Sp18 - PHYSICAL SIMULATION (51810)

Jump to Today

Physical Simulation for Computer Graphics

CS 395T (51810)

Essential Information

Instructor:
Contact:
Location:
Time:
Office Hours:

Course Piazza:

Etienne Vouga
evouga@cs.utexas.edu
GDC 4.302
2:00 — 3:30 T & Th
4:00 — 5:00 M & W
GDC 5.508
here (http://piazza.com/utexas/spring2018/cs395t)

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Course Summary: An increasingly important sub-area of computer graphics is physics-based simulation: such simulations are used by movie studios for creating realistic special effects, game engines like Bullet and ODE, interactive design tools for architecture and 3D printing, tools for studying problems in biology and soft-matter physics, etc. This project-oriented course will introduce you to the key concepts and algorithms for simulating physical systems: starting from the ground up with particle systems and mass-spring networks, we will move on to cover topics such as rigid and elastic bodies, collisions, cloth, and fluids.

Prerequisites: Multivariable differential calculus; linear algebra; comfortable working knowledge of C++. The Computer Graphics graduate class will cover the latter two prerequisites, but knowledge of computer graphics is not itself a requirement. The course is intended for CS students curious about combining CS with physics, but does not assume an existing strong physics background.

Required Textbooks: None.

Recommended Textbooks: House and Keyser, Foundations of Physically Based Modeling and Animation.

Assignments and Grading: The course includes one written worksheet, three programming projects, and one final project; the final grade for the course will be computed based on performance on these assignments alone. There will be no final exam. Your final grade will include pluses and minuses. The five projects and final grade breakdowns are:

- **Math Review Worksheet (10%):** Physical simulation relies heavily on multivariable differential calculus and linear algebra machinery such as inner product spaces. Since it may have been several years since you've studied these subjects, this worksheet will review that knowledge.
- **Universe of Goo (20%):** You will implement an interactive 2D application similar to the popular indie game *World of Goo*. In addition to mass-springs system, in this project you will implement rigid bodies, ropes, several different numerical time integrators, and rudimentary collision response.
- **Seveneves (20%):** Neil Stephenson's novel *Seveneves* predicts that if the moon exploded, pieces would rain down on Earth and end all life. In this project, you will write a program that verifies (or debunks) this scenario by simulating rigid bodies with collisions and impact.
- **Virtual Catwalk (20%):** This project is focused on cloth simulation, and the interaction of cloth with rigid bodies. You will write a program that predicts how various clothing would look when draped on a moving, virtual mannequin.

Goldenthal et al '07

- **Final Project (30%):** For the final project, you have free reign to show off the skills you have learned in the course: you might implement one of the topics discussed in lectures that's not covered by the projects above, or substantially expand one of your existing applications, or research and implement an algorithm not covered in class at all.

Each project, except for the final project, will be split into **two milestones** with separate due dates; each milestone will be worth half of the total project grade (12.5% of the course grade). The second milestone will use and expand on the same code you write for the first milestone.

Please see the schedule below for the due dates of the different project milestones.

With the exception of the final project, each milestone will consist of two components: a **technical component**, worth 100% of the project grade, where you must implement specific features detailed in the project specification, and an optional **creative component**, worth up to 15% extra credit, for showing off how to use the features and themes of the project in a flashy, aesthetic, creative, and fun way.

Due Dates, Lateness, and Late Days: Each programming assignment is due by 1:59 PM (before class) on the dates listed in the schedule below. Each project specification will include details for how to submit that project. For every day that a milestone is turned in late, rounded up to the nearest day, one letter grade (10%) will be deducted from the total milestone grade.

We all know that sometimes unforeseen events disrupt the best-laid plans: an assignment turns out to take a lot more time than you expected, you have to spend a lot of time studying for an exam in a different course,

you need to travel to an interview, etc. Some leniency has therefore been built into the above policy: each student begins the semester with **three late days**. The first three times a letter grade would be deducted per the above policy, that student loses a late day instead. Please plan ahead: other than the three late days, ***no exceptions*** will be made to the lateness policy, except in the case of documented medical emergency or as mandated by university policy. *Plan ahead!*

Examples: An assignment is due on Friday, and Alice turns in the assignment at 2:01 PM; Bob turns it in at 9:00 PM; and Charles at 3:00 PM on Saturday. Alice and Bob will both be charged a late day, or if they have no late days remaining, will lose 10% of the project grade. Charles will lose two late days, or one late day and 10%, or 20%, depending on how many late days he has remaining.

It is courteous, but not required, to inform the instructor and TA if you intend to turn in a project late using late days.

Formal Collaboration: You are allowed (but not required) to work on each assignment in self-selected (and self-managed) teams of two. If you work in a team, you must submit, with each assignment, an individual collaboration report stating, from your perspective, how much and which parts of the project each student contributed to. Discrepancies will be investigated by the instructor, and credit for the project will be distributed in proportion to each student's contribution.

Informal Collaboration and Academic Honesty: You are allowed, and encouraged, to discuss the projects with your classmates, to work together on understanding the theory and math involved in the projects, to help each other debug, etc. You may also use Internet resources like Stackoverflow to get help on the math and theory, or to ask generic questions about C++, calculus, or physics. That said, ***the code submitted by each team must be their own***, except for a) "starter code" provided by the instructor, and b) external libraries explicitly approved by the instructor.

If in doubt, please contact the instructor. Violations of this policy will be reported to Student Judicial Services.

CS Lab Account: You must obtain an account for the CS department computer lab. Visit this website to request an account: **https://apps.cs.utexas.edu/udb/newaccount/** **(https://apps.cs.utexas.edu/udb/newaccount/)** . (If you had an account the previous semester it should renew automatically.) Accounts take at least a day to become active, so please request your account as soon as possible so that it is available in time for the first assignment. Please obtain an account even if you intend to complete the assignments on your personal computer: all grading will be done on the CS lab machines and it is ***your responsibility to ensure your code runs on these machines***.

Piazza: The best way to get in touch with the instructor and TA outside of office hours is via the Piazza page linked at the top of the syllabus. Important announcements and clarifications about the assignments will also be posted to Piazza, so please create an account and check in regularly.

Students with Disabilities: The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259.

Some Final Advice: Writing working simulation code is very rewarding, but also challenging and at times frustrating. To get the most out of this course,

- **Start Early:** Yes, every professor in every computer science class has told you the same thing. Simulation code can be particularly tricky to debug, since it's not always immediately obvious whether or not code is correct, or whether a bug is due to wrong code or wrong math. By starting early, you have plenty of time to fix things if they go wrong.
- **Get Help:** Double-check your math formulas with your classmates; take advantage of the opportunity to work in teams; come to office hours for help deriving formulas, finding bugs, or even just to check whether you're on the right track.

Schedule: A tentative schedule of lecture topics is listed below.

Course Summary:

Date	Details	
Tue Jan 16, 2018	Intro to Physical Simulation; DOFs and Configuration Spaces (https://utexas.instructure.com/calendar?event_id=1269973&include_contexts=course_1214542)	2pm to 3:30pm
Thu Jan 18, 2018	Inner Product Spaces (https://utexas.instructure.com/calendar?event_id=1269974&include_contexts=course_1214542)	2pm to 3:30pm
Tue Jan 23, 2018	Differential Calculus Review (https://utexas.instructure.com/calendar?event_id=1269975&include_contexts=course_1214542)	2pm to 3:30pm
Thu Jan 25, 2018	Mass-Spring Systems (https://utexas.instructure.com/calendar?event_id=1269976&include_contexts=course_1214542)	2pm to 3:30pm
Tue Jan 30, 2018	Time Integrators I; Newton's Method (https://utexas.instructure.com/calendar?event_id=1269977&include_contexts=course_1214542)	2pm to 3:30pm
Thu Feb 1, 2018	Math Worksheet (https://utexas.instructure.com/courses/1214542/assignments/4282176)	due by 1:59pm
	Time Integrators II: What Does "Physically Correct" Even Mean? (https://utexas.instructure.com/calendar?event_id=1269978&include_contexts=course_1214542)	2pm to 3:30pm
Tue Feb 6, 2018	The Time Integration Recipe: Hamilton's Principle I (https://utexas.instructure.com/calendar?event_id=1269979&include_contexts=course_1214542)	2pm to 3:30pm
Thu Feb 8, 2018	The Time Integration Recipe: Hamilton's Principle II (https://utexas.instructure.com/calendar?event_id=1269980&include_contexts=course_1214542)	2pm to 3:30pm

Date	Details	
Tue Feb 13, 2018	Universe of Goo Milestone I (https://utexas.instructure.com/courses/1214542/assignments/4282177)	due by 1:59pm
	Constrained Optimization Overview (https://utexas.instructure.com/calendar?event_id=1269981&include_contexts=course_1214542)	2pm to 3:30pm
Thu Feb 15, 2018	Constraints in Physical Simulations (https://utexas.instructure.com/calendar?event_id=1269982&include_contexts=course_1214542)	2pm to 3:30pm
Tue Feb 20, 2018	2D Rigid Bodies (https://utexas.instructure.com/calendar?event_id=1270030&include_contexts=course_1214542)	2pm to 3:30pm
Thu Feb 22, 2018	3D Rigid Bodies I, or, The Terror of 3D Rotations (https://utexas.instructure.com/calendar?event_id=1270031&include_contexts=course_1214542)	2pm to 3:30pm
Tue Feb 27, 2018	Universe of Goo Milestone II (https://utexas.instructure.com/courses/1214542/assignments/4282239)	due by 1:59pm
	3D Rigid Bodies II: Equations of Motion (https://utexas.instructure.com/calendar?event_id=1270032&include_contexts=course_1214542)	2pm to 3:30pm
Thu Mar 1, 2018	Collisions I: The Penalty Method (https://utexas.instructure.com/calendar?event_id=1270033&include_contexts=course_1214542)	2pm to 3:30pm
Tue Mar 6, 2018	External Forces and Impulses (https://utexas.instructure.com/calendar?event_id=1270035&include_contexts=course_1214542)	2pm to 3:30pm
Thu Mar 8, 2018	Collisions II: Impulse Methods (https://utexas.instructure.com/calendar?event_id=1270036&include_contexts=course_1214542)	2pm to 3:30pm
Tue Mar 13, 2018	No Class (Spring Break) (https://utexas.instructure.com/calendar?event_id=1270037&include_contexts=course_1214542)	2pm to 3:30pm
Thu Mar 15, 2018	No Class (Spring Break) (https://utexas.instructure.com/calendar?event_id=1270038&include_contexts=course_1214542)	2pm to 3:30pm
Tue Mar 20, 2018	Elastic Bodies I: Rubber Bands (https://utexas.instructure.com/calendar?event_id=1270039&include_contexts=course_1214542)	2pm to 3:30pm
Thu Mar 22, 2018	Elastic Bodies II: Rubber Sheets (https://utexas.instructure.com/calendar?event_id=1270040&include_contexts=course_1214542)	2pm to 3:30pm

Date	Details	
Tue Mar 27, 2018	Seveneves Milestone I (https://utexas.instructure.com/courses/1214542/assignments/4282241)	due by 1:59pm
	Elastic Bodies III: Rubber Beams (https://utexas.instructure.com/calendar?event_id=1270041&include_contexts=course_1214542)	2pm to 3:30pm
Thu Mar 29, 2018	Elastic Bodies IV: Rubber Plates (https://utexas.instructure.com/calendar?event_id=1270042&include_contexts=course_1214542)	2pm to 3:30pm
Tue Apr 3, 2018	Continuous-time Collision Detection (https://utexas.instructure.com/calendar?event_id=1270044&include_contexts=course_1214542)	2pm to 3:30pm
Thu Apr 5, 2018	Seveneves Milestone II (https://utexas.instructure.com/courses/1214542/assignments/4282243)	due by 1:59pm
	Cloth Simulation (https://utexas.instructure.com/calendar?event_id=1270045&include_contexts=course_1214542)	2pm to 3:30pm
Tue Apr 10, 2018	Virtual Catwalk Milestone II (https://utexas.instructure.com/courses/1214542/assignments/4282246)	due by 1:59pm
	Vibration Modes and Model Reduction (https://utexas.instructure.com/calendar?event_id=1270046&include_contexts=course_1214542)	2pm to 3:30pm
Thu Apr 12, 2018	Virtual Catwalk Milestone I (https://utexas.instructure.com/courses/1214542/assignments/4282244)	due by 1:59pm
	Introduction to Fluids (https://utexas.instructure.com/calendar?event_id=1270047&include_contexts=course_1214542)	2pm to 3:30pm
Tue Apr 17, 2018	Eulerian Fluids (https://utexas.instructure.com/calendar?event_id=1270048&include_contexts=course_1214542)	2pm to 3:30pm
Thu Apr 19, 2018	Introduction to the Laplacian (https://utexas.instructure.com/calendar?event_id=1270049&include_contexts=course_1214542)	2pm to 3:30pm
Tue Apr 24, 2018	Heat Flow and Diffusion (https://utexas.instructure.com/calendar?event_id=1270050&include_contexts=course_1214542)	2pm to 3:30pm
Thu Apr 26, 2018	Soap Films (https://utexas.instructure.com/calendar?event_id=1270051&include_contexts=course_1214542)	2pm to 3:30pm
Tue May 1, 2018	TBD (Slack Day) (https://utexas.instructure.com/calendar?event_id=1270052&include_contexts=course_1214542)	2pm to 3:30pm

Date	Details	
Thu May 3, 2018	TBD (Slack Day) (https://utexas.instructure.com/calendar?event_id=1270053&include_contexts=course_1214542)	2pm to 3:30pm
Fri May 4, 2018	Final Project (https://utexas.instructure.com/courses/1214542/assignments/4282247)	due by 11:59pm