

# SECOND SEMESTER 2022-2023

Course Handout Part II

Date: 16-01-2023

In addition to part-I (General Handout for all courses appended to the time table) this portion gives further specific details regarding the course.

*Course No.* : ME F428

*Course Title* : Smart Structures

*Instructor-in-Charge* : Dr. Punnag Chatterjee

*Consultation Hours* : To be announced in the class

# Scope and Objective of the Course:

Overview of modeling, design and application of smart materials such as piezoelectrics, shape memory alloys (SMA), and other miscellaneous smart materials. The topics will include applications and research in vibration control, sensing and power analysis for smart materials. We will discuss fundamental properties of active materials, mechanics of the coupling mechanisms and techniques for incorporating active material models into design, analysis and simulation of engineering systems.

* Students will understand the coupling properties and underlying physical phenomena of different active materials.
* Students will have the foundation to model and analyze engineering devices and systems that incorporate smart materials under static and dynamic conditions.
* Students will be introduced to applications of active materials in sensing, actuation, control and energy harvesting.

# Textbooks (TB):

1. D.J. Leo, Engineering Analysis of Smart Material Systems, Wiley 2007
2. V.K. Varadan, K.J. Vinoy and S. Gopalakrishnan, Smart Materials Systems & MEMS: Design and Development Methodologies. London: John Wiley. 432 p., [Int. Ed. ISBN 978 04700 93610 – 2006]

# Reference books (RB):

1. Smart Structures Theory by Inderjit Chopra and Jayant Sirohi, Cambridge Press

# Course Plan:

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| --- | --- | --- | --- |
| **Lecture**  **No.** | **Learning objectives** | **Topics to be covered** | **Text**  **Book** |
| 1-3 | Motivation for learning  smart materials especially piezoelectrics | Piezoelectric materials: background, fundamental principles and basic  manufacturing | TB 1,  RB 1 |

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| --- | --- | --- | --- |
| 4-7 | Interaction between mechanical and electrical domains | Constitutive mechanics modeling of piezoelectric effect | TB 1,  RB 1 |
| 8-11 | Exposure to real world cases | Static and dynamic modeling of piezoelectric structures | TB 1,  RB 1 |
| 12-15 | Parametric dependencies on design of actuators and  sensors | Design relationships for piezoelectric sensors and actuators | TB 1,  RB 1 |
| 16-19 | Application in real world sensor and actuator designs | Piezoelectric devices: accelerometers, gyroscopes, solid state motors an energy harvester. | TB 1,  RB 1 |
| 20-22 | Motion control using  piezoceramics | Active/passive vibration suppression  including modal filtering techniques | TB 1,  RB 1 |
| 23-26 | Motivation for learning SMA | SMAs, shape memory polymer, superelastic materials | TB 1 |
| 27-30 | Interaction between mechanical and thermal domains | Constitutive modeling: basic physics along with different models | TB 1 |
| 31-34 | Application in real world sensor and actuator  designs | General applications: release mechanisms, active composites and morphing structures | TB 1 |
| 35-37 | Introduction to Magnetostriction | Magnetostriction effect, constitutive relationships, applications in actuation and  sensing | TB 2,  RB 1 |
| 38-40 | Introduction to Electroactive polymers (EAPs) | Electronic and ionic type EAPs and comparison with ceramics, constitutive models and system response behavior | TB 1 |

**Evaluation Scheme:**

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| --- | --- | --- | --- | --- |
| **Component** | **Duration** | **Weightage**  **(%)** | **Date & Time** | **Nature of**  **Component** |
| Mid-Semester Test | 90 min | 20% | 16/03 11.30 - 1.00PM | CB |
| Project | -- | 20% |  | OB |
| Seminar | -- | 10% |  | OB |
| Practical/Lab | -- | 20% |  | OB |
| Comprehensive  Examination | 180 min | 30% | 15/05 AN | CB |

**Notices:** All the notices regarding the course will be displayed on the CMS.

**Make-up Policy:** Only for genuine cases with prior permission

**Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

# Laboratory Experiments

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| --- | --- | --- | --- |
| **Lab No** | **Experiment/Simulation** | **Schedule** | **Mode** |
| 1 | Basics of writing code in MATLAB | Week 1 | MATLAB |
| 2 | Plotting and basic signal analysis in MATLAB | Week 2 | MATLAB |
| 3 | Basic vibration analysis | Week 3 | ANSYS |
| 4 | Vibration analysis with piezo-beam composites | Week 4 | ANSYS |
| 5 | Basics of data collection and analysis | Week 5 | LabVIEW/MAT LAB |
| 6 | Piezo-beam vibration experiment - 1 | Week 6 | experiment |
| 7 | Piezo-beam vibration experiment - 2 | Week 7 | experiment |
| 8 | Project fabrication/assembly - 1 | Week 8 | experiment |
| 9 | Project fabrication/assembly - 2 | Week 9 | experiment |
| 10 | Project experiment - 2 | Week 10 | experiment |
| 11 | Project experiment - 3 | Week 11 | experiment |
| 12 | Lab evaluation | Week 12 | evaluation |

**INSTRUCTOR-IN-CHARGE**