



CS 888 – Physics-Based Animation Winter 2023 Course Outline

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Office Hours: TBD, check Piazza

Class Date/Time/Location: Thurs 2:30pm-5:20pm, DC 2568

First Class: Thurs, January 12, 2023

Piazza Course Sign-Up Link: <https://piazza.com/uwaterloo.ca/winter2023/cs888>

Piazza Course Home Page: <https://piazza.com/uwaterloo.ca/winter2023/cs888/home>

LEARN Course Website: <https://learn.uwaterloo.ca/d2l/home/868497>

Summary: This seminar-style graduate course in computer graphics will cover computational modeling and simulation techniques for a range of physical phenomena. These techniques have become indispensable tools for the generation of both realistic and fantastic animations for modern visual effects films and computer games, from Angry Birds to Avatar and Moana to World of Goo; they also find diverse applications in engineering, biology, robotics, applied mathematics, and beyond. The course will consist of paper presentations and discussions, a major course project, and weekly paper reviews. It will consider key papers encompassing a variety of materials, potentially including:

- Rigid objects
- Hair and flexible rods
- Cloth and thin shells
- Volumetric deformable materials, e.g., flesh, rubber, etc.
- Fracture and tearing

- Smoke and fire
- Liquids
- Collision processing & constraints

Along the way, we will encounter and employ a variety of numerical, computational, and geometric techniques, such as time integration, finite difference/volume/element methods, constrained optimization, continuum mechanics, level set methods, triangle meshes, particles, and more. The course will be structured in the style of a seminar: students will take turns presenting papers, followed by a group discussion of the relative merits of the paper in question. Students are expected to read each paper sufficiently carefully as to participate in class discussions, and submit a short summary/review of one paper per week. There will also be a major course project, which will give you the opportunity to dive in deeply and implement a simulation technique for the physical phenomenon (or phenomena) of your choice. There will also be a small number of traditional lectures to lay some groundwork.

Course Objectives: Students will...

- Develop familiarity with a range of mathematical and computational techniques in physics-based animation, sufficient to begin pursuing research in this area.
- Implement a non-trivial physics-based simulation technique to animate the phenomenon of your choice, based on published literature.
- Gain experience reading/evaluating/discussing research papers
- Practice giving technical presentations.

Grade Breakdown:

- Course Project: 40%
- Paper Presentations: 25%
- Weekly Paper Reviews/Summaries: 20%
- Discussion Participation: 15%

Rough Schedule of Topics:

- Week 1 (Jan 12): Introductory Lecture
- Week 2 (Jan 19): Rigid bodies
- Week 3 (Jan 26): Deformables
- Week 4 (Feb 2): Cloth & Shells
- Week 5 (Feb 9): (Re)Meshing
- Week 6 (Feb 16): Collisions & Constraints
- Week 7 (Feb 23): Reading Week (No class)
- Week 8 (March 2): Hair & Rods
- Week 9 (March 9): Smoke & Fire
- Week 10 (March 16): Liquids
- Week 11 (March 23): Fluid-solid interaction
- Week 12 (March 30): Fracture & Cutting or Project Presentations
- Week 13 (April 6): Project Presentations

Textbook: There is no required textbook. Possibly relevant and entirely optional books may include: “Game Physics” (Davis library), “Fluid Simulation for Computer Graphics” (Davis library), “Real-time collision detection” (available online through the Waterloo library). Additional relevant resources (books, websites, papers) will be made available through Piazza.

Prerequisites: Enthusiasm for computer graphics and animation/simulation is paramount, but knowledge of linear algebra and multivariable calculus are also required. Some experience with numerical computing (e.g., CS370/371, CS475) and computer graphics (e.g., CS488) is recommended. Familiarity with numerical methods for ODE/PDE and optimization may also be helpful (e.g., CS770/CS778/etc) but is not required.

Group Work: All submitted work must be done independently, unless you choose to do the course project with a partner.

Coursework Submission and Grades: All course work (project, paper summaries) should be submitted via the LEARN (<https://learn.uwaterloo.ca/d2l/home/434139>) electronic submission (DropBox) functionality. Late submissions will not be accepted without special permission of the instructor. Grades will be made available electronically through LEARN.

Academic Integrity: In order to maintain a culture of academic integrity, member of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. Refer to Academic Integrity website (<https://uwaterloo.ca/academic-integrity/>) for details.

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70 (<https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-70>) Student Petitions and Grievances, Section 4. When in doubt, please contact the department’s administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g. plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71 (<https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-71>) Student Discipline. For typical penalties check Guidelines for the Assessment of Penalties (<https://uwaterloo.ca/secretariat/policies-procedures-guidelines/guidelines/guidelines-assessment-penalties>).

Appeals: A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities: AccessAbility Services (<http://uwaterloo.ca/disability-services/>), located in the new addition to Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic

integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the office at the beginning of each academic term.

Mental Health: If you or anyone you know experiences any academic stress, difficult life events, or feelings like anxiety or depression, we strongly encourage you to seek support.

On-campus Resources:

- Campus Wellness <https://uwaterloo.ca/campus-wellness/>
- Counselling Services: counselling.services@uwaterloo.ca / 519-888-4567 ext 32655 / Needles Hall North 2nd floor, (NH 2401)
- MATES: one-to-one peer support program offered by Federation of Students (FEDS) and Counselling Services: mates@uwaterloo.ca
- Health Services service: located across the creek from Student Life Centre, 519-888-4096.

Off-campus Resources:

- Good2Talk (24/7): Free confidential help line for post-secondary students. Phone: 1-866-925-5454
- Here 24/7: Mental Health and Crisis Service Team. Phone: 1-844-437-3247
- OK2BME: set of support services for lesbian, gay, bisexual, transgender or questioning teens in Waterloo. Phone: 519-884-0000 extension 213

Diversity: It is our intent that students from all diverse backgrounds and perspectives be well served by this course, and that students' learning needs be addressed both in and out of class. We recognize the immense value of the diversity in identities, perspectives, and contributions that students bring, and the benefit it has on our educational environment. Your suggestions are encouraged and appreciated. Please let us know ways to improve the effectiveness of the course for you personally or for other students or student groups. In particular:

- We will gladly honour your request to address you by an alternate/preferred name or gender pronoun. Please advise us of this preference early in the semester so we may make appropriate changes to our records.
- We will honour your religious holidays and celebrations. Please inform of us these at the start of the course.
- We will follow AccessAbility Services guidelines and protocols on how to best support students with different learning needs.