Dynamics, Vibrations, Acoustics and Controls

Classical dynamics is the study of bodies in motion subject to the action of forces. In the modern mechanical engineering domain, dynamics includes the study of mechanical systems that interact with electromagnetic and fluid systems, and includes the study not only of translational and rotational motion, but also vibration, which often leads to the generation of acoustic waves, commonly known as sound. This topic area spans a spectrum ranging from the dynamics of a single body under the action of a single force, to the dynamics of complex, interconnected, multi-body systems with components and forcing in all three energy domains (mechanical, electromagnetic, and fluid). Finally, once the dynamics of such systems are understood, the automatic control of such systems can be achieved through the design of a control system that ensures specified system behavior under the influence of changing (dynamic) forcing.

Industry Applicability

Mechanical engineers specializing in dynamics, vibrations, acoustics and controls are typically employed by companies, government agencies, or other entities involved with the following topics:

- Any machinery that moves, or that has internal motion, must be designed with dynamics in mind.
- All forms of transportation machinery (cars, planes, trains, ships) are designed for specific dynamic conditions.
- Manufacturing machinery and material handling machinery, from traditional assembly lines to modern microelectronics fabrication machines, are designed with dynamics in mind.
- Design for vibration is an important subset of dynamics. All things that move and that are subject to forcing at sufficiently high frequency can undergo vibration. Vibrations are often suppressed through proper engineering design, though it can also be exploited.
- The interaction of vibrational motion with fluids can generate sound waves. Vibration-induced acoustic waves are often undesired, but in many cases desired, as in is the design of audio hardware for consumer electronics. Understanding and controlling these sound waves is the study of acoustics. Acoustical design of everything from products and devices, to architectural spaces is an important subset of dynamics.
- In all these cases, if automatic control of some aspect of the system is desired, the dynamics must first be understood, and then a control system must be designed.

Examples

Transportation: Most vehicles operating as transportation devices have suspension systems that isolate the occupants or payload from environmental inputs, and to facilitate higher-speed travel, while retaining comfort and safety. The design of such suspension systems is a common application of dynamics and as speeds increase, the system components can undergo vibration. Excessive vibration can cause not only occupant discomfort, but it can adversely affect vehicle performance, and in the extreme, cause the failure of components. At sufficient energy input levels, vibration of components can generate acoustic noise, which usually has a negative impact on the occupants, and suppression of the noise is typically undertaken. Modern quad-copters rely heavily on automatic control systems for stability and navigation in the wind.

Manufacturing and processing systems: Machines that are employed in the manufacturing of everything from cars to computer chips to petrochemical products, have many moving parts. Designing these systems for optimum performance, minimal energy consumption, and versatility is a common application of dynamics, vibration, acoustics and controls. In a simple sense, the machine must be able to pick up a component, move it to the correct location, and attach it to the assembly. The force required to do this in the required time must be determined. Dynamic analysis of such machines facilitates the design. Since all moving objects can be subject to vibration, one must design the system so that vibration of the machine is sufficiently suppressed, or else accuracy and precision of the manufacturing process may suffer. If human operators are involved, the machine must be designed sufficiently quiet. In many cases, an automatic control system is used to guide or enhance the manufacturing process, improving performance and endurance over a human operator.

Acoustic systems: There are many engineering systems in which the acoustic performance of the system is the main interest or is of key importance. These range from communication systems (phones and radios), to audio and music recording and reproduction systems, to sonar and range finding/object detection systems, to the acoustic characteristics of any system (i.e. a quiet kitchen garbage disposal).

Faculty Mentors:
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Undergraduate Elective courses (select up to four)
ME 348C(or D) - Introduction to Mechatronics I (or II)
ME 350R, Robot Mechanism Design
ME 355K, Engineering Vibrations
ME 379N, Engineering Acoustics
ME 360, Vehicle System Dynamics and Control
ME 364L, Automatic Control System Design
ME 364D, Intermediate Dynamics
ME 379M, Theory/Design of Mechanical Measurement
ME 379M, Advanced Vehicle Powertrain Systems and Control
ME 377K, Projects in Mechanical Engineering (good if considering graduate school)
*For course descriptions visit the **University Catalog**.*

Organizations and Societies: ASME, SAE, AIAA, ASA