MAE 495 - Strategically Tuned Absolutely Resilient Structures (STARS) - 3 hrs.
1 or 2 credit hour lab (optional… contact Dr. Gilbert for details)

Spring 2013

Time/Place	Friday 8:00 a.m. - 10:40 p.m. Room: TH S117
Instructor:	John A. Gilbert, Ph.D.
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Text:	Gilbert, J.A., "Strategically Tuned Absolutely Resilient Structures," MAE Department, University of Alabama in Huntsville, Version 2.0, 2013.

Course Description:

MAE 495 - Strategically Tuned Absolutely Resilient Structures (STARS) - 3 hrs.
Prerequisite: MAE/CE 370 (Mechanics of Materials)

The STARS concept makes it possible to build a structure capable of storing potential energy in the form of elastic deformation that can be released in a controlled fashion in the form of work or kinetic energy. The composite section must be designed based on the strength, stiffness, and the position of the component materials. The ability to store and release energy depends upon a complex interaction between the shape, modal response, and the forcing function initiated to the structure. Since the method relies on energy recovery through elastic deformation, steps must be taken to prevent damage so that the structure is absolutely resilient.

The course will include lectures and independent study in this exciting new area. Topics will range from proof of principle to practical application. Specific areas to be addressed include composite section design, structural analysis, stress analysis, integrated sensing, non-destructive evaluation, finite element modeling, and modal analysis.

Grading and Attendance Policies:

Sixty-five percent of the grade will be based on attendance and homework assignments. Grades received for attending class periods and those received for homework assignments will be averaged; students will earn 100 points for being in class and zero points for not being there. Failure to attend three or more classes will result in failure of the course. The homework assignments include a class log (a couple of paragraphs describing the work done in each class) that will be scored on the basis of 100 points. The class log must be submitted electronically to jag@eng.uah.edu by 5:00 p.m. on April 19th. The remaining thirty five percent of the grade will be based on a final oral presentation scored collectively by the instructor and fellow class members. Cover letters and abstracts for the presentations (in MSWord format) are due on March 15th. The presentations (10 minutes long plus 2 minutes for questions) will be scheduled on April 5th, 12th, and 19th. A PowerPoint must be archived at the time that the presentation is given. Students are encouraged to update their class log on a weekly basis and must show satisfactory progress in guided readings and laboratory work where applicable.

Course Outline:

1. Overview of Solid Mechanics - Forces, Moments, Stress, Strain, and Displacement; Equilibrium, Compatibility, Strain-Displacement, Transformation, and Constitutive Equations. Homework assignment includes formulating shear and moment diagrams and calculation of maximum bending and shear stresses in prismatic beams subjected to transverse loading.
2. Design Considerations for STARS - Stiffness, Strength, Geometry, Forcing Functions, Adaptive Reinforcement, Embedded Sensors, Control Elements, Strain Energy, and Strain Energy Density. Homework assignment concentrates on deflection criteria and derivation of the elastic curve for prismatic beams subjected to transverse loading.
3. Stress Visualization - Design of STAR Structures, Transformed Section Theory, Plane and Circular Polariscopes, Isoclinic and Isochromatic Fringe Patterns, Calibration and Compensation Techniques; and Stress Concentration Factors. Homework assignment involves comparing experimentally determined stresses in composite photoelastic models with results obtained from the transform section theory and showing how stress transfer can be accomplished by adjusting the compliance of the materials in a composite section.
4. Modified Transformed Section Theory – Composite Laminates, Inter-Laminar Stresses, Woven Composite Structures, Composite Laminate Plate Theory, Equivalent Material Properties, Material Testing, Electrical Resistance Strain Gages, Rosettes, and Circuitry. Homework assignment involves analysis of a tension specimen, torsion specimen, and an end-loaded cantilever beam; geared toward showing how the constitutive equations depend on material properties such as the elastic modulus, Poisson's ratio, and the shear modulus.
5. Optimization of STARS – Structural Optimization of a Cantilever Beam. Laboratory exercise demonstrates the efficient design of structural members through variation of the section modulus of a beam with the applied bending moment.
6. Morphing and Tracking STARS – Compliant Structures, Perspective, Collapse of World Trade Center, Failure Analysis, Proposal Writing, In-Plane Moiré Methods, Optical Filtering, Stress Analysis, and Shadow Moiré. Homework assignment involves determination of material properties using the moiré method.
7. Dynamic Characterization of STARS – Discrete Systems, Continuous Systems, Modal Analysis, Resonance, Eigenvalues, Mode Shapes, Finite Element Analysis, Modal Analysis of Plates, Modal Testing of Structures, Remote Sensing, MEMS, Accelerometer Measurements, Health Monitoring, Diagnostics, and Prognostics. Homework involves preparation of cover letter and abstract for final presentation.
8. Concrete Mixture Design - Binders, Aggregates, Admixtures, Mix Proportioning, and ASCE Concrete Canoe Competition. Homework geared toward improving UAH performance at the ASCE Southeast Regional Student Competition.
9. Structural Information Systems – Reinforcement, Embedded Sensors, Hollow Tendons, Structural Design, and Failure Analysis.
10. Self-Healing Structures - Method of Attack, Failure Modes, and Proof-of-Principle.
11. Next Generation STARS - Control Elements, Advanced Polymers, Atomic Bonding, Molecular Interaction, and Theory of Interaction.

Homework Policy:

Homework is due at the beginning of the class on the date prescribed. Homework assignments shall be done on one side only of 8 1/2" x 11" paper.

Each problem shall begin on a separate page.

Each page shall contain the following (in the upper right hand corner): Your name, the date, and page __ of __.

All final answers must be boxed and work must be legible.

Problems shall be restated prior to solution.

Free-body diagrams (FBDs) shall be drawn for problems requiring such.

Loose sheets shall be placed in the correct order and stapled together in the upper left hand corner.