The Unofficial Guide to Life as a Physics Major: How to Survive and Thrive at TCNJ 2nd Edition

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1 Preface

The purpose of this guide is to provide all incoming and current physics majors with the "things I wish someone had told me earlier". It is a culmination of advice from upper level majors and consultation with department faculty. The content here is geared toward those considering graduate school as this intimidating, but rather straightforward process is not well documented for the uninitiated. Nonetheless, those considering a job after obtaining an undergraduate degree in physics will also find much of the content useful. This is by no means a complete guide to the major, and I alone am by no means qualified to write it all, but it should provide a solid foundation to help carry you through your four years here. It is my hope that this truly informal and unofficial guide will save you much frustration and many "if I had only known earlier" moments. I urge all incoming majors to read this in its entirety to save much headache and frustration. Good Luck!

-Mitchell Revalski, Class of 2014

2 Introduction

You're a freshman sitting in the sweltering heat of your dorm in your second week of college trying to decide if being a physics major is what you really want to do. You're a sophomore in the middle of the semester learning for the first time all those complicated theories of the 20th century and beyond that you always dreamed of learning, realizing that it's quite overwhelming, but exciting. You're a junior sitting at home during winter break having an anxiety attack about what you want to do after college; there isn't much time left. You're a senior in your last week of college in disbelief that it's coming to an end, walking out of Dr. Ochoa's office for what might be the last time. No matter what stage you're at during your time as a physics major, physics is both surprisingly and unsurprisingly an emotional and difficult subject that makes us ask questions in ways that we never imagined and a lot of times no one can answer those questions. This guide is something I have always wanted to add my two cents to because it has helped me answer those questions in different ways every time I've looked at it and now I'm getting my chance to provide that same assistance. There is so much I have learned during my time at TCNJ and I'm not just talking about the actual physics. This guide of course won't tell you everything you will go through during your time here and it honestly shouldn't, but it's nice to know those before you experienced the same emotions along their different paths and have granted you some reassurance that you can do it. So now, without further ado, I give to you The Unofficial Guide to Life as a Physics Major: How to Survive and Thrive at TCNJ, I hope you find it useful.

-Terance Schuh, Class of 2019

3 Freshman Year

Get to know your fellow Freshmen:

With the advent of separating the freshmen physics majors from all the other majors also required to take general physics I and II, it is now easier than ever to get to know your fellow majors from the moment you have your first physics class. These people will most likely be with you in most of your classes up until you graduate which can be both a good thing and a bad thing. Good in the sense that if you find that you really get along with someone, then you'll be able to maintain that partnership/friendship quite simply. Bad in the sense that if there is someone you don't quite meet eye-to-eye with, then you have to find a way to be able to work with them which is also just a good life skill in general.

Get to know the Upperclassmen:

The physics department at TCNJ is small so after your first couple weeks you'll start to see the same people around. The upperclassmen are most of these people and they once were in your shoes too so definitely try to introduce yourself, they won't mind and I promise they aren't THAT intimidating. They also shouldn't have a hard time recognizing you later on because there aren't many freshmen either.

Get to know the Professors:

Another benefit of a small department is that it's very easy to get to know your professors. You will have almost all of the professors at least once during your time and you might even have some of them 4-5 times so you best get to know them sooner than later. All their offices are on the first floor of the physics building (yes, even Dr. Wiita's, I swear it's in the department office), and they will always stop what they are doing and direct their attention to you as soon as you come in. Ask them questions, tell them what you're interested in or what you think you might be interested in, ask about their research, etc. I view the professors at TCNJ as grown-up students; they want to be your friend as much you want to be theirs so take advantage of that.

Hangout in the Lounge:

Whether you realize it right away or not, the physics department is one of the few departments at the school that has a lounge specifically for its students where no one else is technically allowed (anyone else that finds their way in there we call undesirables). Take advantage of this! You might think your dorm or the library is the best place to get work done, but I promise that the lounge is the best. There is a ton of space for you to spread out, there are never more than 8-10 people in there at any given time, and, best of all, everyone in there is a physics major so if you ever need help they will almost always offer assistance. This is also a great place to come even if you don't have anything to work on because it's another way you can get to know the other majors, upperclassmen and underclassmen alike.

Go to Office Hours:

Being new to college you might not be familiar with how office hours work. Usually scheduled twice a week, but often available more than that, each professor holds what they call office hours where they allow time for students to come in and ask questions regarding homework,

lecture material, you name it. The professors literally are waiting for you to come in so make the most out of this because you never when you'll need help and no one but the professor knows the answer.

Go to Department Colloquia:

Each semester the department invites speakers to give bi-weekly, 45 minute talks. These presentations are almost always interesting and the professors will also notice which students go and don't go since it's such a small department so it'll score you brownie points. At the end you will have the opportunity to ask questions about the speaker's work as well as their career path. If you're especially interested in the talk, you can attend a post-talk lunch to further introduce yourself and get more specific career advice.

How to buy/rent Textbooks:

Before starting your first semester at TCNJ you probably received a list of textbooks that are required/recommended for your classes. This list, although convenient for listing all your books, does a very good job of making you think that the only place to get your books is at the on-campus bookstore. The bookstore knows that most students will go right to their store so they obnoxiously mark-up their prices and make you pay so much extra. If you fell for this the first time it's alright, but going forward you should be aware of alternate sources. Amazon and Chegg are the first that come to mind, but there are many other sites and places that offer the exact same books that you need for your classes, but they are so much CHEAPER. You also should always consider whether you want to buy the book, rent it, get an older edition, or just skip out on the book altogether. Every professor is different and their intentions regarding their books are always different. To figure this out, I usually email professors a couple weeks before the semester to see what they think (this is also a good way to introduce yourself). In my experience I usually rent all my non-physics books and buy only the physics ones. If you are considering graduate school in physics this is a very good idea, but it is totally up to you. The only exception to all this is books that come with an online access code. There isn't much you can do to avoid buying these and they are often quite expensive.

More Info:

For more information regarding freshman year that isn't covered in this section, see the following sections.

Section 4: Choosing Classes

Section 5: Outside the Classroom

4 Choosing Classes

Choosing classes is simplified by talking to upperclassmen majors and using the online list for when classes are offered. Core classes are offered every year, though not every semester. Upper level option classes are offered on a rarer basis, usually every other year, making it possible to loosely plan out all four years. Put it on paper, and be sure you meet all your major and liberal learning requirements. This is where your advisor and other fellow majors come in handy. In addition, for those planning on graduate school, take MORE than the basic requirements. Specifically, take as many upper level physics classes as you can handle in addition to math classes. In particular, in terms of non-physics classes we recommend Differential Equations, Introduction to Logic, and either Computer Science 215 or 220. It is best for a future physicist to learn as many computer languages as possible.

Other advice when thinking about classes is to have the big picture in mind. That is, think about how you will fit in independent research with a professor. Don't wait until your last year to think about this! Also, when it comes to planning, think about studying abroad. TCNJ offers many outstanding study abroad opportunities, and these need to be carefully planned in advance so that you continue your progress towards your physics degree. These will be discussed more later.

Always talk to the other majors and professors before deciding on your classes; never take one word as definitive, as a general rule. A list of upper level course offerings along with a sample four year schedule for most majors are available on the department website, see the below links.

Physics Department Website

Upper Level Course Offerings

Sample 4-Year Schedule

4.1 Degree Paths

Within the physics major there are few sub-paths to choose from depending on what your goal is after college. Each path has slightly different graduation requirements, but in the end they each grant you the same BS in physics degree. It's also important to know that it is possible to change your path along the way, just speak with your advisor. TCNJ offers the three following degree paths:

Standard BS in Physics:

This is the most common path students take because it is the most general in terms of preparation. Whether you want to get a job in the physics field directly after school or you'd like to go on to graduate school in a more specific, related field, this path allows you to have those options. Beyond that, this path offers the option to have a specialization. Physics encompasses a variety of sub-disciplines so having a specialization allows you to focus your studies on a specific field while still taking your standard, required courses. For more

information regarding specializations including what TCNJ physics offers see the following link.

Section 4.2: Specializations

Physics and Secondary Education Dual BS Degree:

If you didn't know already, TCNJ is one of best schools in the country for producing high-quality teachers. On top of that, TCNJ students who receive a teaching degree in physics have a 100% job placement rate. Physics-trained high school physics teachers are currently in high demand and TCNJ has recently received a government grant to provide physics majors on this track full scholarships for their last two years in an effort to combat this need. Choosing this path, although not for everyone, is definitely worth considering. Some initial facts to make you think about it: you would have a very respectable career immediately after college, you would make roughly $60,000 as a starting salary, and you would be doing exactly what you were trained to do in college (this is not always the case). If you are unsure if you would like being a teacher and don't want to instantly commit to the path, the department offers a summer program called STEP-UP for underclassmen to test it out. If you wish to know more about this path please contact Dr. Nathan Magee or Dr. AJ Richards, or even any of the upperclassmen who are currently on this path. For more information about STEP-UP and other summer opportunities see the following section.

Section 6.2: Summer Plans and Studying Abroad

7-year Physics BS/MD Program:

This path is definitely the least common of the three, but that's probably because it requires the most work and time, and that it's, of course, only available to incoming students who apply while still in high school (you can't switch into it once you already go here). Regardless, the 7-year med program, as how most people refer to it, is a program where students aspiring to be medical doctors study a TCNJ-approved med school preparatory major for 3 years at TCNJ and then they attend New Jersey Medical School (NJMS) for the other 4 years. They receive their BS in their undergraduate major during their first year at NJMS making them eligible to walk in graduation with their original class, and then then they receive their MD after their fourth year at NJMS. It may not sound like it makes much sense at first, but choosing physics as your preparatory major is one of the best of the available options. Of all the students who take the MCAT (the exam to get your MD), those who have a background in physics have proven to achieve among the best scores. Why? Because studying physics teaches you how to think and solve problems of any kind, not just physics problems. This path is very difficult to get accepted to because you have to graduate from TCNJ in 3 years and still satisfy almost all the same requirements as someone on the standard BS in physics 4 year path. For more information about the degree path as well as frequently asked questions see the following link.

7-Year Med Program Info

4.2 Specializations

As mentioned in the previous subsection, specializations are optional concentrations within the major that further prepare you for certain post-graduate situations. Most commonly done by students aspiring to attend grad school, adding a specialization lets you take more courses in a field that you think you'd want to study further in grad school. All specialization courses count toward your major requirements, so you won't be taking extra courses if you declare a specialization and the specialization may be declared at any time, even after some classes have already been taken toward it. If you would like to add a specialization, talk to your advisor or the office secretary. The department offers the following specializations:

Astrophysics:

Astrophysics is basically physics beyond Earth. Study celestial objects like galaxies, stars, and black holes. Become an observatory technician and learn to use state-of-the-art telescopes. Take courses like our Astrophysics course and General Relativity & Cosmology.

Biomedical Physics:

Biomedical physics is the direct application of physics to medicine and health care. Learn about neuroscience or how the body reacts to different medicine. Take courses like our Biomedical Physics course and Biophysics.

Condensed Matter Physics:

Condensed matter physics studies both the macroscopic and microscopic properties of matter. Combine the fields of physics and chemistry. Take courses like our Condensed Matter course and Inorganic Chemistry.

Computational Physics:

Computational physics is the study and implementation of numerical analysis to solve problems in physics. Combine the fields of physics and computer science. Take courses like Numerical Analysis and upper level computer science courses.

Geophysics:

Geophysics is the study of physical processes and physical properties of the Earth. Learn about the formation of the Earth and climate change. Take courses like Geology and Cloud Physics.

Graduate Physics Preparatory:

This specialization is for students who would like to go to graduate school, but they aren't quite sure in what field. As a result you get more flexibility than the other specializations in that you can take courses from all the disciplines.

Design your own Specialization:

If what you have in mind as a specialization doesn't fall into any of the other categories, you can design your own. Together with your advisor, you may create a brand new specialization that best captures your interests. A past example of a self-designed specialization is scientific writing. The student combined physics and journalism, and is now a writer for science magazines and news articles.

5 Outside the Classroom

As important as your courses are, there is so much more to being a physics major at TCNJ. The people you will meet during your journey, both students and professors, will become some of your closest friends. The community you have unknowingly put yourself in is very tight-knit and does a lot of physics and non-physics activities together. Take advantage of this and get involved in as much as possible.

5.1 Physics Organizations

Physics and Astronomy Clubs:

Physics club aka The Society of Physics Students is like that free gift you get when you call right now and make a purchase from one of those infomercials. As soon as you become a physics major, you become a member of physics club. Some members are more active than others, but every major acknowledges physics club's presence and will attend at least some of their events. It is a student-lead organization that meets once a week usually at noon on Wednesdays. I like to think of the meetings as weekly student-get-togethers where no professors means anything is fair game.

To go along with physics club there is also the astronomy club. They usually meet on Wednesdays directly after physics club and they concern themselves with, obviously, more astronomy-related events. Although separate from physics club, they collaborate on a lot of events together.

For more information regarding both clubs, see the below TCNJ Lion's Gate links.

Physics Club

Astronomy Club

Sigma Pi Sigma ($\Sigma\Pi\Sigma$):

A physicist's dream: a physics fraternity! Not quite. Sigma Pi Sigma ($\Sigma\Pi\Sigma$) is the national physics honor society that some of the country's most famous physicists are members of...and you can be too! Every other year the department holds a very formal induction for junior/senior students who have above a certain threshold physics and overall GPA. As hinted at, the honor society is very prestigious so it is taken very seriously; it is a national organization so this accomplishment will surely be something you want to add to your resume. For more information on the honor society see the following link.

Sigma Pi Sigma ($\Sigma\Pi\Sigma$) website

Other Honor Societies:

Although not necessarily physics-related, there are other honor societies you may find yourself eligible for during your time at TCNJ. The most prestigious of that bunch is Phi Beta Kappa ($\Phi\beta$K). This is the nation's oldest and most selective honor society; only a small fraction of TCNJ's best students across the liberal arts and sciences get invited. If you

don't find yourself getting into this one, don't sweat it. Remember, physics is hard and your grades might not be as good as your underwater basket weaving major friend. Other, more achievable honor societies are Phi Kappa Phi (ΦΚΦ) which is a national honor society for distinguished scholarly achievement, Omicron Delta Kappa (OΔK) which is a national leadership honor society, and Golden Key which is an international honor society for students in the top 15% of their class across all majors. My only note: if selected for some of these, be wary of the organizations charging you a lot of money to join. For more information on honor society chapters at TCNJ see the following link (for some reason the physics honor society is not on this list, but trust me, it's real).

TCNJ Honor Societies

5.2 Department Events

Through cooperation between the department itself and the physics and astronomy clubs there are always events going on within the department so be sure to keep up-to-date with what's happening. A list of some of the events to look forward to are as follows:

- Freshmen vs Upperclassmen Volleyball Game
- Water Rocket Competition
- Physics T-Shirt Sale
- Bi-weekly Colloquia
- Bi-annual Star Party
- Planetarium Shows
- Movie Nights
- Tuesday and Thursday Mid-day Tea and Cookies
- Annual Department Dinner
- End of the Year Department Picnic

6 Life as an Upperclassman

So, you have survived the first year and taken the previous advice to get involved with the department and meet fellow majors and professors. Now what? The remaining 3 years provide a number of challenges which need not be too stressful if understood.

6.1 Research

Get involved in research! Typically freshmen are not allowed to take credit for research, as administration wishes you to get acclimated to college life. While this is true, if you find a professor whose work interests you, most will be open to letting you "shadow" freshman year and learn what you can. This puts you in an excellent position to pick up research sophomore or junior year and hit the ground running. Speak with the professors you are interested in working with and see what can be done.

The demands of each research project will vary, however typical majors will take research on top of their normal four class course load and only claim a half credit of research so as not to overload. This normally involves working six or so hours per week as opposed to roughly twelve for a full credit. A full credit of research can also be done, either as a fourth class or by overloading for a semester with five classes. The exception is for senior level research which is typically the capstone required for graduation, and is taken as a full credit due to the time demands needed to produce a quality result.

It might be helpful to mention that any research is better than no research. Even if you aren't sure what you want to do and don't know what really interests you yet, this is no excuse to avoid doing research. It's better to get involved in some projects to gain valuable research skills and so you have experience to put on your applications for future programs and jobs. Even if you find out you don't like it, you will still learn something and can move on to trying different areas knowing that that one wasn't for you.

In general, doing some kind of research with a professor is an outstanding way to build a network that will help immensely in your post-TCNJ life.

Who's Doing What?

The best way to see what each professor is doing is to talk to them and/or ask for a quick tour of their lab when they are available. But as a general guide, the full-time faculty members work in the following areas:

- Dr. Angela Capece - Plasma Physics
- Dr. Danielle Dalafave - Computational Biophysics
- Dr. Nathan Magee - Cloud Physics and Meteorology
- Dr. David McGee - Experimental Condensed Matter and Photonics
- Dr. Tuan Nguyen - Experimental Biophysics
- Dr. Romulo Ochoa - Optics and Lasers
- Dr. AJ Richards - Physics Education Research
- Dr. Thulsi Wickramasinghe - Cosmology
- Dr. Paul Wiita - Astrophysics and Fluid Dynamics

6.2 Summer Plans and Studying Abroad

Okay so now you've gotten a crash course in what to do for your first few years. What about the summer? Regardless of whether you're looking to go to graduate school or get a job directly after you graduate, there are research internships to consider that will greatly boost your resume no matter what you end up applying for.

MUSE:

MUSE is an acronym for TCNJ's Mentored Undergraduate Summer Experience. This is essentially a paid 2-month research internship at TCNJ. Many professors are open to MUSE opportunities, but talk with them early to be sure. Applications are generally due early during the spring semester. Discuss this with your professors in the previous fall semester. Professors form their summer research plans early, and the sooner you show an interest in a professor's work, the better.

This is an excellent chance to immerse yourself in research. Since it is full-time without other classes taking up your time, a student or a group of students can often complete the equivalent of an academic year's amount of work if things are managed properly. This is an excellent opportunity to work with a professor and fellow majors, and is also a lot of fun!

The beauty of this program is it is open to all levels, including freshmen. This provides an excellent platform to start or continue research, and eventually obtain an REU (you'll here more about these in a second). Also keep in mind that some TCNJ professors have government funding for summer research that may be separate from MUSE funding. Be sure to ask, as this presents yet another opportunity for summer research. For more information about MUSE see the following link.

More Info on MUSE

REU:

REU is an acronym for Research Experience for Undergraduates. The purpose of these National Science Foundation (NSF) funded programs, held at universities around the country, are to give undergraduates, particularly those interested in going to graduate school, a chance to see what graduate research could be like. Typically these programs highly favor juniors during their summer before their senior year. However, it is worth applying as a sophomore as you still can get accepted and the experience gained in the application process is exceedingly valuable for improving your application the second time around.

These programs span a 10-week period of the summer where you are basically treated as a grad student for the time being. You receive a healthy stipend, housing, travel, and usually food. You get to work as part of a professor's research team at a large research institution, attend weekly physics seminars, and get to know a dozen or so physics students from around the country. As a result, these REU's are highly competitive but also highly valued for those applying to graduate school. Grad schools like to see that you have field research experience as well as someone at a different university like your REU advisor who can vouch for your skills. This is also your chance to branch out and try intensive research in an area of your

choice. Most students apply to many REU's to better their chances, ranging from 10 to 30 different programs in general. If you never obtain an REU, do not fret, many students still get into excellent graduate programs.

This is where your cultivated relationships with professors pay off, as you usually need 2-3 letters of recommendation for REU's, and eventually for graduate school. If you have not been involved and present in your classes, department events, and research, it is hard for professors to write a strong letter. Help them help you, be involved! For more information about REU's talk to upperclassmen who have done an REU, talk to your advisor, or, conveniently, the National Science Foundation (NSF) website link below has info and a list of all the schools offering an REU this coming summer.

National Science Foundation/REU website

SULI:

SULI is an acronym for Science Undergraduate Laboratory Internships. These programs are similar to REU's in that you receive pretty much the same benefits, but there are a few differences. The main one is that instead of going to another university, you go to one of the 17 Department of Energy (DOE) National Labs such as Fermilab or SLAC. Other differences include being able to apply for not just the summer, but fall and spring terms, and only being allowed to apply to a max of two labs. I won't say much else about SULI because it is so similar to REU's, but it is definitely something you should consider applying to if you're also interested in REU's. They are just as reputable and I've heard that they are slightly easier to get accepted to because a significantly less amount of students apply. For more information see the following link.

Department of Energy/SULI website

STEP-UP:

STEP-UP is an acronym for TCNJ's Summer Teaching Exploration Program for Undergraduate Physics. This program is meant for underclassmen who have even the slightest curiosity about what teaching physics is like. It's like a way for students to try out the physics/secondary education dual degree path without fully committing to it first. If you find you love it you can easily transition to the education path starting in the proceeding fall semester or if you find it's not for you, you can return to your original degree path without having delayed your planned graduation time.

The program only takes up about a month of the summer and most of it will take place at TCNJ with a few local school visits. The best part is that you will receive on-campus housing, a minor stipend, a guaranteed Learning Assistant position in the coming fall semester, and you will most likely be with a small group of students that you already know. STEP-UP is something you should really consider applying for during your first two years as a physics major. For more information about STEP-UP see the following link.

More Info on STEP-UP

Other Internships and Tips:

Although the most common and popular summer internships were covered, keep in mind that there are several other types not mentioned here. Unfortunately, a lot of internships try to hide their existences so their committees don't have to forage through a large amount of applications, but if you dig around online or ask different people in the department you will be led to so many and you will get one. You should also know that getting any internship requires not just being a good student, but hard work, and trust me, it'll all be worth it. Overall, the take-away message for summer internships is that it's never too late to start considering them or even applying to some.

Studying Abroad:

Physics is an international enterprise, and it is almost certain that in your career in physics, engineering, or science in general, you will be working with people from different countries around the world. Getting international experience as an undergraduate is valuable (and fun) as you apply for graduate schools and/or jobs, particularly since so few US students pursue this option. Something else to consider is that the people hiring you or deciding on your grad school acceptance will likely have international experience themselves. In the most recent past, physics majors have studied abroad in the Netherlands and Germany. TCNJ also offers the opportunity for those on the secondary ed. track to do their student teaching in a variety of countries such as Australia, Spain, Thailand, etc. For more information about studying abroad as a physics major, talk to Dr. Dave McGee or visit the following links.

TCNJ Studying Abroad homepage

Student Teaching Abroad

6.3 Department/On-Campus Jobs

Even with everything mentioned so far, if you find that you still have some time to spare and are looking to make some money you should consider applying for some department/on-campus jobs. The following jobs are all physics-related so you'll definitely want to consider them and in fact they'll be a great addition to your ever-growing resume/application.

Tutor:

Tutoring is probably the most common on-campus job. For physics majors there are two types of tutoring jobs available. First, you can work as a department tutor where you hold two weekly, 2 hour sessions in the physics lounge. This type of tutoring is considered open-hour tutoring meaning students taking general physics, majors and non-majors alike, can come in, ask questions, stay as long as they need, and then head out. The other type of tutoring position is through the tutoring center. There you create a weekly schedule for yourself and students sign-up for one of your hour-long time slots. You and the student (or a group of students) meet once a week at that same time each week and work on homework, go over lecture material, etc. The tutoring center is a campus-wide facility so they have tutors available for all subjects, not just physics. In addition, tutors can work up to 15 hours a week as opposed to the department tutoring's 4 hour limit. Both jobs are great opportunities to

test your own knowledge of the subject as well as practice teaching physics for those who may have to do that one day. For more information regarding TCNJ's tutoring center see the following link.

TCNJ Tutoring Center

Learning Assistant (LA):

This position was briefly mentioned before, but not elaborated on. The learning assistant job is relatively new in the department, but it's a pretty standard job at other schools. A LA is basically a TA with a slightly different name. As a LA you work with a professor in a general physics lab. The labs are often filled to capacity so it's difficult for a professor to help everyone out and give each student individual attention. The LA lifts some of this weight off the professor while further honing their understanding of the labs they first did themselves not too long ago. It doesn't pay actual money, but you get partial course credit on top of your other courses which still goes a long way. This position is usually desired by aspiring teachers, but it is still beneficial for those with other career aspirations. See the following link for more information about becoming a LA.

Learning Assistant Info

Lab Technician:

Lab technicians, like the name suggests, also work in the general physics labs. Instead of working with the students though, the technicians actually prepare the labs each week. Most students in lab either don't worry about how the lab equipment got there, or they assume it was by the professor, but all the labs are set-up by upperclassman majors. Lab technicians must truly understand the ins and outs of every lab to accurately prepare them. This again gives students the opportunity to further fiddle around with labs they may have only done once a long time ago. This job is great for those who wish to go into experimental physics.

Observatory Technician:

This job is among the most unique at TCNJ. First of all, TCNJ is of the minority among colleges in that they own not one, but two on-campus observatories. In addition, majors are allowed to work in the observatory and gain skills operating an optical telescope. The astronomy courses during the day require its students to attend the observatory approximately one night a week. The observatory is open Monday through Thursday (weather dependent) and open to the public. Even with average telescopes we can see various astronomical objects such as Jupiter, the Pleiades Star Cluster, and the Andromeda Galaxy. This job is great for those wishing to study astrophysics and astronomy.

SEM Technician:

SEM is an acronym for Scanning Electron Microscope and TCNJ has the luxury of having one that's on-campus AND free to use (most schools don't even have one and if they do, you have to fight for observing time). Located in the biology building, the state-of-the-art microscope is actually maintained by physics professor Dr. Nate Magee and run by physics majors. The majors learn to independently operate the device as well as the physics behind

its "magic". The microscope uses a beam of electrons striking any type of object that fits inside to produce high-quality, nanometer-scale images. Students can bring in any objects they are curious about and take a much closer look at them whether it's for a research project or for fun. This job provides invaluable experimental skills and should be something you want to learn more about.

AFM Technician:

AFM is an acronym for Atomic Force Microscope and similar to the SEM, TCNJ has its very own that is free to use. This device is held in the physics building, maintained by Dr. Dave McGee, and run by physics majors. As a technician you learn to operate the microscope and assist students and professors who may come in to use it for research purposes. The microscope works by using a probe that is in constant contact with the observation specimen as it is moved around in the machine. The probe stays in a fixed location and essentially feels out the object of interest. If there is a dip in the specimen the probe follows it and same with a bump. From these continuous measurements, the microscope forms a three dimensional image of the specimen and thus we can learn more about it. Like the SEM technician job, being an AFM technician is good experience for those wishing to go into experimental work.

Other On-Campus Jobs:

Of course there are more on-campus jobs, but these are just the ones physics majors tend to hold. Depending on your situation you may want a different job, a non-physics job, and you should definitely explore these options, but remember, the jobs just described will provide experience and skills difficult to find elsewhere. For more information regarding student employment see the following link.

TCNJ Student Employment

7 Graduate School

Question: With what undergraduate major can you attend graduate school for FREE and get PAID?
Answer: PHYSICS!

Yes, this is the world's best kept secret about physics (and other physical science degrees). If you get into grad school, your PhD is (almost always) free and you receive a monthly stipend that is enough to live on.

In addition to this and briefly touched on before, studying physics not only prepares you for physics graduate school (obviously), but also med school, dental school, law school, economics, earth sciences, astronomical sciences, engineering, etc. The point is if you have a desire to go on to grad school, even if it's not exactly in physics, studying physics will most likely adequately prepare you. While the rest of this section is geared toward those planning on going into physics, keep this in mind because the material is still informative for the graduate school application process in general.

7.1 The Requirements:

Going to graduate school (this coming from those much wiser and older than me) can be a mentally trying, but also very rewarding experience. The whole application process, start to finish, is very similar to applying to undergraduate college which need not be too stressful if adequate preparation time is allowed. Graduate schools will generally weigh, with different importance depending on the school, the following areas:

Personal Statement:

Your personal statement is the very first thing the admissions committee will see when they review your application (most of the time). Your personal statement is basically a less-than-1-page introduction about you and what your goals are in grad school and beyond. Now you don't want to write something cliche like "My whole life I've wanted to be...", but you do want to express your passion for the subject and your desire to succeed in it. Make a few drafts, have several people read it over, and eventually craft an anecdote about yourself that will make people interested in the rest of your application. If you don't have a strong, unique personal statement, admissions may never even read the rest of your application.

Undergraduate GPA:

Your overall and in-major GPA will always be looked at along with the specific courses you've taken. It is important to learn and do well in your physics classes and show schools you did so. Graduate classes will only be harder so you want to prove to a school that you aren't going to give up when the going gets tough. A good goal to shoot for is making Dean's List at the end of each semester which requires a 3.5 semester GPA. Of course anything over this is even better, but this will put your GPA in the competitive range.

Research Experience:

Your research experience is so valuable. When you are in grad school your overall goal will be to get a PhD or masters degree which are granted based on your success in doing independent research. Programs want you to prove that you can do this research so what better way to prove it than having research experience. The ability to be creative and problem solve can be demonstrated here and is crucial for a strong application. Publications, oral and poster presentations at conferences, and the summer internships discussed earlier fall into this category.

Letters of Recommendation:

This one sort of combines the previous two. Graduate schools want to hear from your professors on how you stack up and what you have to offer in terms of knowledge and character. This is why research and involvement in and out of the classroom are so important. You alone are responsible for giving professors the ammunition they need to show schools you have the perseverance and talent to perform at a higher level. The best way to get a professor to write you a letter is by working hard in their class or as their research student.

Other Requirements:

There are of course other requirements including the GRE which is discussed in depth below, but these are probably the most important. Your application requires the ability to take everything you've learned as a physics major and condense it down to a short, comprehensible amount. If successful, you will have no problem getting into grad school.

7.2 General and Physics GRE's

The last major requirement not mentioned above is the GRE. Now there are two GRE's, the general and the physics, and they both are wacky exams that you have to power through. Hopefully the following information and advice will lessen the struggle and help you prepare.

The General GRE:

You took the SAT's to get into college, well the Graduate Record Exam (GRE) is the equivalent of the SAT for graduate school. It's a 4-5 hour exam that covers general math (not even Calculus), reading, and writing skills. The test is offered on a daily basis in computer format and less frequently in paper format. It's similar to your driver's test in that you can take it up to 5 times a year with a minimum 21 days between testing dates. Everyone applying for grad school, regardless of their major, has to take this test so therefore there are tons of prep books out there for this basic skills exam. The general GRE is generally taken at the beginning of your senior year, but it may be taken earlier as well, including over the summer so you don't have to study on top of a semester course load. Either way, be sure to take this sooner rather than later as some application deadlines can be as early as December.

The format of this exam is not at all traditional. When you start the test you will have two 30-minute intervals to write two separate essays. From there you will take a 30-minute, 20 question math or reading section with a 10-minute break afterwards. For the rest of the exam

you'll take four more alternating reading/math sections that follow the same format as the section just described. All in all this equates to 2 writing sections and either 2 math sections and 3 reading sections, or 3 math sections and 2 reading sections (for scoring purposes, only 2 math sections and 2 reading sections matter, one of them is just for research, but you won't know which one). The other thing to keep in mind is that the difficulty of each section scales based on how well you did on the previous section. For example, if you did really well on the first math section, the next one will be harder.

The last thing to mention is how the test is scored (you will get three separate ones). The writing section is scored by an actual grader on a $\frac{1}{2}$-point interval between 0 - 6 so you will get that part of the score back in 2 weeks. The math and reading sections are scored by the computer on a 1-point interval between 130 - 170 (I have no idea why this is the range and not 0 - 40). Each math/reading question is worth 1 point, you don't get penalized for answering questions wrong, and you get these two scores back as soon as the exam is over. Now what grad programs really look at is your percentile which is just your raw score converted to a percentage of people that you scored higher than. For example, if you got a 150 raw score on a section that would probably correspond to roughly the 50th percentile, but it really all depends on how other students did who took the exam in the past 5 years.

Before you start to stress, this test is far less significant compared to the physics GRE if you are applying for physics grad school (for other programs it becomes more important). With this in mind, you should really only be concerned with your math score and not the other sections. As a physics major, schools expect you to get above the 80th percentile on the math (this part of the exam can make or break a school's decision to accept you), but it's totally fine to do average or even slightly below average on the reading and writing sections. Nevertheless you should take this exam seriously and try to do as best as possible.

For more information about the general GRE check out the following link.

Offical General GRE website

The Physics GRE:

If the general GRE wasn't enough and you want to go to physics graduate school, you (may) have to take the physics GRE. The physics GRE is the equivalent of the SAT II subject tests that you may have taken before coming to TCNJ, only this test is more important than the general GRE. This 100 multiple choice written exam is your chance to demonstrate to graduate schools that you really learned what your grades reflect, or that you have since improved your knowledge and your grades are not all that make you up. American students are generally expected to not do as well compared to international students because they may take a gap year or more to study solely for this exam. Cramming in a few weeks is typical for American students, but shooting for three or so months should be considered a practical minimum to refresh and improve on all your undergraduate coursework. This test is offered twice in the fall and once in the spring, and if you're serious about this test you should consider taking it in the spring of your junior year. This way you can get a base score and set a goal to do even better after you study during the in-between summer.

As just mentioned, this exam is a 100 multiple choice physics test. It might not sound too bad at first, but you'll soon learn from your classes that this is not the typical format for physics tests and it's also not the format you'd prefer. Almost all the physics tests you will take in your life will be 4-5 open-ended type questions that you have 1-2 hours to complete with the ability to use a calculator. This exam is quite the opposite, 100 non-open-ended questions in 2-3 hours with NO CALCULATOR. This means that you have about 1.5 minutes to answer every question, but the questions are of the type where you'd like to take a lot more time to solve them. The good thing is you don't get penalized for wrong answers so if you are under a time crunch, you should always guess.

Having a strong knowledge of undergraduate physics is of course the goal for this test, but there are few strategies to employ that will allow you to answer nearly half the questions with even a minimal understanding of physics. One of the most useful strategies and easiest to learn is unit analysis. Almost every question has a few answers that you can eliminate immediately without even reading the question, and some you can answer correctly with this technique alone. Another strategy is to try to get into the test-makers' heads and figure out how they came up with each wrong answer choice and why they don't make any sense. If you can do this you'll be very successful because that means you can think like a true physicist and know how to read between the lines of equations and formulas. There are of course other strategies to learn, but they require actually studying and taking practice tests.

The scoring of the physics GRE is also not what you'd expect and/or prefer (why would it be). It's scored on a 10-point interval between 200 - 990. From there, like the general GRE, your score is converted to a percentile that tells schools how you did compared to all other test-takers on that day, even the international students. Even weirder, getting all 100 questions right is not the only way to get a perfect score, in fact, no one gets all the questions right. No one even gets more than 90 questions right. That's right, you can get $\frac{4}{5}$ of the questions right and get a perfect 990 (this of course also corresponds to the 99th percentile). With this in mind you probably want to shoot for at least a 700. This corresponds to less than half the questions right and approximately the 50th percentile. This score will be good enough for a majority of solid grad schools, but if you want to go to a top 10 physics program you're going to need at least an 80th percentile.

Now to be honest, the physics GRE is a very stupid test because it isn't a real physics test (you didn't hear this from me), and more and more schools are starting to realize this. Maybe one day it'll become obsolete altogether, but for now there are still a number of schools that require it so you'll probably have to take it. Because of this, before you take the exam be sure to check if any of the schools on your list require it; don't waste your time and money if you don't have to.

For more information regarding the exam and what's on it see the following link. Also dig around on online forums and ask your fellow professors for their advice.

Official Physics GRE website

7.3 Applying, Resources, and Advice

If you've made it this far, the actually-applying-to-graduate-school part is the last major step. As discussed earlier, it involves getting letters of recommendation, finding programs which interest you, etc. For this I defer to the advice of professors and other majors more familiar with the process.

Making an effort to contact the people you are interested in working with can be a good idea. Ultimately, you are probably only going to be working very closely with one or two faculty members so if you already know the field you want to work in don't hesitate to reach out and ask questions. Generally, professors seem happy to answer questions and like to hear from students who are interested in their work. On the other hand, it isn't uncommon to be unsure of what you would like to research in grad school. If that's the case you will want to find a department that has faculty members who do research in a variety of areas so that you have some options to work with.

While there are other resources to guide you, I hope this will help all those reading it orient themselves. I would strongly recommend the following resources which will help students decide if graduate school is right for them, where and how to apply, and how to find success with the physics GRE. Again, professors who have all gone through this process can comment more!

Recommended Readings:

"Getting In to Grad School for Physics, Vincent Klug
(See additional recommendations on the last page of this book)

"Conquering the Physics GRE", Yoni Khan and Adam Anderson
(THE book for those looking to crush the exam)

Going through Graduate School:

While not the purpose of this guide, the following general pieces of advice are common for those who do decide to go to grad school.

- Take time to decide if grad school is really for you; don't just go because you don't know what else to do.
- If you do go to grad school, keep your mind open about what you would like to do following it as there are no set paths!
- Apply to many schools, depending on the applicants for that year you can often be declined offers from places which you may be well qualified for.
- Don't set your mind on one school or one particular region. There are excellent grad programs in physics and related fields all around the world.

8 Debunking Physics Myths

I am going to work much harder than other majors and not have a social life!

False!
It is true, you may put in more time or effort than some other majors, but you get out what you put in and hard work yields great opportunities. Most upperclassmen are involved in many clubs, have hobbies, play sports, see significant others (on a regular basis!), etc. It is possible to study hard as well as have fun if one stays organized and balances their time well.

If I don't go to graduate school I won't be able to get a job!

False!
Many undergraduates find jobs in industry, teaching, etc. The department maintains a log detailing the many companies and fields majors have gone to work for with only an undergraduate degree so looking at that will be helpful. In addition, undergraduates have been accepted to non-physics graduate programs such as engineering, medical school, and law school. Industries, high schools, and government labs love physics majors at all levels, including the bachelor level, but you won't find these jobs in the Sunday NY Times job-listings section under the letter "P". You have to dig and you need to network. In general, if you want to go into industry with your BS degree, take as many applied/lab/computer classes as you can while at TCNJ and be sure to have research experience with a professor. Dr. Dave McGee worked in industry for some time and can tell you more about all this. If you are interested in high school teaching, Dr. Nate Magee and Dr. AJ Richards direct the secondary education program for physics majors, and can tell you more about these outstanding opportunities.

If I can't get into a physics or math class I need, there is nothing I can do!

False!
It is rarely a problem getting into an upper level physics class. While often there is a problem getting into correlate math classes, a simple trip to the math office where you explain your situation will usually result in you being enrolled in the course. In addition, if you are missing a pre or co-requisite talk to your advisor or the department chair and see what can be done. As a general rule of thumb you'll want to put off (some of) your liberal learning until you've completed many of your major courses so as an upperclassman you will be able to register early and get the liberal learning classes you need/want.

If I want to one day be a university professor, I should be in the Physics Teaching Track

False!
Almost all faculty positions require a masters degree or Ph.D. and the teaching track is specifically for "secondary education", meaning high school. Secondary ed. physics teachers are in high demand so this route is often an excellent idea, but if you desire to go to graduate school, the teaching track is most likely not for you.

9 Closing Remarks

I would like to again thank all the physics majors and faculty who read this guide and made excellent suggestions. In many cases their suggestions have been dropped in nearly word for word in the appropriate sections. Without their notes, this guide would not be nearly as complete as it is. If there is anything you feel is incomplete or misleading, or you have additional material you would like to see added, do not hesitate to contact me!

If there is one message to take out of this entire writing, it is, GET INVOLVED! Good Luck!

Terance Schuh
Class of 2019

Mitchell Revalski
Class of 2014