoral Course

## Programs

| Abbreviation | Description |
|---|---|
| BS CSE | BS Computer Science and Engineering |
| MS CSE | MS Computer Science and Engineering |
| PhD CSE | PhD Computer Science and Engineering |

## Course Goals

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| Master graphics programming and the theory of real time rendering. |
| Be familiar with various techniques for creating 3D realism. |
| Be exposed to the state of the art in graphics hardware API. |
| Be competent with developing real time graphics applications |

## Course Topics

| Topic | Lec | Rec | Lab | Cli | IS | Sem | FE | Wor |
|---|---|---|---|---|---|---|---|---|
| Overview of graphics APIs (OpenGL and GLSL) | 1.0 | | | | | | | |
| Overview of graphics hardware - geometry processing, fragment procssing, pixel processing; graphics pipeline | 2.0 | | | | | | | |
| Coordinate systems in rendering pipeline - local space, world space, eye space, clip space, window space | 1.0 | | | | | | | |
| Modeling transformation - rotation, scaling, translation; hierarchical transformation; transformation between different spaces | 3.5 | | | | | | | |
| 3D viewing - viewing transformation, projection transformation | 2.0 | | | | | | | |
| Basic lighting algorithms - Phong illumination model and Gouraud shading | 1.0 | | | | | | | |
| Introduction to OpenGL Shading Language | 0.5 | | | | | | | |
| OpenGL shader overview - vertex shaders, geometry shaders, fragment shaders | 1.0 | | | | | | | |
| OpenGL vertex shaders | 2.0 | | | | | | | |
| OpenGL geometry shaders | 2.0 | | | | | | | |
| OpenGL fragment shaders | 2.0 | | | | | | | |
| OpenGL raster operations - scissor test, stencil test, depth test, blending | 1.0 | | | | | | | |
| OpenGL buffer objects - vertex buffer objects, frame buffer objects, pixel buffer objects | 2.0 | | | | | | | |
| Real time shadow algorithms - planar shadows, shadow volumes, shadow maps | 4.0 | | | | | | | |
| OpenGL texture mapping | 2.0 | | | | | | | |
| Bump mapping | 3.0 | | | | | | | |
| Environment mapping | 2.0 | | | | | | | |
| Advanced texture mapping and anti-aliasing | 3.0 | | | | | | | |
| Advanced shading and lighting algorithms - real time global illumination | 3.0 | | | | | | | |
| Non-photorealistic rendering | 2.0 | | | | | | | |
| Real time volumetric rendering | 2.0 | | | | | | | |

## Representative Assignments

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| Write a basic OpenGL 2D render with hierarchical transformation |
| Augment the previous renderer with OpenGL lighting and texture mapping |
| OpenGL Shading Language - enhance the OpenGL with shaders support, bump mapping and environment mapping |
| Final project - advanced topics in graphics |

## Grades

| Aspect | Percent |
|---|---|
| Midterm exam | 20% |
| Final exam | 20% |
| Four lab assignments | 60% |

## Representative Textbooks and Other Course Materials

| Title | Author |
|---|---|
| *Real-Time Rendering* | Tomas Akenine-Moller and Eric Haines |

## ABET-EAC Criterion 3 Outcomes

| Course Contribution | | College Outcome |
|---|---|---|
| ** | a | An ability to apply knowledge of mathematics, science, and engineering. |
| ** | b | An ability to design and conduct experiments, as well as to analyze and interpret data. |
| *** | c | An ability to design a system, component, or process to meet desired needs. |
| * | d | An ability to function on multi-disciplinary teams. |
| * | e | An ability to identify, formulate, and solve engineering problems. |
| * | f | An understanding of professional and ethical responsibility. |
| * | g | An ability to communicate effectively. |
| * | h | The broad education necessary to understand the impact of engineering solutions in a global and societal context. |
| * | i | A recognition of the need for, and an ability to engage in life-long learning. |
| * | j | A knowledge of contemporary issues. |
| ** | k | An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. |

## BS CSE Program Outcomes

| Course Contribution | | Program Outcome |
|---|---|---|
| ** | a | an ability to apply knowledge of computing, mathematics including discrete mathematics as well as probability and statistics, science, and engineering; |
| ** | b | an ability to design and conduct experiments, as well as to analyze and interpret data; |
| ** | c | an ability to design, implement, and evaluate a software or a software/hardware system, component, or process to meet desired needs within realistic constraints such as memory, runtime efficiency, as well as appropriate constraints related to economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability considerations; |
| * | d | an ability to function on multi-disciplinary teams; |
| * | e | an ability to identify, formulate, and solve engineering problems; |
| * | f | an understanding of professional, ethical, legal, security and social issues and responsibilities; |
| * | g | an ability to communicate effectively with a range of audiences; |
| * | h | an ability to analyze the local and global impact of computing on individuals, organizations, and society; |
| ** | i | a recognition of the need for, and an ability to engage in life-long learning and continuing professional development; |
| * | j | a knowledge of contemporary issues; |
| * | k | an ability to use the techniques, skills, and modern engineering tools necessary for practice as a CSE professional; |
| ** | l | an ability to analyze a problem, and identify and define the computing requirements appropriate to its solution; |
| ** | m | an ability to apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices; |

| Course Contribution | | Program Outcome |
|---|---|---|
| ** | n | an ability to apply design and development principles in the construction of software systems of varying complexity. |

**Prepared by:** Han-Wei Shen