Newsletter

for students in

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1 Introduction
by Dr. Sarah Holliday

Welcome to the first issue of the third volume of the Southern Polytechnic State University Mathematics and Physics Newsletter sponsored by the Student Chapter of the Mathematical Association of America and the Society of Physics Students. In it you’ll find contributions from students and former students in both the Mathematics and Physics Departments. The contributors and organizers have my thanks and congratulations. The newsletter is a chance to see some of the physics and mathematics that students and faculty are thinking about and working on at Southern Polytechnic. Look for future issues to continue to serve as a forum for interesting articles that range from problems (solved and unsolved) to informative and expository material to new ideas and results. I’m very pleased to introduce what I am sure will become a continuing part of the SPSU community.

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2 Math Stinger #132
by Dr. Steve Edwards

It is possible to divide a right triangle into smaller triangles so that all of the smaller triangles have only acute angles.
The right triangle pictured has been dissected into 13 smaller acute triangles. What is the smallest number of acute triangles that this right triangle can be dissected into?

Send your solution to sedwards@spsu.edu, or by snail mail to Steve Edwards in the Math Department. The names of the first solvers will be posted at fac-web.spsu.edu/math/stinger/132.htm.

3 How to Get Into Grad School

by Michael Bowles

First, apply; next, get accepted. If only life were that simple...

In this document, I present a few tips I have on how to successfully navigate the world of graduate school applications and I’ll follow up with a couple of step-by-step lists of how to ease your burden and manage your precious time.

The first thing to do is begin looking at schools as early as possible. There can be no overstatement of the importance of knowing what you want. So, when considering schools be open-minded. If you’ve heard of a school then check it out. See which school has a good program for the field you think you’d like to work in; then check out fields that are peripherally related.

Also, consider whether you want a big city or more rural experience. I’m told that a big city experience is more electric and goes well with the creative, demanding atmosphere of grad-school. Going from a school with 5,000 to 20,000 students has been great for me. There are more people to interact with, more buildings, more campus, more everything and it’s both overwhelming to go from small to big, and also completely amazing, alive, inspiring, stimulating and so on.

Consider whether you want to stay in the south or would like to experience the mid-west,
the north or possibly even the west coast. Some people even go over seas, typically the UK to attend a graduate school. It seems to me that most people are afraid to leave their little bubble and so the likelihood of attending a school is proportional to the inverse square of the distance, like sound or gravity. At this point don’t worry about how you’ll actually perform the move when it’s time, just get the questions flowing so you can consider all your options. Never limit yourself, life does that enough for you.

Always remember that you may be one of the smartest, most skilled or otherwise qualified students you know, but you may be a big fish in a small pond. Don’t be afraid to check out the schools that are less prestigious than the top 50.

My personal case is that I got into a school that is considered 70th in physics. But I would truthfully not want it any other way. It’s a private school with tons of stuff to do, I’m funded (more than anyone else I’ve met on campus) and the professors are awesome!

Now, I present a step-by-step guide so you can manage your time and rock out life!

**Pre-Preparation Steps - for sophomores and juniors**

1. Be friendly and outgoing, especially to teachers; they write your letters of recommendation and if they think you aren’t very skilled their letter may reflect that.

2. Always do more than you think you must to be a complete success. Welcome criticism and don’t be afraid to make mistakes. Those red marks on tests are all the ways you can be better, so keep it positive. Don’t be discouraged, ever.

3. If you can, do an REU (Research experience for Undergraduates) the summer after you’ve completed your sophomore year. Do one after junior year too, if you can. This requires being prepared by going online to look for them about 6 months or so in advance. They usually cost nothing to apply for and sometimes they may waive your graduate application fee, even if you didn’t actually do the REU! This can save you up to $150, so it’s worth considering.

**Preparation Steps - for juniors and seniors**

1. General GRE - (after Junior year or before Senior Year). Math is **really** important, it should be simple but getting a perfect score isn’t the easiest thing. In order to be prepared for non-Calculus based questions buy Kaplan/Barron, study it hardcore; you want > 750 or equivalent. $150 - 190

2. By Senior year start checking out schools you’ve heard of. This is free so do it early! Search for “Best (insert subject) grad schools” to get a relatively decent picture of who’s good and who’s great. Remember to check out schools you’ve never heard of as well.

3. Within the first month of being a senior, start writing up a letter of intent, also known as a statement of purpose. This should contain information on why you’re better than
the competition. Don’t list the classes you’ve taken (it’s on your transcript). But do
tell if you’ve audited a class, met with a professor after hours for a special learning
session, mention your own private studies. Here is an excerpt of one of my many
statements: “My academic experiences both as student and as a teacher, my passion
for learning, and my determination to continue with higher education make me a strong
candidate for your program. Beyond the standard math and physics requirements of a
dual degree, I have also studied...” and I go on to say that “the atmosphere of (school
name) is an electric, engaging intellectual breeding ground that I would thrive in. With
my passion and for learning as well as my tutoring and teaching experience...” I would
kick complete ass at your institution and you should totally pay me! Don’t brag too
much, but if you’re too modest they won’t know you well enough to accept you. Be
diplomatic and engaging as a writer.

4. Also, begin to put together a resume. Have the career center, your professors, your
parents and your friends look it over. Take everything anyone says with a grain of salt,
though.

5. Around the first few weeks of your last year, (wait until you’ve aced a homework or
test) start to ask professors (2 - 4, depending on the number of schools you’re looking
at) if they have time to write a letter of recommendation, or two, for you. They may
ask what schools you’ve considered and why. Be prepared to give them a preliminary
statement of purpose or a resume (now becoming more popular on applications).

6. Professors may have advice that may help you make a hard decision like not applying
somewhere. “You really shouldn’t apply there, you won’t get in. They are snobby and
you haven’t got research experience.” That advice saved me a hundred bucks, and
realistically it was dumb for me, at least to even think about applying to anything
higher than top 10.
7. Take the Subject GRE either Oct/Nov the schools are usually pretty lenient about when they get these scores considering you may not be done applying until late November or mid-December. You’ll get scores like the day after Christmas. This will cost around $150.

8. Arrange to have transcripts sent directly to the school or to you to mail as part of a grad application package. Do this before holiday break senior year; in fact do it before finals and arrange to have them go out after final grades are in (or if you want to be deceptive then don’t include your latest grades) $2-7 per transcript so plan for about $5 for each school.

So essentially, we can sum up the main points quickly

1. General GRE before Senior year & study the math! @ $150
2. Find Schools and continue looking at least until mid-October
3. Make a spreadsheet of containing the things you need to do for each school (this one really helped me stay organized and on top of things)
4. Begin writing your letter of intent and resume
5. Butter the profs up for some letters by early October
6. Subject GRE prep until the week of (Mid-October or November depending) @ $150
7. By November begin filling out online apps @ $0 or $50-150 per app
8. Prepare to send away transcripts after grades @$5 per school (some need two!)
9. Prepare to send away GREs after both scores are in @ $23 per school
10. By your last semester you should just relax, it’s done until fall!

I didn’t mention every little detail (although it sure seems like it). When you find a school you like add it to your spreadsheet and contact someone there if it all possible. All-in-all: grad school is great, but getting there isn’t easy. If you have questions, that’s what your professors are for. I wish you the best of luck in your travels.

4 Math Stinger # 135
by Dr. Steve Edwards

This time we have a counting, or combinatorics problem. On a circle, pick an even number of distinct points and pair them up to draw chords. How many ways can this be done for 3, 4, or (bonus question) any number of chords? Consider two ways equivalent if the points can be pushed around the circle to transform one into another without any point crossing another. Consider two ways different if the chords intersect in a different number of ways. Consider two ways the same if they are mirror images. The two ways for the 2 chord case
are pictured. Three ways for the 3 chord case are pictured.

Harder question: what if all the points do not have to be distinct?

Send your solution to sedwards@spsu.edu, or by snail mail to Steve Edwards in the Math Department. The names of the first solvers will be posted at fac-web.spsu.edu/math/stinger/135.htm.

5 Search For The Rigidity Transition In A Lithium Oxide Silicate Glass System Using MDSC
By Jennifer Black

Glass - most of us take it for granted, everyone uses it, no one completely understands it and some of us study it. As an undergraduate I was offered the opportunity to work with Dr. Ranasinghe on a research project studying the lithium oxide silicate glass system. The objective of our study was to determine the rigidity transition of the glass. The nomenclature
used to describe the glass is: $x\text{Li}_2\text{O} \cdot (1 - x)\text{SiO}_2$ where $x$ is the fractional amount of lithium oxide (Li$_2$O). The rigidity transition typically exists in a small compositional region (range of $x$ values) where the glass has high strength and low stress. These optimized glass-forming properties are why the intermediate region is of interest.

Other studies have shown the rigidity transition to exist in other glasses like $x\text{Ge} \cdot (1-x)\text{Se}$, $x\text{Ge} \cdot x\text{P} \cdot (1-2x)\text{Se}$ and $x\text{Si} \cdot (1-x)\text{Se}$. Theoretical models have been performed for oxide glasses and previous studies of $x\text{Na}_2\text{O} \cdot (1-x)\text{GeO}_2$ and $x\text{Na}_2\cdot (1-x)\text{SiO}_2$ suggest the possibility of the existence of a rigidity transition in oxides glasses. Lithium was chose as our silica additive because alkalines have been found to form a stable metasilicate with a low melting temperature, high refractive indices, thermal expansion coefficients and electrical conductivity.

To create the glasses, we first mixed the appropriate amounts of lithium carbonate (Li$_2$CO$_3$) and silica (SiO$_2$) depending on the compositional value (we made $x = 0.30, 0.31, 0.32, 0.33, 0.34$ and $0.35$ samples). The mixture was then placed in an alumina crucible and left for 3 hours at 1400°C to melt. During melting, carbon dioxide (CO$_2$) gas is released and the desired $x\text{Li}_2\text{O} \cdot (1 - x)\text{SiO}_2$ mixture is left. After melting, we quenched (cooled quickly) the glass on a cleaned stainless steel plate. This allowed the melt to cool quickly enough to form a glass and not a crystal.

Thermal analysis of the glasses was performed at Northern Kentucky University. We used temperature Modulated Differential Scanning Calorimetry (MDSC). MDSC measures the heat flow into two aluminum pans; one empty (reference) and one with the glass (sample). Both underwent a heating cycle through melting and the heat flow measured. MDSC is able to separate the total heat flow into reversing (thermodynamic, heat capacity) and non-reversing (expresses enthalpic recovery, evaporation, crystallization, some melting and decomposition) components.
We measured two properties for each glass sample: the non-reversing heat enthalpy ($\Delta H_{nr}$) and glass transformation temperature ($T_g$). $\Delta H_{nr}$ gives insight into how much stress is in a glass and is measured by integrating the endothermic peak of the non-reversing heat flow peak which appears when the sample transforms into a glass. It determines the latent heat between the liquid melt and the amorphous solid (glass) and the larger the $\Delta H_{nr}$, the more different it is from its melt. Most glasses’ $\Delta H_{nr}$ increase with time but in the rigidity transition a drop in $\Delta H_{nr}$ is found and it does not increase with age.

$T_g$ is the temperature in which the super-cooled liquid becomes a glass and gives insight into how tightly the molecules are bonded to one another. It is found by measuring the temperature where an inflection point is in the reversing heat flow. Though $T_g$ is a commonly measured property of a glass, it is somewhat ambiguous because it can change depending on the glasses’ thermal history. Therefore, we were careful to use the same procedures for each sample in order to study trends in their properties as a function of composition.

As mentioned above, glasses in the rigidity transition have high strength and low stress. Therefore, one would expect to see a drop in $\Delta H_{nr}$ and a rise in $T_g$ trends. Both our $\Delta H_{nr}$ and $T_g$ vs. compositional value ($x$) plots exhibit these trends. We conclude that a rigidity transition exists in this compositional region ($0.31 \leq x \leq 0.33$). As stated, we achieved our goal for this research project. Working on this research project helped prepare me for graduate work and I encourage others interested in a graduate degree in the sciences to participate in undergraduate research as well.

6 Math Stinger # 136
by Dr. Steve Edwards

Everyone knows that some right triangles have sides that are integers. The best-known one is the $3 - 4 - 5$ right triangle. There is also the $5 - 12 - 13$ right triangle. In fact, there are infinitely many such triangles. Show that any right triangle with integer sides has at least one side that is a multiple of 3.

Hint: First show that no number that is a perfect square has the form $3k + 2$, where $k$ is an integer.

Send your solution to sedwards@spsu.edu, or by snail mail to Steve Edwards in the Math Department. The names of the first solvers will be posted fac-web.spsu.edu/math/stinger/136.htm.
My Summer Research Experience
by Rashad Tatum

During the summer, I traveled to the state of Texas for a research program held at Texas AM University-Corpus Christi. The research program, entitled Research Experiences for Undergraduates, was sponsored by the National Science Foundation (NSF). The NSF provides funding to different universities with the goal of providing research opportunities to American citizens in STEM (Science, Technology, Engineering, and Mathematics) areas. Each university sponsored by the NSF receives funding to pay for the cost of the program as well as to pay students. Students are usually paid around 4,000–5,000 along with room and board.

The university I selected, Texas AM University-Corpus Christi, is located in the city of Corpus Christi. Corpus Christi is a beachfront city located near the Gulf of Mexico, although it’s separated from the Gulf of Mexico by an island called Port Aransas. My home department for research was the Computer Science department.

During the first two weeks of the program, we toured the campus and attended presentations on conducting research and the various topics we could choose for our research project. I came to the university with the intention of researching a topic related to computer networks. The focus of the program was Wireless Sensor Networks, networks that collect data wirelessly from a collection of small devices. After watching a presentation by Dr. Dulal Kar on Elliptic Curve Cryptography, I decided to choose that area for research since cryptography makes significant use of math, especially number theory and abstract algebra.
At the beginning of the research phase, our mentors gave us survey papers to introduce us to the fields. I read papers on cryptography protocols for wireless sensor networks and papers on Elliptic Curve Cryptography. My research partner, Keith Zejdlik, and I met weekly with our mentor, Dr. Kar, to discuss research ideas and our current progress. We decided to develop a security protocol for wireless sensor networks. However, I had to spend some time learning the math behind Elliptic Curves and Identity-Based Encryption.

I studied properties of groups, rings, and finite fields as well as elementary number theory. I was then ready to study the fascinating field of Elliptic Curve Cryptography. Elliptic Curve Cryptography is a field of cryptography that employs the use of elliptic curves defined over finite fields. My partner and I used the properties of elliptic curve arithmetic, the discrete logarithm problem, and Identity-Based Encryption to create a secure key distribution and management protocol. In a future article, I plan to discuss the math of Elliptic Curve Cryptography and Identity-Based encryption.

The research experience was challenging, yet fun. I made lasting friendships and acquired experience that will help prepare me for graduate school. If you are interested in obtaining research experience, I recommend participating in the NSF REU program. You can find more information about the program at http://www.nsf.gov/home/crssprgm/reu