

**ME 597  
MOBILE MICROROBOTICS**

**Course Objectives**

Upon completion of this course, the student should be able to:

1. Model, design, fabricate, and control a mobile microrobot for different applications
2. Understand microrobot fabrication techniques
3. Understand and apply micro/nano mechanics and scaling laws
4. Understand and analyze microscale sensing principles
5. Understand and analyze microrobot powering, and actuation methods
6. Understand and analyze microrobot locomotion, localization, planning, and control approaches

**Fundamentals  
(3 wks)**

1. Survey of state-of-the-art mobile microrobots
2. Scaling laws
3. Forces acting on a microrobot
4. Microrobot fabrication techniques

**Sensing & Actuation  
(4 wks)**

1. Sensors for microrobots
2. On-board actuation methods
3. Self-propelled actuation methods
4. Remote actuation methods

**Power, Locomotion, Localization, &  
Control (4 wks)**

1. Microrobot powering methods
2. Microrobot locomotion techniques
3. Microrobot localization and path planning
4. Multi-microrobot control

**Microrobot Applications  
(4 wks)**

1. Micropart manipulation
2. Biomedical
3. Scientific tools
4. New applications with emerging materials and fabrication techniques
5. Open challenges

**1. COURSE NUMBER AND NAME:** ME 5XX00 Mobile Microrobotics

**2. CREDITS AND CONTACT HOURS:** 3 credits

a. Lecture – 2 days per week at 75 minutes for 16 weeks

**3. COURSE COORDINATOR OR INSTRUCTOR**

D. J. Cappelleri

**4. TEXTBOOK**

Mobile Microrobotics by Metin Sitti, Publisher: The MIT Press, 2017

**5. SPECIFIC COURSE INFORMATION**

**a. Catalog Description:**

Mobile microrobot fabrication techniques; micro/nano mechanics and scaling laws; microscale sensing principles; microrobot powering and actuation methods; microrobot locomotion techniques; microrobot localization and path planning; microrobot control approaches; mobile microrobot applications

Typically offered in the fall.

**b. Prerequisites:**

First Semester Senior Standing or Higher

**c. Status:** Elective

**6. SPECIFIC GOALS FOR THE COURSE**

**a. Course Outcomes**

Upon completion of this course, the student should be able to:

1. Model, design, fabricate, and control a mobile microrobot for different applications
2. Understand microrobot fabrication techniques
3. Understand and apply micro/nano mechanics and scaling laws
4. Understand and analyze microscale sensing principles
5. Understand and analyze microrobot powering, and actuation methods
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**b. Related ME Program Outcomes:**

- A1. Engineering Fundamentals;
- A2. Analytical Skills;
- A4. Modern Engr Tools;
- A5. Design Skills;
- A6. Impact of Engr Solns;
- B1. Communication Skills;
- B2. Teamwork Skills;
- B3. Prof/Ethical Responsibility;
- C3. Innovation

**7. LIST OF TOPICS:** See following page.

**PREPARED BY:** D. J. Cappelleri

**Revision Date:** January 27, 2022

## Tentative lecture schedule

| Week | Lecture | Date  | Topic  | Reading   |                       |
|------|---------|-------|--------|---|-----------------------|
| 1    | 1       | Tues  | 23-Aug | Course Overview; Introduction                                 | 1.1-1.3               |
|      | 2       | Thurs | 25-Aug | Survey of miniature mobile robots                             | Notes + paper handout |
| 2    | 3       | Tues  | 30-Aug | Scaling Laws  | 2.1-2.4               |
|      | 4       | Thurs | 2-Sep  | Forces Acting on Microbot - Surface Forces; Adhesion          | 3.1-3.5               |
| 3    | 5       | Tues  | 6-Sep  | Forces Acting on Microbot - Contact; Friction; Microfluidics  | 3.6-3.10              |
|      | 6       | Thurs | 8-Sep  | Microrobot Fabrication  | 4.1-4.8               |
| 4    | 7       | Tues  | 13-Sep | Sensors for Microrobots                                       | 5.1-5.2               |
|      | 8       | Thurs | 15-Sep | On-Board Actuation Methods - PZT & SMA                        | 6.1-6.2               |
| 5    | 9       | Tues  | 20-Sep | On-Board Actuation Methods - Polymer & MEMS                   | 6.3-6.7               |
|      | 10      | Thurs | 22-Sep | Self-Propelled Actuation Methods - Gradients or Fields        | 7.1                   |
| 6    | 11      | Tues  | 27-Sep | Self-Propelled Actuation Methods - Bio-hybrid Cells           | 7.2                   |
|      | 12      | Thurs | 29-Sep | Remote Actuation Methods - Magnetic                           | 8.1                   |
| 7    | 13      | Tues  | 4-Oct  | Remote Actuation Methods - Electrostatic, Optical, Other      | 8.2-8.5               |
|      | 14      | Thurs | 6-Oct  | Quiz 1  | --                    |
| 8    | --      | Tues  | 11-Oct | No Class / October Break                                      |                       |
|      | 15      | Thurs | 13-Oct | Microrobot Powering - On-Board energy storage                 | 9.1-9.2               |
| 9    | 16      | Tues  | 18-Oct | Microrobot Powering - Wireless; Energy harvesting             | 9.3-9.4               |
|      | 17      | Thurs | 20-Oct | Microrobot Locomotion - Solid surface                         | 10.1                  |
| 10   | 18      | Tues  | 25-Oct | Microrobot Locomotion - Swimming; Water surface               | 10.2-10.4             |
|      | 19      | Thurs | 27-Oct | Microrobot Localization                                       | 11.1                  |
| 11   | 20      | Tues  | 1-Nov  | Microrobot Control; Path Planning                             | 11.2 + notes + paper  |
|      | 21      | Thurs | 3-Nov  | Multi-microrobot control                                      | 11.3 + paper handout  |
| 12   | 22      | Tues  | 8-Nov  | Microrobot Applications - Micromanipulation                   | 12.1                  |
|      | 23      | Thurs | 10-Nov | Microrobot Applications - Biomedical, Others                  | 12.2-12.5             |
| 13   | 24      | Tues  | 15-Nov | Smart Polymers and 4D printing for Microrobotics Applications | Handout papers        |
|      | 25      | Thurs | 17-Nov | Summary and Open Challenges; Project Intro                    | 13.1-13.2             |
| 14   | 26      | Tues  | 22-Nov | Quiz 2  | --                    |
|      | --      | Thurs | 24-Nov | No Class / Thanksgiving Break                                 |                       |
| 15   | 27      | Tues  | 29-Nov | No Class / Project Work                                       | --                    |
|      | 28      | Thurs | 1-Dec  | No Class / Project Work                                       | --                    |
| 16   | 29      | Tues  | 6-Dec  | Project Presentations   | --                    |
|      | 30      | Thurs | 8-Dec  | Project Presentations   | --                    |

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