Department of Materials Science and Engineering
University of Toronto

MSE1023H1F: Special Topics in Materials Science II: Soft Materials and Machines

Fall 2020

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Course title Special Topics in Materials Science II: Soft Materials and Machines
Code MSE1023H1 F
Credit 0.5

References

1. John R. Dutcher (Editor), Alejandro G. Marangoni , Soft Materials: Structure and Dynamics, Taylor and Francis, 2004 1st Edition
2. Verl, A., Soft Robotics: Transferring Theory to Application, Springer, 2015
3. Bar-Cohen, Electroactive Polymer (EAP) Actuators, SPIE Press, 2005.
4. Fortuna, L., Soft sensors for monitoring and control of industrial processes, Springer, 2006
5. Elsevier Journal of Sensors and Actuators A and B: Physical and Chemical
6. IEEE Sensors journals
7. SPIE Smart Structures and Materials Proceedings 1999-2020
8. ASME Smart Materials and Adaptive Structures and Intelligent Systems proceedings 2009-2020

Calendar description

The future of smart manufacturing will depend on integrating multi-functional materials and devices. Flexible sensors, actuators and energy devices will help as a platform in sharing information as well as multitasking. Interacting smart systems will change how the manufacturing industry operates, enhance automation Internet of Things (IOT), (Industry 4.0). Soft materials are a class of materials characterized by their unique flexible and malleable properties that can be easy to deform and manufacture with distinct multifunctional properties. They can be used in a wide range of applications since they can exceed the current abilities of traditional materials especially in new devices and machines including sensors, actuators, energy devices, wearables and textiles. This course is designed to provide an integrated and complete knowledge to soft materials and machines, which makes a strong foundation for further studies and research on these materials and devices. Topics include structure, processing, properties of soft materials; definition of soft devices and machines; Processing and design; Applications of soft material and machines: Soft Sensors and E-skins, Soft Actuators and Robotics, Flexible Energy Storage, Flexible Energy Harvesting, Wearables and Textiles.

Locations Lecture hours Online, 2 hrs per week

Timetable

	Wednesday
12:00-14:00	LEC

LEC: Lecture

Grading Scheme

Interim Report & Presentation	15%
Final Report & Presentation	35%
Final Exam (Take Home)	50%

Project Guideline

Individual Projects, virtual presentation, and electronic report

Academic Policy

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the General Academic Regulations on Academic Integrity, students are reminded that plagiarism or any other form of cheating in examinations, term tests, assignments, projects, or laboratory reports is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating by another student is also subject to serious academic penalty.
https://www.academicintegrity.utoronto.ca/

Late Penalties

20% penalty for each portion of 24-hour period past the deadline.

Pre–requisite Knowledge

- Materials properties (physical, mechanical, electrical, magnetic, etc.)
- Materials in manufacturing
- Mechanical behavior of materials

Learning Objectives

- Understand the key practical theory with the operation principles of soft materials, their manufacturing, properties and their applications
- Address the key challenges and obstacles with manufacturing of different soft materials to devices including sensors, actuators and wearables
- Design and justify appropriate materials for specific applications

Course Schedule & Key dates

Lecture Topics	Subject
Introduction	- Course Administration & Overview - Introduction to smart manufacturing - Soft materials and machines
Soft Materials	- Polymers and composites - Colloids and suspensions - Foams, gels, aerogels - Granular materials, liquid crystals - Biological materials
Advanced Manufacturing	- Design for additive manufacturing - Bioprinting - Micro- and Nanoscale AM - Printed Electronics

Lecture Topics	Subject
Soft Sensors and E-Skins I	- Pressure sensing - Force sensing - Strain sensing - Intrinsic sensors vs. printed sensors - Biomedical applications
Soft Sensors and E-Skins II	- Soft substrate materials - Sensor testing principles - Temperature sensing - VOC sensing - Soft sensors for industrial processes
Soft Actuators and Robotics I	- Dielectric elastomers - Ionic polymer-based actuators - Shape memory polymers for actuation - Artificial muscles - Musculoskeletal robot - Nanostructured materials for soft robotics - New concepts for distributed actuators
Soft Actuators and Robotics II	- Soft robot control - Soft robot dynamics - Fibrous materials and textiles for actuators - Composites for soft robotics - Variable stiffness actuators
Flexible Energy Storage	- Wearable supercapacitors vs. batteries - Design of the nanostructured electrodes - Electrochemical characterization - Flexibility requirements and testing - Energy characterization and applications - Materials design principles
Flexible Energy Harvesting	- Overview of energy harvesting principles - Piezoelectric energy harvesting - Triboelectric energy harvesting - Thermoelectric energy harvesting - Multimodal flexible energy harvester design - Nano- and micro-structuring for energy harvesting
Wearables and Textiles	- Textile-based multifunctional platforms - Sensing environmental stimuli - Properties and mechanisms for smart textile designs - Textile actuators - Simulation and modeling for smart textile designs