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CSCI 595.02: ST: Game Physics Engines

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Special Topics in Computer Science: Game Physics Engine Development CSCI 491 and 595 Spring 2018 Syllabus

> Focused, hard work is the real key to success. Keep you eyes on the goal, and just keep taking the next step towards completing it. If you aren't sure which way to do something, do it both ways and see which works better.
>
> –John Carmack

Instructor Details

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Office Hours:	MW 15:00–16:00 , Interdisciplinary Science Building 406A *Or, by appointment.*

Prerequisites

Students taking this course are expected to have:

- Object oriented programming experience demonstrated by passing CSCI232 (Data Structures) or a similar course.
- An ability to modify and extend programs written in `C++`.
- Organizational skills and familiarity with computers sufficient to modify and build a `C++` repository.

- Maturity enough to self direct through projects and assignments.
- The ability to attend class.

Course Objectives

The course objective is to gain a working understanding of the physics commonly used in video games. The physics is drawn from the areas of *classical mechanics* relating to particles, collections of particles connected by springs, rigid body mechanics, collision detection, and contact physics. For the sake of game play, programmers often use techniques that enhance the experience - for example, increasing the gravitational acceleration for more lively responses, or modifying the way equations are integrated forward in time to allow faster frame rates. In this course we will study both the fundamental physics *and* the non-physical slights of hand needed to make play satisfying. A working knowledge of the physics will be assessed through impromptu exercises, written examinations and programming projects.

Student Outcomes

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

- capture physical processes with computational methods, and
- make game play enhancing modifications to those methods.
- apply knowledge of computing and mathematics appropriate to game engine physics.
- design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs.
- function effectively on teams to accomplish a common goal.
- communicate effectively with a range of audiences.

Textbook

This semester I'll be using the following text. You'll need to purchase a copy.

Game Physics Engine Development (Second Edition)
Ian Millington
CRC Press
2010

Online Resources

Please book mark the following online resources immediately:

- with the exception of the textbook, all course material will be made available online, through the University of Montana's Moodle system,
- the software repository for the textbook at this git repo.

Software

You'll need to have a `C++` compiler, the `gnu make` build system, OpenGL, and GLUT installed on your system. For your final project in the course, you may want a commercial physics engine, like the Unreal Engine 4. If acquiring or installing any of this presents a problem for you, *you may be in the wrong course*.

Course Format

This a hands-on course, structured around working through math problems on paper or on the white boards, and developing a series of projects. Projects are developed from a working code base found in the `Cyclone` physics engine, except the final project, which will allow students to use their choice of software tools. Our time together in the classroom will be spent as follows:

Board work We will begin each lecture by randomly selecting students to go to the board and demonstrate their work. This will take about 20 minutes. Based on the student's performance I will award the same grade to both the student and the group. This is done so that the group is responsible for each member's understanding. Rubric for assessment is on the course Moodle. While presenting, students may ask their group two questions that have once sentence answers.

Lecture After board work, I will lecture for about 40 minutes. Beyond the background theory, I will focus on working examples that are similar to the assigned work.

Group problem solving Finally, groups will form and have the remainder of the time, about 20 minutes, to work on their assignments. Groups will be of four students, randomly selected. Groups will be created three times during the semester, at more or less equal time increments.

Meeting Times/Place

Times: Tuesday, Thursday 11:00–12:20
Place: Social Science 362

Final Exam Time and Place

Time: 10:10-12:10, Thursday, May 10
Place: Social Science 362

Grading Policy

Grading scale

A	94-100
A-	90-93
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-82
D+	67-69
D	63-76
D-	60-62
F	0-59

Students achieving the numerical scores above are guaranteed the associated letter grade. However, if average performance is low, I may decide to assign a higher letter grade for a lower score; e.g. a B+ for a numerical score of 84.

Students taking the course pass/no pass are required to earn a grade of D or better in order to pass.

Assessments and weights

The following assessments will be used and weighted according to the values in the table to determine final grades.

Component	**Description**	**Weight** (491/595)
In-class problems	Problems worked on the board, by individual students. Assessed according to the rubric on the Moodle.	20/10%
Group work	Assessment of individual student performance at the board will be given to each member of the group the student is in.	20/30 %
Midterm	Test of your knowledge of material presented in class and projects. Inclusive of material presented since first day of class.	10/5%
Project	Use tools of your own choosing to develop a physics based game.	30/40%
Final Exam	Test of your knowledge of all material presented in class and projects. Inclusive of all material.	20/15%

Co-convening course

This course co-convenes, or involves both graduate (taking 595) and undergraduate (taking 491) students. The following aspects of the class format differentiate graduate and undergraduate experiences.

- the standard for the graduate student final projects are higher. This is true in terms of the final project's weight, and further elaborated in rubrics.
- the group work counts more for graduate students, forcing them to be responsible for every group member's understanding of the material. Groups will be structured such that graduate students are distributed across groups.
- time for interaction in class will allow groups to work in a structured way, with graduate students leading discussions.

Tentative schedule:

TUESDAY	THURSDAY
Jan 23rd **1** Introduction	25th **2** Particle Physics: Mathematics of Particles
30th **3** Particle Physics: The Laws of Motion	Feb 1st **4** Particle Physics: The Particle Physics Engine
6th **5** Project I: No lecture - work and presentation at the *end* of class.	8th **6** Mass Aggregate Physics: Adding General Forces
13th **7** Mass Aggregate Physics: Spring and Spring-like Things	15th **8** Mass Aggregate Physics: Hard Constraints
20th **9** Mass Aggregate Physics: The Mass Aggregate Physics Engine	22nd **10** Rigid Body Physics: The Mathematics of Rotations
27th **11** Rigid Body Physics: Law of Motion for Rigid Bodies	Mar 1st **12** Rigid Body Physics: The Rigid-Body Physics Engine
6th **13** Project II: No lecture - work and presentation at the *end* of class.	8th **14** **Midterm Exam**
13th **15** Project Milestone	15th **16** Collision Detection: Collision Detection
20th **17** Collision Detection: Generating Contacts	22nd **18** Contact Physics: Collision Resolution

TUESDAY	THURSDAY
27th *Spring Break*	29th *Spring Break*
Apr 3rd **19** Contact Physics: Resting Contacts and Friction	5th **20** Contact Physics: Stability and Optimization
10th **21** Contact Physics: Putting it all Together	12th **22** Project III: No lecture - work and presentation at the *end* of class.
17th **23** Further Topics in Physics: Physics in Two Dimensions	19th **24** Project IV: No lecture - work and presentation at the *end* of class.
24th **25** Padding for chapters that run long	26th **26** Padding for chapters that run long
May 1st **27** Project Presentations	3rd **28** Wrap up/Course Evaluations
8th **29** Study	10th **30** **Final Exam**

Attendance Policy

Attendance will not be taken. Students absent when called up to work problems on the board will be given a grade of 0%. Another team member will be selected to go to the board at random. Students informing the instructor of a valid reason for missing class *in advance*, via email, will not be called to the board. Valid reasons include family emergencies and illness. I may ask for documentation of absence (doctors note, death certificate, etc.).

Academic Integrity

All students must practice academic honesty. Academic misconduct is subject to an academic penalty by the course instructor and/or a disciplinary sanction by the University. All students need to be familiar with the Student Conduct Code. I will follow the guidelines given there. In cases of academic dishonesy, I will seek out the maximum allowable penalty. If you have questions about which behaviors are acceptable, especially regarding use of code found on the internet or shared by your peers, please ask me.

Disabilities

Students with disabilities may request reasonable modifications by contacting me. The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students. Reasonable means the University permits no fundamental alterations of academic standards or retroactive modifications.