

TIMESTEP

Finding and implementing research projects

Please Start with this Quick Survey



Slides modified from T. Eifler

Part 1 Grad School Preparation – Start Early !

Category 1 - Academic:

Considerations

- Grades in courses
- Choice of challenging courses (also choosing many more courses than others or double major in physics and math)
- Academic record given the offered curriculum at their institution
- Trajectory of grades in courses, e.g. strong improvement in junior/senior

Process followed by many committees:

- 1) Look at transcript
 - a) Look for challenging courses
 - b) Grad courses
 - c) Grades
 - d) Gradient in Grades
 - e) Cross-reference with personal statement +letters
- 2) GPA (most programs have a minimum cut off of 3.0)

Category 2 - Research: 30-50% of your application rank!

(consider normalization wrt to opportunity space)

Considerations:

- Creativity, curiosity, motivation, grit
- Original thinking and/or technical inventiveness.
- Leadership in independent research (incl independent study)
- Publication record
- Contributions to instruments, software frameworks, databases, patents
- Unique combination of original and logical scientific thinking combined with cogent, fluent and grammatical writing skill.
- Consider research interests of candidates and research conducted at the institution; keep in mind however that there may be little correlation between a candidate's expressed research interest and the candidate's PhD project years later. Primarily, we aim to select the candidates with the largest potential.

Many UA Committees Follow this Process:

- 1) Look at research section in CV (research descriptions, papers, products, code repos, talks)
- 2) Look at Research description in personal statement (depth, detail, clarity, future plans, is there a link to UA research)
- 3) Cross-check with reference letters (bad if CV and PS focus on research that's not reflected in letters)

We'll get back to research later

Category 3 - Additional factors

Considerations:

- Trajectory; circumstances or background limiting current level of accomplishment, with indicators of potential and degree to which existing opportunities were exploited.
- Initiative, experience in teaching, mentoring, and/or work in diversity, equity, inclusion (DEI), and/or astronomy clubs
- Motivation, Curiosity, Grit (outside of research)
- Outside employment, demonstrating initiative and/or necessity limiting academic and other activities.
- Relevant post-college experience for those applying to restart academic training.
- Competitive sports or professional career
- Opportunity to bring valuable diverse perspectives to Steward with applicants of strong qualification and/or potential.

Process followed by many committee members:

- 1) Look at CV for activities
- 2) Look at personal statement
- 3) Answers to additional questions (UA collects some additional info about background, other universities do so as well)
- 4) Cross-reference with letters

GRE/PGRE & Cost of Graduate School



<https://docs.google.com/spreadsheets/d/19UhYToXOPZkZ3CM469ru3Uwk4584CmzZyAVVwQJJcyc/edit?gid=0#gid=0>

To apply to ~10 schools = ~\$1000

On average students apply to at least 10.

You don't need to excel in every category to
get into grad school

Don't be discouraged!

Part 2: Research Opportunities

Why research projects

- Fun
- Grad school (more later)
- Decide whether you want to continue in academia. **Figure out WHY you want to go to graduate school.**
- Reference letters
- Teach important skills for jobs inside+outside academia – apply your classroom knowledge
- Become part of a larger team (sometimes even an international research collaboration)
- Create connections to PhD students, PDs, faculty
- Can play with cutting edge technology (HPCs, satellites)

How to prepare for a Research Opportunity

- Learn to code:
 - Intro: CSC 110/ECE 175;
 - Soph: CSC 120/ECE 275;
 - Advanced: CSC335/337 SFWE 301,402
 - KEEP PRACTICING – e.g. Code Academy
 - Languages: Python, C++ are most useful
 - Learn to use the Command Line & Basic Unix commands
- Learn Version Control: e.g. Github <https://skills.github.com/>
- Write your CV: <https://timestep.arizona.edu/undergraduate-research>
- Learn how to write an email



Different types of research opps

Least “Competitive”:

- Local Opportunities at UArizona Departments, TIMESTEP, NOIRLab
- Local Opportunities at institutions in your hometown (great for summer)

Medium “Competitive” : (strong GPA, some research experience)

- Local, across departments: UROC, Space Grants

Most “Competitive”: (if you already have strong research experience)

- National Opportunities
 - Governmental Research Labs
 - NSF REU
 - NASA Internships
 - Institutional Research Programs (e.g. Caltech CRESST)
- International Opportunities

How to find them

- TIMESTEP collection <https://timestep.arizona.edu/undergraduate-research>
- UA website <https://ur.arizona.edu/find/search-ua-researchers>
- Browse research websites in the departments -> write people (TIP: writing to [postdocs](#) can be a good idea if you are interested in a group but the Prof is too busy)
- Talk to your academic advisor, undergrad advisor, teacher in classes
- You can ask Profs whether you can sit in a grad level course, as a research project
- You can ask Profs whether you can join their research group meetings.
- Just ask for a meeting to discuss their research to start
- **Finding a research op is hard, you'll have to try often...**

Email Etiquette

- Be specific and look into the person's research – don't send a generic email that could be sent to anyone.
- Include honorifics in the greetings □ Hello Dr. Or Hello Prof.
- Check your spelling !!
- Don't write an essay.
- Write to PDs or PhD students in the group. Ask how it's like and whether there are undergrad projects. Ask to meet and ask them about their research. PDs and PhDs have much, much, much more time... and get orders of magnitude fewer emails
- Try to get an introduction from your academic advisor/instructor/etc.

Don't give up!

- Follow up; there's no harm in sending several emails... what would the downside be?
- Try to get an introduction from your undergrad advisor, your class teacher or else
- Don't write too long emails. Be
 - friendly (always),
 - short (say who you are and what you have done in the past and want to do in the future)
 - concise (what research experience exactly are you looking for)
 - attach CV with details (1-2 page is fine).
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Good Luck! Questions...

Hi Dr. Besla,

An example

My name is XX, a freshman in Astronomy at the U of A. You **might remember me from** one of the TIMESTEP meetings and some of my e-mails in which I also asked about TIMESTEP.

Recently, I was **browsing through the faculty list** when I came across your and Nico's research paper about the Large Magellanic Cloud and its influence on the Milky Way. Though I could understand no more than 5% of the paper, I liked the ideas behind it, especially the part about galactic tides, **which reminds me of the articles on galactic tides that I read for my final project last semester**. I **reached out to Nico** and had a conversation with him this afternoon, where he **told me about stellar streams and the planes of satellite galaxies problem**, both of which were fascinating. Given that your areas of interest include galaxy formation, **I wonder if you tend to focus on topics like the one in the above-mentioned paper or the ones as told by Nico**, and if yes, **might there be any part of your research that I can take part in next semester as a sophomore?**

Admittedly, I am not well-versed in galactic archaeology at all; I am simply writing this out of a pure fascination for your group's research paper. Still, **I would love to discuss this topic with you sometime and see if it might be possible to work in your group.**

Thank you so much for your time. I look forward to hearing from you soon!

Best regards,

XX

Different types of research opps

- Theoretical
- Observational
- Experimental
- Instrumentation

All three areas will likely require coding (in the long run or immediately).

Different types of research ops

- Attend grad course
- Ask for special project in one of your undergrad classes (e.g., Term Project, write 4 page report)
- Read paper, summarize, present
- (Help) analyze data (details how you can help will come from mentor)
- (Help) build+test instrument (details how you can help will come from mentor)
- Run+test code, write report/documentation
- Build code or web-interfaces

Whatever you do, make sure it has a well-documented result/product that you can link. And that you have gotten some **credit hours and/or pay** for the research.

Making the most of your research opp.

- You may have a lot of different goals: learn what it means to do research in physics/astronomy, learn what it might mean to be a graduate student.
- Two practical goals:
 - Get a strong reference – this requires knowing the **expectations** of your advisor.
 - Get an experience you can list on a CV – this is stronger with a **research product**.

“Succeeding” in your research experience – start off with clear expectations.

- Meet with your advisor at the start to **establish expectations**. Do not wait for them to do this.

Ask:

- Meetings : how frequently? (get on their schedule!), what is their preferred format (zoom? In person?), are you expected to attend group meetings – what is the format? How do you cancel meetings if you have an exam, etc?
- If you have more urgent questions: who to ask (student/PD/them), what format (email/slack?), what do they expect you to have done before messaging them (google search an error message/contact grads)
- If they email you – how fast do they expect you to reply?
- How many hours do they expect you to work a week? What does that mean – what will they expect as “acceptable” work progress? When would they start to get concerned that you are not meeting obligations?

”Succeeding” in your research experience – maintaining good research progress and being prepared

Throughout:

- Come prepared to meetings – create a power point slide deck that lists what you did since you last met – e.g. read a paper (what did you find? what do you have questions about?) , debugged some code – (what did you try, where did you get stuck?), trouble shooting/talked to a PD/grad students, attended a talk, made a plot (!) -- date the slides “9/18/24 Meeting”
- “What did you do since you last met”/ “What are you going to do before the next meeting?” / “What is in your way?”
- Do not cancel meetings regularly. Write emails politely/formally. Stay in touch with your advisor – they need to get to know you to write a strong letter.
- Be a good community member – help your teammates, be respectful and humble.
- Push yourself to present updates in group meetings – get practice public speaking!

Grad School - Research is 30-50% of the admission

- Grad admission committee members look for the aspect mentioned on the past slide in you personal statement, your CV, your letters.
- Try your best to ensure that these application components form a coherent picture
- Have your statement read multiple times by experienced readers who are willing to go through it with a fine comb (incl language)
- Make sure “Research Experience” is a section in your CV (ideally 3ish research topics, all with title, two sentences what you did, link to a product)
- Definitely talk about these past research experience and future interests in your personal statement (a lot)
- Make sure that there is information in the letters that confirms these research experiences. It's bad if things that you mention a lot in CV and statement are not mentioned at all in the letters.
- You should give letter writers bullet points on what they should write about. The more details you send them the better your letter will be.

You need a result/product from your research op for grad application

- Credit hours
- Grades in grad class on transcript
- Grades in “independent study” on transcript
- Thesis or Class Report, link online
- If you built code, **put it online** (github)
- If you gave a presentation, **link it online**
- If you made a poster, wrote a report, **link it online**
- Try to get a science paper (co-) authorship

Put this on your CV... Have a section “Research” on your CV where you bullet point all your research ops and write a sentence on what you did. Add link to product.

Example CVs

courtesy Jay Motka (UA Astro/Physics major, Class of 23)

RESEARCH EXPERIENCE

Numerical Simulations of Charged Black Holes

Relativity Group, Department of Physics, The University of Arizona

August 2022 - May 2023

Project: Simulating a Charged Black Hole in Extremal Limit on Charge using Numerical Relativity Simulations

Undergraduate Thesis Link: <https://repository.arizona.edu/handle/10150/668671>

Advisor: Dr. Vasileios Paschalidis

Goal: To simulate black holes that are closer to the extremal limit on charge than has ever been accomplished before, which will help understand conditions around such black holes and lead to a path for possible theoretical tests of the weak cosmic censorship hypothesis.

Results: Calculated initial conditions for the simulations of charged black holes that can achieve the extremal limit on charge using analytical techniques. This work is published as an undergraduate Honors thesis.

Connecting Cosmological Simulations to Observables in the Infrared

SÍGAME Group, Steward Observatory, The University of Arizona

January 2020 - September 2021

Project: Creating Spectral Cubes and Moment Maps from the Output of a Python Module Named SÍGAME

Project Link for Moment0 Maps: https://github.com/jaymotka/moment0_maps

Advisor: Dr. Karen P. Olsen

Goal: To create data visualization tools that correlate with the underlying physics of the simulated galaxies, which can be cross-checked with observations to better understand galaxy formation and evolution.

Results: Created algorithms to generate spectral cubes, moment maps, and line ratio maps from simulated 3D galaxy datacubes, which are output of SÍGAME. My code is submitted to SÍGAME main branch published on GitHub. This work is published in a co-authored paper in The Astrophysical Journal ([Olsen et al. 2021](#)).

Research Products: Ideally you'd want to write a paper... but

- Writing a paper during undergrad is hard and hardly achievable. Some areas it's easier than others.
- Being part of a research project/group and being a co-author on a paper is an excellent alternative (sweet spot of happiness and productivity).
- If you want to write a 1st author paper, express this to your mentor upfront. Ask for a project that can be published and develop a clearly structured work plan with your mentor. Expect to work overtime...lots.
- Ask to have a PD or senior PhD student as an additional mentor. Meet once a week. Be prepared. Cancel meeting if there is nothing to discuss. Don't cancel often.
- You'll have to focus on one area if you want 1st author paper; you can't have multiple projects if you are going for a paper; expect 2 years of work in one group.

Research Products: An Alternative to a Journal Paper

- AAS Research Note:
<https://journals.aas.org/research-note-preparation>
- <https://iopscience.iop.org/journal/2515-5172>



Common Mistakes

- Multiple research projects at the same time
 - Don't try to start 3 research projects at the same time and join 3 groups at the same time.
 - Instead start with one, go deep, aim for a product, add later
- Not being clear about your goals
 - **One goal should be to have a research product**... communicate clearly and have it defined.
 - Not communicating with your advisor about expectations. Another **goal is to have a strong reference letter.**
- Having too many shallow research projects on your CV
 - Ideally you want 1-2 really deep research projects and additional 2 line items on your CV
- Aiming for a first author paper
 - It takes a long time to get to the research frontier, **try to be a co-author on a paper**...it counts similarly and is much easier to obtain
- Thinking that your project is not worth it
 - Even small projects or small experiences can be presented smartly on your CV and explained in your statement (don't exaggerate, but also don't be shy)
- Not asking for feedback
 - Ask for feedback on the research section in CV and personal statement; ask for them to be matched in letters

Funded positions

- Funding is scarce and finding funded research ops can be difficult but not impossible. (e.g. TIMESTEP!)
- Clearly state that you are looking for a paid position when writing/talking to the Prof. Have a number of work hours in mind.
- If you need the money, since you'd otherwise have to work for a living, say it.
- Be prepared to do some more infrastructure work. Being paid to read a paper is not that likely.
- Perhaps include a suggestion into your email. For example, “looking for a paid position to test+document code” or “document instrumentation tests”.
- Include your CV in your initial email if you have relevant skill sets/experience. Make your CV look professional (see relevant TIMESTEP workshops).

Final Survey

- Please fill this out !

