

# Syllabus for Introduction to Physics Based Modeling & Simulation

## Course name: Introduction to Physics-Based Modeling & Simulation

### 1) **Course coordinator / point of contact and contact information:**

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2) **Course description:** This course is intended for DoD non-technical acquisition professionals who do not have engineering or science degrees so that they can obtain a general understanding of key M&S capabilities necessary for design, analysis, and maintenance of engineering systems. The course will introduce basic concepts in the modeling of engineering systems. The steps involved in the idealization of systems to produce a “computable” model will be discussed. Examples will involve structural, thermal, fluid, and electrical aspects. Fundamental physical quantities such as rates of change, (e.g. acceleration, stress) and force will be defined heuristically. The simulation of simple physical processes (e.g. falling object) will be described and simple simulation algorithms will be described. No computer programming is required. Spatial discretization, finite difference and finite element methods will be introduced.

3) **Modules incorporated into Course:** 12 modules as described in the topics.

4) **ESRs that the course supports and the corresponding level of mastery.**

Basic understanding for ESR E-1 through E-5 as stated below:

a) ESR E-1: Structural Mechanics, Shock and Vibrations - Describe basic structural mechanics including stress-strain relations, buckling and fatigue, shock and vibration, and finite element methods in M&S.

b) ESR E2: Fluid Dynamics and Weapon System - Describe the basics of computational fluid dynamics for CFD application and use for M&S. Fluid dynamics of subsonic and supersonic weapons, warheads and their effects.

c) ESR E3: Dynamics and Control - Describe the basics of M&S in process and multi-physics (mechanical, electrical & hydraulic) based dynamic system controls.

d) ESR E4: Thermodynamics and Heat Transfer - Describe the fundamentals of thermodynamics and heat transfer with applications to M&S in engineering power cycles, propulsion and auxiliary system cycle analysis and design.

e) ESR E5: Materials and Fabrication - Describe the basic materials technology associated with manufacturing, welding and corrosion control. Have an introduction to composite, superconducting materials, and fiber optics as applied to M&S.

5) **Prerequisites assumed, and corresponding level of mastery.** None.

6) **Course maturity:** Not previously taught

7) **Number of contact hours and pace contemplated:** 4 hours lecture/week for 11 weeks for a quarter (Total 44 hours)

8) **Proposed Delivery modality:** Resident and/ or Distance Learning; Synchronous or Asynchronous

9) **Proposed references and texts:** Course notes will be provided

10) **Course learning objectives:**

- a) Understand basic concepts of system modeling and idealizations applied to physics-based engineering M&S
- b) Understand basic concepts of physical quantities of physics-based engineering M&S
- c) Understand basic equations of engineering physics applied to physics-based engineering M&S
- d) Understand basic concepts of engineering simulation applied to physics-based engineering M&S
- e) Understand basic concepts of simulation methods applied to physics-based engineering M&S

11) **Course Assessment Plan**

1. Mid-term and final exams
2. Homework assignments
3. Term paper

12) **Topic list by hour of instruction and reference.**

References include various basic texts in introductory engineering and numerical methods

Lecture 1 – The Design Process

Lecture 2 – What is Modeling & Simulation?

Lecture 3 – A Sample Simulation Problem

Lecture 4 – Fundamental Physical Quantities

Lecture 5 – Specifying Position

Lecture 6 – Specifying Position in Rectangular Coordinates

Lecture 7 – Time Dependence

Lecture 8 – Velocity

Lecture 9 – Average Speed

Lecture 10 – Instantaneous Speed

Lecture 11 – Instantaneous Rates of Change

Lecture 12 – Numerical Calculation of Rate of Change

Lecture 13 – Another Interpretation of Rate of Change

Lecture 14 – Another Important Rate of Change

Lecture 15 – Applied Forces

Lecture 16 – Newton's Laws

Lecture 17 – A Discussion of Systems of Units

Lecture 18 – Back to Newton's 2nd Law

Lecture 19 – Application of 2nd Law

Lecture 20 – Computing the Solution

Lecture 21 – Displaying the Solution

Lecture 22 – Introduction to Computers and Programming

Lecture 23 – Representation of Information on a Computer

Lecture 24 – Representation of Information on a Computer, Part 2  
Lecture 25 – Basics of CPU and RAM Operation  
Lecture 26 – Basics of Operating Systems  
Lecture 27 – Disk Storage and File System  
Lecture 28 – Elements of Computer Programming, Part 1  
Lecture 29 – Elements of Computer Programming, Part 2  
Lecture 30 – Elements of Computer Programming, Part 3  
Lecture 31 – Elements of Computer Programming, Part 4  
Lecture 32 – Elements of Computer Programming, Part 5  
Lecture 33 – A Simple Simulation Computer Program, Part 1  
Lecture 34 – A Simple Simulation Computer Program, Part 2  
Lecture 35 – Rates of Change, Revisited  
Lecture 36 – Stress  
Lecture 37 – Material Deformation & Strain  
Lecture 38 – Strain as a Derivative  
Lecture 39 – Partial Derivatives  
Lecture 40 – Complete State of Stress and Strain  
Lecture 41 – The Stress-Strain Relationship  
Lecture 42 – Idealization of Physical Systems  
Lecture 43 – Creating Simulation Models of Physical Systems

**Review and 2 exams**

**(3 hrs)**

**Total hours:**

**(46 hrs)**