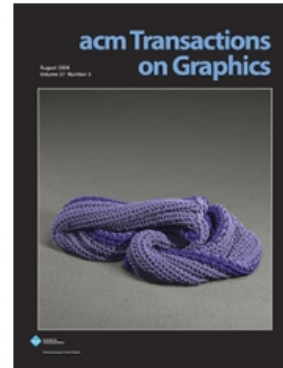
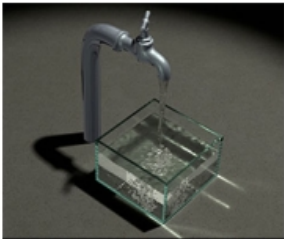
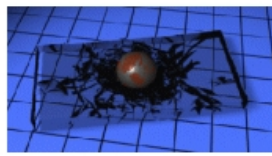


CSCI 520 Computer Animation and Simulation

Spring 2021



Spring 2021, Monday and Wednesday, **2:00-3:50**,
online on zoom



Instructor: [Jernej Barbic](#)
Office: online on Zoom
Office hours: Wednesday 4:00
- 5:00
Email: jnb@usc.edu

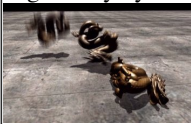
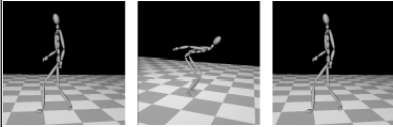
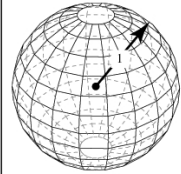
TA: Mianlun Zheng
Office: online on
Zoom
Office hours: Tue 3-
5pm
Email:
mianlunz@usc.edu
Grader: TBA


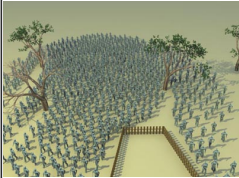

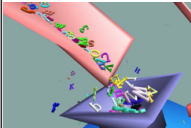
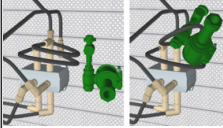
Introduction and Purposes

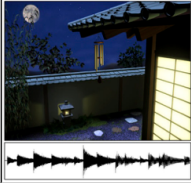
This course introduces students to computer animation and related simulation techniques, as applicable to computer games, virtual reality systems, and film special effects. Efficient numerical methods for simulating a variety of visually interesting physical phenomena will be discussed in the context of both interactive and offline simulation. Topics include deformable objects (solids, cloth), fluids, character rigging, quaternions, inverse kinematics, motion capture, sound simulation, collision detection, haptics, rigid body dynamics, and GPU programming.

Schedule | [Prerequisites](#) | [Readings](#) | [Assignments](#) | [Grading](#) | [Class participation](#) | [Academic Integrity](#)

Date	Topic	Reading, slides, and other material	Notes
Mon Jan 18 2021	No class (Martin Luther King Day)		
Wed Jan 20	Overview of computer animation and simulation 	Course slides	
Mon Jan 25	Overview of computer animation and simulation		
Wed Jan 27	Primer on numerical simulation and linear algebra for graphics	D. Baraff and A. Witkin: Physically Based Modeling , course notes , SIGGRAPH 2001	
Mon Feb 1		Helper slides for hw1 (jello cube) 6X-BW OpenGL "Hello world" application (with GLUT) Makefile (Mac OS X) OpenGL Red Book, Chapters 1-3 CMU slides on OpenGL CMU slides on OpenGL shading CMU slides on texture mapping OpenGL Red Book, Chapters 4 (Color), 5 (Lighting), 9 (Texture Mapping)	

Wed Feb 3	Structured deformable objects: cloth 	Slides (thanks to Andy Pierce, USC REU) D. Baraff and A. Witkin: Large steps in cloth simulation , SIGGRAPH 1998	Assignment 1 out
Mon Feb 8	Structured deformable objects: FEM 	M. Mueller and M. Gros: Interactive virtual materials , Graphics Interface 2004 J. Barbic: Real-time Reduced Large-Deformation Models and Distributed Contact for Computer Graphics and Haptics , PhD thesis, 2007 (pages 33-42) M. Mueller and co-organizers: Real-time physics , course notes, SIGGRAPH 2008 (pages 43-51) S. Capell, S. Green, B. Curless, T. Duchamp, Z. Popovic: Interactive Skeleton-Driven Dynamic Deformations , SIGGRAPH 2002	
Wed Feb 10	Rigid body dynamics 	D. Baraff and A. Witkin: Physically Based Modeling, course notes (the chapter on Rigid Body Dynamics), SIGGRAPH 2001	
Mon Feb 15	No class (President's Day)		
Wed Feb 17	Keyframe Animation 	Lecture slides	
Mon Feb 22	Motion capture 	Motion capture slides Jessica Hodgins's slides on motion capture J. Lee, J. Chai, P. Reitsma, J. Hodgins, N. Pollard: Interactive Control of Avatars Animated with Human Motion Data , SIGGRAPH 2002 J. Barbic, A. Safonova, J. Pan, C. Faloutsos, J. Hodgins, N. Pollard: Segmenting Motion Capture Data into Distinct Behaviors , Graphics Interface, 2004	
Wed Feb 24	Quaternions 	Course slides version for printing Ken Shoemake: Animating rotation with quaternion curves , SIGGRAPH 1985 Alan H. Barr, Bena Currin, Steven Gabriel, John F. Hughes: Smooth interpolation of orientations with angular velocity constraints using quaternions , SIGGRAPH 1992	Assignment 1 due Assignment 2 out
Mon Mar 1	Inverse Kinematics 	Rick Parent's slides on Inverse Kinematics Chris Welman: Inverse Kinematics and Geometric Constraints for Articulated Figure Manipulation , M.S. Thesis, Simon Fraser University, 1993	
Wed Mar 3	Character Rigging 	Ladislav Kavan, Steven Collins, Jiří Žára, Carol O'Sullivan: Geometric Skinning with Approximate Dual Quaternion Blending , ACM Transaction on Graphics, 27(4), 2008	
	Facial Animation	Ming Lin's course slides on facial animation Digital Emily video Video on	

Mon Mar 8		paired muscles Jun-yong Noh, Ulrich Neumann: A Survey of Facial Modeling and Animation Techniques , University of Southern California E. Sifakis, I. Neverov and R. Fedkiw: Automatic Determination of Facial Muscle Activations from Sparse Motion Capture Marker Data , SIGGRAPH 2005	
Wed Mar 10	Crowd Animation 	Craig W. Reynolds: Flocks, herds and schools: A distributed behavioral model , SIGGRAPH 1987. SIGGRAPH 1997 course notes A pseudocode implementation Matt Anderson, Eric McDaniel and Stephen Chenney: Constrained Animation of Flocks , Symposium on Computer Animation 2003 Crowd research at UNC Course slides on crowd animation , Ohio State University	
Fri Mar 12	Wellness day		
Mon Mar 15	Maya 	Maya tutorials at Lynda.com (free of charge access for USC students). Autodesk: The Art of Maya The Maya scene used in class.	
Wed Mar 17	Maya		Assignment 2 due
Mon Mar 22	Constraints and contact	D. Baraff and A. Witkin: Physically Based Modeling, course notes (the chapters "Constrained Dynamics" and "Collision and Contact"), SIGGRAPH 2001	
Tue Mar 23	Wellness day		
Wed Mar 24	Inverse Kinematics homework (theory and implementation)	Eigen example 1 Eigen example 2 Eigen example 3	Assignment 3 out
Mon Mar 29	Catch-up day		
Wed Mar 31	Collision detection 	Ming Lin's course slides on collision detection PDF Collision detection at UNC, Chapel Hill Ming Lin's course slides on bounding volume hierarchies and spatial partitioning PDF S. Gottschalk, M. Lin, D. Manocha: OBB-Tree: A Hierarchical Structure for Rapid Interference Detection , SIGGRAPH 1996 S. Quinlan: Efficient Distance Computation between Non-Convex Objects , ICRA 1994	
Mon Apr 5	Catch-up day		
Wed Apr 7	Wellness day		
Mon Apr 12	Haptics 	F. Conti's haptics slides: Introduction to Haptics K. Salisbury and F. Conti: Haptic Rendering: Introductory Concepts , IEEE Computer Graphics, 2004 (a survey) M. Lin and M. Otaduy: Recent Advances in Haptic Rendering & Applications , SIGGRAPH 2005 Course Notes J. Barbic and D. James: Six-DoF Haptic Rendering of Contact between Geometrically Complex Reduced Deformable Models , IEEE Transactions on Haptics 2008	
Wed Apr			Assignment

14	Guest lecture: TBA		3 due
Fri Apr 16	Background reading: Sound simulation 	J. O'Brien, C. Shen, and C. Gatchalian: Synthesizing Sounds from Rigid-Body Simulations , SCA 2002	
Mon Apr 19	Fluids (Navier-Stokes) 	J. Stam: Stable Fluids , SIGGRAPH 1999 Stable Fluids presentation	
Wed Apr 21	Simulation on programmable graphics hardware (CUDA) 	Nvidia's CUDA Trefftz and Wolffe: Tutorial on CUDA (modified version; used in class) OpenCL J. Georgii, R. Westermann: Mass-spring systems on the GPU	
Thu Apr 22	Wellness day		
Mon Apr 26	Computer Animation Engines	Slides Unity Unreal Engine Havok Physics Open Dynamics Engine (ODE) Vega FEM	
Wed Apr 28	Review for exam		
Mon May 10	Final exam	Online on Zoom	

Prerequisites

- A grade of at least B in CS420 or CS580, or explicit permission of instructor. If you took a similar course at another university, contact the instructor.
- Familiarity with calculus, linear algebra, and numerical computation
- C/C++ programming skills

Readings

There is no required textbook. Selected articles and course notes will be made available online.

A good reference on computer animation:

- Rick Parent: **Computer Animation, Second Edition: Algorithms and Techniques**, Second edition, Publisher: Morgan Kaufmann, ISBN: 9780125320009

A reference book on OpenGL is recommended for help with the homeworks:

- Dave Shreiner: **OpenGL Programming Guide: The Official Guide to Learning OpenGL, Versions 3.0 and 3.1**, Seventh edition, Publisher: Addison-Wesley Professional, ISBN: 9780321552624

Assignments

There will be three programming homework assignments in C/C++ and OpenGL, related to the material covered in class. Please see the schedule for links to assignments and due dates. All assignments must be done **individually**.

Grading

- Assignments: 21% each (63% total)
- Final exam: 37%

All assignments must be completed to pass the course. The assignments will have a small amount of extra credit. Students must take the final exam to pass the course.

Late policy: Programming assignments should be turned in by midnight on the day they are due. A total of **three late days** may be taken during the semester on programming assignments. For example, you can use one late day on the second assignment, and two on the third assignment. All days are counted, including any weekends and holidays, as follows:

Less than 24 hours late = 1 late day, 24-48 hours late = 2 late days, 48-72 hours late = 3 late days, and so on.

The flexibility provided by the late days is intended to get you through the time where all your classes just happen to have assignments due on the same day. Beyond the three late days, there will be a penalty of 10% of the value of the assignment / day. Exceptions will be granted only under most dire circumstances and must be discussed with and approved by the instructor at least one week in advance. Assignment and exam grading may be discussed within three weeks of them being returned to the students.

Academic integrity

All students are expected to maintain the utmost level of academic integrity. Do not copy any parts of any of the assignments from anyone. Do not look at other students' code, papers, assignments or exams. The university policies on academic conduct will be applied rigorously, and the USC Office of Student Judicial Affairs and Community Standards will be notified.

Statement on Academic Conduct and Support Systems

Academic Conduct

Plagiarism - presenting someone else's ideas as your own, either verbatim or recast in your own words, is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards, <https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/>. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct/>.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity <http://equity.usc.edu/> or to the Department of Public Safety <http://capsnet.usc.edu/departments/public-safety/online-forms/contact-us>. This is important for the safety whole USC community. Another member of the university community -- such as a friend, classmate, advisor, or faculty member -- can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men <http://www.usc.edu/student-affairs/cwm/> provides 24/7 confidential support, and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute <http://dornsife.usc.edu/ali>, which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information <http://emergency.usc.edu/> will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.

Statement for Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.-5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.