

# Fundamentals of Vibration for Test Applications

## Course No. 116

**APPLICATIONS** Random vibration and shock are important in most engineering applications where the product is exposed to transportation and to possible vibration and shock during service. An understanding of vibration and shock is crucial to improving the reliability of today's products, wherever electronic components appear.

**FOR WHOM INTENDED** Many engineers need specialized education to properly measure, quantify, and analyze this generally unfamiliar environment and to reproduce it in environmental test laboratories. This course is for test laboratory managers, engineers and technicians. It also helps quality and reliability specialists and acquisition personnel in government and military activities and their contractors. It is designed to serve the needs of personnel in a wide range of industries where equipment problems may be encountered during the shipment and use of their product.

**BRIEF COURSE DESCRIPTION** This course covers a wide range of topics associated with vibration and shock applications in order to enable the course participants to acquire a basic understanding of the complex field of vibration and shock. Each of the subject areas covered in this course have expanded coverage in their own three day courses for those individuals who need a more thorough understanding for their application.

Lectures and videotaped physical demonstrations show for example: how structures behave when mechanically excited, how to use pickups to sense input and response forces and motions, how to read out and evaluate the resulting electrical signals.

The course commences with an introduction to vibration and its effects and then proceeds to cover the basic theory needed to understand the material covered during the course. Mathematics are kept to the minimum necessary for the concepts of vibration to be understood. The theory of dynamics is covered, including the relationships between displacement, velocity and acceleration. Electronic filters are covered, and then random vibration theory. Test equipment is discussed next, including the various types of vibration exciters, along with test fixtures and power amplifiers.

The course next presents some basic theory of measurement systems before addressing vibration measurement and data acquisition. Spectral analysis and transforms are discussed before covering sine and random vibration testing, mechanical shock applications and dynamic test standards and specifications.

**DIPLOMA PROGRAMS** This course is required for TTI's [Environmental Engineering Specialist \(EES\)](#) and [Dynamic Test Specialist \(DTS\)](#) Diploma Programs and may be used as an optional course for any other [TTI Diploma Program](#).

**RELATED COURSES** [Course 116-117](#) includes content from this course and [Course 117, Fundamentals of Vibration for Design Applications](#). These courses (or any TTI course) may be presented onsite at your organization, for a group.

**PREREQUISITES** There are no definite prerequisites. Supervisors are invited to telephone or e-mail TTI on prospective attendees' backgrounds and needs.

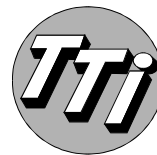
**TEXT** Each student will receive 180 days access to the on-line electronic course workbook. Renewals and printed textbooks are available for an additional fee.

**ONDEMAND INTERNET COURSE** 116 features over fourteen hours of video as well as more in-depth reading material. All chapters of course 116 are also available as OnDemand Internet Short Topics. See the on-line course outline for details.

**COURSE HOURS, CERTIFICATE AND CEUs** Class hours/days for on-site courses can vary from 14–35 hours over 2–5 days as requested by our clients. Upon successful course completion, each participant receives a certificate of completion and one Continuing Education Unit (CEU) for every ten class hours.

## Course Outline

Introduction to Vibration  
Basic Concepts and Terminology: Spectra • Transfer Functions  
Understanding Decibels (dB) and Octaves •  $\frac{1}{3}$  Octave Bands  
Dynamic Force and Motion: Laws of Motion, Weight vs. Mass  
Gravity • Force, Mass, Acceleration • Work, Power, Energy  
Degrees of Freedom • Natural Frequency  
Harmonic Waves • Transmissibility • Isolation • Damping  
Vibration Considerations for Design Engineers  
Electronic Filters & Measurement Systems  
Low-pass, High-pass and Bandpass Networks  
Understanding RMS • Complex Signals, Random Signals  
Random Vibration: Statistics • Probability Distributions  
Random Data Spectrum • Normal Distribution Curve  
Power Spectral Density • Deriving RMS G from Spectral Plot  
Vibration Exciters (Shakers)  
Electrohydraulic (EH) Shakers • Electrodynamical Shakers  
Force Rating and Available Acceleration  
Table Expanders and Oil-Slip Tables  
Fixtures: Materials, Fabrication methods  
Power Amplifiers, Effects of Resonance  
Vibration Measurement: Velocity, Displacement Sensing  
Strain Measurement • Wheatstone Bridges • Accelerometers  
Mounting, Cabling • Signal Conditioning • Charge Amplifiers  
Basics of Spectral Analysis: Time and Frequency Domain  
Spectral Analysis • Windowing • Forcing Measured Data  
Vibration Testing: Types of Testing: Development, Qualification,  
Acceptance, Screening, Reliability, Life  
Accelerated Testing • Designing Accelerated Durability Tests  
Applied Environment ... Philosophy • Closed Loop Control  
Shaker Control—Input or Response • Accelerometer Location  
Unwanted Table Movement • Resonant Distortion of Table  
Slip Tables • Axial Resonance • Notching • Strobe Light  
Multiple DoF Testing • "Quasi-Random" • 3-axis Testing  
Sine Vibration Testing: Closed Loop Control • Sine Sweeps  
Effect of Sweep Speed • Slow Rates • Crossover Frequency  
Control of Vibration Systems  
Random Vibration Testing: Calculating RMS from PSD  
Gaussian Random Signal • Standard Deviation  
Statistical Degrees of Freedom • Accuracy/Confidence  
Time and Frequency Domain Terminology • Spectral Plots  
Transfer Functions • Sine on Random, Random on Random •  
Overtest & Vibration Protection  
Mechanical Shock: Causes, effects and remedies of shock  
Shock Testing machines: Pneumatic, Freefall, Drop, MIPS  
Sample shock test procedures • Shock Response Spectrum  
Transient Tests: Definition, Types, Analysis Options  
SRS Mechanical Analog • SRS Analysis Procedure  
Dynamic Test Standards and Specifications  
Summary, Final Review  
Award of certificates for successful completion



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