



# SOCIETY OF PHYSICS STUDENTS

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## SPS Chapter Research Award Proposal

Project Proposal Title	Creating a Creator: Using a 3D Printer to Build A 3D printer from Scratch
Name of School	Ithaca College
SPS Chapter Number	3183
Total Amount Requested	\$1,100

### Abstract

The SPS chapter at Ithaca College, alongside the school's Engineering Club, seek to construct a 3D printer from scratch. Using parts printed from the school's existing 3D printer, we will gain new knowledge and experience while building a machine with incredible potential to aid us in future research projects.

### Proposal Statement

#### Overview of Proposed Project

- **Research question**
  - Can a functional 3D printer be made using a combination of both purchased and 3D printed components at an affordable cost (less than \$2000)?
- **Motivation**
  - 3D printers have great potential to have a profound impact in manufacturing in so many different industries (healthcare, robotics, automotive, national defense, etc.). Many of us in our local SPS chapter are amazed at some of the things we've seen which have been created by 3D printing. Some members even have experience using them for research at the school. However, most of our members are not familiar with how the machines themselves are built and how they're able to do what they can do. Many of the students here will be pursuing work in engineering or other technology-based fields, and there's a good chance that they'll encounter 3D printers or objects printed by them on the job. It's important that our students have a good understanding of what they're made up of and how they work so that they can utilize them in the near future. Having the knowledge of how these 3D printers are built would also give our students an advantage when pursuing jobs in both engineering-based fields, research, and non-researched based occupations.

- **Brief description**
  - This project will involve a group of 15-20 SPS and Engineering Club students planning and carrying out production of a 3D printer, keeping detailed research records along the way. Involved in its construction will be purchased components and other 3D printed parts. Once initial design is completed, the printer will need to be tested and then possibly improved, based on how it's performing after its test runs. The project will require members to attend bi-weekly progress meetings and will allow all involved to play meaningful roles in the build.
- **Research goals of the project**
  - At the end of the project, we will have a working 3D printer. Each student will have new knowledge of how to work as a team, meet deadlines, and communicate effectively. They will also understand how these machines are built and gain confidence in themselves in future projects.
- **SPS connection**
  - In working as a team to complete such a daunting, involved task, our members will certainly grow as leaders and improve upon their communication skills, just as the mission statement of SPS calls its chapter members to do. SPS and Engineering club can then use the printer to reach out to other departments at our schools, helping them in any way we can using the printer. This machine will also help us with future projects; materials which might need to be purchased can instead be printed out with our creation, saving our clubs costs and time.
  - Nationally, we would work to share our work with other SPS chapters so that they can embark on their own 3D printing projects. We will gain knowledge which will be valuable to the SPS community and will eagerly share it with any chapter which needs it.

## Background for Proposed Project

Since this proposed project is unlike a classic thesis or research project, it doesn't involve a large portion of background on theory. However, as 3D printers become more involved in manufacturing processes, their impact on and relevance in our own lives will continue to grow. The potential for 3D printer use in manufacturing is virtually limitless; many think large scale (bridges, cars) or specialized fields (prosthetics, for example) when they hear of 3D printing. Of course these machines are helping to push boundaries in these fields, but they are already being used for products which are even more so intertwined with our lives. Clothing can be made from the machines, form-fitted and ready use as soon as it's printed out. Modern jewelry and accessories are already being fashioned by these printers to compliment the clothing or as stand-alone products (Volkman 2014). A Shanghai-based 3D printing company managed to 3D print a six-story apartment building with 10 living spaces, along with a one-story home, using a material consisting of construction wastes like fiberglass and concrete (Sevenson 2015). Not only are these structures environmentally friendly: they're also built to withstand strong earthquakes, and they're even self-insulating!

This list is far from exhaustive, but all of these materials and structures take considerable amounts of time to make. However, in the past decade alone, prints which used to take days now take hours, and the technology is continually improving. By building our own 3D printer from the ground up, participants will have the knowledge necessary to contribute to the improvement of this remarkable technology.

## Expected Results

We expect that we will have a fully-functioning 3D printer built by the end of the school year, though we do expect changes and improvements to be made to the machine between its first working print (ideally in April 2016) and November of 2016. Our goal is that by the end of this process, everyone involved has a good understanding of the different components of a 3D printer and how each works to print out an object. We hope that this collective understanding will lead our members to ideas for improving the machine, and that we can use it to aid us in future projects.

Aside from the machine itself, we want this project to help our students prepare for work after graduation. This is an involved project where planning, organization, record-keeping, communication, and persistence are all vital to success. All members involved will gain experience with these skills. They should also be able to speak about this project in job interviews, which should impress potential employers.

## Description of Proposed Research - Methods, Design, and Procedures

Bi-weekly progress meetings will be held with the heads of each committee listed below. In these meetings, one member will be in charge of taking meeting minutes. In each meeting, we will analyze the progress made since the last, address any problems or issues which come up in-between meetings, and discuss the action steps which need to be taken before the next gathering. We will also compile a document summarizing each committee's records at the meetings. That which is discussed will be summarized in a short report sent to our project advisor for review after each bi-weekly meeting.

Bi-weekly e-mails to members will be sent out as well, updating all on the progress we've made, and explaining our expectations for the weeks ahead.

- Project Start: Assignments/Interest
  - Going over the timeline of the project, deciding on who will lead 1 of 4 committees (more may be formed as necessary):
    - Printed Materials
    - Electronics & Programming
    - Purchasing, Inventory & Materials
    - Construction & Testing
    - Record Keeping (Made up of Committee leaders)
  - Gauge interest from members & find out how much time each member can devote to the project per week
  - Assign members to committees they are interested in. **All members must keep track of their progress in their committee's research notebook (possibly in a Google document instead, whatever is easiest).**
- Ordering a Startup Kit/ Purchasing all products - PIM Committee
  - Based on the money awarded to us, we will make a decision to either order a DIY (do-it yourself) kit which will provide us with many of the parts we can't print or order the parts individually.

- These items will be purchased as needed. Good records will be kept as to who purchased what, for how much, etc.
- **Printing - PM committee**
  - The committee will use the school's 2 3D printers (A Makerbot Replicator 2 and a Makerbot Z18) to begin printing the parts. They will either download existing designs for the printer to make or design them themselves in Sketchup or another CAD tool as necessary.
  - Each student involved will keep careful records of each print, approximately how much plastic was used for each print, etc.
- **Electronics & Programming - EP Committee**
  - The printer will need proper wiring in order for the project to be successful, so we will include in this group at least two upperclassmen with prior experience (though most of our members have basic wiring experience).
  - They will work closely with the PIM committee to ensure that proper electronics are purchased
  - They will handle all of the programming duties necessary to ensure the extruder has proper x, y and z motion.
- **Construction & Testing - CT Committee**
  - CT will work closely with the PM committee to make sure that each printed part is inspected and fit for construction.
  - Upon completion of the build, CT will head the testing phase. This will likely involve members from multiple departments (especially if problems arise).

## Plan for Carrying Out Proposed Project

- **Personnel**
  - 10-20 SPS and engineering club members will be involved. At least 7 of us will have experience with using 3D printers.
  - 5 members will have had prior experience with wiring and electronic setups.
  - 2-4 Faculty members will advise us as needed. They will have experience with 3D printers, configuring electronic equipment, wiring, motors, shop tools and machinery, laboratory safety, and mechanics.
- **Research Space**
  - We will be able to use a professor's laboratory space (Professor Michael "Bodhi" Rogers) as well as the Advanced Physics Laboratory room, which is kept locked with a college ID swiping system that allows only those individuals who have been cleared to enter the room.
- **Contributions of faculty advisors or the department (equipment, space, etc.)**
  - We will be able to use both of the existing 3D printers in the department, soldering tools, outlets, and other department general construction tools (hammers, screwdrivers, wrenches, etc.).

We will start the project with a full general body meeting to take note of which of our members want to be involved with the different parts of this project. We'll need to print out certain parts for the structural makeup of the

machine, but we'll also need to purchase, keep track of, and install other parts (bearings, motors, screws, etc.). Furthermore, the electrical configuration and computer mechanical controls (CNCs) will need to be installed. Since our members have different skill sets and schedules, it will be important to make sure that they are all assigned to tasks which they are interested in and capable of completing.

After this meeting, we will begin production of the printer as outlined in the project timeline. We will hold bi-weekly progress meetings to make sure that everyone is on the same page and completing the tasks assigned. This will also enable us to adjust our plan if necessary. We will send bi-weekly updates to our advisor and go to him for advice as needed.

## Project Timeline

1. Assignments/Interest (Jan. 25th - Feb. 5th)
  - a. Gauge interest, realistic time commitments from project members.
  - b. Assign members to committees they are interested in (Assembly, printing, programming, testing, purchasing)
2. Printing Parts - Have all printed parts prepared, tested for strength/defects by March 18th.
3. Begin Interim Report - April 1st
4. Wiring & Assembly - Have all Wiring/Electronics set up by April 8th. Assemble the printer by April 15th.
5. Programming & Functionality: Have everything programmed and the printer successfully tested by April 22nd (needs to be able to print 1 simple object, maybe a screw or a cup).
6. Interim Report Completed by April 29th
7. Summer Recess - Further testing & Improvement to printer done by members spending the summer in Ithaca (not guaranteed any of our members will do this, so there may be a break here)
8. Meeting to discuss further improvements which can be made September 12th.
9. Improvements tested, printer working successfully by October 1st.
10. Final Report Completed by October 21st

## Budget Justification

Our budget is based off of a past student's actual expenses when he built his own 3D printer. While we can print many of the structural parts using the department's 3D printer, many of the electronic and metal components must be purchased. We've also budgeted for a small amount of emergency money in case anything truly unexpected occurs (a piece breaks, faulty equipment is purchased, loss of a few screws, etc.). Each piece of equipment outlined in the budget is necessary to put together a working 3D printer. We will also be applying for money which can be allocated to us by the Student Government Association (SGA) at Ithaca College. Unfortunately we cannot estimate how much they could award us at this time; however, we are hopeful that we will receive at least \$50 to help with some of the cost.

## Bibliography

Sevenson, Brittney. "Shanghai-based WinSun 3D Prints 6-Story Apartment Building and an Incredible Home." *3DPrintcom*. N.p., 18 Jan. 2015. Web. 22 Nov. 2015.

Volkman, Elliot. "8 Unbelievable Ideas 3D Printing Is Already Being Used For." *TechCo: Tech Startup News & Resources*. TechCo, 28 Dec. 2014. Web. 18 Nov. 2015.