2016

# Microfluidic Devices in Biotechnology

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*CUNY City College*

# BME510/I7700: Microfluidic Devices in Biotechnology

**BME 510:** Fundamentals of modern microfluidic devices with applications to biomedical measurements, e.g., electrophoretic systems, flow cytometers, and immunoassays. Review of fundamental properties of microfluidic systems including the effects of fluid mechanics, heat transfer, and electromagnetic phenomena on biological systems. Critical overview of design, manufacture, and operation of micrometer scale systems that use photolithographic and surface treatment techniques for device development.

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| **Lectures:** | Mondays | 11:00AM-12:15PM | ST-402 |
| | Wednesdays (10 Labs) | 11:00AM-2:50PM | ST-481/ASRC |


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| **Instructors:** | Professor M. Vazquez<br>Biomedical Engineering, ST-403D | vaZqueZ@ccny.cuny.edu<br>Office: 212.650.5209 |
| | Dr. Jacob Trevino<br>Director, Nanofabrication Facility | Jacob.trevino@asrc.cuny.edu<br>Office: 212.413.3310 |
| | Mr. Shawn Mishra (TA)<br>Biomedical Engineering, ST-481 | smishra00@citymail.ccny.cuny.edu<br>Office: 212.650.6766 |


**Office Hours:** Tuesdays from 3PM-4PM, and by appointment as necessary.

**Pre/Co-Requisites:** All students must have completed an undergraduate fluid mechanics or transport course (e.g. ME356 or ChE341) as well as an undergraduate wet laboratory course (e.g. BME310) NO EXCEPTIONS.

**Readings:** Assignments uploaded onto blackboard.com must be read prior to lectures.

**Lateness:** Students are expected to attend every lecture in a prompt fashion. *Please silence electronic devices during each class*. Students who must use a cell phone for emergency purposes are asked to please do so outside of the classroom.

**Participation:** Class participation in lecture counts! Ask questions and be ready to discuss questions posed in class. Students don't always have to know the right answer, but should be prepared to guess intelligently. Each student should ask and answer multiple questions every lecture.

**Lecture Format:** Each lecture will generally follow the format shown below:

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|---|---|
| Administrative Items | 5 min |
| Technical Lecture | 40 min |
| Group Problem Solving | 15 min |
| Discussion | 15 min |

**Exams and HW:** One midterm examination and one practical examination will be administered during this course. No makeup exams will be permitted unless the student can document an emergency. Five homework sets will be assigned throughout the semester. Assignments are due at the beginning of class.

**Laboratories & Presentation:** The course will incorporate a micro-manufacturing laboratory component required of all students. Labs will be conducted during 10 dedicated class times as shown on the syllabus. One comprehensive presentation and prototype of a microfluidic system must be presented and submitted as part of the course.

**Grade Distribution:**

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|---|---|
| Homework Sets (5 of 5) | **25%** |
| Midterm Exam | **20%** |
| Practical Exam (ASRC) | **20%** |
| Poster Presentation | **25%** |
| Class Participation/Effort | **10%** |
| | **100%** |

**Academic Integrity:** Students are welcomed and encouraged to discuss homework problems, lecture material, laboratory exercises/reports, and technical analysis with all of their classmates, as well as proofread each other's documents. Students Cannot: (1) Use data from another group without explicit instructor permission; (2) Copy (even in part) text from another report (including previous years); (3) Collaborate during examinations. Students who copy OR allow their work to be copied will be de-registered from the course and subject to investigation by the Grove School of Engineering (GSOE).

**Course Outcomes**: Upon course completion, students will demonstrate abilities to:

**1**. Successfully analyze a contemporary microfluidic flow problem by considering the underlying transport phenomena and dimensional constraints.
**2.** Develop and evaluate microscale designs that address bioengineering challenges and spatial constraints including consideration of manufacture, materials, and operation.
**3.** Micromanufacture microscale devices used for engineering analysis and/or system throughput.

| Lec | Date | Topics Discussed | Due |
|---|---|---|---|
| 1 | 08.29.16(M) | Introduction and Course Overview | In-Class Diagnostic |
| 2 | 08.31.16(W) | Review of Math/ Fluid Mechanics | |
| 3 | 09.07.16(W) | Review of Heat Transfer/Thermodynamics | |
| 4 | 09.12.16(M) | Overview of Clean Room Spaces and **Lab Safety** | HW 1 (Analysis) |
| 5 | 09.14.16(**W**) | Overview of Key Microfabrication processes<br>Photolithography (Technical Lecture) | |
| 6 | 09.19.16(M) | Surface Bonding/Micromolding (Technical Lecture) | |
| 7 | 09.21.16(**W**) | **CCNY Lab 1** (Photolithography/micromolding) | HW 2 (Protocols) |
| 8 | 09.26.16(M) | Discussion of Results from CCNY Lab 1 | |
| 9 | 09.28.16(**W**) | **ASRC Lab Safety and Orientation** | |
| 10 | 10.05.16(**W**) | **ASRC Lab 1A** (Photolithography) | |
| 11 | 10.06.16(TH) | Etching (Technical Lecture) | |
| 12 | 10.17.16(**M**) | **ASRC Lab 1B** (Bonding/Planar Etching) | HW 3 (Protocols) |
| 13 | 10.19.16(**W**) | **CCNY Lab 2** (Chemical Etching and DRIE)<br>Midterm Review | |
| 14 | 10.24.16(M) | In-Class Exam | MIDTERM |
| 15 | 10.26.16(**W**) | **ASRC Lab 2** (Chemical Etch, DRIE) | |
| 16 | 10.31.16(M) | Physical Vapor Deposition (Technical Lecture) | |
| 17 | 11.02.16(W) | Chemical Vapor Deposition (Technical Lecture) | HW 4 (Analysis) |
| 18 | 11.07.16(**M**) | **CCNY Lab 3** (CVD Demo) | |
| 19 | 11.09.16(**W**) | **ASRC Lab 3** (CVD) | |
| 20 | 11.14.16(M) | Imaging of Devices (Technical Lecture) | |
| 21 | 11.16.16(W) | Microfluidic Designs (Technical Lecture) | |
| 22 | 11.21.16(M) | Micro Flows/Actuation/Valving (Technical Lecture) | HW 5 (Design) |
| 23 | 11.23.16(**W**) | **ASRC Lab 4** (Comprehensive) | |
| 24 | 11.28.16(**M**) | **ASRC Lab 5** (Comprehensive) | Practical Exam |
| 25 | 11.30.16(M) | Open Lab: Prototype Design and Microfabrication | |
| 26 | 12.05.16(M) | Open Lab: Prototype Design and Microfabrication | |
| 27 | 12.07.16(**W**) | **PROJECT PRESENTATIONS** | PPTs |
| 28 | 12.12.16(M) | Review/Recap of Course | |

# Lecture 1: August 29, 2016

## A. Course Logistics

1. Syllabus Handout (bb.com upload)

## B. In Class

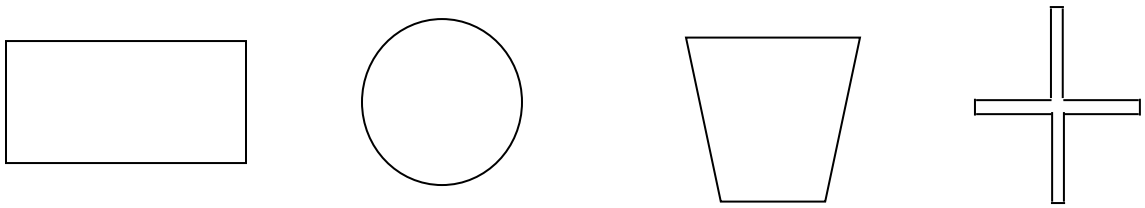
- Scale
- Geometry
- Continuum

## C. Group Problems

1. Identify the following symbols with units and definitions

| | |
|---|---|
| a. F | f. g |
| b. Q | g. h |
| c. W | i. P |
| d. T | j. $\underline{u}\ \underline{v}$ |
| e. R | h. $\underline{u} \times \underline{v}$ |

2. Identify (and justify!) what you would use as the characteristic length of the following geometries.



3. A packed-bed microreactor has a depth of 200μm and cross-section of 500μm by 500μm. The chamber is loosely packed with 10-μm-diameter microspheres that occupy 40% of the chamber volume. Estimate the number of spheres and the ratio between the reacting surface and chamber volume.

## D. Look Forward

Review of Mathematics and Fluid Mechanics