CS 216 Physically Based Modeling for Computer Graphics

Course Information

- Instructor: Kevin M. Smith
  - Telephone: (415) 960-7085
  - Email: kevin.smith@sjsu.edu
  - Office Hours:
    - Mondays & Wednesdays 3:30 PM – 4:30 PM
    - Location: DH 288 (Monday), Zoom (Wednesday) – zoom link in Canvas
    - You do NOT need to make an appointment for these office hours. You can simply stop by my office.
- Class Days/Time: MW 1:30-2:45 PM
- Class mode: Hybrid
- Class Location: Monday (MacQuarrie Hall 223), Wednesday (Online – Zoom link in Canvas)
- CS 116A with a grade of B or better, or its equivalent, or with permission from the instructor.

Catalog Description

This course provides a physically based approach to creating realistic images and animation applicable to film, games and other industries. In a project-based approach, students will study the algorithms commonly used for animation and modeling in computer graphics.

Course Summary

This course provides a physically based approach to creating realistic images and animation with applications in both the film and games industry. Simulating reality will be the primary goal by modeling the interaction of light and matter to create photorealistic images. For animation, we will explore the use of rigid and soft-body dynamics to produce realistic animations using physics. In a project-based approach, students will implement the algorithms covered in the course to solve problems found in both the film and game industry. Some of the topics covered: Ray marching fractals and terrain, real-time simulation of particle effects, flocking, simulation of clothing, organic modeling with subdivision surfaces, and AI-driven approaches to animation. A variety of platforms will be used including a C++/OpenGL framework and industry standard applications such as Maya and Houdini.

Course Learning Outcomes (CLO)

Upon successful completion of this course, students will be able to:

- Implement a flocking algorithm as part of a complete interactive animation system.
- Use the ray-marching algorithm in order produce repeating geometric structures and terrain in the context of a physically based rendering system.
- Be able to describe and demonstrate the basic techniques of a procedural-based modeling system and use this system to program/generate rendered 2D, 3D fractals and L-system based organic structures.
- Determine how different use-cases in computer graphic production can be solved using the techniques covered in the course.
- Combine several physically based modeling techniques and a *use case* to create a comprehensive final project prototype and presentation.

Textbooks and Recommended Reading

- Steve Marshner, Peter Shirley, *Fundamentals of Computer Graphics (Fourth edition)*, CRC press, 2016 (Recommended)

- Donald H. House, John C. Keyser, Foundations of Physically Based Modeling and Animation, CRD Press, 2017 (Required)

Other Equipment

- OpenFrameworks C++ Development environment available on Windows, Mac and Linux (free)
- Houdini (Apprentice Student Edition) (free)
- Maya Educational Version (free)
- Student is required to have a reasonably fast laptop or desktop computer capable of running 3D software and development tools.

Grading

Exams, Assignments, and Projects

- Programming Projects (minimum of 2)
- Engagement (includes participation, attendance and class presentations)
- Homework and Labs (mostly completed in class)
- Final Project (includes code prototype and live presentation)

Item	% in Final Grade
Programming Projects	30%
Engagement/Participation	10%
Homework and Labs	30%
Final Project	30%

Grading Table

Total Grade	Letter Grade
97% and above	A plus
93% to 96%	A
90% to 92%	A minus
87% to 89%	B plus
83% to 86%	B
80% to 82%	B minus
77% to 79%	C plus
73% to 76%	C
70% to 72%	C minus

67% to 69%	D plus

Total Grade	Letter Grade
63% to 66%	D
60% to 62%	D minus
59% and below	F

Extra-credit and Reworks

No additional extra credit assignments or rework opportunities will be given.

Late Submission

Late submissions within 24 hours will be deducted 10% of its final grade. Submissions over 24 hours late will have 20% grade deducted. Late submissions over 2 days will not be accepted.

Laptop and Cell Phone Policy

With exception of labs that are completed in class, laptops are only permitted for taking notes for the class. Cell phones are not permitted to be used in class unless required to login into the SJSU system.

Attendance

Class attendance is required to gain maximum benefit from the course material. Students not attending either of the first two classes will be dropped to make room for students on the waiting list. Attempting to get marked as present (by having someone else attend in your place or using technological deceptions) will be considered academic dishonesty and at a minimum will result in you getting dropped from the course.

Engagement

Students are expected to fully participate in class sessions (in-person or online) by asking questions and contributing to class discussions. Classes given online are considered “live” classes which require the same level of engagement on as in-person classes. There will be opportunities for students to present homework solutions and/or projects in the classroom (in addition to the final project, which has a required presentation) and should be prepared to present at least two (2) times during the semester.

Course Content Policy

The class materials (including any lecture slides, notes, videos and PDF files) are protected by copyright. It is illegal to copy or distribute the class materials without permission from the instructor. There is no photography allowed (including mobile phone cameras) or recording of the lectures permitted without permission of the instructor.

Grading Policy

The University Policy S16-9, Course Syllabi (http://www.sjsu.edu/senate/docs/S16-9.pdf) requires the following language to be included in the syllabus:

“Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally three hours per unit per week) for instruction, preparation/studying, or

course related activities, including but not limited to internships, labs, and clinical practice. Other course structures will have equivalent workload expectations as described in the syllabus."

For homework and project solutions, only algorithms and mathematical methods (inclusive of the textbook) will be accepted. Students must implement their solutions using the tools specified in the assignment. ChatGPT or AI-based programming assistance can be used as a reference to look up functions or find examples (which often contain errors), but the student is required to develop their own unique solution to the problem. Any submitted work that doesn't meet these requirements will not be accepted and the student will not receive credit for the assignment.

University Policies

Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs' Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/. Make sure to review these policies and resources.

Tentative Schedule and Topics

Date	Topic	Reference	Note
1/27	Overview + Math Review		
1/29	Math Review (Linear Algebra)		
2/3	Foundations of Simulation		
2/5	3D Motion		
2/10	Basic Collisions		
2/12	Collisions with polygons		
2/17	Particle Systems		
2/19	Particle System Choreography		
2/24	Interacting Particles		
2/26	Spatial Data Structures and Astronomical Simulation		
3/3	Flocking Systems		
3/5	Ray Marching		
3/10	Ray March Primitives and Heightfields		
3/12	2D Fractals - Mandelbrot		

3/17	3D Fractals	
3/19	Numerical Integration	
3/24	Springy Objects	
3/26	Springy Collision Detection	
3/31	Spring Break	
4/2	Spring Break	
4/7	Lattice Deformation and Cloth	
4/9	Simulated Clothing	
4/14	Student Presentations	Project Topic Due
4/16	L-Systems Grammar	
4/21	L-Systems Lab (Houdini)	
4/23	Fluid Simulation (Math Foundations)	
4/28	Smoothed Particle Hydrodynamics	
4/30	Advanced Topic 1 or makeup	
5/5	Advanced Topic 2 or makeup	
5/7	Final Presentations	Final Project Content Due
5/12	Final Presentations (last day of class)	