ENGR 1282.02H

Fundamentals of Engineering for Honors II

Nanotechnology Project Description

Nanotechnology – Big Lab on a Tiny Chip Research & Design Project Description and Specifications

NANOTECHNOLOGY RESEARCH & DEVICE DESIGN

It is assumed that all students enrolled in the 1282.02H course have read and understood this document. It is up to the student to clarify any points that may seem unclear.

Project Overview:

In tandem with the development of a microfluidics chip for research on cell attachment, your CENSE team (**C**ell **E**ntrapment and **N**ovel **S**ensing **E**ndeavors) is also tasked with designing a device capable of detecting disease from a blood sample. This project, deemed the **NANOLYSER** (**N**anofunctionalized **A**ssay **N**ested in an **O**nboard **L**aboratory **Y**ielding **S**pecific **E**xpeditious **R**esults) chip, must be able to capture and detect a specific analyte of interest from a collected blood sample. This analyte must be able to be found in the blood and must be indicative of a specific disease state (inflammation, heart disease, cancer, HIV, etc.). This project includes advanced concepts used in a rapidly developing field requiring extensive literature research by your team.

Your goal for this project is to propose a device that is able to detect a specific disease from a single drop of blood. Your team will present and support your design with a digital Project Portfolio, a judged Poster Presentation, and a National Institutes of Health (NIH) grant proposal to gain funding to take your proposed idea to the fabrication and testing stages. The submission deadline is at the end of the term and specified in the DAL for APP N26-2: Nano Report – Final Grant Proposal.

In preparation for your submission to the NIH, your Principal Investigators (or PIs), Paul Clingan, Dr. Mike Parke, and Cassie Wallwey, want to track your progress throughout the semester. The following submissions of your grant proposal will be required throughout the semester:

1. Outline
2. Part 1 Draft
3. Final Draft

Each of these submissions should include all information that your team has available at the time of submission. The specific requirements for each submission are detailed on the course's Carmen page.

A grant proposal template will be provided. Students must use this template for the Part 1 Draft and the Final Draft submissions. The NIH will not accept your grant proposal if any of the formatting or length requirements are not met.

Ideation using Nanotechnology:

For the nanotechnology project, your team will propose a LOC device to detect a disease with a drop of blood through literature reviews, innovative design, and CAD. The semester long design/research/develop project will offer the team working knowledge of microfluidic devices with the incorporation of nanoscale features used for separation, fluid flow, analyte detection, etc. Knowledge will be attained through various readings, videos, and in-class presentations from student teams. The

challenge for this project is to produce a design for a theoretical microfluidic device and to advocate for the project to receive funding for future fabrication and experimentation.

Project Objectives:

1. Exposure to nanotechnology applications in various fields of engineering
2. Experience in essential time management, task scheduling, and project management skills
3. Experience in initiating a design cycle including brainstorming, ideation, sketching, literature research, preliminary designs, CAD modeling, and a grant proposal
4. Experience in conducting literature reviews
5. Exposure to an interdisciplinary team-based work environment

NANOLYSER General Device Requirements:

Teams will design a NANOLYSER for a specific medical application by detecting the presence of an analyte (protein, antibody, virus, cell, DNA, etc.) in a blood sample. The NANOLYSER devices proposed should incorporate the following characteristics to create a realistic, clinically relevant tool.

Ideal characteristics of a well-designed device include the following:

- Process and diagnose using small sample of blood (e.g. single drop of blood, volume of ~0.05ml)
- Detect an analyte found in the blood stream that can diagnose a disease or condition
- Isolate the target analyte from blood using separation techniques
- Dispose unnecessary blood components and waste reagents
- Incorporate a nanoscale detection strategy that is compatible with the analyte
- Constructed with low cost materials (especially for disposable device designs)
- Designed for simple operation that requires minimal training
- Processes in a timely manner (less than 8 hours)

Required Components for CAD Model:

1. Fluid circuit to load blood sample
2. Fluid circuit to load any reagents needed
3. Fluid circuit for separation/capture of analyte
4. Nanoscale strategy for specific detection of analyte
5. Ability to interface appropriately with technology for reading sample
6. All fluid movement will be either electromotive, pressure driven, or capillary force
7. Valves, if appropriate, to control flow
8. If device is reusable, describe cleaning and sterilizing approach

Required constraints:

1. Appropriate manufacturing techniques for producing nanoscale, microscale, and other features should be identified where they exist.
2. Human interaction with the device is limited to: (a) loading blood sample and reagents, and (b) inserting the chip into a reader and/or pump. If you decide to use an external reader/pump (e.g., fluorescence reader), you must explain how the external device works and include specific parameters (e.g., size, wavelengths used for a fluorescence reader, pressure applied for a pump).

Proposal for NANOLYSER Devices*:*

This is a theoretical design project, and teams will be asked to document your design and development throughout the semester through the following:

1. A set of working drawings (prepared in SolidWorks) describing your device. The working drawings are to include at least:
    a. a 3D assembly of the completed device
    b. an exploded 3D assembly of the completed device
    c. 3D assemblies of all significant components of the device
    d. individual part drawings for each fluidic circuit properly dimensioned
    e. layout of each layer present in any 3D features
    f. a bill of materials
2. Full documentation of the research process and drawings in the Project Portfolio
3. A final grant proposal detailing your design. The specific requirements of the proposal are detailed in a separate document on Carmen, but the final proposal will incorporate the following:
    a. your design philosophy and considerations
    b. a complete description of each feature (or circuit) and how it operates in your design
    c. advantages your design offers over current detection methods
    d. the fabrication techniques required for your device
    e. a complete list of materials, time, and costs required to fabricate your device
    f. a description of any unresolved issues or special difficulties in your design