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# Mechanical Design for Product Reliability

## Course No. 310

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

**FOR WHOM INTENDED** This course is for design engineers and project managers. It also helps quality and reliability specialists, also personnel in any industry where equipment problems may be encountered during the shipment and use of their product. Project personnel, structural and packaging engineers learn how to take the effects of vibration and shock into account in the design process.

**BRIEF COURSE DESCRIPTION** The course commences with an introduction to vibration and then covers basic dynamics theory including relationships between displacement, velocity and acceleration. Dunkerley's and Rayleigh's methods are introduced, with examples. Damping, transmissibility ratio and resonance stacking are addressed. The course then covers basic structural theory: tension, compression, stress, strain, torsion and moments of inertia. Examples show the torsional shape factors of different structures. The instructor then addresses frequency and stiffness of beams, plates and gussets, providing useful graphs, formulas and examples.

Modal analysis is then discussed, with mention of multi-degree-of-freedom systems, modes and complex systems. Measurement and fixturing for modal analysis and testing are covered before moving on to a brief discussion of random vibration, including power spectral density theory. The concept of RMS acceleration is discussed. Mechanical shock and its design implications are then discussed. Methods of isolating assemblies from shock and vibration are covered.

Fatigue is covered, including discussion of crack-growth rates, fracture mechanics, the S-N curve, and the use and abuse of accelerated testing, including Miner's hypothesis.

Material selection is then covered, with information on overall and design-limiting material properties. Tools are provided for comparing different materials. The course concludes with chassis analysis and general design suggestions, such as methods for increasing natural frequencies.

**CERTIFICATE PROGRAMS** This course is required for TTI's [Mechanical Design Specialist \(MDS\) Certificate Program](#) and may be used as an elective for any other TTI [Certificate Program](#).

**RELATED COURSES** Course 310 is equivalent to the mechanical design portion of [Course 157-5, Vibration and Shock Test Fixture Design](#), which runs concurrently.

**PREREQUISITES:** Prior participation in TTI's "[Fundamentals of Vibration](#)" or the equivalent would be helpful. Participants will need first-year college mathematics (or equivalent experience) and some facility with fundamental engineering computations. Some familiarity with electrical and mechanical measurements will be helpful.

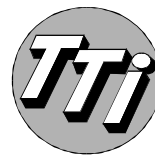
**TEXT** Each participant will receive a [course workbook](#), including most of the viewgraphs used in the presentation.

**COURSE HOURS, CERTIFICATE AND CEUs** Open courses meet seven hours per day. Upcoming presentation dates can be found on our current [open course schedule](#). 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.

For [schedules](#), [general information](#) and [registration forms](#), see TTI's web site.

## Course Outline

Introduction to Vibration  
Dynamic Force and Motion  
Laws of Motion, Weight vs. Mass • Gravity • Density  
Force, Mass and Acceleration • Degrees of Freedom  
Displacement • Velocity • Acceleration • Natural Frequency  
Sinusoidal Waveform • Modeling Complex (MDOF) Systems  
Dunkerley's and Rayleigh's Methods  
Transmissibility • Isolation • Damping • Examples  
Review of Structural Design Fundamentals  
Material Properties • Tension and Compression  
Stress and Strain • Shear • Torque • Moments of inertia  
Torsional Stiffness • Torsional Shape Factors  
Bending Stiffness • Instability of beams and flanges  
Frequency and stiffness: Beams, Plates, Gussets  
Natural frequency and stiffness graphs for various structures  
Beam Formulas • Plate frequency parameters, examples  
Column Resonance • Axial Resonance  
Example: Stresses in a Loaded Beam  
Bolted Connections • Preload • Data on Bolts  
Design of Bolted Joints • Stiffness Data  
Required flange material area • Material thickness, stiffness  
Modal Analysis and Modal Testing  
Applications • Modes, Natural Frequencies  
Fixturing for Impedance and Modal Testing  
Finite Element Analysis (FEA) • Example  
Random Vibration: Demonstrations—Sinusoidal Vibration,  
Complex Waveform, Random Vibration  
Probability Density • Power Spectral Density (PSD)  
Shaker Power Spectral Density Response • Equalization  
Calculating the RMS Acceleration from Spectral Plot  
Mechanical Shock:  
Causes of Shock, Effects and Remedies of Shock  
Transient or Shock Tests  
Shock Pulse shapes, Shock Isolation Example  
Fatigue: How Materials Behave: The S-N Curve  
Factors Influencing Fatigue Behavior  
Failure Models & Mechanisms • Crack Growth  
Time-Dependent Failures, Time to Failure  
Goodman and Constant Life Diagrams • Miner's Hypothesis  
Accelerated Testing • Durability, Functional Tests  
Material Selection in Engineering Design  
Overall & Design-Limiting Material Properties  
Application-Specific Material Properties  
Example: Optimization of Shaker Table  
Chassis Analysis Example  
Chassis Dynamics, Section Properties  
Increasing Resonant Frequency, Torsion • Rotational Inertia  
Design Suggestions: Overcoming Problems • Design Guidelines  
Structural rules of thumb • Stresses in Printed Circuit Boards  
Summary, Final Examination  
Award of Certificates for Successful Completion



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