

**BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI- HYDERABAD
CAMPUS**

FIRST SEMESTER 2023-2024

Course Handout (Part II)

Date: 11/08/2023

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 Name : Smart Materials
Instructor-in-charge: AMIT KUMAR GUPTA
Instructors : AK Gupta, GV Pardha Saradhi
Lecture schedule: Mon, Wed, Fri – 9 (4-5 PM) @ G-205
Practical schedule: Thu – 7-8 (2-4 PM) @ E-002

1. Course Description:

Overview of smart materials. Piezoelectric materials (Ceramics and polymers), Electro and Magneto-Rheological Fluids, Shape Memory Alloys (SMA) – One way and two-way SMAs, Magnetic Shape Memory Alloys (M-SMA), Fiber optic sensors, Miscellaneous smart materials – Magnetostrictive, electrostrictive materials and others. Basic modelling of smart materials, Dynamics and control knowledge for smart materials. Applications in the field of civil, mechanical, aerospace, biomedical, energy industry such as sensors and actuators, vibration control and damping, structural health monitoring. Intelligent devices based on smart materials.

2. Scope and Objective:

Overview of modeling, design and application of smart materials such as piezoelectric, 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 and control.

3. Text Books:

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]

4. Reference Books:

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

5. 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 and 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

6. Evaluation Scheme:

EC No.	Evaluation Component	Duration	Weightage	Date & Time	CB/OB
1.	Mid-Sem. Test	90 min	20 %	13/10 - 9.30 - 11.00AM	CB
2.	Seminars	---	10 %		OB
3.	Practical / Lab project	---	30 %		OB
4.	Compre. Exam.	180 min	40 %	18/12 FN	CB

7. Chamber Consultation Hour: Every Tuesday 4 – 5 PM

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

9. Make up Policy: Make-up will be granted only to genuine cases with prior permission from the IC.

For cases related to illness, proper documentary evidence is essential.

Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester. Any form of academic dishonesty would lead to serious actions.

**Instructor-in-charge
ME F428**