NS 548 Computer Modeling of Physical Phenomena
Course Schedule

N.B.: The schedule below has not yet been adapted to the blended schedule of online and in-class meetings. Course readings may vary between course offerings.

Session 1: Overview I.

An overview of simulation packages, including Physlets, VPython, Phet simulations, and the Falstad simulations.

Session goal: Become aware of the various Physics simulations that are freely available on the Internet

***Assignment*:** Create a lesson plan or classroom activity, such as a virtual laboratory experiment, built around a Phet simulation

Reading Assignment for Session 2:

- Finkelstein, N., Perkins, K., Adams, W., Keller, K., Kohl, P., LeMaster, R., Podolefsky, N., and Reid, S. (2005). When learning about the real world is better done virtually: a study of substituting computer simulations for laboratory equipment. *Physical Review Special Topics: Physics Education Research,1,* 010103, 1-8.

Scripting Physlets: Force and motion using Animator.

Session goal: Start learning to script Physlet simulations

***Programming assignment*:** Modify an existing Physlet simulation, or create your own, to demonstrate a physics concept you discuss in your own classroom. The simulation should be based on the Animator Physlet.

Reading Assignment for Session 3:

- Cox, A., Belloni, M., Dancy, M. and Christian, W. (2003). Teaching thermodynamics with Physlets in introductory physics, *Phys. Educ. 38*, 433-440.

Session 3: Scripting Physlets II: Electric field; Optics.

Session goal: Continue learning to script Physlet simulations

***Programming assignment*:** Modify an existing Physlet simulation, or create your own, to demonstrate a physics concept you discuss in your own classroom. The simulation should be based on a Physlet other than the Animator Physlet.

Reading Assignment for Session 4:

- Dancy, M., Christian, W. and Belloni, M. (2002). Teaching with Physlets: Examples from Optics. *Phys. Teach., 40,* 494.

Session 4: Easy Java Simulations I - Modeling harmonic motion.

Session goal: Learn how to download and install the EJS package on your own computer. Work through chapter 1 of the EJS manual to become familiar with the EJS system.

***Programming assignment*:** Modify an existing EJS simulation, or create your own, to demonstrate a physics concept you discuss in your own classroom.

Session 5: Easy Java Simulations II – Modeling projectile motion

Session goal: Work through chapters 2 and 3 of the EJS manual to gain more insight into how to use EJS.

***Programming assignment*:** Modify an existing EJS simulation, or create your own, to create a simulation of projectile motion that you could use in your own classroom.

Reading assignment for Session 7:

- Poincaré, H. (2001). "Mathematical magnitude and experiment." *in Science and Hypothesis* New York: The Modern Library.

Session 6: Easy Java Simulations III – Modeling rotational motion.

Session goal: Use EJS to simulate rotational systems. Spend some time designing a simulation project using EJS.

***Programming assignment*:** Start your own simulation project.

Session 7: Easy Java Simulations IV – Modeling interactions

Session goal: To learn how to use EJS to model particle interactions, such as the interactions of objects with mass via gravity, or the interactions of objects with charge via Coulomb's law, or the behavior of an ideal gas.

***Programming assignment*:** Modify an existing EJS simulation, or create your own, to create a simulation of a system of particles that you could use in your own classroom.

Reading assignment for Session 8:

- Laws, P.W. (2004). A unit on oscillations, determinism and chaos for introductory physics students. *American Journal of Physics 72*, 446-452.
- Carnap, R. (1966) "Determinism and free will." In *An introduction to the philosophy of science*. New York: Dover Publications.

Session 8: Chaos I – An introduction to non-linear dynamics

Session goal: Becoming familiar with the concepts of non-linear dynamics and chaos. Modify the Mandelbrot set EJS program to create a Julia set program.

***Programming assignment*:** Continue your own simulation project.

Sections from Baker & Gollub: Chapter 1

Experiment: The forced harmonic oscillator

Simulation: Modeling the forced harmonic oscillator using EJS

Session 9: Chaos II - Modeling the forced harmonic oscillator

Session goal: Use EJS to model a forced harmonic oscillator, and use your simulation to investigate chaotic behavior.

***Programming assignment*:** Continue your own simulation project.

***Sections from Baker & Gollub*:** Sections 2.1, 2.2, optional 2.3

Experiment: The forced harmonic oscillator

Session 10: Chaos III - Modeling the double pendulum.

Session goal: Use EJS to model a double pendulum, and use your simulation to investigate chaotic behavior.

***Programming assignment*:** Continue your own simulation project.

Sections from Baker & Gollub: Chapter 3
Experiment: Demonstration of double pendulum; Paper clip pendulum in a magnetic field

Session 11: Chaos IV - Logistic maps and bifurcations
Session goal: To understand logistic maps and bifurcations.
Sections from Baker & Gollub: Chapter 4
Experiments: Fluid flow instabilities – Hele-Shaw patterns; Laplacian instabilities in electrochemical deposition
Project Presentations

There is no class on Monday June 18th, Bunker Hill Day

Session 12: Chaos V - Deterministic chaos continued.
Session goal: To understand more features of deterministic chaos.
Sections from Baker & Gollub: Chapter 5
Project Presentations

Session 13: Wrap-up
Final Exam.
Course evaluation.

Bibliography

Selections from primary sources
Poincaré, H. (2001). "Mathematical magnitude and experiment." *in Science and Hypothesis* New York: The Modern Library.

May, R.M. (1976). Simple mathematical models with very complicated dynamics. *Nature, 261,* 459-.

Selections from secondary sources
Hilborn, R.C. (2004). Sea gulls, butterflies, and grasshoppers: A brief history of the butterfly effect in nonlinear dynamics. *American Journal of Physics, 72*, 425-427.

Carnap, R. (1966) "Determinism and free will." In *An introduction to the philosophy of science*. New York: Dover Publications.

Selections from Physics Education Research Literature
Cox, A., Belloni, M., Dancy, M. and Christian, W. (2003). Teaching thermodynamics with Physlets in introductory physics, *Phys. Educ. 38*, 433-440.

Dancy, M., Christian, W. and Belloni, M. (2002). Teaching with Physlets: Examples from Optics. *Phys. Teach., 40*, 494.

Finkelstein, N., Perkins, K., Adams, W., Keller, K., Kohl, P., LeMaster, R., Podolefsky, N., and Reid, S. (2005). When learning about the real world is better done virtually: a study of substituting computer simulations for laboratory equipment. *Physical Review Special Topics: Physics Education Research,1,* 010103, 1-8.

Laws, P.W. (2004). A unit on oscillations, determinism and chaos for introductory physics students. *American Journal of Physics 72,* 446-452.