Trying the research track

From undergrad research to grad school applications

Prof. Anand Sarwate, Rutgers ECE, April 24, 2023

What is research anyway?

Warming up with a few questions

- What do you think does “doing research” involves?
- What about it seems interesting or appealing to you?
- What do you think you’ll get out of it?

Research is multifaceted

There's no single answer…

In a research project you get to work on a project with a professor or their research group. What you do depends a lot on the kind of project!

- Group projects vs. individual projects
- Finding related work (reading papers) vs. running experiments
- Programming vs. "hands-on" work with lab equipment
- Mostly remote vs. mostly in-person
- During the semester vs. during the summer

Why do research?

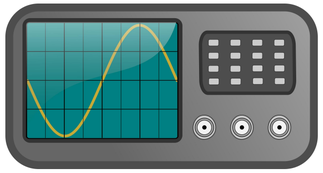
There are a ton of reasons

There are many benefits to doing undergraduate research:

- Get to learn about the cutting-edge (more than you get in classes).
- Develop professional skills: lab work, programming, technical writing, technical communication.
- Get to see what grad school might be like.
- Work more closely with professors (recommendation letters, references).
- Can get paid (in money or course credit)

What would I do in a research project?

The work is quite variable



- Reading papers and background research
- Programming/simulations
- Data analysis and visualization
- Fabricating or testing devices
- Building circuits/boards/sensors
- Data collection

Do I know enough to do research?

It depends on what you want to do…

Some projects definitely require having some background knowledge or skills from specific courses. Other projects may be accessible to first-year students.

More important is that you are:

- Interested and open-minded
- Resourceful and motivated
- Willing to put in the work

You might not have an opportunity to work on your dream project, but you can still get a lot out of it.

Do I have the time to do research?

Successful work takes time!

Think of research as a serious time commitment: ***as much as a regular class***.

- Regular meeting times each week
- Required time in lab, time sheets, etc.
- Maintaining consistent communication about progress.

Most importantly, you have to be self-driven and make time each week **even though there are no homework deadlines or quizzes**.

Finding a research project

Different ways to get started

There are many options

- **Programs at Rutgers:** WINLAB Summer Internship, Aresty Center, JJ Slade (for seniors)
- **Summer programs:** Research Experience for Undergraduates (REU) programs at many different universities on different topics.
- **Research internships:** many at government or government-funded labs: Department of Energy, NIST, MIT Lincoln Labs, JHU Applied Physics Lab.
- **Work with a research group:** working with a prof/group at Rutgers or elsewhere

Summer research outside Rutgers

A chance to explore new places

Summer is a good time to get involved in a full-time research experience since it won't conflict with classes. These programs sometimes have more *structure*, with talks, professional development, mini-courses, etc.

- **REU Programs:** the National Science Foundation (NSF) funds a large number of STEM programs for undergrad research at manyuniversities (e.g. search for "NSF REU Engineering").
- **Federal agencies and labs:** https://www.energy.gov/eere/education/internships-fellowships-graduate-and-postdoctoral-opportunities
- **Other summer research programs:** MIT Lincoln Labs, Johns Hopkins Applied Physics Lab, etc.

Deadlines are end of Fall Semester to Early Spring Semester
Need 1-2 Letters of Recommendation

Research at Rutgers

Opportunities all year round

There are summer and school-year opportunities at Rutgers:

- **Aresty Center:** Summer Science Program, Research Assistant Program (2 semesters, 3 credits), https://aresty.rutgers.edu/
- **WINLAB Summer Internship:** https://winlab.rutgers.edu/
- **Directly working with a professor:** You don't have to only look for opportunities in ECE! The skills ECE students have are in high demand all over campus!

Deadlines vary: sign up for mailing lists!

Looking for a research position

Overview of steps to take

Google Scholar

Most professors will not have a job advertisement for "open positions" so you have to ***do some legwork***:

1. **Self-reflection:** what am I interested in and what do I want to get out of it?
2. **Look at your options:** labs/professors's websites or Google Scholar (https://scholar.google.com/) will give you a sense of what they work on.
3. **"Pre-research research":** challenge yourself by looking at some recent papers.

Digging a little deeper

Gauging your interests and their interests

1. What projects have they been working on recently?
   Research topics are often different than class topics!

2. Try to read the abstract/intro of a paper that sounds interesting.
   ***Show that you have curiosity and self-motivation*.**

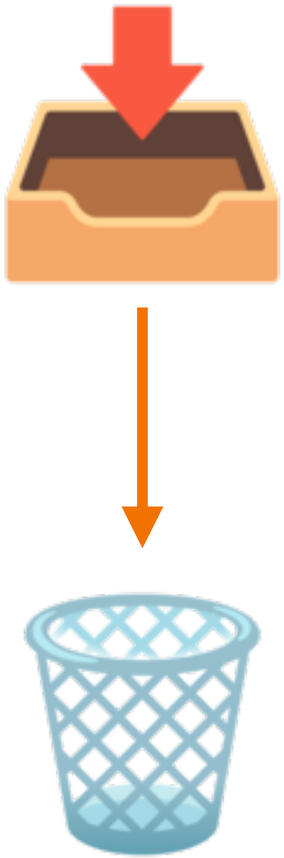
   - What real-world issue this paper is trying to address?

   - What kind of work is involved? Programming? Designing circuits? Lots of experiments and comparisons? Proving theorems?

3. If it seems interesting… email the professor.
   Do not copy-paste the same email.

How not to email

What's wrong with this?



Dear Professor,

I hope you are doing well! My name is [REDACTED] and I am very interested in any research opportunities you might have. I'm attaching my resumé. Please let me know if you have time to meet with me.

Sincerely,

[REDACTED]

Some tips for a good email

Being thoughtful makes a good impression

Things to do in an email:

- **Make it personal:** Introduce yourself!
- **Show that you've done some pre-research research!**
  - Why is research interesting to you?
  - What paper did you look at? What was interesting/confusing?
  - What kind of work are you interested in?
- **Respect people's time.**
  - Suggest a few times you are free.
  - Zoom or in-person or either?

An example email

Don’t copy paste this either 😅

Explains who you are and what you’re interested in →

Dear [REDACTED]

My name is [REDACTED] and I am a sophomore majoring in ECE. I am taking probability this semester and am enjoying it quite a lot. I wanted to get a chance to use what I learned outside of class and I thought doing a research project would be a good way to do that. I am also considering grad school in the future.

Show that you did a little pre-research →

I tried to read your paper on “High Dimensional Inference with Random Maximum A-Posteriori Perturbations” but it was a bit challenging for me. I looked up “Gibbs distributions” but I found physics stuff that I wasn’t sure had to do with the image processing in Figure 1. I want learn more about “applied probability” though, especially if there was some programming component. Do you have projects like that?

Open to new ideas, suggest specific times to meet →

If you have time to talk about this or other research opportunities, please let me know! I am generally on Busch campus Monday, Tuesday, and Friday, and am free before noon or after 4:40.

Sincerely,

[REDACTED]

Possible responses

It can go many different ways

- **Sure, please come to my office on Monday at 10:** yay!
- **No response:** wait a few days and then send a follow-up.
- **I'm busy for the next N weeks, after that is ok:** do they have time to supervise another project? Can you talk to a grad student?
- **I don't have time for another student:** don't take it personally!
- **I don't have an appropriate project right now:** see above!

Doing research for credit or pay

Feels awkward to bring up…

Many of the more formal research programs offer credit or pay for research.

- More structured programs at RU (Aresty, JJ Slade) give course credit.
- Summer programs (REUs, internships) almost always come with a stipend.

Doing research “informally” with a professor/lab is more complicated because you have to show that you will be able to do the work, will make time for the work, and won’t ghost.

- Cold-calling about registering for “Special Problems” (ECE 491/492) without some track record is often a non-starter.
- Professors sometimes have a budget in the grant to pay hourly but how do you convince them that you’re a good investment?

Is unpaid research worth it?

Maybe, maybe not

How can you build a track record? Many students “try it out” (unpaid) for a semester. *It’s not great, ethically, to be asked by a prof to do an unpaid internship.*

- “Trying it out” gives you a chance to back out if you decide you don’t like it, but it means you are possibly doing work and getting only “experience”.
- The “formal” programs (Aresty, REUs, etc.) have expectations and accountability that “informal” research does not.
- Ask up front whether you can switch to credit/pay if things go well (and what is the criterion for “going well”).

Doing the work

Succeeding in your research experience

- **Get organized.** Consider using a research journal or some other way of keeping track of what you've done and what you plan to do.
- **Be prepared for surprises (good, bad, and ugly).** Research has a lot of starts and stops.
- **Stay in communication with your advisor/mentor.** Don't ghost!
- **Engage in self-reflection.** Remember why you are doing this research project and how it fits into your goals.

After research, grad school?

Different options for postgraduate study

Knowing the options is important

One reason to try undergraduate research is to see if grad school might be a good choice for you.

- **MS/MEng:** 1-2 years, either coursework-only or with a thesis, *usually self-funded*.
- **PhD:** 5-6 years (including MS), coursework and research culminating in a dissertation, *usually funded by department and research advisor*.

Grad school is not necessary: Most students don’t do grad school, so it should be an active choice.

Grad school doesn’t have to be now: Many students work for a while before coming back to grad school.

MS or Phd?

Which program is the right choice?

“I want to learn more about X”

→ Class-based MS program

“I want to work on a project involving new technologies that use Y”

→ Thesis-based MS program

“I want to design new technologies to address problem Z.”

→ Ph.D. program

Pros and Cons

It’s a challenging decision!

Upsides of going to grad school:

- Chance to gain some specialization.
- Exposure to “cutting edge” topics that aren’t part of the curriculum.
- More interesting job prospects (not just academia) and networking opportunities.
- Higher starting salary after graduating

Downsides of going to grad school:

- It’s even more school, and the classes are usually harder.
- MS programs usually cost $$$.
- PhD programs are a big commitment, time-wise.
- Delaying the start of your career/ earning a good salary.

The “terminal” (non-thesis) MS degree

Shorter commitment, out of pocket

The value proposition for an MS degree is simple: pay more tuition now, earn more money later (estimates vary but between $10k-$20k)

- Some jobs will pay for you to do an MS part time, but this is the exception and not the rule.
- Unless you are doing a MS/PhD program (i.e. planning to stay for PhD) *you will most likely not get a TA appointment*.
- Whether you stay at RU for a PhD or go somewhere else, the tradeoffs are between the cost and benefit: what are your professional goals?

PhD-curious?

I’m not sure I really want a PhD…

Many students feel like they want to “try out an MS before deciding on a PhD.”

- It’s very hard to do a non-thesis MS and go on to PhD.
- If you have a serious interest in possibly getting a PhD, consider applying for MS/PhD programs.
- If you get to grad school and discover you don’t like it, you can often leave with a MS and not go on to PhD.
- If you think you might want to go later for a PhD, consider the thesis option for the MS.

Building an application

Ingredients of a grad school application

Planning ahead can help a lot

In rough order of importance, from most to least:

- **Letters of recommendation:** usually need 3 for PhD, ideally from people with PhDs themselves (professors, internship supervisors, etc.) and people who can write about your *potential as a researcher*..
- **Coursework:** strong GPA in your major and related fields (e.g. math, physics), relevant electives for your chosen area
- **Personal statement/essays:** important for the admission committee to see if your interests are a good fit, how clearly you can write, and give a picture beyond your resume
- **GRE:** increasingly optional, but if the program requires it, be sure to study.

Letters of recommendation

The most important component of a strong application

- **Ideal letter writers are** a professor you did research with, a professor from a relevant class where you did really well, an internship supervisor with whom you worked closely.
- Letter writers can **explain parts of your transcript** (e.g. poor grades from one semester due to personal issues).
- **Think early about who potential letter writers might be.** Tell them you might be interested in grad school, ask them for any advice or thoughts.
- **Be organized when you ask for a letter:** give them your resume, transcript, and personal statement (or draft), and a list of programs where you are applying and deadlines for each of them. Do this well in advance!

How to present a strong application

Thinking from the admissions committee side

Graduate programs are looking to see if you are a good fit:

- Do you have what it takes to be successful as a MS or MS/PhD student?
- Have you read about the department and graduate program and can name some specific potential research advisors?
- Are your interests and prior experiences aligned with your goals/those professors' research?
- What are you going to bring to the lab/group/program?

Types of decisions from grad programs

What can you expect?

There are many types of admission offers that schools make:

- **Fellowship:** no teaching/research responsibilities, tuition waiver, monthly stipend, possible additional funds
- **Teaching assistant (TA):** one class each semester/quarter, tuition waiver, salary
- **Research assistantship (GA):** offer to do research with a specific professor or lab, tuition waiver, salary
- **Partial tuition waiver or scholarship:** covers some costs (usually not most).
- **No funding:** you have to pay for tuition and fees.

Strategizing about grad school

Plant the seeds early if you can

Most students don’t know if they want to do grad school or not until later. That’s ok! There are still things you can do early to help guide your path:

- **Do some undergrad research:** gives a taste of what a PhD would be like, get to talk to and learn from grad students here.
- **Talk to professors:** if you think you might be interested, be curious and learn more. Ask questions and get advice.
- **Think about possible futures:** the future is uncertain and trying to make decisions now is stressful. Focus on what interests you and what might interest you later.