ME Bulletin

News for Mechanical Engineering Majors

Vol. 59, No. 2 ME Advising Office • 2560 EB • 355-3338 Spring, 2022

PHOTO PROVIDED BY DR. KNUDSEN

Pictured is the Kelvin Refrigerator upper main cold box in the Facility of Rare Isotope Beams (FRIB). Turn to page 6 and learn more about how you can get involved in the exciting field of cryogenics!

Curriculum News

IMPORTANT RE: Concentrations: If you decide to do a concentration, you **MUST** meet with Gaile and arrange for the concentration code to be added to your record before you apply for graduation to that the concentration statement will appear on your final transcript. To make an appointment, call 517-355-3338.

Co-op Students: BEFORE you leave for your Summer or Fall 2022 co-op rotation, be sure to discuss your schedule for Fall 2022/ Spring 2023 with your academic advisor.

ME 433–Intro to Computational Fluid Dynamics will be offered this summer as a second session course. ME 433 is a non-design senior elective.

ME 451–Control Systems requires *department approval* before you can enroll for fall or spring. If you have an accurate long-term schedule on file in the ME Advising Office, request approval by submitting the ME 451 Approval Form: https://me.msu.edu/me-451-enrollment-approval-form. If you do not have an accurate long-term schedule on file, schedule an appointment with Gaile by calling 517-355-3338.

ME 456–Mechatronic System Design will be offered next spring. ME 456 is a design intensive senior elective.

ME 465–Computer Aided Optimal Design will be offered this summer as an online full session course. ME 465 is a design intensive senior elective.

ME 477–Manufacturing Processes will be offered this summer as a first session course. ME 477 is a non-design senior elective.

ME 481–ME Design Projects requires *department approval* before you can enroll. If you have an accurate long-term schedule on file in the ME Advising Office, request approval by submitting the ME 481 Approval Form: https://me.msu.edu/me481-approval-form. If you do not have an accurate long-term schedule on file, schedule an appointment with Gaile by calling 517-355-3338.

Class Standing. ME juniors and seniors can obtain this information by emailing Gaile (griffore@egr.msu.edu).

Job Search Advice: The Center is available to answer questions about your job search. To ask a question or schedule an appointment, go to https://www.careers.egr.msu.edu/ or email them at: careers@egr.msu.edu

IAH/ISS Diversity Requirement: Each IAH and ISS course emphasizes a form of diversity: national diversity (designated "N" at the end of the course title), international and multicultural diversity (designated "I" at the end of the course title), or both (designated "D" at the end of the course title). *Students must include at least one "N" course and one "I" course in their Integrative Studies programs. A "D" course may meet either an "N" or an "I" requirement, but not both.*

Prerequisites: The ME department requires all students, *INCLUDING MEMBERS OF THE HONORS COLLEGE*, to observe all course prerequisite requirements. If you have a question about prerequisites, contact the ME Advising Office.

Career Peers

The Career Peer Program serves as a way for Spartan Engineers to receive high-quality career advice from their peers in a timely manner. Links to ME career peers can be found here: https://www.careers.egr.msu.edu/career-peer

Here is a schedule for our current ME career peers:

Jake Demski - Senior: Mon: 10am-12pm; Tu: 4:30-8pm; Wed: 12:30-2:30pm; Th: 6-8pm.

James Fordyce - Sophomore: Mon: 3-5pm; Wed: 3-6pm.

Ciara Regan-Moore - Junior: Mon: 3:30-8pm; Tu: 11:30am-3:30pm; Wed: 4:30-8pm; Fri: 11:30am-1:30pm.

Ross Davis - Junior - Mon: 2:30-6pm; Tu: 10am-11:30am; Wed: 2:30-4:30pm; Th: 10am-12pm.

ME Bulletin

The *ME Bulletin* is published twice a year (fall & spring) for sophomores, juniors, seniors, faculty, and staff of the Department of Mechanical Engineering. Photographs were taken by Craig Gunn unless noted otherwise.

Send all correspondence to:

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In This Issue

ASME Awards Prestigious National Medal to Michele Grimm

by Patricia Mroczek, College of Engineering Communications Manager

MJ MURAWKA

An award-winning professor at Michigan State University will receive a prestigious national medal from the American Society of Mechanical Engineers (ASME) for her ongoing and outstanding achievements in educating and mentoring current and next-generation leaders in engineering.

Michele J. Grimm, the Wielenga Creative Engineering Endowed Professor of Mechanical and Biomedical Engineering, will be presented with the 2022 Robert M. Nerem Education and Mentorship Medal. The medal was established by the Bioengineering Division of ASME in 2017 under the guidance of **Laurel Kuxhaus**, an alumna of MSU's Department of Mechanical Engineering.

ASME Executive Director and CEO **Thomas Costabile** said it was his honor to make the announcement.

"The medal is for leadership in mentoring hundreds of faculty members through stewardship at the National Science Foundation," he said, "and for establishing a cutting-edge biomedical engineering department, including undergraduate and graduate programs, and for supporting high-quality biomedical engineering across the United States."

Grimm will accept the medal and be a featured plenary speaker at the Summer 2022 Biomechanics, Bioengineering and Biotransport Conference in Cambridge, Maryland, in June.

Tammy Reid Bush, interim chair of the MSU Department of Mechanical Engineering, said an ASME medal is an ultimate honor because only a handful of medals are awarded by the division each year.

"The competition for these medals is fierce," she continued. "We are fortunate to have Dr. Grimm as part of our faculty in the Department of Mechanical Engineering. This is another outstanding honor not only for her, but our department and the college."

Grimm joined MSU in January 2019. Prior to that, she completed a three-year rotation as a program director for three BME-related programs at the National Science Foundation. During this time, she served as co-chair of the White House's Office of Science & Technology Policy Task Force on Research and Development for Technology to Support Aging Adults. She is currently concluding her service on the Commission on a Global Roadmap for Healthy Longevity for the National Academy of Medicine. She had a prior, 25-year career as a faculty member at Wayne State University. The biomedical engineering department and educational programs were developed at that institution.

ASME.ORG

Grimm is a Fellow of the American Society of Mechanical Engineers, the Biomedical Engineering Society, and the American Institute of Medical and Biological Engineering.

Her scientific research focuses on injury biomechanics – from characterizing important tissue properties to developing appropriate models for the assessment of injury mechanisms. Most recently, this has included working with obstetricians to identify the

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Going for the Gold with Aerodynamic Luge Sleds

Luge was one of the three sliding sports on the program at the 2022 Winter Olympics in Beijing this past February. The sport requires athletes to barrel down an ice track on small sleds accelerating to speeds of nearly 90 mph. Traditionally, lugers design and build their own sleds, often through trial and error.

Now, Clarkson University Mechanical and Aeronautical Engineering Professors **Doug Bohl*** and **Brian Helenbrook**, in collaboration with **Colby Mazzuca** of Aeroworks, are using advanced computational and experimental methods to optimize sled geometries for developing faster, more aerodynamic sleds.

On a recent episode of Here's an Idea™, Professor Bohl discusses the new approach to help shave off those extra 1/1000ths of a second that can be the difference between silver and gold at the Olympics. You can listen to the discussion by going to: https://www.techbriefs.com and searching for Going for the Gold

**Doug Bohl received his M.S. and Ph.D. degrees from the MSU Dept. of Mechanical Engineering in 1996 and 2002. His major professors were Drs. John Foss and Manooch Koochesfahani*

Do You Know What You're Doing This Summer?

By Rachel Mangiavellano, Career Consultant

The snow is starting to melt and career event season is winding down so it's time to look to summer! Have you secured an internship or co-op? Are you graduating and have that full time position locked down? If you answered yes to either of these questions then we need you to complete the Destination Survey: https://login.msu.edu/?App=Shibb-MSU-12Twenty (If you answered no, don't stop reading!) The information shared in the Destination Survey is really important to help future Spartan Engineers see the companies that recruit, average salaries, locations and more. Thank you for filling out the survey to help your fellow Spartans!

Now that you have completed the Destination Survey, let's get back to talking about your summer. Did you know you can earn credit for your internship or co-op? Even better, did you know it's a FREE credit? EGR X is the one-credit course designed to support your professional development while you engage in your work experience. The course is completely online and can be taken wherever you are this summer! Learn more and how to enroll here:

https://www.careers.egr.msu.edu/the-co-op-semester

If you didn't secure an internship or co-op for this summer, we invite you to join us for the virtual internship experience! This is also a one-credit FREE course and is designed to provide you with professional development and technical skill building outside of a formal work experience. We provide a series of seminars and mini projects as well as opportunity to engage in self-directed projects to enhance a skill area. Keep an eye on your email for more information or email careers@egr.msu.edu to learn more!

Academic Advising

1) **ME Juniors and Seniors** are advised by **Gaile Griffore**. For an appointment, call 517-355-3338.

2) **ME Freshmen and Sophomores** are advised by **Jeffrey Tsang**. Instructions for making an appointment with him can be found here: https://docs.google.com/document/d/1R8UbpqjZNJqM5vDTcRcPfz7Fh5RooDiY0cfpUe-WU-I/edit

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pathomechanics of neonatal brachial plexus injury. Based on this work, she served on the American College of Obstetricians and Gynecologists Task Force on Neonatal Brachial Plexus Palsy.

In September 2021, Grimm and Bush shared a national recognition for developing and implementing noteworthy diversity and inclusiveness practices in the ASME Bioengineering Division's Women's Networking Group.

Tutoring

•**The ME Learning Center** (https://me.msu.edu/me-learning-center)has free mentors for ME 201, 222, and 361. It is open at 6-10 p.m. on Sunday through Thursday.

•**Paid Undergraduate Tutors** are available for many ME courses. Students in need of tutoring help for a particular course are matched with fellow students who have performed well in that course. Payment is negotiated privately between the tutor and the student within appropriate limits. For help go to: https://sites.google.com/view/msu-tbp-pts-tutoring-database/home

•**The Guided Learning Center** (GLC) offers free drop in tutoring in math up to differential equations, science courses (chemistry, physics, etc.), and many core engineering courses. To request assistance, go to: https://www.egr.msu.edu/dpo/academics/guided-learning-center [Scroll down and click on application form]

•**The Cornerstone & Residential Experience (CoRe) Program** offers free tutoring on Sunday through Thursday from 6 - 10 pm. It provides help for MTH 132, 133; 234, and 235, CEM 141, and PHY 183 and 184. It is located here: https://core.egr.msu.edu/#section3 [Scroll down to CoRe Tutoring]

•**ME Graduate Student Tutors** can be contacted through the ME Advising Office. These tutors charge a fee, which you can negotiate with them. If you are interested, email **Gaile Griffore** at griffore@egr.msu.edu

Inside Out - A Few Thoughts on Communication by Craig Gunn, Director of Communications

Over the years I have looked at lot of communication issues that everyone needs to be concerned with when it comes to being an engineer in the real world. I have written about proper grammar, asking questions, plagiarism, building a readership, puzzles, and the steps in the writing process. I haven't exhausted the topics, but I thought that maybe it was time to just go back to the basics and speak to the issue of communication in general, just in case someone has been lost in the engineering wilderness for a while and has lost contact with reality. Therefore, reality is something that engineers deal with on a daily basis.

The things that you encounter in your classes and will encounter on the job involve real world activities. This is not the imaginary and silly stuff that goes on in "The Real World" of television. You investigate and solve problems that impact the lives of those around you and those you will never come in contact with. It is important then to put as much effort into the content of your engineering as you do with the communication of that content. Now more than ever you will have to speak and write to people who do not have the engineering background that you do. They will have to understand what you are talking about in order to make critical decisions that will, in turn, impact your life.

Promotions, success, and satisfaction will hinge on your ability as a great communicator. While you will claim that you are "not" English majors, that subtle ability will be reflected in all that you do. By presenting a coherent, intelligent, and interesting presentation you will sway your listeners. By creating a document that not only contains all the information needed but also presents it in a manner that draws in your readers and excites them to want to read your text, you will place yourself above other engineers. Communication works hand in hand with engineering because Great Engineering is Great Communication!

Dean's List

Congratulations to these 338 ME majors who made the Dean's List after Fall 2021. To be on the Dean's List, you must have a semester GPA of 3.5 or better. This list is from January 28. For updates, go to: https://reg.msu.edu/ROInfo/GradHonor/DeansList.aspx

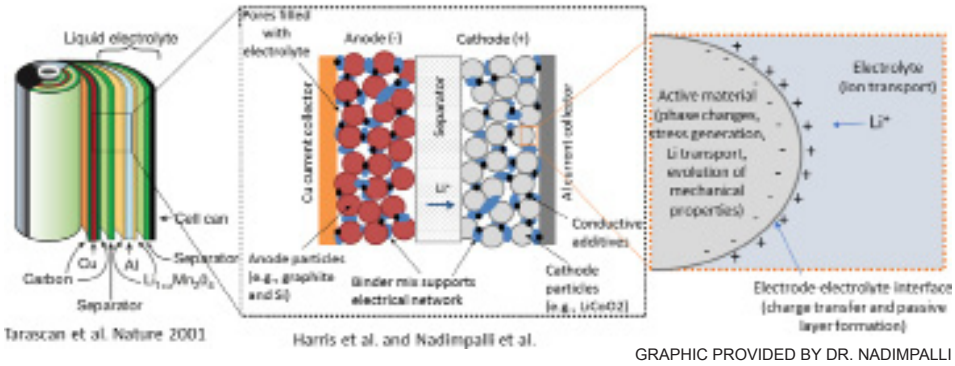
Fall 2021: Yusuf Abbas, Ahmed Abboushi, Devyansh Agrawal, Matthew Ajlouny, Ali Al Brahim, Omran Alawadhi, Jahzeel Alcantar Gallegos, Renad Alhassani, Zaid Almodhi, Bill Altier, Xiaoqiu An, John Andres, Nathan Ansbro, Alexander Arnold, Jordan Arnold, Nick Aseritis, Zach Atkins, Jenni Aubin, Axel Avram, Ethan Azeez, Evan Backer, Graham Bailey, Jeremy Balzer, Angelo Bartolome, Dominic Battiata, Jack Beddow, JoshBennett, Taku Benson, Ian Beshears, Elco Blanco,Daniel Blondell, Abigail Bowman, Atharva Burande, Thomas Burgess, Jeremy Busch, Brittany Bush, Matthew Bush, Bashhar Byrouthy, Ian Calandrino, Faith Call, Oriol Canellas Salles, Mitchell Carroll, Peter Caruso, Connor Casey, Alayna Celestini, Matthew Celini, Claudia Chen, Tanaka Chonyera, Artik Chowdhury, Erin Chynoweth, Emma Clawson, Nathan Clinger, Garrett Colasinski, Sean Colling, Steven Coscino, Atticus Crimmins, Andrew Culver, Vince Cushing, Delano Dalfonsi, Olivia Dario, Colin Davidson, Ross Davis, Justin De Coster, Kylie Decker, Jacob Demski, Karli Deutscher, Bryn Dittmar, Brendan Doane, Nick Dodge, Eric Douglas, Danny Drennan, Michael Dufresne, Van Duong, Jonathan Elias, Chelsey Ely, Andrew Emery, Daniel Erfani Zachi Yazd, Eric Ernvall, Mitchell Essenmacher, Stacy Fakhoury, Joe Fantin, Nate Farhat, Deniz Farmaka, Megan Fazio, Kyle Fischer, Andrew Flight, James Fordyce, Matt Fular, Alexa Garavaglia, Ben Gaynier, Hanna Gehrke, Nicole Gibbons, Christian Giggy, Jack Girling, Noah Goldman, Matthew Good, Seth Gower, Matt Greene, Jacob Grimmer, Roman Grishin, Srujan Gubbi, Bennett Guensche, Sarthak Gupta, Sohan Gupta, Branton Guri, Marvin Haddad, Joe Hamouda, Brian Hanton, Edmond Hashem, Jack Hasselbring, Braden Heiler, Douglas Heine, Justin Helmer, Zach Hetfield, Lazerick Hill, Fritz Hittner, Bryant Hixson, Chloe Ho, Jacob Hoffman, Henry Horak, Sepehr Hosseinkhani, Nolan Houghteling, Dylan Huck, Jacob Huskin, Samir Hussain, Rolanda Hutson, Alex Ifkovits, Nathan Jansen, Christian Jaraczewski, Amanda Jeffers, Thomas Jennett, Charley Jiang, Pahul Kahlon, Ethan Kalkman, Kelsey Karasek, Anthony Kasiyan, Allison Keller, Sydney Kelly, Max Kempisty, Rahmi Khalil, Shahab Khorasanizadeh, Edward Kim, Carson Kipp, Deaven Kirn, David Knapp, Natalie Knisley, Katlyn Knudsen, Ryan Knutson, Jared Koekkoek, Greg Koenigsknecht, Keerthi Kothapally, Justin Kowalchik, Nathan Kowalski, Nicole Kowalski, Elan Krakoff, Alex Kriese, David Kwok, Ethan Labelle, Nelson Ladomer, Evan Lamb, Joe Lambert, Raj Lamport, Oliver Larroquette, Nicholas Lauinger, Ryan Leinweber, Alec LeVasseur, David Levasseur, Ali Lewis, Chris Li, Jeffrey Li, Richard Lin, Matthew Lipscomb, Sean Lishawa, Ryan Lokar, Adolfo Lopez, Santos Lopez, Kendall Lusk, Cole Lutkenhoff, Olivia Lyle, Jessica Lypka, Elias Mackoul, Aditya Madhukar, Kirk Maibach, Logan Malak, Nicholas Malcolm, Eyob Mamo, Patrick Marchal, Tyler Marshall, Alexa Mazur, Fallou Mbengue, Brad McMahon, Claire McMillen, Douglas Mcnanney, Charlie Meilinger, Anirudh Menon, Charles Mercer, Connor Michel, Alex Miciuda, Hailey Minton, Anthony Montemayor, Nick Montpas, Parker Morris, Sara Moscone, David Mueller, Ethan Mulder, Nicholas Nastovski, Joe Nelson, Minh Nguyen, Tung Nguyen, Lila Ninotti, Livia Noble, Tanner Nurnberger, Nick Occhiuto, Peter Olszewski, Aliza Opolka, Brady O'Shea, Lauren Osiwala, Abby Pankey, Tyler Paparella, Vanessa Pariso, Eric Parsons, Anita Patel, Khush Patel, Smitkumar Patel, Vedi Patel, Jon Paul, Jacob Pawloske, Kyle Pawlowski, Ricardo Paz Weber, Sam Pellinen, Mason Perillo, Anthony Pero, Evan Petersen, Emily Peterson, Julie Pham, Peter Phan, Nathan Phelps, Jordan Piatek, Eli Pickard, Lehomm Pickard, Andrew Pieper, Rhett Pimentel, Race Piontkowski, Ryan Prost, Jax Prusakiewicz, Garrett Puehler, Devon Pung, Sara Purdue, Abhyuday Rastogi, Jackson Rayer, Andrew Retzlaff, Olivia Reyes, Joey Rheaume, Monica Roberts, Karisa Rodeghiero, Ryan Rowe, John Royston, Mitchell Ruczynski, Garrett Ruhala, Jacob Rupprecht, Matthew Russell, Jake Rutkowski, Chris Sadler, Gina Sapiano, Nicholas Sarver, Gus Scheier, Noah Schott, Matt Schram, Deshawn Schwan, Jason Scott, Zac Seeds, Hammer Shalawylo, Noah Shephard, David Shim, Jack Sikkema, David Smith, Max Smith, Youngbin Song, Alain Sotolongo-Carballo, Steven Souphis, Jake Stanesa, McKyle Stanfield, Hunter Staton, Spencer Stefani, Justine Stewart, Steven Stine, Stephen Stormzand, Michael Strong, Zach Stroud, Haosen Sun, Aidan Svoboda, Hailey Swamy, Aditya Swarnkar, Kengo Takenouchi, Jerica Tallman, Kai Thin, Jessica Thomas, Alejandro Tlatelpa, Ben Toaz, Connor Trask, Gus Tsalas, Brandon Tsivitse, Emma Turkmani, Drew Tyrrell, Daniel Vance, Michael Vangel, Val Vargas, Wade Varney, Grace Veenstra, Bobby Vette, Dayana Villagran, Jack Voigt, Atharva Wadhokar, Sarah Walrath, Katharine Walters, Vanessa Wang, Connor West, Jack Whitcomb, Coleson White, Poom Wichitrakanlikit, Max Wiedemann, Luke Willemsen, Paul Williamson, Connor Witham, Joshua Woodford, Yang Xu, Zhihao Xu, Griffin Yakey, Kenny Yue, Tahha Zahid, Zapiain Pruneda, Ryan Zerona, Jacob Zettle, Haohua Zhang, Richmond Zhang, Siyuan Zhang, Andy Zhao, Yu Zheng.

Role of Mechanics in the Design and Development of Rechargeable Batteries by Dr. Siva Nadimpalli

Have you ever wondered why the capacity of a cell phone or a laptop battery decreases over time? Well, the mechanical stresses developed in the battery electrodes are one of the reasons for this. Energy stored in a rechargeable battery is a function of cell voltage (V), and the voltage of the cell is also affected by the stress field generated in the electrodes during electrochemical cycling. Hence, the electrochemistry and the performance of a battery are affected by the stresses. Therefore, it is important to understand the stress generation and the associated structural changes in electrodes during electrochemical cycling of a battery. Also, mechanics and electrochemistry of battery materials are inherently coupled. For example, chemical reaction of Li with Si (a potential electrode material for next generation batteries) results in rich mechanics and materials phenomenon such as phase transformation, large deformation plasticity, variation of mechanical properties with Li concentration, and fracture. Understanding this coupling between electrochemistry and mechanics is essential to a successful design of durable and light weight batteries.

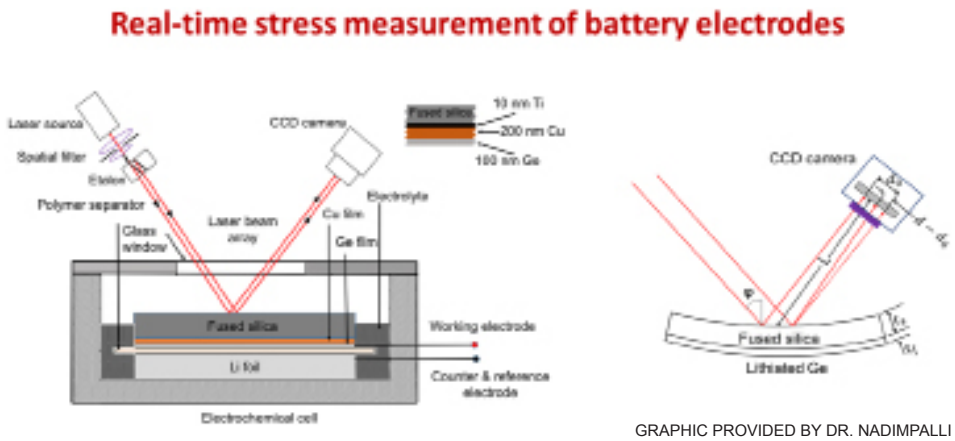
Why do stresses develop in electrodes? The schematic in Fig. 1 shows the details and three key components of a battery: anode, cathode and electrolyte. Li-ions shuttle between anode and cathode during charge and discharge cycles. When Li-ions react with active particles (i.e., circular particles in Fig.1b), they undergo volume changes. The surrounding materials prevent free expansion/contraction of particles which leads to development of stresses in the particles and electrodes. This is analogous to thermal stresses that develop in a beam supported between rigid walls when subjected to heating/cooling cycles.

Rechargeable batteries are key to the success of clean energy production



GRAPHIC PROVIDED BY DR. NADIMPALLI

Fig.1 (a) Schematic of a cylindrical lithium-ion battery, (b) shows the details of electrode construction. The anode is a composite made from graphite particles (similarly LiCoO2 particles in case of cathode) with which Li+ ions react; the electrode particles are held together by a polymer binder (light blue, PVDF) and (c) shows a list of phenomenon that occur at the particle level in the battery electrodes. The volume changes of active particles during charge/discharge reactions induce strain/stress in the electrode which leads to mechanical degradation.



GRAPHIC PROVIDED BY DR. NADIMPALLI

Fig. 2 Mutli-beam optical sensor setup for substrate curvature measurement integrated with an electrochemical cell to measure electrode stresses in real time during electrochemical cycling.

(wind and solar energy) and green transportation (electric vehicles). The capacity (total energy stored) and energy density (energy stored per unit weight) of the state-of-the-art rechargeable batteries are not able to keep up with the future demands (electric car, aerospace, and biomedical fields); the future improvements of capacity and energy density will only be achieved by developing new chemistries (i.e., new electrode materials and electrolyte design) and cell engineering (i.e., optimized electrode microstructure). Major efforts in battery research have been focused on the synthesis of novel active materials (for cathode and anode) to achieve higher energy and power densities. However, finding high energy density materials only solves the capacity requirement of the batteries but not their durability, which is another key performance factor. In other words, batteries have to survive thousands of charge/discharge (or stress) cycles

with minimum loss of capacity to be a viable technology. Batteries lose capacity primarily due to two reasons: (i) chemical degradation (i.e., passive layer formation in Fig.1c) and (ii) mechanical degradation such as fracture and delamination of electrodes. As mentioned above, mechanical degradation in electrodes is primarily driven by mechanical stresses.

Prof. Nadimpalli and his team established unique experimental facilities (one such example is shown in Fig.2) that enable real-time stress measurement of electrodes while the battery is subjected to charge/discharge cycles, and they measured stresses in various electrode materials of Li-ion and Na-ion batteries with this setup. They observed that the high energy density future electrodes such as Si develop significant stresses during charge/discharge process which lead to electrode failure within few cycles. It was also observed that highly brittle materials such as Si when reacted with lithium undergoes elastic-plastic deformation. Electrochemical alloying of Li with Si results in an amorphous LixSi alloy, but the alloying of Li with Al results in LixAl intermetallics. These alloying mechanisms caused a very different mechanical response of the electrodes which will have a distinctly different effect on battery performance and durability. In addition, they were able to quantify how much the stress affects voltage of a cell and how the diffusion of Li in electrodes is hindered/enhanced by stresses.

Building upon the experimental studies detailed above, Prof. Nadimpalli's group is developing advanced theoretical models that include a more accurate description of Li solution thermodynamics and transport, as well as a treatment of the capacity loss; these models also consider the large deformation kinematics (i.e., elastic-plastic deformation of electrodes) as well as electrochemical reactions using Butler-Volmer kinetics. Prof. Nadimpalli's research team continues to develop new in situ experimental methods to shed more light on the phenomena of batteries that occur at various length scale spanning from nanoscale to continuum scale (see Fig.1 from left to right). Also, the comprehensive multiphysics-based models developed by Prof. Nadimpalli's group enable accurate simulation of battery operation and degradation to guide a damage tolerant and long cyclic life high performance batteries for automotive, biomedical, aerospace, and other applications.

Michigan State University
Department of Mechanical Engineering

ENGINEERING MECHANICS CONCENTRATION

(12 Credits)

Leonardo DaVinci reportedly described the study of mechanics as "the paradise, the Garden of Eden of mathematics, for therein it bears its fruit." The engineering mechanics concentration is designed to provide undergraduate students with a more thorough understanding of analytical, computational and experimental methods for investigating the response of structures and fluids to external forces, pressures, thermal effects and other environmental loads. These skills have applications in all areas of mechanical engineering as well as in many interdisciplinary fields, and they are the key to modern mathematics-based design processes that are used by all major engineering firms. This concentration is also well suited for preparing students for graduate study in mechanical engineering or engineering mechanics.

To complete a Bachelor of Science degree in mechanical engineering with an engineering mechanics concentration, students must complete the requirements for the B.S. degree, including the following 12 credits:

- ME 423 Intermediate Mechanics of Deformable Solids – 3 credits (Fall Semester)
- ME 475* Computer Aided Design of Structures – 3 credits (Fall Semester)
- ME 425 Experimental Mechanics – 3 credits (Fall Semester)
- ME 464 Intermediate Dynamics – 3 credits (Spring Semester)

IMPORTANT: 1) For the latest and most accurate version of this concentration, please refer to the Dept. of Mechanical Engineering website. Earlier versions are invalid and will not be honored. 2) You MUST meet with the ME junior/senior advisor and arrange for the concentraiton code to be added to your record prior to applying for graduation. This ensures that the concentration statement will appear on your final transcript. To make an appointment, call 517-355-3338.

CREDIT DISTRIBUTION: The 12 credits in the concentration will fulfill the Senior Elective requirement, including the "design intensive" course component. Completion of the option will be noted on the final transcript.

Cryogenic Engineering

by Dr. Pete Knudsen

Cryogenic engineering involves the mechanical and thermal-fluids design of systems that operate at very low temperatures, normally starting at liquefied natural gas down to liquefied hydrogen and helium (i.e., from -260 to -452 degrees Fahrenheit).

Cryogenic engineers are employed in aerospace, the energy and industrial gas industry, and at government lab and research centers (e.g., NASA, DOE, DOD). And, they will be play a critical role in the hydrogen economy. Cryogenic systems are complex, and their design requires a firm understanding and application of thermodynamics, heat transfer, fluid mechanics, and mechanical design, while taking into account non-ideal fluid and material properties. In addition, thermal-mechanical optimization and integration is inherent in their design.

MSU's College of Engineering and its Mechanical Engineering Department, in collaboration with the Facility for Rare Isotope Beams (FRIB) at MSU, offer three cryogenic engineering courses to introduce students to various aspects of the field. Available courses:

ME 414-Mechanical Design of Cryogenic Systems is offered during fall semesters. It focuses on:

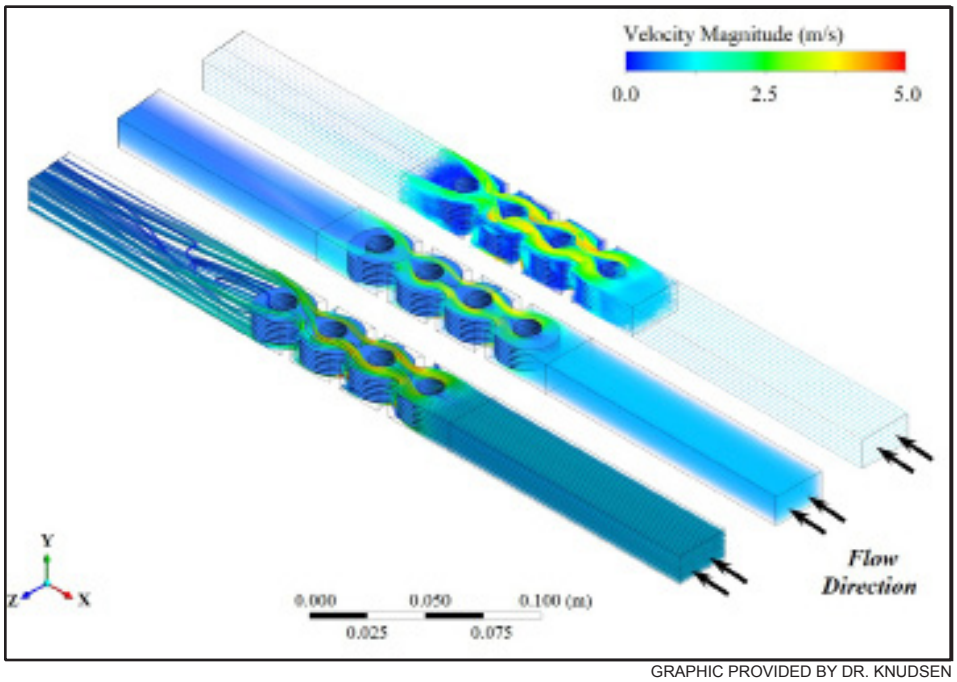
- Mechanical design of cryogenic piping systems
- Analysis of stresses due to process conditions such as pressure, temperature, and momentum
- Examples in the optimization and trade-off of the thermal and mechanical design
- Consideration of non-constant material properties
- Introduction to ASME design codes (to give students an understanding of what is required in the industry)

ME 413-Cryogenic Thermal Systems is offered during spring semesters. It focuses on:

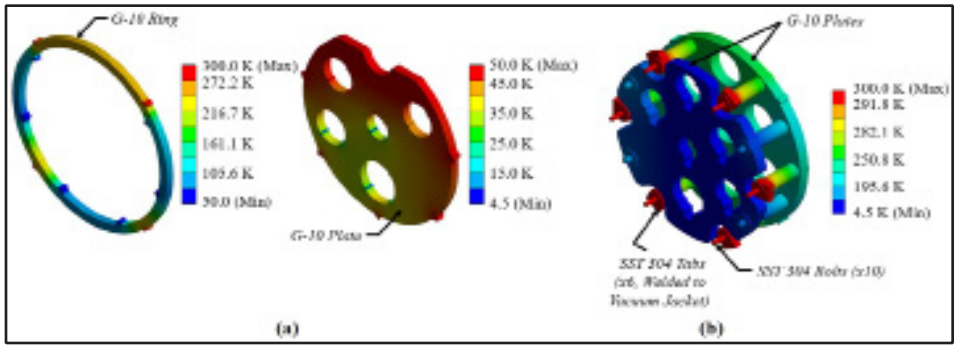
- Thermodynamics and modeling of cryogenic process cycles
- Modeling of components (e.g., rotating machinery, heat exchangers, separators, etc.)

PHOTO PROVIDED BY DR. KNUDSEN

Kelvin Refrigerator lower main cold box in the Facility of Rare Isotope Beams (FRIB).



GRAPHIC PROVIDED BY DR. KNUDSEN



GRAPHIC PROVIDED BY DR. KNUDSEN

- Cryogenic distillation and adsorption (i.e., how gas mixtures with boiling points substantially below the environment are separated and purified)
- Introduction to vacuum systems (which are integral to the thermal insulation)
- Instrumentation used in these systems

Every other fall, the graduate class ME 940-Cryogenic Process Engineering is offered. This class continues where ME 413 leaves off, focusing in greater detail on the thermal-fluid process design and analysis aspects of cryogenic systems. The next course is planned for Fall 2022.

The MSU Cryogenic Initiative (frib.msu.edu/cryoinitiative) is a collaboration between FRIB and MSU's College of Engineering. It offers research assistantships (RA's) and opportunities for graduate students interested in applied research in cryogenic engineering. *It also offers opportunities for undergraduate students to be exposed to cryogenic systems design.* Contact:
Dr. Venkatarao Ganni (ganni@frib.msu.edu),
Dr. Pete Knudsen (knudsen@frib.msu.edu), or
Dr. Nusair Hasan (hasann@frib.msu.edu) for more information.

175 Seniors to Graduate in May and August!

Congratulations and best wishes to all May & August ME graduates! If your name is missing, please contact me immediately at *griffore@egr.msu.edu* (Tele: 517-355-3338).—Gaile

May Graduates

Devyansh Agrawal
Sarah Abdulrahman Albawardi
Nathan Ansbro
Valerie Aten
Michael Batina
William Berlage
Ian Beshears
Daniel Blondell
Drew Boudreau
Abigail Bowman
Connor Bragg
Hernan Brarda
Paige Brechtelsbauer
Adam Bresson
Ian Burress
Jacob Campion
Emanuelle Carduner
Rohan Challa
Claudia Chen
Emma Clawson
Nathaniel Clinger
Sean Colling
Paige Cordts
Noah Crusoe
Delano Dalfonsi
Olivia Dario
Kylie Decker
John Paul Dela Cruz
Nicholas Demeester
Drake Deming
Cameron DePauli
Karli Deutscher
Robert DiPanni
Christopher Douglas
Ty Ebling
William Erskine
Stacy Fakhoury
Zhemeng Fan
Joseph Fantin
Kyle Fischer
Allison Fox
Zackary Friess
Benjamin Gaynier
Hanna Gehrke
Veronica Giordano
Jessica Gothro
Garrett Gould
John Gregor
Jacob Grimmer
Srujan Gubbi
Hunter Zachary Hansen
Brian Hanton
Zachary Harrison
Jack Hasselbring
Cody Hayse
Braden Heiler
Douglas Heine
Justin Helmer
Tucker Hendrie
Chloe Ho
Jacob Hoffman
Samir Hussain
Nelson Huynh
Alexandra Ifkovits
Ailohi Izirein
Thomas Jennett
Anthony Kasiyan
Allison Keller
William Kempisty
Rahmi Khalil
Justin Kinville
Katlyn Knudsen
Ryan Knutson
Robert Kolpasky
Ryan Koschay
Nicole Kowalski
Kace Krauss
Alexander Kriese
Alyssa Lafeir
Jack Lambrix
Rajan Lamport
Oliver Larroquette
Alec LeVasseur
Tyler Lim
Ryan Lokar
Jared Ludacka
Landon Luyckx
Kanglin Ma
Brendan MacDonald
Elias Mackoul
Kirk Maibach
Logan Malak
Blake Mallamo
Sean Martella
Nickholas Masini
James McDonald
Claire McMillen
Andrew McNamara
Hailey Minton
Daniel Mondrusov
Ethan Mulder
Lila Ninotti
Livia Noble
Tanner Nurnberger
Nicholas Occhiuto
Thomas Ott
Vanessa Pariso
Eric Parsons
Mark Pastoria
Smit Patel
Jacob Pawloske
Robert Pedder
Samuel Pellinen
Mason Perillo
Julie Pham
Elijah Pickard
Rhett Pimentel
Henrique Pio
Jax Prusakiewicz
Jiachen Qu
William Ranik
Abhyuday Rastogi
Maggie Ritchie
Elias Rodriguez
Mitchell Ruczynski
Christopher Sadler
Harrison Schaub
David Schulte
Jason Scott
Zachary Seeds
Matthew Simental
Youngbin Song
Steven Souphis
McKyle Stanfield
Justine Stewart
Steven Stine
Martin Stokes
Stephen Stormzand
Cooper Strebeck
Zachary Stroud
Matthew Stucky
Madeline Stump
Akhilesh Swaminathan
Hailey Swamy
Sophia Swiecki
Kengo Takenouchi
Jerica Tallman
Jessica Thomas
Emma Todd
Alexander Toth
Michael Trajkovski
Suhail Turkistani
Adam Van Gieson
Zachary Vander Stel
Michael Vangel
Nathan Vigneau
Jack Voigt
Quentin Wade
Atharva Wadhokar
Katharine Walters
Jacob Wescott
Connor West
Coleson White
Joshua Woodford
Zhihao Xu
Griffin Yakey
Marcelo Zapiain Pruneda
Ryan Zerona
Xichen Zhu

August Graduates

Cameron Depauli
Jack Hennessey
Nina Palazzolo
Jui-Wen Pang
Garrett Ruhala
Willis Wuebben

ME Senior Electives for 2022-2023

•*The following ME Senior Elective list was accurate as of March 4, but it is subject to change. Important changes will be emailed to you with "ME Bulletin Update" on the subject line.*
•*Design Intensive courses have an asterisk (✻) after the course number.*
•*The ME department cannot overfill a required course or section to solve a Senior Elective schedule conflict.*
•*Instructor assignments had not been finalized when the newsletter went to press. They will be posted later on the Class Search website.*
•*Course override instructions can be found in the shaded box on* page 11.

SUMMER SEMESTER

ME 433 Introduction to Computational Fluid Dynamics. 3(3-0). Prereq: (ME 410 or concurently). *Second Session.*

ME 465✻ Computer Aided Optimal Design. 3(3-0). Prereq: (ME 222 and ME 280) and (ME 370 or concurrently). *Full Session.* ▶***Online Course.***

ME 490 Independent Study. 1-4 credits. *See Override Instruction #2 on page 11*. You may reenroll for a maximum of 6 credits.

FALL SEMESTER

ME 414✻ Mechanical Design of Cryogenic Systems. 3(3-0). Prereq: (ME 470 or concurrently).

ME 416✻ Computer Assisted Design of Thermal Systems. 3(4-0). Prereq: (ME 410 or concurrently).

ME 422 Introduction to Combustion. 3(3-0). Prereq: (ME 332 or concurrently).

ME 423 Intermediate Mechanics of Deformable Solids. 3(3-0). Prereq: (ME 222).

ME 425 Experimental Mechanics. 3(2-3). Prereq: (ME 222).

ME 440 Aerospace Propulsion. 3(3-0). Prereq: (ME 332).

ME 444 Automotive Engines. 3(3-0). Prereq: (ME 410 or concurrently).

ME 475✻ Computer Aided Design of Structures. 3(3-0). Prereq: (ME 370).

ME 477 Manufacturing Processes. 3(3-0). Prereq: (ME 222 and MSE 250).

ME 490 Independent Study. 1-4 credits. *See Override Instruction #2 on page 11*. You may reenroll for a maximum of 6 credits.

ME 491 Selected Topics in Mechanical Engineering. Section 001. Topic: Biomechanical Analysis of Human Movement. See Override Instruction #1 on page 11. Course Description: Experimental methods used in the biomechanics of human movement. Topics will include equipment used for capturing movement (e.g, motion capture, force plates, EMG), data analysis techniques, and reviews of important studies in the biomechanics literature. Emphasis will be on writing code in MATLAB for data analysis. Applications of these techniques to human movement from different contexts (e.g., gait, sports, ergonomics) will be discussed. Prereq: (ME 370 or concurrently). ***Biomechanical Concentration Course***.

ME 494 Biomechanics and Heat Transfer. 3(3-0). Prereq: (ME 410 or concurrently). ***Biomedical Concentration Course***.

CHE 472 Composite Materials Processing. 3(2-3). Prereq: (ME 332).

CHE 483 Brewing and Distilled Beverage Technology. *See Override Instruction #6 on page 11*. Class meeting on Mondays is scheduled in room TBD and the hours arranged are located at MBI, 3815 Technology Blvd., Lansing, MI. Prereq: (Age 21 or higher) and (Senior standing) and (ME 410 or concurrently).

ECE 415 Computer Aided Manufacturing. 3(2-3). Prereq: (ME 451). *See Override Instruction #3 on page 11*.

ECE 445 Biomedical Instrumentation. 3(2-3). Prereq: ECE 345. *Biomechanical Concentration Course.*

MSE 425 Biomaterials & Biocompatibility. 3(3-0) Prereq: (MSE 250). Recommended Background: (PSL 250).

MSE 476 Physical Metallurgy of Ferrous & Aluminum Alloys. 3(3-0). Prereq: (MSE 250). Recommended background: MSE 310. *For more info, see Override Instruction #4 on page 11*.

ME 812 Conductive Heat Transfer. 3(3-0). *See Override Instruction #5 on page 11*. Prereq: (ME 412 plus GPA of 3.5+).

ME 830 Fluid Mechanics I. 3(3-0). *See Override Instruction #5 on page 11*. Prereq: (ME 332 plus GPA of 3.5+).

ME 860 Theory of Vibrations. 3(3-0). *See Override Instruction #5 on page 11*. (Prereq: ME 461 plus GPA of 3.5+).

SPRING SEMESTER

ME 413 Cryogenic-Thermal Systems. 3(3-0). Prereq: (ME 410 or concurrently).

ME 417✻ Design of Alternative Energy Systems. 3(3-0). Prereq: (ME 410 or concurrently).

ME 426 Introduction to Composite Materials. 3(3-0). Prereq: (ME 222).

ME 433 Introduction to Computational Fluid Dynamics. 3(3-0). Prereq: (ME 410 or concurently).

ME 441 Aerodynamics and Aircraft Performance. 3(3-0). Prereq: (ME 332).

ME 442✻ Turbomachinery. 3(3-0). Prereq: (ME 332).

ME 445✻ Automotive Powertrain Design. 3(3-0). Prereq: (ME 444).

ME 456✻ Mechatronic System Design. 3(2-3). Prereq: (ECE 345 or concurrently) and (ME 391 or concurrently).

ME 464 Intermediate Dynamics. 3(3-0). Prereq: (ME 361).

ME 465✻ Computer Aided Optimal Design. 3(2-3). Prereq: (ME 222 and 280) and (ME 370 or concurrently). ▶***Online Course.***

ME 477 Manufacturing Processes. 3(3-0). Prereq: (ME 222 and MSE 250).

ME 478✻ Product Development. 3(3-0). Prereq: (ME 477).

ME 490 Independent Study. 1-4 credits. *See Override Instruction #2 below*. You may reenroll for a maximum of 6 credits.

ME 495 Tissue Mechanics. 3(3-0). Prereq: (ME 222). ***Biomedical Concentration Course***.

ME 497✻ Biomechanical Design in Product Development. 3(3-0). Prereq: (ME 370 or concurrently). ***Biomedical Concentration Course.***

BE 444 Biosensors for Medical Diagnostics. 3(3-0). Prereq: (BS 161) and (CEM 141 or 151) and (ECE 345). ***Biomedical Concentration Course.***

CE 407 Materials Engineering: Properties, Selection and Processing. 3(3-0). Prereq: (CE 221 and ME 222). Recommended background: MSE 250.

CHE 483 Brewing and Distilled Beverage Technology. *See Override Instruction #6 Below*. Class meeting on Mondays is scheduled in 1145 EB and the hours arranged are located at MBI, 3815 Technology Blvd., Lansing, MI. Prereq: (Age 21 or higher) and (Senior standing) and (ME 410 or concurrently).

ENE 422 Applied Hydraulics. 3(2-2). Prereqs: (ME 332).

Graduate Level Courses: Honors College members and/or students with 3.5+ GPAs might consider taking a graduate course as a senior elective. Before enrolling, several signatures, including that of the instructor, are required. Possible choices for Spring 2023 include ME 810, 861, and 872. *See Override Instruction #5 below*.

OVERRIDE INSTRUCTIONS

1) Submit the ME Override Request Form: https://me.msu.edu/me-override-request

2) ME 490–Independent Study Enrollment Procedure: Find a professor who is willing to supervise your independent study, and discuss your plans with him/her. Complete an *ME 490/490H Enrollment Contract* (independent study form), which you can pick up in the ME Department office (2555 EB). After you and your professor have completed and signed both sides, return the form to Gaile for the remaining signatures, override, and enrollment.

3) Six seats in ECE 415 have been allocated for MEs who are on record as Manufacturing Concentration students. To be "on record," you must meet with Gaile to plan a long-term schedule. To request an override, email Gaile griffore@egr.msu.edu and be sure to include your PID number with your request. NOTE: A prerequisite override will be given to students who will need to take ECE 415 & ME 451 concurrently.

4) ME majors do not need to have taken the Recommended Background courses, but you will probably need to do some additional background reading. Contact the instructor for more information.

5) Complete the Graduate Course Override form, available from Gaile (griffore@egr.msu.edu).

6) CHE 483–To request an override, submit the CHE Override Request form: https://www.egr.msu.edu/chems/override/index.php

Department of Mechanical Engineering

MICHIGAN STATE UNIVERSITY

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Dept of Mechanical Engineering
Engineering Building
428 S. Shaw Lane, Rm 2560
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Spring Semester Calendar

April 8	Computer enrollment begins for Fall 2022. (Enrollment for Spring 2023 will begin in October.
May 2-May 6	Final Exams.
May 8	**Commencement Ceremony-12:30 p.m. in Breslin. Lasts about 2 hours.**
May 16-June 30	First Summer Session.
July 5-Aug 18	Second Summer Session.
May 16-Aug 18	Full Summer Session.
August 30	Fall Semester classes begin.