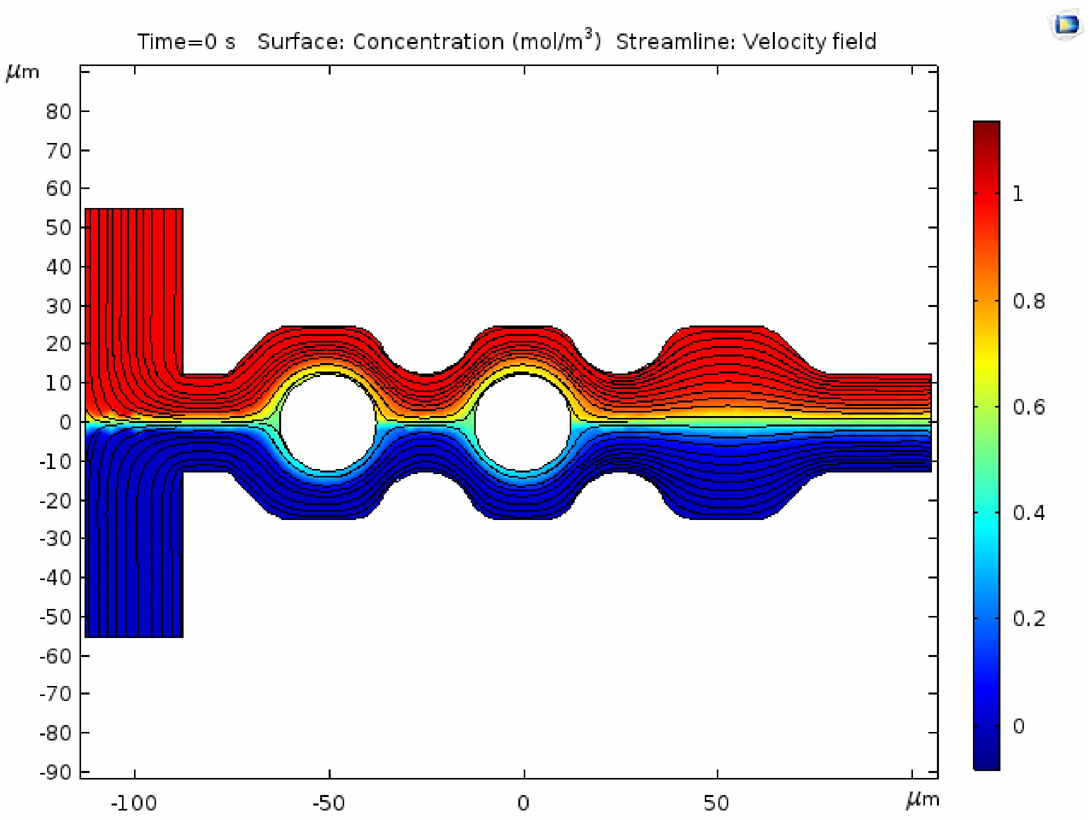
Design of an Electro-Osmotic Microfluidic Mixer



Stefan Keilich, Drs. Tom Eppes, & Ivana Milanovic

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COMSOL CONFERENCE 2018 BOSTON

University of Hartford

ME341: Heat Transfer (Spring 18)

- Announcements
- Instructor Information
- Course Documents
- Textbook
- EBooks
- Ch 1 Introduction
- Ch 2 Conduction
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- Simulation Assignments
- Simulation FAQ
- Tech Report FAQ

Announcements

New Announcements appear directly below the repositionable bar. Reorder by dragging announcements to new positions. Move pr them to the top of the list and prevent new announcements from superseding them. The order shown here is the order presented to s announcements.

Create Announcement

Colleges where engineering students go on to earn the most money

Posted on: Saturday, April 28, 2018 12:05:29 PM EDT

The 27 colleges where engineering students go on to earn the most money

BUSINESS INSIDER CAREERS

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University of Hartford/Facebook

14. (tie) University of Hartford

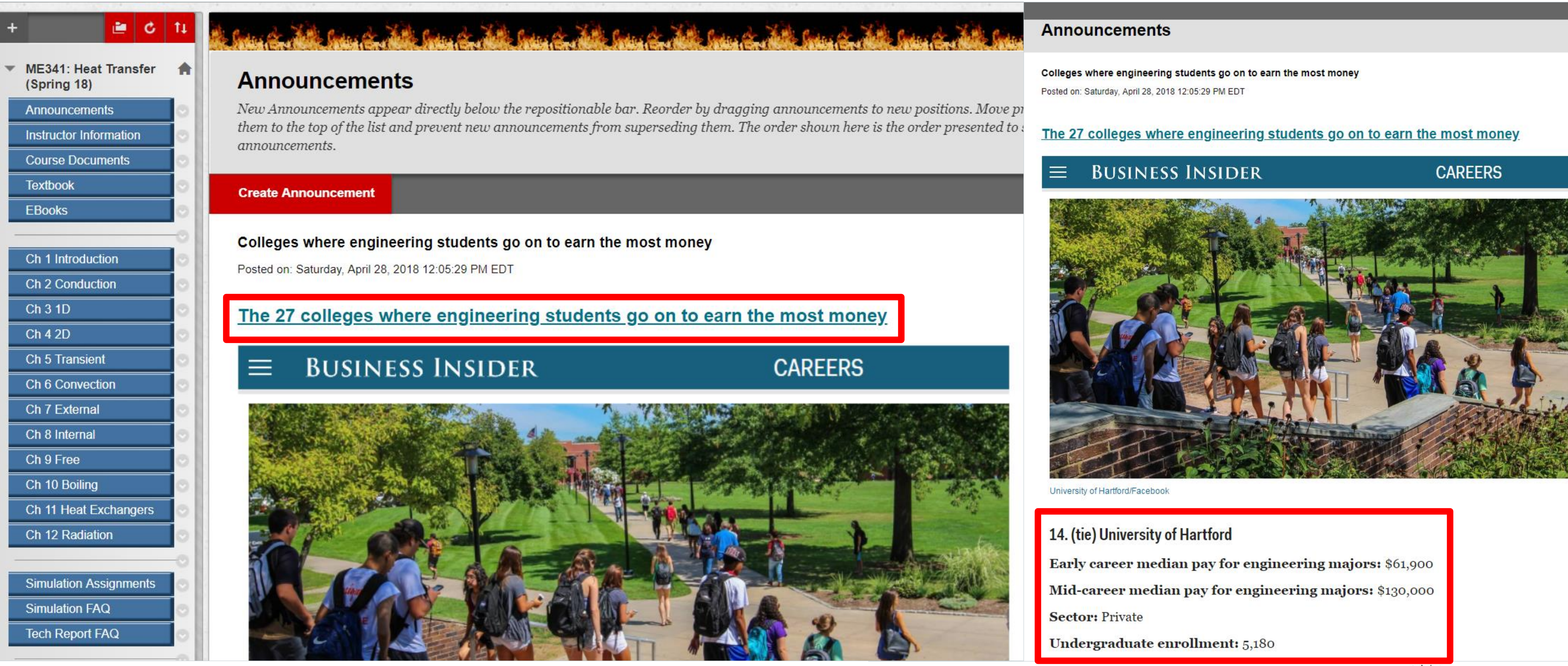
Early career median pay for engineering majors: $61,900

Mid-career median pay for engineering majors: $130,000

Sector: Private

Undergraduate enrollment: 5,180

BACKGROUND?



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INQUIRY-BASED LEARNING (IBL) APPROACHES

- **Approach 1: Internally Funded UG Research**
    - One semester, one student
    - Faculty mentored
    - Oral presentation at University-wide colloquium

- **Approach 2: Design Assignment in Simulation Course**
    - 3 weeks, 1-2 students per team
    - Largely autonomous
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Design Input

- Key focus areas:
    - Geometric shapes & dimensions
    - Electrode count & positioning
    - Voltage amplitude & frequency

Parameter	Value
Mean inlet velocity of fluid	0.1[mm/s]
Zeta potential	-0.1[V]
Amplitude of voltage signal	0.1[V]
Frequency of voltage signal	8[Hz]
Diffusion coefficient of fluids	1e-11[m^2/s]
Conductivity of fluids	0.11845[S/m]

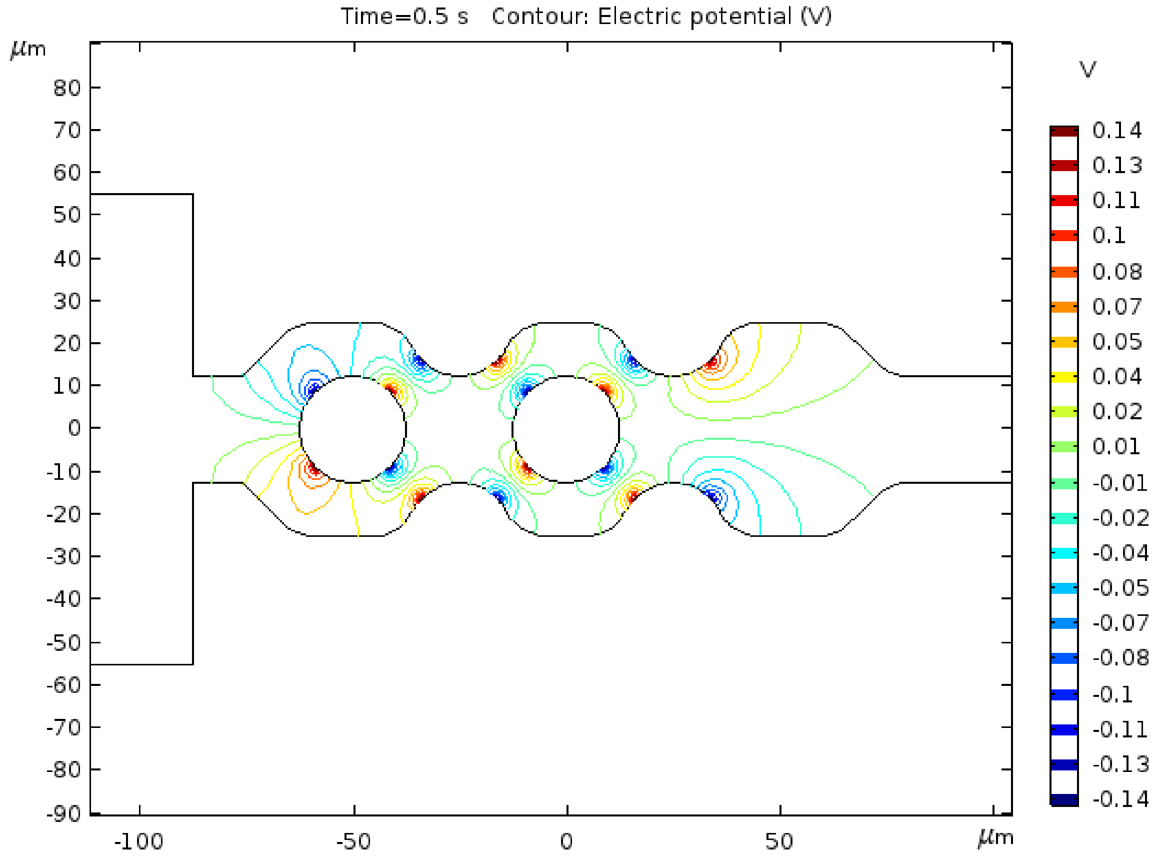
Design Input

- Fluid Constraints
  - Electrolyte
  - Two species
- Inlet Concentrations
  - 0 = Species 1
  - 1 = Species 2

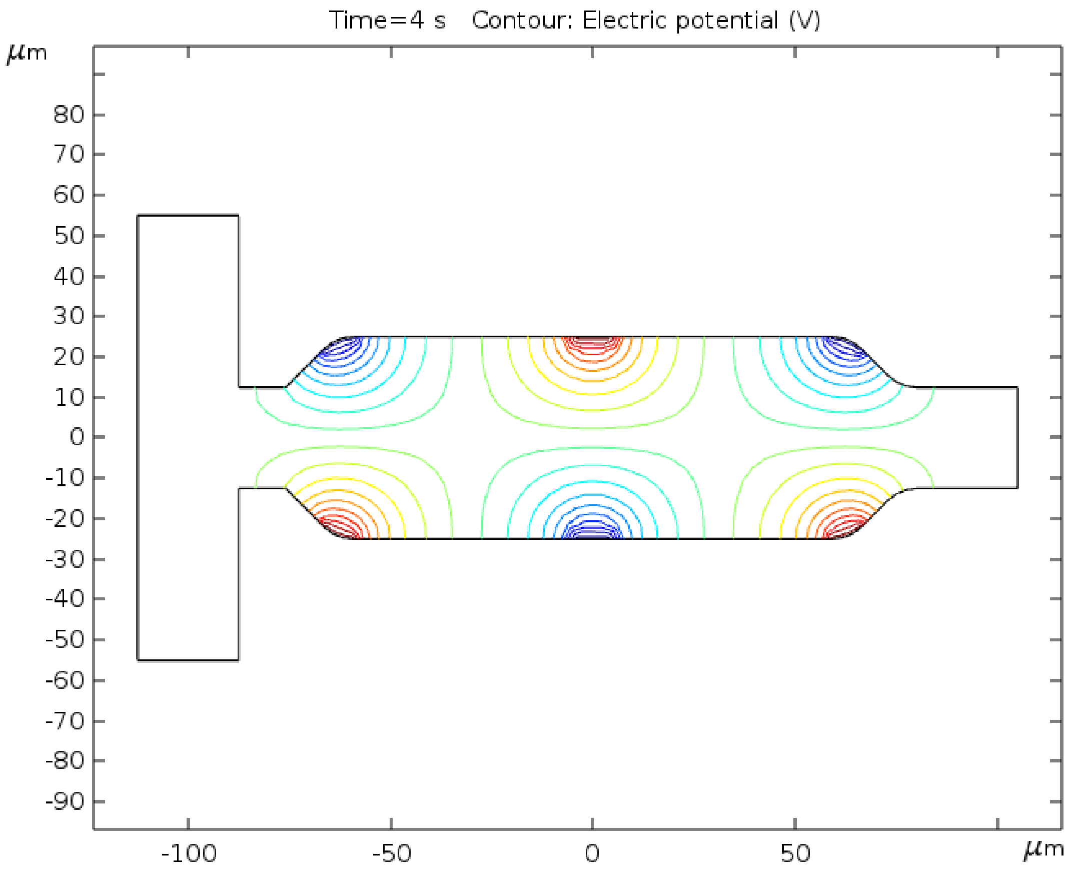
Material property	Value
Density	1e+3[kg/m^3]
Dynamic viscosity	1e-3[Pa*s]
Electrical conductivity	0.11845[S/m]
Relative permittivity	80.2

GEOMETRIES & ELECTRODES

GEOMETRY +1



GEOMETRY -1



Design of an Experiment: Results

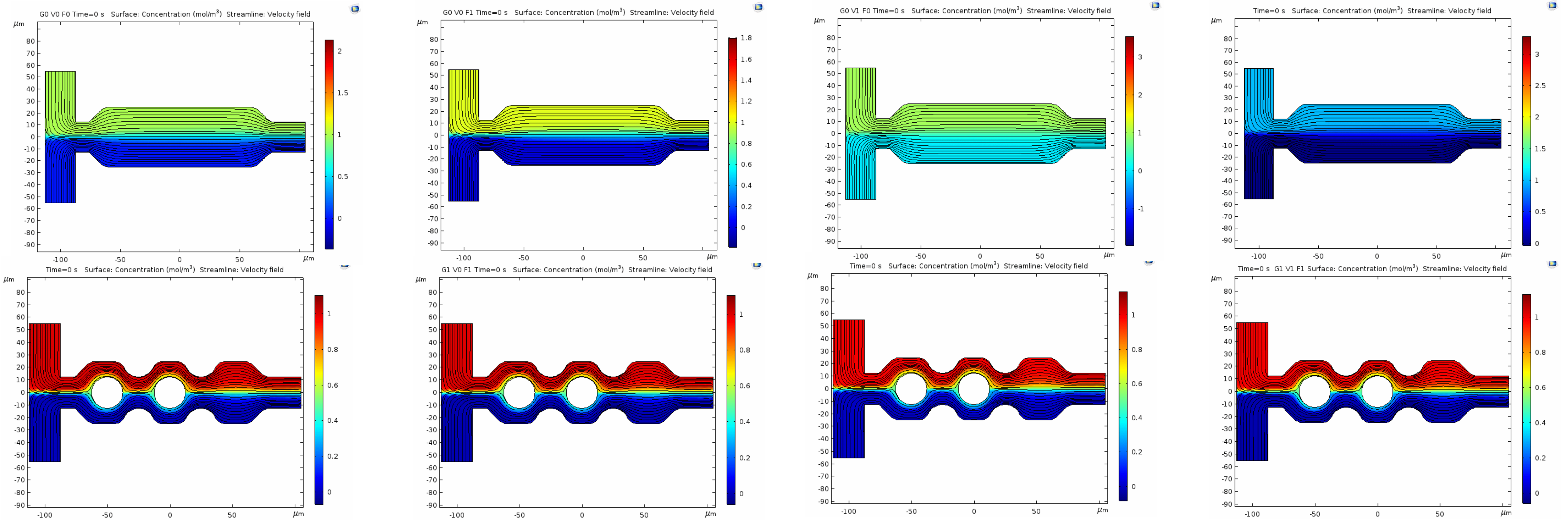
Voltage

[0.15 V] [0.15 V] [0.3 V] [0.3 V]

Geometry

-1

+1



[4 Hz] [8 Hz] [4 Hz] [8 Hz]

Frequency

Inlet & Outlet Concentrations

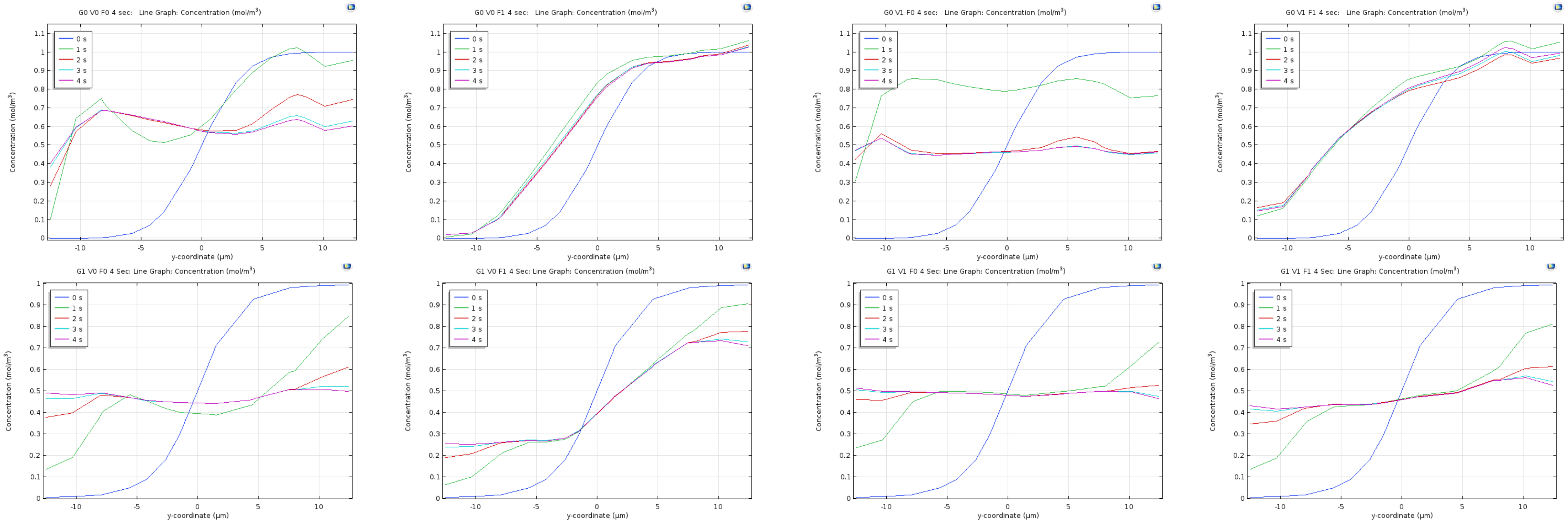
Voltage

[0.15 V] [0.15 V] [0.3 V] [0.3 V]

Geometry

-1

1



[4 Hz] [8 Hz] [4 Hz] [8 Hz]

Frequency

Steady State Concentrations

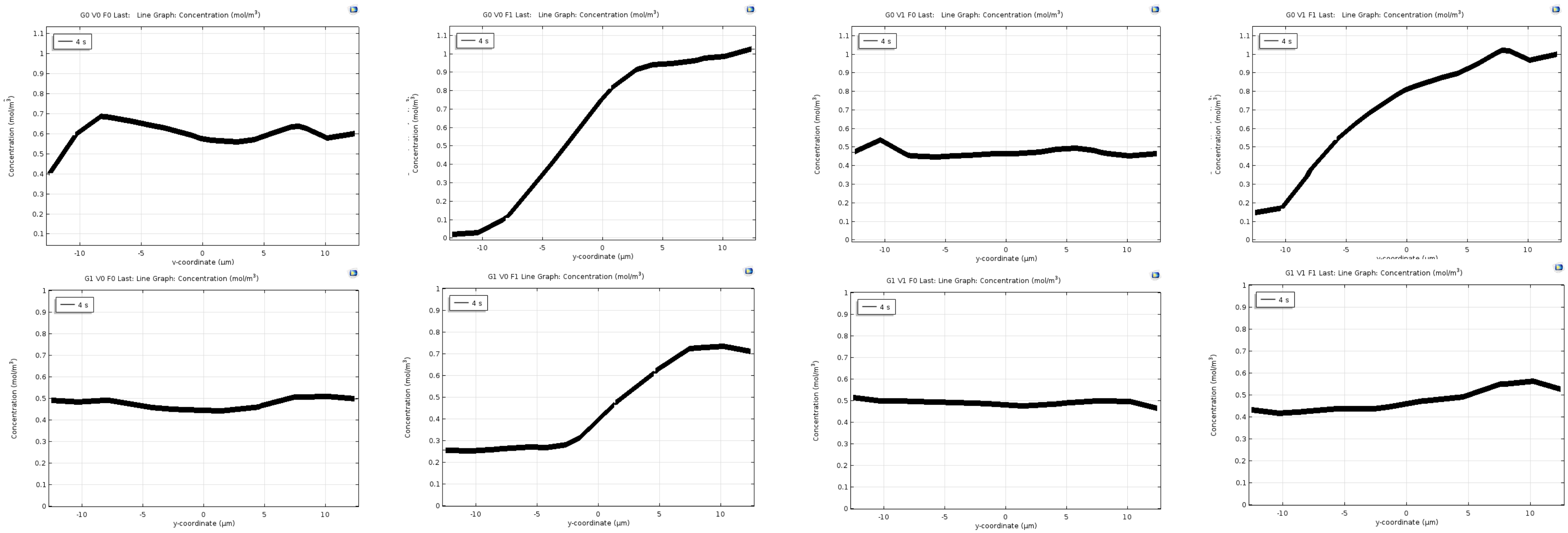
Voltage

-1 [0.15V] | -1 [0.15 V] | 1 [0.3 V] | 1 [0.3 V]

Geometry

-1

1

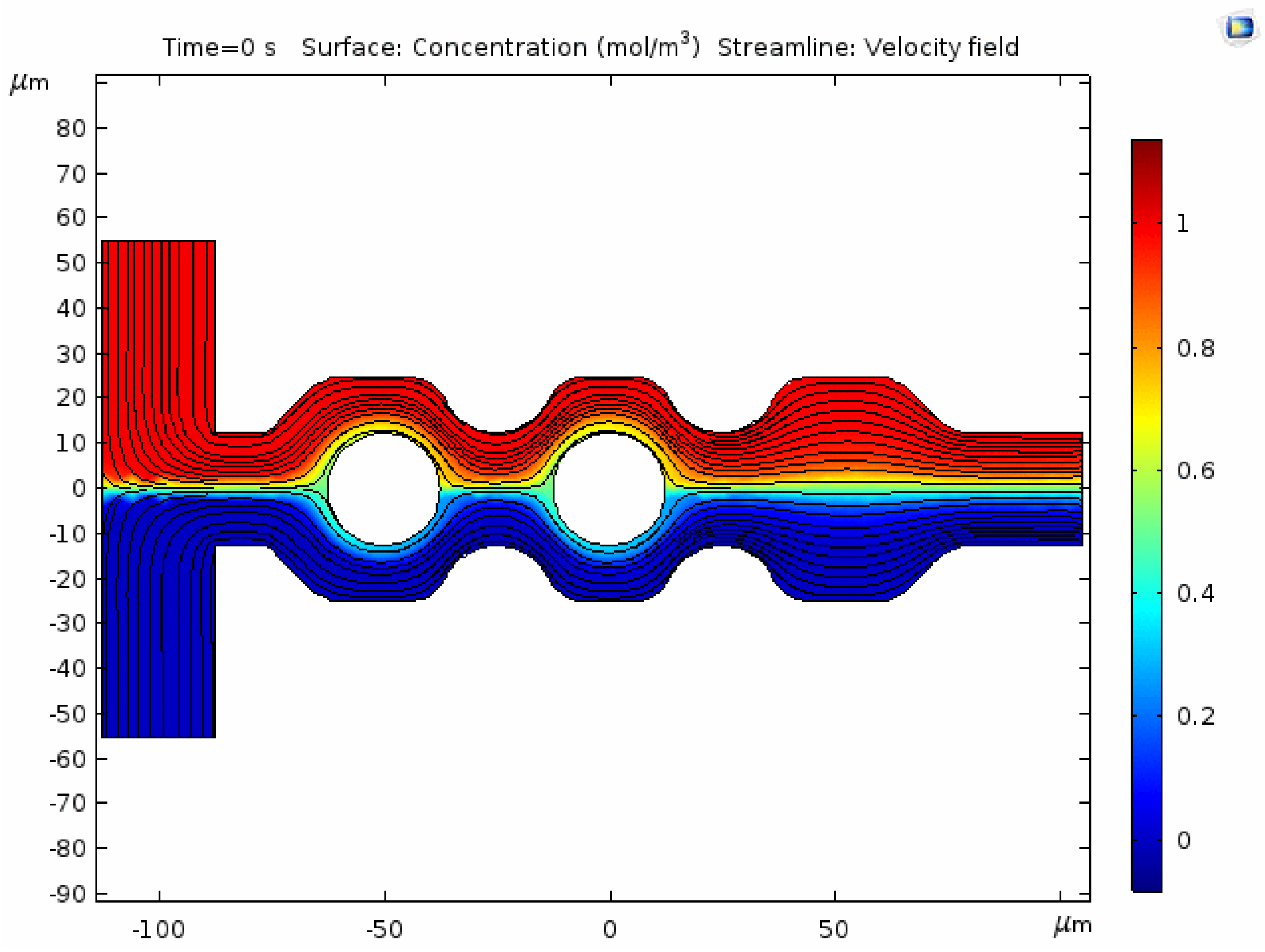


-1 [4 Hz] | 1 [8 Hz] | -1 [4 Hz] | 1 [8 Hz]

Frequency

Best Design

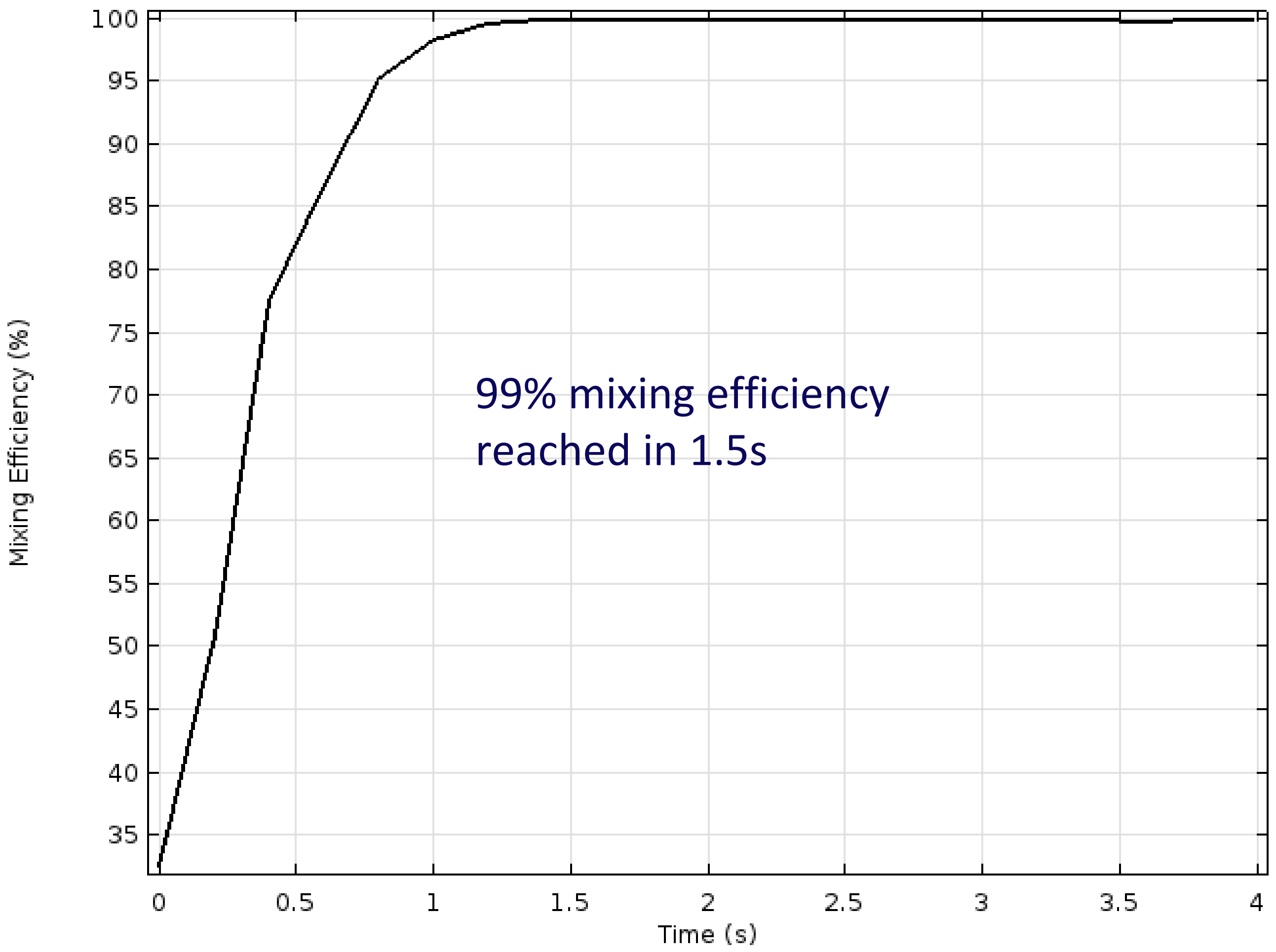
- **Geometry +1**
- **0.3V amplitude**
- **4 Hz**



Mixing Efficiency

$$ME = (1 - \{\Gamma_o[(c_o - c_{avg})^2]/\Gamma_i[(c_i - c_{avg})^2]\}^{1/2})*100\%$$

c_o = Concentration across outlet
c_i = Concentration across inlet(s)
c_{avg} = Mean concentration
Γ = integral across inlet or outlet



CONCLUSIONS

- Pedagogy
  - Extra-curricular approach generated interest & motivation
  - Faculty mentoring required
- Technical
  - Many Well-performing Designs
  - Sensitivity & Optimization Analysis Would Have Added Value

Lee, C.Y., Chang, C.L., Wang, Y.N., and Fu, L.M., "Microfluidic Mixing: A Review," *Int. J. Mol. Sci.*, **12**(3263-3287), (2011)

Lee, C.Y., Chang, C.L., Wang, Y.N., and Fu, L.M., "Passive Mixers in Microfluidic Systems: A Review," *Chem. Eng.*, **288**(146-160), (2016)

Cai, Gaozhe, Xue, Li, Zhang, Huilin, and Lin, Jianhan. "A Review on Micromixers." *Micromachines* **8**(9), (2017)

ON THE ROAD TO Success

David Drakes '15, left, works with Mark Markiewicz '18, center, and Mohammed Alabdulqader '15 to reconstruct the wind tunnel in the Turbomachinery Lab in CETA.