ASEN 5519 Special Topics: Introduction to Phononics (Fall 2018)
(Formally, Special Topics: Vibrations in Mechanics and Physics)

Instructor: Prof. Mahmoud Hussein, Aerospace Eng. Sciences, ECAE 194, 492-3177, mih@colorado.edu

Schedule: TTh 5:00-6:15 pm, Engineering Classroom Wing 1B08 **Office Hours:** By Appointment

Objective and Scope:

This course will provide an advanced exposure, coupled with hands-on development, of concepts and techniques in the theory of phonons with a focus on vibrations, wave propagation, and transport in periodic materials. Motivated by the growing interest in interdisciplinary research, the course will take a unique perspective of approaching the topic from both the mechanics and physics points of view, hence multiple system size scales will be considered ranging from the continuum to the atomistic. This approach promises to broaden the potential for cross-flow of ideas and the development of novel insights, techniques and applications, particularly in the emerging areas of *nanomaterials* and *metamaterials*.

Topics (tentative):

Intro to course; intro to phononics at macro and nanoscales; motivation and applications

Macroscale Phononics (Vibrations in Mechanics)

Discrete models: Vibration/dispersion analysis of finite/infinite systems
Single-DOF and multi-DOF systems
Modal analysis (mode superposition and selection):
Treatment of damping (non-proportional and general)
Vibration absorber and locally resonant elastic metamaterials
Continuous models: Vibration/dispersion analysis of finite/infinite systems
Transfer matrix method (undamped and damped)
Finite element method (undamped and damped; steady-state vibrations, wave simulation, and dispersion)
Introduction to multi-dimensional lattices: Symmetry, Brillouin zone,
Applications of macroscale phononic crystals and elastic metamaterials

Nanoscale Phononics (Vibrations in Physics)

Basic crystallography and interatomic potentials
Lattice dynamics: dispersion, mode shapes, and density of states
Thermal transport: thermal conductivity prediction; physical phenomena

Research and development outlo

Course Themes:

Discrete vs. continuous models
Macroscale vs. nanoscale models
Steady-state vibration vs. wave simulation vs. dispersion descriptions of the dynamics
Analytical (e.g., transfer-matrix) vs. numerical (e.g., finite-element) methods
Mathematics and physics of vibrations and wave propagation with a focus on the phenomena of dispersion, resonance, dissipation, and nonlinearity
Intersection of disciplines between mechanics (elastodynamics) and physics (condensed matter physEMC TQq0.

Statements on University Rules and Regulations:

If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at dsinfo@colorado.edu.

If you have a temporary medical condition or injury, see Temporary Injuries under Quick Links at Disability Services website (http://disabilityservices.colorado.edu/) and discuss your needs with your professor.

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, a student with a religious obligation should contact the instructor to discuss possible arrangements for accommodation.

See full details at
http://www.colorado.edu/policies/observance-religious-holidays-and-absences-classes-andor-exams

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, color, culture,

ntation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise the course instructor of this preference early in the semester so that I may make appropriate changes to my records. See policies at *http://www.colorado.edu/policies/student-classroom-and-course-related-behavior*
and at
http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code