INDUSTRIAL SOLUTIONS LABORATORY

Company Information

Company Name	*UNCC ME Dept*	**Date Submitted**	*MM/DD/YYYY*
Project Title	*Design and Build of a Bench-Top Perfusion System (UNCC_ME_PERFUSION)*	**Planned Starting Semester**	*Spring 2026*

Senior Design Project Description

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills.

Discipline	Number	Discipline	Number
Mechanical	5	Electrical	0
Computer	0	Systems	0

Company and Project Overview:

The Microvascular Engineering & Regeneration Laboratory (MERL) focuses on developing advanced human-specific microvascular and blood–brain barrier (BBB) models to study vascular function, aging, and regenerative strategies. The lab integrates bioengineering, microfabrication, fluid mechanics, and imaging technologies to mimic the 3D structure and function of human microvessels in vitro.

Understanding how blood vessels respond to mechanical and biochemical stimuli is critical for both biomedical research and clinical applications. This project aims to design a microfluidic perfusion platform that can precisely control and monitor flow, pressure, and shear stress in engineered microvessels cultured within a microfluidic chip. The system will allow real-time visualization of vascular responses under different physiological and pathological conditions.

Project Requirements:

The student team will design and build a bench-top perfusion system for 3D-printed or hydrogel-based microvessel models.

Key design requirements include:

- A transparent chamber compatible with confocal or fluorescence microscopy.
- Stable perfusion capability with controllable flow rate (0.1–5 mL/min) and shear stress (0–30 dyn/cm²).
- Integration of a miniature peristaltic or syringe pump with adjustable pressure and low pulsatility.
- Real-time monitoring of flow rate and pressure using embedded sensors.
- Modular, sterilizable components (e.g., silicone tubing, Luer-lock fittings, removable culture insert).
- Compact, user-friendly control interface for fluid handling and data logging.
- Compatibility with standard incubator conditions (37 °C, 5% CO_2).

The project will require mechanical design of the chamber and flow loop, electrical integration of sensors and pumps, and development of basic control circuitry or software for monitoring and data acquisition.

Expected Deliverables/Results:

- Functional perfusion bioreactor prototype capable of sustaining perfusion for >48 hours under controlled flow conditions.
- CAD models and engineering drawings of the full system and modular components.
- Validated sensor system (flow and pressure) integrated with a basic data acquisition interface.
- Testing data demonstrating flow stability, leak prevention, and compatibility with imaging.
- User manual including setup, sterilization, and operating instructions.
- Poster and presentation for the Senior Design Expo.

Disposition of Deliverables at the End of the Project:

The completed perfusion bioreactor system will be returned to UNC Charlotte for exhibition at the Senior Design Expo. After the Expo, the prototype, associated hardware, and documentation will be transferred to the Microvascular Engineering & Regeneration Laboratory (MERL) for further research and optimization. All physical components must be returned to the lab within 7 days of the Expo.

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

Candidates should have experience in one or more of the following areas:

- Mechanical Design: CAD modeling (SolidWorks or Fusion 360), 3D printing, machining, or laser cutting.
- Fluid Mechanics: Understanding of laminar flow, pressure drop, and shear stress in microchannels.
- Electrical / Instrumentation: Basic circuit design, sensor integration and calibration, and signal acquisition.
- Programming (optional): Arduino, LabVIEW, or MATLAB for pump and sensor control.

- Biomedical Background (preferred): Fundamental knowledge of microfluidics, biomaterials, or cell culture systems.