20MD010 Design of Shape Memory Alloy Actuators

L	T	P	C
3	-	-	3

Course Description and Objective:
The purpose of this course is to introduce at senior level graduate students seeks to provide an accessible account of SMA behavior together with examples of preliminary design of SMA actuators.

Course Outcomes: Students will be able to

- Understand the concepts, fabrication techniques and benefits of Shape Memory Alloys
- Identify the basic geometries and components of SMA for simple applications
- Design temperature controlled and preliminary SMA actuators
- Analyze coupling SMA actuators with mechanisms
- Demonstrate the SMA actuators for aeronautical and biomedical applications

UNIT – I **L - 12**

Introduction to Shape Memory Alloys: Over - view, system level response of smart structures, temperature induced transformations in SMA, shape memory effect, super/pseudo-elasticity, common types of SMAs and applications of SMAs, Fabrication methods and post treatment of SMA components.

UNIT – II **L - 12**

Functionality Analysis of SMAs: Design process, semantics in design of SMAs, identification of functionality, basic SMA components and geometries for tension, torsion, spring response, Influencing factors for SMA actuators design.

UNIT – III **L – 12**

Temperature Controlled SMA Actuators: SMA wire – Bias spring arrangement, graphical design approach for stroke estimation, linear to rotary arrangement, linearized loading and unloading, Hysteretic loading and unloading response.
Preliminary SMA Actuators: Constant force mode, constant deflection mode, simultaneous load and deflection mode, design of SMA wires and Ti – Ni SMA Springs, design of remote controlled flow control valve, heating and cooling of SMA wires

UNIT – IV **L – 12**

Coupling of SMA Actuators: Principle of Virtual work, need for mechanisms, loading curve and SMA response, 3-D design, bias forces
Fatigue of SMAs: Structural and functional fatigue, Reporting Fatigue

UNIT – V **L – 12**

SMA for Aeronautics: Overview, Morphing Flap Architecture Based on SMA Actuators: Design and Validation Process, Morphed Target Shape and Aerodynamic Loads, SMA-Based Actuator: Design and Test, Morphing Architecture Based on Distributed Actuators within the Structure, Morphing Architecture Based on SMA Actuated Rib Mechanism.

SMA for Biomedical: Introduction to Ni-Ti, Orthodontics, Orthopedics, General Surgery, Colorectal Surgery, Otolaryngology, Neurosurgery, Ophthalmology, Urology, Gynecology and Andrology, Physiotherapy, Other Applications: Active Prostheses and Robot-Assisted Surgery

Text Books:

1. Ashwin Rao, A R Srinivasa, J N Reddy, "Design of Shape Memory Alloy (SMA) Actuators", Springer, 2015.
2. Leonardo Lecce and Antonio Concilio, "Shape Memory Alloy Engineering for Aerospace, Structural and Biomedical Applications", Elsevier, 2015.

Reference Books:

1. Mohammad H. Elahinia, "Shape Memory Alloy Actuators", Wiley, 2016.
2. Dimitris C. Lagoudas, "Shape Memory Alloys", Springer, 2008