

Syllabus for Basic Engineering Concepts in M&S I

Course name: Fundamentals of Mechanical Engineering

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

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Course description: This course will provide introductory concepts of various engineering topics to 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 topics covered in the course include structural mechanics, shock & vibrations, fluids, heat transfer & thermodynamics, dynamics and controls, and materials and fabrication. Upon completion, students should have basic understanding of the wide range of engineering concepts that are essential for physics-based engineering modeling and simulation.

2) Modules incorporated into Course: Five modules as described in the topics.

3) 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.

4) Prerequisites assumed, and corresponding level of mastery. Technical BS degree recommended. “Overview of Computers, Weapons Platforms and Electrical Systems” (may be taken concurrently) and “Introduction to Physics-Based M&S.”

5) Course maturity: Not previously taught

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

- 7) **Proposed Delivery modality:** Resident and/ or Distance Learning
- 8) **Proposed references and texts:** Course notes will be provided. (See Topic List.)
- 9) **Course learning objectives:**
- Understand basic concepts of structural mechanics applied to physics-based engineering M&S
 - Understand basic concepts of shock & vibrations applied to physics-based engineering M&S
 - Understand basic concepts of fluid & thermal sciences applied to physics-based engineering M&S
 - Understand basic concepts of dynamics & controls applied to physics-based engineering M&S
 - Understand basic concepts of materials & fabrication applied to physics-based engineering M&S
- 10) **Course Assessment Plan**
- Mid-term and final exams
 - Homework assignments
 - Term paper
- 11) **Topic list by hour of instruction and reference.**

Course Syllabus (Lectures 1 hour each)

- Module 1: Introduction to structural mechanics (9 hours)
 - Definition of force, moment, stress, strain, and their relationship (1 hr)
 - Newton's laws, free-body diagram and equilibrium (1 hr)
 - Examples of stresses and strains (1hr)
 - Statically determinate and indeterminate structures (1 hr)
 - Buckling (1 hr)
 - Fracture and fatigue (1 hr)
 - Basic concept of finite element method (1 hr)
 - Finite element modeling (1 hr)
 - Examples of finite element applications (1 hr)
- Module 2: Introduction to shock & vibrations (8 hours)
 - Basic concepts from dynamics, Newton's 2nd Law (1 hr)
 - Single vs. Multi-degree-of-freedom systems (1 hr)
 - Distributed parameter systems; mode shapes (1 hr)
 - Damped free vibration, natural frequency (1 hr)
 - Energy method; Rayleigh's method (1 hr)
 - Forced Vibration (1 hr)
 - Vibration isolation (1 hr)
 - Vibration measurement (1 hr)
- Module 3: Introduction to fluid & thermal sciences (9 hours)
 - Conservation of mass, momentum, and energy and their relationship

- (2 hrs)
- 3.2 Examples of conservation of mass (1 hr)
- 3.3 Examples of thermodynamics of closed and open systems fundamentals (1 hr)
- 3.4 Examples of thermodynamics - closed and open systems applications (1 hr)
- 3.5 Examples of fluid mechanics fundamentals (1hr)
- 3.6 Examples of mechanics applications (1hr)
- 3.7 Examples of heat transfer by conduction, convection, radiation fundamentals (1 hr)
- 3.8 Examples of heat transfer by conduction, convection, radiation applications (1hr)
- 4. Module 4: Introduction to dynamics & controls (8 hours)
 - 4.1 Equations of motion for physical systems (1 hr)
 - 4.2 Dynamic response of first order systems (1 hr)
 - 4.3 Dynamic response of second order systems (1 hr)
 - 4.4 Dynamic response of higher order systems (1 hr)
 - 4.5 Fundamentals of feedback control (1 hr)
 - 4.6 Feedback control: Frequency response (1 hr)
 - 4.7 Feedback control: State space techniques (1 hr)
 - 4.8 Summary and current trends developments (1 hr)
- 5. Module 5: Introduction to materials & fabrications (7 hours)
 - 5.1. Structures of crystalline solids, ceramics, polymers and composites (1 hr)
 - 5.2. Mechanical properties and strengthening of metals and alloys (1 hr)
 - 5.3. Properties of ceramics and polymers (1 hr)
 - 5.4. Corrosion and degradation of materials (1 hr)
 - 5.5. Failure of materials (1 hr)
 - 5.6. Processing of metallic alloys, ceramics and polymers (1 hr)
 - 5.7. Examples of modeling and simulations in materials science problems. (1 hr)
- 6. Review and 2 exams (3 hours)

Total hours: 44 hrs