

AEROSPACE

SHORT COURSES

Dynamics for Aerospace Structures (AERO0220)

Instructor: Dennis C. Philpot

Course Description

This course is designed to provide participants with a strong theoretical, as well as practical knowledge of the methodologies for performing rigid body and modal-based dynamics analysis on a wide range of structural and mechanical systems. The course builds upon the theoretical foundation with practical applications that can be immediately put into practice in the workplace. Both the theory and practice of classical "hand" analysis techniques are presented, along with the more modern (numerical/computational) methods used in the industry. The subject matter difficulty-level is intermediate.

Course Highlights

- Solid mechanics: the big picture
- Dynamics for structural verification
- Time-domain vs. frequency-domain analysis
- The structural dynamics analysis process
- Kinetic energy and momentum
- Strain energy in structural elements
- d'Alembert's Principle
- Mode shapes, boundary conditions and natural frequencies
- The nature of dynamic response
- Newtonian dynamics: first- and second-order systems
- Response of first-order systems to various load conditions
- Second-order systems
- Dynamic response of second-order systems
- Introduction to random vibration
- Probability density functions
- Power spectral density functions
- Multiple-degree-of-freedom (MDOF) Systems
- Computation of eigenvectors and eigenvalues
- Dynamic response of MDOF Systems
- Common failure modes for dynamically-loaded structures
- Practical examples for the aerospace industry
- Shock and vibration testing
- Introduction to MIL-STD-810G
- Deriving environments from flight test data
- Computing RMS values of acceleration, velocity and displacement

Who Should Attend?

This course will benefit design engineers who would like to become more familiar with the techniques and modern practices of dynamics analysis to help them be more knowledgeable and bring more capability to the workplace. It is also appropriate for mechanical engineers who need to become more proficient in the area of structural dynamics due to a particular job assignment or new career opportunity. Department managers whose staff are involved in loads and dynamics work are also encouraged to attend.

Learning Objectives

Upon completing this course, participants should be able to:

- Identify and correct problematic designs based on dynamic analysis results
- Assess primary and secondary structure due to a plethora of dynamic loading conditions
- Understand the theory behind classical and numerical methods of structural dynamics
- Define environments for shock and vibration testing based on accelerometer data
- Work with government standards in the area of shock and vibration testing
- Speak knowledgeably in the area of structural dynamics to customers and management

Course Outline

Day 1

Introduction

- The concept of dynamic response
- Solid mechanics: the big picture
- The product development process
- Analysis in mechanical design
- Analysis for structural verification
- Time-domain vs. frequency-domain analysis
- The structural dynamics analysis process
- The importance of analysis early in the design cycle

Foundational Topics

- Kinetic energy and momentum
- Strain energy in structural elements
- Virtual work
- d'Alembert's Principle
- Generalized coordinates
- Lagrange's equations of motion
- The Superposition Principle
- Unit impulse response
- Duhamel's Integral

Loads, Mode Shapes & Boundary Conditions

- Learn to think like a dynamicist
- Dynamic loads: primary or secondary
- Load categories
- What is meant by quasi-static loads

- Mode shapes, boundary conditions and natural frequencies
- The nature of dynamic response
- Extensive example

Day 2

Newtonian Dynamics: First- and Second-Order Systems

- First-order systems
- Response of first-order systems to harmonic loads
- Second-order systems
- Dynamic response of second-order systems
- Viscous and structural damping
- Force transmission of second-order systems
- Second-order systems subjected to inertial harmonic loading
- Second-order systems subjected to shock loading

Introduction to Random Vibration

- Probability density functions
- Fourier transforms
- The autocorrelation function
- Power spectral density functions
- Frequency domain analysis
- Response of SDOF systems to random vibration
- Miles' Equation
- Random vibration environments in mechanical design

Multiple-Degree-of-Freedom (MDOF) Systems

- Introduction to MDOF systems
- Computation of Eigenvectors and Eigenvalues
- Static and inertial coupling of modes
- Uncoupling MDOF systems into natural coordinates
- Orthogonality of modes
- MDOF systems with damping
- Modal effective mass

Day 3

Dynamic Response of MDOF Systems

- Direct integration of the equations of motion
- Numerical methods
- Runge-Kutta program flow chart
- Numerical solutions to MDOF systems
- Modal superposition
- Modal participation factors
- Rigid body motion
- Modal truncation vectors
- Comparison of methods

The Finite Element Analysis Method

- How finite elements are derived
- Modern finite element analysis
- Preprocessing essentials
- Basis of dynamic analyses
- Frequency response analysis
- Transient response analysis
- FEA solution examples
- Eigenvalues and Eigenvectors
- Frequency response analysis example
- Modal transient analysis example

Structural Dynamics in Mechanical Design

- Common failure modes for dynamically-loaded structures
- Strength
- Fatigue
- Other common failure modes
- Practical examples for the aerospace industry
- Electronic packaging analysis
- Airplane wing analysis

Day 4

Shock and Vibration Testing

- Background and motivation
- Introduction to MIL-STD-810G
- Deriving environments from flight test data
- Testing for random vibration environments
- Testing for shock environments
- Environmental stress screening
- Computing RMS values of acceleration, velocity and displacement
- Sine sweep testing for determination of natural frequency and damping ratio

Classroom hours / CEUs

24.5 classroom hours

2.45 CEUs

Certificate Track

Aircraft Design

Aircraft Structures

Course Fees

Early registration course fee: \$2,295 if you register and pay by the early registration deadline (45 days out).

Regular registration course fee: \$2,495 if you register and pay after the early registration deadline.

Course Materials

Course materials, including outlines, presentation copies, and supplementary materials, will be accessible through Canvas, KU's online learning system. Instructions to access Canvas will be provided upon completed registration. Students are required to bring a computer or other electronic device with PDF-viewing capabilities with them to class each day. If you require accommodation contact us at professionalprograms@ku.edu and we will work with you on an accessible solution.

U.S. Federal Employee Discount

This course is available to U.S. federal employees at 10% off the registration fee. To receive the federal employee discount, you must enter the code **FGVT116** during the checkout process. Please note that you must validate your eligibility to receive this discount by entering your U.S. government email address (ending in .gov or .mil) when creating your online registration profile. This discount is available for both the early registration and regular registration fees.

Instructor Bio

Mr. Philpot began his career in the aerospace industry at the Rocketdyne Division of Rockwell International in 1983, immediately after completed his bachelor's degree in Mechanical Engineering at Oregon State University, Corvallis. During his nearly 14 years at Rocketdyne, Mr. Philpot was involved in several diverse programs, including the Space Shuttle Main Engines (SSME), the National Aerospace Plane (NASP) and the International Space Station; also, during his employment at Rocketdyne Mr. Philpot completed his master's degree in Applied Mechanics at California State University, Northridge.

During the late 1990's Mr. Philpot became involved with performing advanced fighter aircraft structural analysis on both the F/A 18 E/F program for Northrop Grumman and the Joint Strike Fighter for Lockheed-Martin Skunk Works. He also served as a principal structural analyst on two launch systems? the Kistler reusable launch system and the Delta IV EELV developed by the Boeing Company.

Currently, Mr. Philpot is the Airframe IPT Technical Lead for the AARGM ER EMD program; in that role he leads or oversees all of the technical/analytical aspects of hardware design development and works with the design team to help ensure that all aspects of the product meet requirements. Mr. Philpot has held many roles in missile development, including Section Head for mechanical analysis, Test Director for the AARGM Environmental Qualification Testing, Mechanical Analysis Lead AARGM missile integration on the Tornado aircraft for the Italian Airforce, IPT Lead for AARGM ER FEDA Program Aerodynamics, Modeling & Simulation, Mechanical Design and Internal Loads and Static Strength Analysis, MSST Mechanical Analysis Lead, Structural Dynamics Lead and Technical Advisor to the Jordan Multirole Combat Aircraft JLG & JMCA Programs, Technical Lead on the Hyper-Velocity Projectile (HVP) Program, based out of Plymouth, MN, Structural Analysis SME for all advanced (SAP) programs that require that skill set at Northrop Grumman, Advanced Weapons Division.

An internationally-recognized expert in aerospace structural analysis, Mr. Philpot has been teaching post-graduate courses on Stress Analysis and Structural Dynamics in the greater Los Angeles area, Seattle, WA, Orlando, FL, and on-site at The Boeing Company, Northrop-Grumman, NASA-Ames Research Center, Moffett Field, California, NASA-Johnson Space Center in Houston, TX, NASA-Kennedy Space Center in Titusville, FL, Hill Air Force Base in Ogden, UT, the Holloman Air Force Base near Alamogordo, NM, Eglin Air Force Base in Fort Walton Beach, FL, Aviation and Missile Research, Development, Engineering Center at Redstone Arsenal, Huntsville, AL and at ST Aerospace in Singapore. At the 50th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, Mr. Philpot was honored to present a special two-day seminar on Structural Dynamics in Mechanical Design at the Palm Springs Convention Center/Wyndham Palm Springs. The public courses are very international in nature, attracting students from Austria, South Korea, New Zealand, Brazil, Turkey, The Netherlands, China, South Africa, Japan, Singapore, Indonesia, Australia, Canada, Chile, Denmark, Norway, Switzerland, Sweden, Germany, Luxembourg, Mexico and, of course, the United States of America. Mr. Philpot holds two US Patents and is a licensed Professional Engineer in the State of California.

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