Birla Institute of Technology & Science, Pilani
Hyderabad Campus

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:

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

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:

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

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/MATLAB
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