B.Tech III Year I Semester

JNTUA COLLEGE OF ENGINEERING (AUTONOMOUS) PULIVENDULA

19AME55e – SMART MATERIALS

(Open Elective-I)

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Course Objectives: The objectives of the course are to make the students learn about

- Familiarize the smart materials and its role in developing intelligent systems.
- Introduce the students with HBLS and LBHS smart materials.
- Expose the students in smart systems development and uses.
- Understand the working principle of smart actuators and smart sensors.

UNIT I **12 Hours**

Introduction to Smart Materials: What is Intelligence? Artificial intelligence Vs. embedded Intelligence, Definition of smart material, need for smart materials, classifications of smart systems, components of a smart systems, smart system applications, the role of Smart Materials in developing Intelligent Systems and Adaptive Structures.

Learning Outcomes:

At the end of this unit, the student will be able to

- Recall what is intelligence. **L1**
- Define smart materials. **L1**
- Describe the role of smart materials in development of intelligent systems and adaptive structures. **L2**
- Illustrate the applications of smart systems. **L2**

UNIT II: High bandwidth - Low strain generating (HBLS) Smart Materials **10 Hours**

Piezoelectric Materials – constitutive relationship, electromechanical coupling coefficients, piezoelectric constants, piezoceramic materials, variation of coupling coefficients in hard and soft piezoceramics, polycrystalline vs single crystal piezoelectric materials, polyvinyldene fluoride, piezoelectric composites.

Magnetostrictive Materials – constitutive relationship, magneto-mechanical coupling coefficients, Joule Effect, Villari Effect, Matteuci Effect, Wiedemann effect, Giant magnetostriction in Terfenol-D, Terfenol-D particulate composites, Galfenol and Metglas materials.

Learning Outcomes:

At the end of this unit, the student will be able to

- Describe the constitutive relationship of piezoelectric materials. **L2**
- Compare polycrystalline and single crystal piezeoelectric materials. **L2**
- Explain concepts of Joule effect, Villari effect, Matteuci effect, Wiedemann effect. **L2**
- Discuss Galfenol and Metglas materials. **L6**

UNIT III **8 Hours**

Low bandwidth - High strain generating (LBHS) materials: Shape Memory Alloys (SMA) – Introduction, Phenomenology, Influence of stress on characteristic temperatures, Modelling of shape memory effect. Vibration control through shape memory alloys. Design considerations, multiplexing embedded NiTiNOL actuators. Electro-active Polymers (EAP)- Introduction, Phenomenology, Influence of stress on characteristic temperatures

Learning Outcomes:

At the end of this unit, the student will be able to

- List various types of LBHS smart materials. **L1**
- Identify the influence of stress on characteristic temperatures in SMA and EAP. **L3**

- Explain the concept of vibration control through shape memory alloys. **L2**
- Discuss design considerations of shape memory alloy. **L6**

UNIT IV: Smart actuators **8 hours**

Based on HBLS smart materials: Piezoelectric Actuators – Induced Strain actuation model, Unimorph and Bimorph Actuators, Actuators embedded in composite laminate, Impedance matching in actuator design, Feedback Control, Pulse Drive, Resonance Drive. Magnetostrictive Actuators – Magnetostrictive Mini Actuators, Thermal instabilities, Discretely distributed actuation, Manetostrictive Composites.

Based on LBHS Smart Materials - Shape Memory Alloy based actuators for Shape Control, Electro-active Polymers for Work-Volume Generation

Learning Outcomes:

At the end of this unit, the student will be able to

- Recall working principle of actuators. **L1**
- Explain impedance matching in actuator design, feedback control, pulse drive and resonance. **L2**
- Describe the working principle of Piezoelectric Actuators & Magnetostrictive Actuators. **L2**
- Discuss the concepts of actuators based on HBLS and LBHS. **L6**

UNIT V: Smart sensors **8 Hours**

Sensors based on HBLS Smart Materials - Piezoelectric Sensors Magnetostrictive Sensors Techniques of Self Sensing MEMS Sensors.

Sensors based on LBHS Smart Materials - EAP based sensors, SMA based encoders, Optical Fibre based Sensing.

Learning Outcomes:

At the end of this unit, the student will be able to

- Select the type of sensor required for smart systems. **L1**
- Explain techniques of self sensing MEMS sensors. **L2**
- Discuss EPA based and SMA based sensors. **L6**
- Explain optical based sensing system. **L2**

Text Books:

- M.V. Gandhi, B.D. Thompson" Smart Materials and Structures" Springer Science & Business Media, 31-May-1992.

Reference Books:

1. Brian Culshaw, Smart Structures and Materials, Artech House, 2000.
2. Gauenzi, P., Smart Structures, Wiley, 2009.
3. Cady, W. G., Piezoelectricity, Dover Publication

Course Outcomes:

At the end of this Course the student will be able to

- Describe the role of smart materials in development of intelligent systems and adaptive structures. **L2**
- Compare polycrystalline and single crystal piezoelectric materials. **L2**
- Identify the influence of stress on characteristic temperatures in SMA and EAP. **L3**
- Explain techniques of self sensing MEMS sensors. **L2**

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