2021 MSE Expo

Rajat Mittal
Director of Graduate Studies
Mechanical Engineering
November 15, 2021

Agenda
• 5:00 Rajat Mittal
  • Overview – full-time MSE
  • Overview – EP Master’s
• 5:20 Mark Savage - Life Design Lab
• 5:25 Faculty Presentations
• 6:00 Closing

Full-Time - Degree Requirements

Section A - 8 advisor-approved courses
• 2 must be applied math, numerical analysis, or computational
• 4 (all-course) or 3 (essay) - Mechanical Engineering (530.xxx or 535.xxx)
• Up to 2 - Engineering for Professionals (535.xxx)
• Up to 4 - upper-undergrad level (xxx.4xx only)
• No independent research, graduate research, or special studies.

Section B – choose one
• 2 more courses (530.820 MSE All-Course - Graduate Research can be one)
• Master’s Essay – 6 credits, either...
  • 530.821 MSE Essay - Research and Writing
  • 530.822 MSE Essay – Co-Op

Info: https://me.jhu.edu/education/graduate-studies/advising/
Full-Time - Master’s Essay

- Identify a research advisor
- Conduct research or go on co-op
  - 6 total credits of 530.821 or 530.822 (equivalent of 2 courses);
  - Prepare and submit an essay that summarizes your research
    (final approval by advisor + one other faculty reader)
  - No essay defense
- Advantages of MSE Essay
  - Become part of a research team and/or professional co-op experience.
  - Learn from topic-area experts.
  - Conduct research that might lead to papers and/or conference presentations.
  - Improve your writing/presentation skills.
  - Impress potential employers with your expertise.
  - Improve chances of entering a PhD program.

Info: Section 3.2 of the MechE Master’s Advising Manual (page 10).

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Full-Time – FAQs - MSE Essay

How do I find an advisor?
- Contact professors in your area of interest
- Contact the Director of Graduate Studies (Rajat Mittal)

What kinds of research projects do MSE student do?
- MSE project is decided by you and your advisor
- MSE research may be a fundamental scientific investigation involving theory and/or experiments and/or computational modeling or it might involve experimental design and/or testing of a device.

How long is the MS Essay?
- There is no recommended length. The essay is a summary of your work. Your advisor will usually guide you in the writing.

Research can be open-ended. What if I cannot achieve my research objectives even after 6 credits of research? Will that delay my graduation?
- No! The MS essay is written, submitted and approved at the end of 6 credits of MSE research. As long as your advisor is satisfied that your research effort was appropriate and you prepare an essay that is approved, you are done.

For the 5-Yr MSE program, can I do an essay and finish in 1 year?
- Yes! Talk to potential advisors in your Senior year to start planning.

Is there funding available for MSE students who conduct research?
- Most MS research is unfunded.

Info: https://me.jhu.edu/education/graduate-studies/masters-program/
**EP – Master’s - All-Course Requirements**

**Ten courses – finish in 5 years or less**

- 1 Math
- 2 Core “Group 1” courses
- 3 “Group 1” or “Group 2” of focus area
- 4 Technical Electives
  - EN.535.820 Master’s Graduate Research can substitute for 1 Technical Elective
  - Can work with advisor, a full-time Mechanical Engineering professor, or EP instructor

Info: [https://ep.jhu.edu/programs/mechanical-engineering/masters-degree-requirements/](https://ep.jhu.edu/programs/mechanical-engineering/masters-degree-requirements/)

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**EP – Master’s - Thesis Requirements**

**Eight courses and a Thesis – finish in 5 years or less**

- **Courses**
  - 1 Math
  - 2 Core “Group 1” courses
  - 3 “Group 1” or “Group 2” of focus area
  - 2 Technical Electives
    - At least 1 from core engineering discipline
    - Up to 1 from selected engineering alternate option
- **Thesis**
  - Submit proposal any time but no later than 3rd to last semester of 5-year limit
  - Enroll in 535.820 Master’s Graduate Research and 535.821 Master’s Thesis Writing
  - Work with advisor, full-time Mechanical Engineering professor, EP instructor, or APL research staff

Info: [https://ep.jhu.edu/programs/mechanical-engineering/masters-degree-requirements/](https://ep.jhu.edu/programs/mechanical-engineering/masters-degree-requirements/)
**EP – FAQs – Master’s Thesis**

**How do I find an advisor?**
- Contact professors in your area of interest
- Work with academic advisor and program chair.

**What kinds of research projects do MSE student do?**
- Students in the Baltimore region or have access to equipment at their workplace can work on experimental projects.
- Students from other areas or without experimental equipment access work on theoretical or computational projects.

**How would remote EP students and those working full-time be able to do the thesis?**
- Students in the Baltimore region or have access to equipment at their workplace can work on experimental projects.
- Students from other areas or without experimental equipment access work on theoretical or computational projects.

**How long is the MS Essay?**
- There is no recommended length. The essay is a summary of your work. Your advisor will usually guide you in the writing.

**What is the expected level of research complexity and level of involvement?**
- Full-time Homewood and “part-time” EP students would have the same level of rigor and vigor. Your advisor and program chair will help guide the thesis essay expectations.

**Are the same opportunities available to EP students and well as full-time Homewood students?**
- Faculty ultimately have the discretion of who they accept to do research for a thesis in their labs.

**Would doing a thesis change the EP degree from “Master of Engineering” to “Master of Science in Engineering”?**
- No. The degree title is independent of whether or not a thesis is completed.

Info: [https://ep.jhu.edu/programs/mechanical-engineering/masters-degree-requirements/](https://ep.jhu.edu/programs/mechanical-engineering/masters-degree-requirements/)

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**Register on Handshake to make appts, apply for jobs, sign-up for events:**
[https://handshake.jhu.edu](https://handshake.jhu.edu)
Prof. Sean Sun
Cell Mechanics (Biology Meets Mechanics)

- Fundamental roles of mechanical forces in cell and tissue movement, morphogenesis, and disease
- Organ-on-chip, recapitulation of biological system in micro-devices
- Mathematical model: quantitative theories of major cell functions

Learn: microscopy, cell culture, genetic engineering techniques, image analysis and device building
Learn: microfluidic methods, tissue and organ culture, biotechnology questions and commercial opportunities
Learn: fluid mechanics, solid mechanics, dynamical systems and control theory.

Flow Physics and Computation Lab
(FPCL)

PI: Rajat Mittal

Themes
- CFD method development
- Moving Boundaries
- Fluid-Structure Interaction
- Acoustics
- Flow Control

Application Areas
- Active control of flow separation
- Rough Wall BLs
- Flow-Induced Flutter
- Biological Locomotion
- Cardiovascular Biomechanics
- Bioacoustics
Most robots use geometric maps to avoid obstacles but are poor at traversing them.

Animals use physical interaction to traverse obstacles robustly.

We study how robust locomotor transitions emerge from interaction with complex terrain, by integrating:

- animal experiments
- robotic experiments
- physics modeling

Student Mentee Achievements

Authorships
- 5 master, 5 undergraduate, and 1 high school students - journal/conference papers
- 10 master, 11 undergraduate, and 1 high school students - conference abstracts

Undergraduate and High School Students
- 1 LCSR REU first place presentation
- 1 winner of competitive summer research scholarship
- 3 undergrads won 5 competitive ME departmental research and scholarly outstanding achievement awards
- 2 competitive awards at high school Science Fairs

PhD/MSE programs - MIT, Princeton, Berkeley, UPenn, JHU, CMU, Northwestern, UMich, UW, Virginia Tech, Columbia

Employment - Google, Facebook, among others

Learn more from the Terrodynamics Lab: https://li.me.jhu.edu/mentoring/ https://li.me.jhu.edu/join/
Computational Studies of Multiphase Flows

Gretar Tryggvason’s Group

We study multiphase flows, such as flows with bubbles and drops, atomization, boiling, etc. by fully resolved numerical simulations.

Possible MSE projects include using already existing codes to examine various physical problems or writing codes to explore new ideas for data processing. Examples include:


Materials @ Extremes

- Nilanjun Mitra
  (nmitra1@jhu.edu)
Ramesh Lab: Making of Armor Ceramics

Focus: Improving dynamic performance of boron carbide (B,C) ceramics for protective applications
Approach: Unraveling the relationship between high-rate mechanical properties and microstructure through experiments

Strong and light weight B,C

Sudden brittle fracture on atomic scale

Studying deformation mechanisms by nanoindentation & microscopy

Combining Machine Learning, Multiscale Modeling, and in situ Experiment to Design Materials with Superior Properties

Prof. Jaafar El-Awady
ejelawady@jhu.edu

Presenter: Ali Rida

Overview:
- Our group couples machine learning and physics-based multiscale modeling tools to design and predict the thermo-mechanical properties, deformation and failure of materials.
- We also develop advanced microscale experiments to quantify location based properties of advanced metals and alloys.

Microstructure Prediction

Multiphysics Multiscale Modeling

Defect Characteristics in Alloys

Damage Evolution in Polymer Matrix Composites

Mechanical Properties and Microstructure Evolution in Additive Manufacturing of Alloys/Alloys

Machine Learning of Defect Evolution

Location Specific In situ High Temp. Testing of Metals
Defect Engineering of Structural Materials
Laszlo Kecskes’ Group

Focus: improving materials for engineering applications
Approach: study underlying physical mechanisms and understand processing-structure-property relationships
Projects: thermomechanical processing and characterization of Mg alloys, additive manufacturing of refractory alloys, and process modeling

- Thermomechanical Processing of Lightweight Alloys
- Additive Manufacturing of Refractory Alloys
- Deformation Engineering

Mechanical Properties

Mg-Al Model Alloy System
Equal Channel Angular Extrusion
SPD* Processing

Mechanism-Based Deformation Behavior

Property Characterization

Mechanical

Microstructural

Load [klbs]
Displacement [inches]

Contact Information: lkecske1@jhu.edu

The Advanced Medical Instrumentation and Robotics Research Laboratory (AMIRo) conducts research to aid and support the robotic assisted medical technology encompassing medical diagnosis and therapy, and clinical research. The main goal is to create the future medical robots and devices that will help clinicians to deliver earlier diagnosis and less invasive treatments at lower cost and in shorter time.

Iulian Iordachita Ph.D., Director
iordachita@jhu.edu
Intelligent Medical Robotic Systems and Equipment (IMERSE) Lab
Prof. Axel Krieger, email: axel@jhu.edu

Research Vision
- Replace critical portions of manual surgery/intervention with robotic precision
- Give physicians access to best images during surgery/intervention
- Prepare physicians with realistic plans and access to relevant patient information
- To reduce complications
- Accelerate learning curve
- To enable previously unimaginable tasks

3D Printing Patient Specific Vascular Graft

Research Information from other Professors unable to join us today...
Gayme group projects

Master’s Essay projects staring Spring 2022
- High Reynolds number reduced order wall-turbulence modeling tools
  - Model validation through simulation over a range of conditions
  - Characterizing the role of the physics in refining the model reduction approach
- Research tasks and required skills
  - Simulations of channel flow using existing codes (CFD)
  - Analysis of results (Matlab and Python)
  - Modification of tools to simulate improved models based on findings (modeling)

Contact Prof. Dennice Gayme at dennice@jhu.edu.

Dynamics of Cell Grown & Division
Noah J Cowan and Sean X Sun
ncowan@jhu.edu and ssun@jhu.edu
- Goal: understand cell-cycle dynamics using dynamical systems theory
- Approach:
  - Create simplified models to explain cell growth
  - Make model-based predictions for experiments
  - Analyze cell-cycle data from the Sun laboratory
- Who should consider this?
  - Required: hardworking, curious student with solid background in dynamical systems
  - Desired: skilled in dynamical system simulation in Matlab, Mathematica, or Python
### MSE Essay Research Opportunities in 2021-2022

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<th>Fluid Mechanics &amp; Thermal Sci.</th>
<th>ME in Biology and Medicine</th>
<th>Mechanics and Materials</th>
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Best of luck to you this year!

Questions? Contact Prof. Rajat Mittal, mittal@jhu.edu

Department of Mechanical Engineering