

## Term Paper

Whether you go on to be a professor after you finish college or work in industry, all of you will likely be in the position of asking someone (a government agency, your boss, a venture capital investor...) for the financial resources to work on a new idea. The goal of this assignment is for you investigate a biosensor-related technology, to develop an idea of something novel that you could do with the technology, and to make a plan for how you would implement that idea. The end result of your work will be a 6-page document, prepared in the style of a National Science Foundation (NSF) proposal. Even though we will use the NSF format as a template, the same information and format could be used for any situation in which you make a strong argument for supporting a technical idea.

Although this is a final project, you will be required to turn in your proposal at various stages of preparation throughout the semester, as indicated on the course schedule. The instructor will provide feedback at each stage, potentially asking you to make changes before the next part of the assignment is due. Each incremental section will be worth 10 points (for a total of 50) and the final document will be worth 50 points.

Each student is responsible for his/her own Term Paper. There are no teams allowed.

**All pages are to be single spaced, 12-point font, with 1-inch margins.**

### **Part 1 – Selection of a Topic** (due in class 2/10/21)

A list of suggested potential topics is provided. You may choose a different topic, but it must be approved by the instructor. **Topics must deal with biological detection in some way** (i.e. not drug delivery or medical imaging). You can focus on evaluating and developing the biosensing technology itself, or you may choose to develop an interesting new biological application for an existing technology. You may not choose a topic if it is related to your thesis research (for graduate students) or undergraduate research project.

For Part 1, your assignment is to explore the list of potential topics and to do a bit of internet browsing on topics that are most interesting to you. Choose a topic, and indicate your choice as part of your homework assignment.

### **Part 2 – Literature Review** (due in class 2/24/20)

Following leads from your initial web browsing, in this part of the assignment your goal is to learn more depth about your chosen topic. You need to find published scientific journal articles (i.e. in peer reviewed journals or text books. not newspapers, not web sites, not marketing documents) that describe the technology in depth.

You need to find:

- At least one recent review paper or book chapter on the general topic
- 3-5 journal papers about the method you will research

- At least 3 papers describing alternative approaches and methods that have been used in the past to address the same problem.

What you need to turn in:

- Here is where you will draft the “Background/Significance” part of your proposal.
- It should be ~1.5 pages, single spaced, 12 point font, 1-inch margins
- Describe a problem that the technology addresses. This can be a societal issue, a technical challenge for biologists, or an unmet need. You should have one paragraph devoted to describing the problem and why it is an issue that is worth addressing in terms of lives saved, suffering relieved, capability created, etc. Hopefully the review papers can help you to articulate this.
- Describe how this need has been addressed in the past, or is being addressed inadequately by currently available technology.
- Give a concise description of what your technology is (1-2 paragraphs). **You should include 1-2 figures to help explain what it is more clearly.** These can be figures you make yourself using a tool like Powerpoint, and a hand-drawn sketch is not acceptable. You will not have space here to say everything about how the technology works.
- Describe how the new technology addresses the unmet need or represents an improvement of other methods. Improvements can be in terms of sensitivity, cost, speed, throughput, or any other figures of merit.
- Use references appropriately in the text that you write. Your referenced sources should appear in a bibliography at the end of the document. **The referenced literature list is not included in the proposal’s page limit.**

### **Part 3 – New Idea** (due in class 3/10/21)

Here is the hardest part. Think of an idea, experiment, application, or modification of the technology you selected that has not been previously described. If you are having trouble, make an office hours appointment with the instructor to discuss ideas and options.

Here are a few potentially useful directions for thinking:

- If you are studying a biosensor technology, can it be adapted and applied in a new way for addressing a problem for which it has not been used before?
- Can you think of an idea for making the technology perform better in some way?
- Can the technology be combined with something else that creates a new capability?
- Can the technology be used to address a biological hypothesis?
- Can the sensor be packaged into a new format that might make it useful for something else? (i.e. incorporating sensors into plastic tubing for detection of drugs being delivered through an intravenous line. Now you can’t use that one!)

What you need to turn in:

- 1-2 paragraphs (one page) describing your idea.
- This section of the proposal should be added to the “Background/Significance” part that you turned in last time.

- This section might start with the words: “In this proposal, I plan to investigate/build/analyze/design...”
- You should develop a figure that schematically describes your idea.

#### **Part 4 – Specific Goals** (due in class 3/29/21)

Now that you have an idea, how will you implement it? Try to boil down the tasks into **no more than three** specific goals. Even the biggest 5-year proposals can typically be reduced to no more than three major objectives.

Example specific goals might be:

- To use electromagnetic design tools to simulate and optimize a device structure for a specific performance requirement
- To perform experiments that characterize ...
- To construct a system capable of...
- To fabricate and test a device that has the characteristics of...

What you need to turn in:

- ~1/2-page “Specific Goals” document
- Each goal should be supported by 2-3 sentences summarizing how the goal relates to the new idea being proposed and summary of the method used to achieve the goal.
- This section should be added to the previous sections of your proposal
- You can make changes to your previous sections as needed, as your understanding of the topic and your thinking evolves.

#### **Part 5 – Preliminary Results** (due in class 4/14/21)

Usually, it is necessary to convince the reviewers that your plan is feasible, based on results that have been obtained previously. In this section, you will describe results (you can take them out of your literature sources) that lend support to the new idea that you are proposing. You can show actual data taken out of your literature sources, but be sure to reference it properly. Describe what the preliminary results are, how they were obtained, and how each result is related to one of the Specific Goals.

*You may also use this section to show any design, computer simulations, or mathematical analysis, or spreadsheet calculations that you have performed yourself – which helps support the most compelling proposals. **IF YOU WANT TO HAVE A REALLY IMPRESSIVE TERM PAPER, YOU WILL DO SOME ENGINEERING ANALYSIS THAT SHOWS THE FEASIBILITY OF YOUR IDEA.*** If you need resources within the University (like multiphysics design software) that might help strengthen your proposal, please see me.

What you need to turn in:

- ~2 page “Preliminary Results” document (including figures)
- This section should be added to the previous sections of your proposal

#### **Part 6 – Research Plan** (due in class 5/5/21 – last day of class)

Here is where you outline your detailed plan for accomplishing each Specific Goal. Devote ~1/2 page to each Specific Goal. Describe experiments that you will perform, the fabrication plan for your device, the equipment that will be used, the modeling software that will be utilized, the statistical analysis methods to be used on the resulting data. To an outside person, it should be clear what you are actually going to do. You may want to break each Specific Goal into several tasks, and describe how each task will be performed.

This section is extremely important. You will need to devote some substantial time to determining how you can meet your goals and making your plan look feasible. You should expect to perform some additional background research on the methods that were used in your literature sources and you may need to add references that describe specific protocols. If your plans are too vague, nobody will give you funding!

What you need to turn in:

- “Research Plan” document, added to the previous proposal sections for a total of 6 pages, plus the list of referenced literature.
- You should devote ¼ of a page to making a schedule. Show each Specific Goal and each task within the Specific Goals. Estimate how long each task will take, and whether some tasks can be addressed at the same time.

### **Grading:**

Scoring of research proposals in the real world is notoriously subjective. You have the opportunity to make adjustments to the first four sections over the course of the semester based on my feedback and your developing understanding.

20% Background/Significance  
20% New Idea Description  
20% Specific Goals  
20% Preliminary Data  
20% Research Plan

For each section:

- To receive credit for a sub-section, it must be turned in on-time, unless you receive my permission to turn it in late.
- Criteria for Background/Significance
  - Quality of reference sources used
  - Is previous work clearly summarized and represented accurately?
  - Are any major previous methods or competing technologies missed?
  - Is the problem being addressed significant to society, human health?
- Criteria for New Idea Description
  - Novelty of the idea
  - Does the new idea address an unmet need?
  - Is the idea described clearly (both words and figures)?
- Criteria for Specific Goals
  - Are the goals outlined clearly?

- Are the goals achievable?
- Do the goals logically lead to demonstrating (or showing feasibility for) the New Idea?
- Is the number of goals less than or equal to 3?
- Is each goal necessary for meeting the objective?
- Preliminary Data
  - Does the data shown support the feasibility for the planned research?
  - Level of effort put into design, simulation, or analysis
  - Are the experiments clearly described?
- Research Plan
  - Is the plan sufficiently detailed?
  - Is the plan feasible?
  - Has the plan been thought through clearly? Are there steps that should be done that were not mentioned?
  - Does the timeline make sense?