

Introduction to Engineering Modeling and Simulation Applications

Course coordinator: Eric W. Weisel, Ph. D.
6596 Main Street
Gloucester, VA 23061
(804) 694-3173 (Office)
(804) 854-5962 (Cell)
eweisel@werneranderson.com

Course description: This course will introduce a wide array of engineering modeling and simulation tools to give acquisition professionals a general understanding of key capabilities available to support design processes. The course will be delivered through lectures with supplemented out of class assignments, readings, and case studies. Upon completion, students should gain a general awareness of the wide range of M&S support available for DoD system designs.

Module learning objectives:

- E1 Describe basic structural mechanics M&S methods (General Awareness)
- E2 Describe basic computational fluid dynamics (CFD) M&S methods (General Awareness)
- E3 Describe basic dynamics and controls M&S methods (General Awareness)
- E4 Describe basic thermodynamics and heat transfer M&S methods (General Awareness)
- E5 Describe basic materials and fabrication M&S methods (General Awareness)
- E6 Describe basic acoustic and electromagnetic M&S methods (General Awareness)
- E7 Describe military platform systems engineering M&S methods (General Awareness)
- E8 Describe the basic computer architectures supporting engineering M&S methods (General Awareness)
- E9 Describe basic circuits and power systems M&S methods (General Awareness)
- E10 Describe basic information transfer M&S methods (General Awareness)
- E11 Describe the principles of networks applied to military applications
- E12 Describe basic terrestrial science M&S methods (General Awareness)
- E13 Describe basic human systems integration in engineering design and supporting M&S applications (General Awareness)
- E14 Describe basic principles of aerodynamics with applications to M&S (General Awareness)

Course assessment plan: Mid-term, final exams, homework assignments, and reading discussions

Course Outline

Lecture 1 Introduction to Engineering M&S

Tutorial Introduction to simulation software for engineering applications (Review MATLAB® & SIMULINK® Tutorials; http://www.mathworks.com/academia/student_center/tutorials/launchpad.html.)

Lecture 2 Using Computers for Engineering Design

Reading David Wangerin, Christopher Decoro, Luis M. Campos, Hugo Coyote, Isaac D. Scherson, "A Modular Client-Server Discrete Event Simulator for Networked Computers," *Proceedings of the 35th Annual Simulation Symposium*, IEEE Computer Society Washington, DC, 2002, last accessed on 31 December 2008 at <http://www.ics.uci.edu/~schark/simpaper.pdf>

Reading John J. Daly and Andreas Tolk, "Modeling and Simulation Integration with Network-Centric Command and Control Architectures," *Proceedings of the 2003 Fall Simulation Interoperability Workshop*, Orlando, Florida, 03F-SIW-121, September 2003, last accessed 28 February 2009, <http://www.sisostds.org/>.

Reading Kristin Giammarco, Michael Carlomusto, and J. D. Lock, "Development and analysis of integrated C4ISR architectures," *Defense Acquisition Review Journal*, August – November, pp 304-321, 2005, last accessed 28 February 2009, <http://www.dau.mil/pubs/arq/2005arq/2005arq-40/Giammarco.pdf>.

Reading Joseph A. Giampapa, Katia Sycara, Sean Owens, Robin Ginton, Young-Woo Seo, Bin Yu, Charles E. Grindle, and Michael Lewis, "Extending the ONESAF Testbed into a C4ISR Testbed," *Simulation*, Vol. 80, No. 12, pp. 681-691, 2004.

Simulation Assignment Heath, Chapter 1, Computer problem 1.10 (Floating point math problem); Experiment with the online interactive example (http://www.cse.uiuc.edu/iem/floating_point/quadratic_formula/)

Lecture 3 Differential Equations Overview

HW Review Review computer problem 1.10

Simulation Assignment In-Class example on slide 3.18 (student complete example outside of classroom)

Reading Y. F. Gao, "An implicit finite element method for simulating inhomogeneous deformation and shear bands of amorphous alloys based on the free-volume model," *Modelling and Simulation in Materials Science and Engineering*, vol. 14, pp. 1329-1345, 2006.

Reading Shawn Kenny, "Continuum Finite Element Methods to Establish Compressive Strain Limits for Offshore Pipelines in Ice Gouge Environments," *Proceedings of the 26th International Conference on Offshore Mechanics and Arctic Engineering*, San Diego, USA, 10-15 June, OMAE2007-29152, 2007, available at <http://www.ome.org/omeadatabase/ome07dbpa.htm>.

Lecture 4 Translational Systems

NPS Case Study Ship Shock Simulation: Survivability as an Integral Part of Ship Acquisition

Simulation Assignment Close, Chapter 4, MATLAB® Problem 4.15

Lecture 5 Block Diagrams and Computer Simulation

HW Review Review computer problem 4.15

Simulation Assignment Close, Chapter 4, MATLAB® Problem 4.18

NPS Case Study Finite Element Analysis for Reducing Acquisition Cost

Lecture 6 Rotational Mechanical Systems

HW Review Review computer problem 4.18

Simulation Assignment Close, Chapter 5, MATLAB® Problem 5.38

Lecture 7 Electrical Systems M&S

HW Review Review computer problem 5.38

Simulation Assignment Close, Chapter 6, MATLAB® Problem 6.41

Lecture 8 Electromechanical Systems

HW Review Review computer problem 6.41

NPS Case Study Life - Limiting Damage in Railguns: Role of Modeling and Simulation in Root Cause Analysis, Design and Acquisition

Reading T. Tsuchiya, Y. Kagawa, M. Doi, and T. Tsuji, "Finite element simulation of non-linear acoustic generation in a horn loudspeaker," *Journal of Sound and Vibration*, vol. 266, issue 5, pp. 993-1008, 2 October 2003.

Lecture 9 Thermal Systems

Simulation Assignment Close, Chapter 11, MATLAB® Problem 11.14

NPS Case Study The Importance of Heat Transfer Engineering in Making Knowledge Based Decisions by the Acquisition Community

NPS Case Study Thermo-mechanical Analysis of Directed Energy Weapons on Satellites - M&S with an Acquisition Perspective

Lecture 10 Fluid Dynamics and Modeling of Fluids Systems

HW Review Review computer problem 11.14

Simulation Assignment Close, Chapter 12, MATLAB® Problem 12.11

NPS Case Study Hurricane and Storm Damage Reduction System

NPS Case Study Flight Characteristics Data of Small Airplanes

Reading Chris L. Rumsey and James L. Thomas, "Application of FUN3D and CFL3D to the Third Workshop on CFD Uncertainty Analysis," *NASA TM-2008-215537*, November 2008, last accessed 28 Feb 2009, available at <http://fun3d.larc.nasa.gov/chapter-9.html#publications>.

Lecture 11 Modeling, Analysis, and Design

HW Review Review computer problem 12.11

NPS Case Study The Use of Modeling and Simulation to Assess Weapon System Performance

NPS Case Study On Control of Inverted Pendulum Like Systems

Reading D.E. Anderson, F.R. Oberman, T.B. Malone, C.C. Baker, "Influence of Human Engineering on Manning Levels and Human Performance on Ships" *Naval Engineers Journal*, vol. 109 Issue 5, pp 67 – 76, Association of Scientists and Engineers 33rd Annual Technical Symposium, 26 April 1996.

Reading Committee on Modeling and Simulation Enhancement for 21st Century Manufacturing and Acquisition, "Chapter 2. Modeling and simulation in defense acquisition," *Modeling and Simulation in Manufacturing and Defense Acquisition: Pathways to Success*, National Research Council, Washington D.C., last accessed on 09 March 2009, <http://www.nap.edu/openbook.php?isbn=0309084822>.

Reading Committee on Modeling and Simulation Enhancement for 21st Century Manufacturing and Acquisition, "Chapter 3. Lessons learned from commercial manufacturing," *Modeling and Simulation in Manufacturing and Defense Acquisition: Pathways to Success*, National Research Council, Washington D.C., last accessed on 09 March 2009, <http://www.nap.edu/openbook.php?isbn=0309084822>.

Reading Balqies Sadoun, "An efficient simulation scheme for testing materials in a nondestructive manner," *Information Sciences*, Vol 137, Issues 1-4, September 2001, pp. 43-51.

Lecture 12 Synthetic Natural Environment

NPS Case Study Ocean Modeling and Simulation for DoD Acquisition

Reading Paul K. Davis, James H. Bigelow, and Jimmie McEver, *Effects of Terrain, Maneuver Tactics, and C4ISR on the Effectiveness of Long-Range Precision Fires: A Stochastic Multiresolution Model (PEM) Calibrated to High-Resolution Simulation*, RAND, Santa Monica, CA, 2007, last accessed 28 February 2009, http://www.rand.org/pubs/monograph_reports/MR1138/. .

Reading R. Hillson and H.J. Shyu, "Modeling and Simulation Architecture for the Effects of Sound on the Marine Environment (ESME)," *Physical Oceanography: Annual Reports: FY04, Document No: N0001404WX20602*, Office of Naval Research, 2004, last accessed 28 February 2009, http://www.onr.navy.mil/sci_tech/32/reports/docs/po/04/pohillso.pdf.

Reading J.V. Candy and E.J Sullivan, "Sound velocity profile estimation: a system theoretic approach," *IEEE Journal of Oceanic Engineering*, Volume 18, Issue 3, pp. 240 – 252, Jul 1993.

References

See reference list in separate document