

**Ceci n'est
pas une
couverture.**

(No-one will notice that this joke doesn't work here, right?)

"WHAT'S YOUR EVIL PLAN FOR APRIL FOOLS' DAY?"

TO REVEAL THE EVIL PLANS OF ALL OUR CONTRIBUTORS, IT SEEMS.

George is asleep, write **mastHEAD**.

For the first time this term, George has decided to leave the **mastHEAD** in the hands of editors besides himself, who may be less experienced but are more awake. This one's for you, Lambrou! [George: It's the *second* time! ToBeDeterminED did it in Issue 2.]

Anyways, another great issue is here for all you readers to enjoy! This sixth issue of **mathNEWS** includes **mathASKS** from Prof. Peter Buhr of **profQUOTES** fame, and some more of his ever-so-popular quotes. More of our writers have also completed their homework as assigned by Prof. Furino, so you can read those as printed in this paper. What appears to be the third installment of 🧠🍷🗨️ is also here, so flip through for some more of 🧠🍷's heiroglyphic goodness!

The **gridWORD** for this week is perhaps... a *tad* more challenging than usual. Don't thank us, thank Zethar! We've already done plenty of that ourselves, in a sense of the word. Thank goodness solving the **gridWORD** is not an editorial duty.

Now, an exciting announcement! As devout followers of **mathNEWS** may know, there are usually only six issues of **mathNEWS** published in any given term. However, in two weeks we're going to put together an *especially* special, limited-edition issue of **mathNEWS**, featuring **mathASKS** from the *President of the university himself* (holy shit, how did we even manage that?), Feridun Hamdullahpur! So keep your eyes peeled, because I'm sure not going to do it for you. I can barely peel oranges without getting my hands covered in the tacky white bits of rind. It would be such a hassle to wash eyeball goop off myself every time I encountered a **mathNEWS** reader in the next two weeks. But that's enough eyeball talk for a single issue's **mastHEAD**.

Also, finals. Hooray to late nights, last-minute cramming and forthcoming disappointment; oh, how I *missed* you. Except wait! I really didn't. You were here with me all along.

Thanks for reading, and hope to see you all reading the next issue in two weeks' time!

GEORGE LAMBROU ITORED, FOR ONCE
EDITOR, **mathNEWS**

SHAY BLAIR	Hide goose nests everywhere
HATOFCHOCOLATE	Actually hand in my assignments on time, forcing the profs to mark them.
GBAD	Put dates, raisins, and oatmeal into my chocolate chip cookies
BEYOND META	Tell outrageous truth and put a hug me sign on my back
TOTALLYLEGITDEVELOPER	Get people to navigate uptown with promise of a concert and watch them suffer trying to find a parking spot! Wait, there is a concert...
ZETHAR	Go to 24 hour Games Night (No, seriously). Prepare (Shadowrun) run. Stuff. You know, the usual.
WALDO@<3.LE-GASP.CA	Fail a course and transfer to Arts... MUHAAAHAHAHAHAHHHAAA!!!! (Not really, though I'll probably avoid Odlaw.)
SOVIET CANADIAN	Nothing, why would I be evil?
I HOPE SHE DOESN'T SEE THIS	Fool my girlfriend into thinking I wrote her a love poem but then SURPRISE no I didn't.
D.	Tell Tiffany to meet me in Mexico, but then go to Canada.
GENJI	Turn off all the lights in the washrooms
A CRAFTY PLAYER	Steal all the board games inside MathSoc, then set them up in C&D.
VICEROY BUTTERFLY	MAKE AN OUTRAGEOUS FALSE FACEBOOK STATUS THAT SEEMS LIKE IT COULD BE TRUE AND SARCASTICALLY REFERENCE THE DATE — THE FAMED TRIPLE BLUFF!
I STILL HAVE NO PIE AND I MUST SCREAM	Fail to write an article for this issue, but still answer the mastHEAD anyways. Take that, mathNEWS editors!
OCTOPODES	Fuck man, I'm too busy.
ITSH	To pretend to be cis (they'll never know!)
DIMINUTIVE REX	#SPIDERFIGHT
TOBEDETERMINED	No PANTS.
EXTROVERTED	Going to Costco and eat all the free samples .
ITORED	Sleep in for too long and miss out on the Costco trip with ExtrovertED.
NOT GEORGE LAMBROU	Wake George up from his nap on the mathNEWS office's extremely comfortable sofa.
GEORGE LAMBROU	Abandon mathNEWS and go home; <i>clearly</i> these guys don't need me anymore. Plus, I miss my PlayStation 2, and that is <i>rare</i> .

Thanks for letting me sleep, guys.

GEORGE LAMBROU, **mathNEWS** EDITOR FOR SEASON 2017
ALONG WITH ANGELA LE, HEATHER STONEHOUSE, AND MICHELLE ZHU

ON PARTYING WITH PROFS

OR AN ADVERTISEMENT FOR THE C&O DEPARTMENT

“We’re here for the free beer!”

You probably hear that a lot from poor undergrads at house parties, but once a term you can also hear that from renowned mathematicians at the Bomber. Besides the free beer at Party with Profs, professors are always happy attend and chat with their students – all you have to do is send out an invite – and it really isn’t all that intimidating.

This term’s party began, as always, with the inevitable “tell me about your field of research” at every table. To get the real conversations flowing, the organizers provided us with a handy list of icebreaker questions, and we got to asking. For example, if you could go back in time and kill one person, who would it be? Answer: Euler, so the prof himself could publish all those famous results instead. (A debate followed about whether or not this was sensible – of course mathematicians would be debating the logical merits of an icebreaker question.) Another example, what’s the website that you frequent the most often? Answer: redacted for being NSFW... Had to be there to hear it for yourself!

We asked the profs about their travels to India and knowledge of Thai culture. We heard about their upcoming wedding, and met their adorable daughters. Although some of them are older than the first Star Wars movie, they’re still just like us: taking selfies to document their beards, talking shit about sports, and checking the number of “likes” they get on Facebook.

A prof even performed a party trick – while standing still, he rotated his arm some 720 degrees without spilling the glass of beer resting on his palm – and the room erupted in applause. Another prof described the feat of bringing his clasped hands from behind his back to the front, and got half the table tried it themselves. All in all, it was pretty much how you would expect a group of nerds to party.

As the event reached its scheduled end time and the crowds thinned, the C&O table was still teeming with excitement. We asked about the pants-inversion theorem, which has become somewhat of an urban legend among the undergrads. (The theorem states that it is possible to tie one’s ankles together and then turn one’s pants inside-out.) Regrettably(?), the subject’s expert refused to demonstrate, but we did hear priceless accounts of other mathematicians’ attempts.

When a first-year came up to get opinions on whether he should major in pure math or C&O, he was told, “Think about this: When you’re 40, would you rather be one of those people who comes to this event and leaves after an hour, or be one of the last ones to leave?” Well that, combined with the departmental expertise on applied topology, certainly settles it.

Plenty more stories and banter followed as the evening went on. At some point, we were down to a small group of students

surrounding only one prof from C and one from O. The two claimed to be representing their respective fields until the end, but really, they’re just good friends who like to drink together. And by the time the disco lights were signalling for us to get out, the students also saw them a little more as friends, and a little less as the larger-than-life figures at the front of the classroom.

Now, the real secret to having a memorable Party with Profs? Just keep the beers coming.

NPC

THE REAL GENDER-NEUTRAL BATHROOM DEBATE

So, occasionally, there exists some self-centered individuals who get disproportionately angry that there exists a service that isn't all about them, and they are bothered by the idea of affording basic human decency to all people by allowing access to a necessity such as a public washroom. This article isn't about that. That's not a real debate. The answer is obvious.

No, we want to talk about the real debate with gender-neutral washrooms. The one that people have arguing about since the invention of the modern toilet: should the toilet seat be left up, or down?

Seeing as gender-neutral washrooms are accessible to all, and the proportion of the population that has a preference for "up" is relatively equal to those that prefer "down", the answer is not immediately apparent.

We can, however, say that it is much easier to put the toilet seat down than it is to put it up because of the nature of gravity. So, if you were using it in the "up" position, you can leave it in that position. As you don't know the preference of the next occupant, it's fairly trivial for them to lower it if it doesn't match.

Conversely, the same applies if you are of the "down" preference. Seeing as how you don't know the preference of the next occupant, there is no point in taking the effort to raise it, as it might be unnecessary. So, as it turns out, either position is acceptable.

One caveat I would add is that if you try to apply the logic of this article to more specific cases of your households, if you are able to predict with a certain amount of accuracy the preference of the next occupant there is no harm in being courteous.

BEYOND META

mathASKS 133.6

FEATURING PROF. PETER BUHR

This week, **mathASKS** has journeyed through the awkward maze that is the DC to bring you answers from Peter Buhr, our **mostQUOTED** professor this term. Professor Buhr studies and develops programming languages in the Computer Science department, and teaches CS 343, a course focusing on concurrent programming.

ZETHAR: WHAT'S YOUR OPINION ON HASKELL?

I've only written a few small Haskell programs to compare with other programming languages, so I don't have enough experience to have an opinion, but if I change the question to "What's your opinion on functional programming?", I *can* say a few words.

I'm not a fan of functional programming: math, functional programming, and colour exist solely in the minds of people, meaning that the foundations of functional programming simply do not exist in the Universe. We live in a Universe with mutation and looping — trust me, we are all getting older and running in circles doing it. There are people who *believe* that every time a quantum string vibrates a new Universe comes into existence, but I'm not one of them; and except for standing between mirrors and procreation, we don't use recursion to solve problems. When I need to move bricks, I get one, then get the next, and so on. I don't carry the first one, create a child, and have the child carry the next one. The restrictions in functional programming make it easier to reason about execution and correctness solely because they make it harder to express what you want to do, so you give up before the problems occur. 30%-40% of traffic accidents occur during left-hand turns, so restricting driving to right-hand turns only solves a huge problem. Now, do you want to give up left-hand turns? A relational database has the same madness: put everything into nested tables and have no pointers, but a pointer is one of the most important and powerful concepts in computer science, so why would you limit yourself like that? And don't get me started on monads!

THE EUROBEAT-'EM-UP: AS A PROFESSOR, WHAT TRENDS DO YOU SEE DEVELOPING IN THE STUDENT BODY THAT EXCITE YOU FOR THE FUTURE? WHAT TRENDS HAVE YOU WORRIED?

One trend over the past 5 years that excites me is the respect and quality of responses on course newsgroups. It is very rare to have a rogue student who has to be culled and put down from a newsgroup. Many of you don't even know the term "flame wars", which is a good thing. Stay away from Twitter!!!

One trend over the past 5 years that worries me is cell phones, which are now computers with tiny screens, and oh yea, a phone app. Turn off the phone, leave the social media, and hang with real people. Look people in the eyes and talk. Be real friends. You never know, maybe a little hugging and kissing might happen, as long as it is respectful and safe. It is a lot of fun, and you're suppose to be learning this, too. 😊

BEYOND META: WHAT'S A COOL BIT OF MATH THAT MORE PEOPLE SHOULD KNOW ABOUT?

I'm told students can now graduate from high school without knowing the multiplication tables or how to divide. While arithmetic is not mathematics, I'd go for "it's cool to be able to multiply and divide numbers with pencil, paper, compass and straightedge".

NO: WHAT IS AN ACCEPTABLE PUNISHMENT FOR THE USE OF A FLAG VARIABLE?

In CS 343, it's -5 for each unnecessary flag variable! But keelhauling under the MC seems more appropriate, while still being lenient.

GENERIC AUTHOR: ASIDE FROM YOUR OWN μ C++, WHICH PROGRAMMING LANGUAGE(S) DO YOU FIND YOURSELF WORKING WITH MOST OFTEN, AND WHY?

95% of the code I write is C and C++ (about 30,000 to 40,000 lines a year). Even when writing a μ C++ program, 95% of it is C++. I use these languages because performance is everything. Basically, I like to sweat the nanoseconds from my code. I like to think I write high-quality code because I have a strong understanding of control-flow, memory layout, data structures, and hardware architecture. In the future, I plan to code in C \forall !

A FOCONERMURRERR ESTUNECDEYN T: HAVE YOU HAD ISSUES USING YOUR BATHROOM LATELY?

How did you know??? Currently, the left-hand flywheel grommet has detached from the vacuum attachment, and I'm getting a rash in a clinically interesting location.

DIANE: SCALA, RACKET, & HASKELL. GO.

See uncontrolled rant above for the first three. I worked on the Go team at MTV for 5+ months in 2013. Google MTV is the centre of the Universe and the Go team is awesome. However, I'm a C kind of guy, and Go is not C except for the curly braces. I like to hover just above the bare metal (actually semi-conductor). Basically, I don't need no stinkin' garbage collector! So when I came back to Waterloo from Google, I changed my research program to create C on steroids, and we are currently building the coolest new programming language called C \forall (or "Cforall"). The C \forall team now has a running prototype and it is possible to write simple C \forall programs. It's not ready for prime time, but look for C \forall ads in your browser soon!

VICE MITT: WOULD YOU RATHER FIGHT ONE HORSE-SIZED DUCK, OR 300 DUCK-SIZED HORSES?

Having done both (and several times each), I can unequivocally say it is easier to take down one horse-sized duck at full gallop, using a beak Half-Nelson, and hog-tie the bastard, then try to attack 300 duck-sized horses, which is like trying to herd fast cats who poop on the run. I mean, think about it!

A CRAFTY PLAYER: WOULD YOU COME TO MATHSOC GAMES NIGHT?

I've never been a games person. I like the occasional game, because we all have to play (or Jack/Jill becomes dull), but I get bored quickly, mostly because I'm losing. I'd rather spend gaming-time playing guitar. In gaming and music, you have to find the time to practise to become good, and so it boils down to where you spend your leisure time. Games, sports, music, etc. are all equally valid approaches to play, but you usually have to pick one. Maybe it should be Games, Curling, and Band Rehearsal Night.

EXTROVERTED: HOW DO YOU FEEL ABOUT BEING FEATURED IN mathNEWS SO OFTEN?

I feel it is an honour, and I want to thank all my fans, especially those who bought my last CD. For the record, I'd make the same idiotic remarks with or without **mathNEWS**, but some terms, I'm lucky and get students who like to share my madness with others, and it's a treat.

GEORGE LAMBROU: HOW WOULD YOU APPLY CONCURRENT PROGRAMMING TECHNIQUES TO STUDENT LIFE, ASSUMING THAT YOUR END GOAL IS TO RECEIVE SCHOOL CREDIT IN ALL PURSUITS (INCLUDING mathNEWS EDITORSHIP)?

To get School credit, you have to get to School. So start the day by entering the shower wearing your clothes, soap in right hand, coffee mug in left hand containing coffee grounds, razor and tooth brush. Run hot water into the coffee mug and on the clothes, lather with the right, while stirring the coffee using the razor/toothbrush with left. Don't forget your hair. Rinse and drink coffee with left hand while shaving legs/face with the right. Brush teeth with coffee grounds, while towelling off. You have saved at least 30–45 minutes, which you can spend on your CS 343 assignment, or at the Bomber. [Ed: Professor, I think I know where at least *some* of your bathroom issues are coming from. Also, what assignment? Didn't I pass CS 343 last year? I did, right?]

PETER BUHR

AFTER UNIVERSITY

If you had asked me, last month, about what I wanted to do after university, I would have shrugged my shoulders. Although I was near the end of undergrad, anything that came after was an empty void. It's like I was being chased, at full speed, towards the edge of a cliff; I knew what was coming but I could not turn back. The closer I got the more terrified I became.

Figuring out daily life had been simple: you get up, go to school, do assignments, go to bed. But what comes after? There's finding a job, finding a better place to live, and paying bills somewhere in there, but how do I get those? Do I stay in the same job or get a new one? How do I develop professionally? These questions haunted me. I had to do some reflection.

I had encountered a similar situation in grade 12 and grade 8 when picking schools. I had spent a few years considering: Where do I want to go for the next four years? What do I want to study? Where will I live? I had encountered the void and I was terrified; these questions haunted me. Since the big picture was scaring me, I had to, in the end, ignore it. I took life a day at a time, but it took a lot of hard work and self-reflection. What did I like doing? I was good at math and had an interest in programming. Are there any schools for that around here? Well, there's the University of Waterloo, they are known for that thing. Oh! And there's co-op too! Things fell into place, but it took very similar reasoning.

Applying what I learned in grade 12 and grade 8, I took it a day at a time. I figured the first thing I could do was start looking for a job. Throughout the months of my last school term I fixed up my résumé, was terrified by job fairs, gave out many copies of my résumé, was interviewed several times, and eventually landed a job. I thought that was it, the end. Then I realized that I had to negotiate the contract. There were things in the contract I did not like. What were my options?

It occurred to me, then, about the nature of my segmented life. It seems my life comes in four-year segments, each separated by a wall. Everything looks okay while I'm in that segment, but it's impossible to see past the wall. For all I know, past the wall is nothing, a void, the end of existence. The worst part is that the wall is fuzzy in the distance, so it's hard to figure out how to overcome it.

It occurred to me, then, what the future held: taking the job, but still looking. I don't just stop. I look for bigger and better opportunities. What I thought was the end was actually the beginning.

Take it day by day, piece by piece. Never give up. You can make it. It's never the end, it's always the beginning.

TOTALLYLEGITDEVELOPER

This one time, we had a full page of quotes from Professor Buhr.

And yes, we did title it "BuhrQUOTES".

THE mathNEWS EDITOR WHO DID LAYOUT THAT WEEK

profQUOTES

BECAUSE mathNEWS CAN NEVER GET ENOUGH OF PROFESSOR BUHR.

CS 343: PETER BUHR

- “ That was a copy-paste error from the assignment that I stole to make this assignment.
- “ This is what we do in computer science and software engineering. It's called "trick the user".
- “ Users are often capable of performing protocols that have one step.
- “ User manuals are something you always throw away immediately.
- “ I once bought a lawn mower. It had a warning: "Do not drink the gasoline". Okay, I won't drink the gasoline.
- “ You are a 3.7.1.2 monitor.
- “ By engineering induction, it must be true.
- “ I don't believe in spurious wakeup. It's a conspiracy. There is a spurious wakeup cult. Check it out on the Web. You can join. "I believe in spurious wakeup".
- “ Someone has conned the world into saying "I have a broken lock. It's really fast. Let's use it".
- “ You'd be wrong to thpbbt me.
- “ They believe that you're an idiot, and if you're an idiot, you can't possibly do co-operation.
- “ It's a slippery slope. Once you believe in spurious wakeup, bargaining is just a consequence, but you're stupid anyway.
- “ It's your job and go out in the world and fight spurious wakeup. Whenever someone mentions spurious wakeup, hit them with a fish.
- “ The Maluuba language shall not have spurious wakeup!
- “ You just have to go to your language's manual and search for "spurious wakeup".
- “ If you find it, you're screwed.
- “ I've never texted. You don't need it. Throw it away. It's beautiful.
- “ It's so romantic. We have to have a rendez-vous.
- “ Remember when Peter and Mary were trying to get in the bathroom and they won the lottery? They hired a co-op student to sit outside the bathroom to make sure only one person goes in at a time.

CS 365: ERIC BLAIS

- “ Useful? This is the wrong class for that.
- “ This is how you know it's a serious math class: you talk about socks.
- “ One day I'll solve a major open problem by asking it in class...
- “ Starting from 1 seems so much more positive [than 0].
- “ If you see a pile of [Magic the Gathering] cards when you sit down [for the exam], then you should be worried.

CS 442: BRAD LUSHMAN

- “ This is a fun game that continues to be fun for about a minute or so.
- “ Math is a little bit unusual.

MATH 136: DOUG PARK

- “ I feel like I should prove something for you today, otherwise all this is black magic.
- “ Oh gosh, I should have picked a better example.
- “ Actually, doing this kind of example builds character.

PHYS 175: RICHARD EPP

- “ Nice snowstorm, eh? It was almost going to be a snow day.
- “ The force that the rocks of the Earth have on this rod is a fictitious force.
- “ Someone made that up. Newton made that up.
- “ Student: If the Earth was a sphere...
Prof: What do you mean, "if the Earth was a sphere"?
- “ What is a straight line? Wikipedia says it's a path for which the tape lies flat (i.e. not crinkled). [class takes this as fact] That's a joke, people.
- “ We'll just do it by hand-waving.

**Yeah, mathNEWS kills
half an hour for me.**

PROF. RILEY METZGER

ROCKET MAN

CHRIS HADFIELD, LIVE IN CONCERT WITH THE VICTORIA SYMPHONY

Is there even any point to writing more words? I saw Chris Hadfield, live in concert, with the Victoria Symphony. Yes, former adjunct professor Chris Hadfield of the University of Waterloo. That guy. You may have heard of him? He's done a couple cool things in his life. Like go to space.

Ostensibly, this piece could be a review of the concert. The symphony was awesome; the selection of popular space-themed music in-between Hadfield compositions was superb; the orchestral arrangements of Chris's songs were stunning; the stories Chris told in between songs were out of this world. Hadfield has a very natural-looking on-stage manner, and he's comfortable with being in front of an audience, and being an inspirational figure for many people. And though many people might perceive him as only an amateur musician, and therefore not worth paying money to see, he is a solid performer. His lyrics and melodies fit his voice, and he captures the emotion of the songs perfectly. He's certainly not Freddie Mercury, or Andrea Bocelli, or Michael Bublé, etc. but he sings better than you might think he does.

But instead, this piece is just going to be a remark or two about how happy we should be to have someone so accomplished, but also so down-to-Earth, among us as an inspiration and role model. If you haven't read his book (*An Astronaut's Guide to Life on Earth*), you should. If you haven't listened to his music (*Space Sessions: Songs from a Tin Can*, and the BNL-collab *Is Somebody Singing*), you should. If you haven't thought about pursuing your dreams, and your hobbies, and becoming the best you can be while trying to be positive and living life in a healthy and sustainable way, well, just ask yourself: what would Chris Hadfield recommend that you do? He'd tell you to do just that. And he'd recommend that you'd better get started, because you've got your whole life ahead of you. It helps if you have the guts to ask if he can sign your book, like a six-year-old did in the middle of the concert. Hadfield said yes, and had the kid come on stage and get his book signed.

I didn't have the guts, and I didn't wait around until they kicked me out, to see if I could sneak an autograph for someone; I figured they would've advertised such a session, and otherwise it's intruding on the rest of his private time. I suppose that's why I'm not going to be an astronaut. But that doesn't stop me from chasing my dreams. It's nice to feel uplifted, doesn't it? We should try that more often.

SCYTHE MARSHALL

SHAPE OF GOOSE

TO THE TUNE OF ED SHEERAN'S "SHAPE OF YOU"

The club isn't the best place to find a lover
So the SLC is where I go
You and your friends are taking shits
You start to hiss and I start to slow
Run over and start an altercation with just me
And trust me I'll fight back now
You bite my hand, I put my foot in your back now
And then we start to dance and now I'm screaming like

Goose, you know I done fucked up
You bit my hand and now you're honking at me
Come on now, leave me be
You know I'm crazy, don't mind me
You say, "Boy, I'm gonna mess you up
You came too close and started looking at me
Come on now, I'll make you bleed, come on now, I'll make you bleed"

My vision's filled with the shape of goose
We punch and kick and I step in poo
You peck my eyes and you bite me too
I'm getting bit by your body
The next day I look at my shoe
And now my Nike's smell like you
Everyday I've gotta wash off all this goo
I'm getting shit from your body

PARU-PARO

WANTED: BODYGUARDS FOR mathNEWS

Due to Zethar's most recent attempt to get us killed by encrypting the fucking crossword recent changes in the **mathNEWS** Production Staff that have resulted in enraged students threatening us in the streets with forced viewings of *Monster Musume* over a puzzle people, come on! credible threats to our person, we at **mathNEWS** have been anxious to increase security around our homes and office. Ideal applicants would require no sleep, be skilled in either hand-to-hand combat or weapons-MacGuyvering, and work for free. Please send your résumés in the form of shirtless demonstration videos to mathNEWS@gmail.com (though please note that any applicants who wear bras need not remove them).

YOUR EDITORS-IN-HIDING, **mathNEWS**

I wrote for mathNEWS → I get free pizza

A mathNEWS EDITOR WITH SOMETHING TO PROVE

HOMEWORK

(FOR STEVE FURINO)

My topic: How to teach students how to prove things. I apologize for the extremely lengthy response.¹

It's an issue later than most of the homework responses, but since I didn't know about it until after the last Production Night... Besides, no deadline was given. And let's be honest, Dr. Furino gave me this homework problem over three and a half years ago, and it's not an easy one. Here's what I've got so far.

Recall that teaching often depends on the audience. Who **needs** to how to prove things? See the appendix article to this one, "Who Should Learn How to Prove Things?", elsewhere in this issue. Assuming that we've determined that not everyone has to know how to prove things, we can try to understand how to teach those students who we decree "need" to know how to prove things, how to prove things. Therein lies a trick, right? Who **are** these students, and why do they need to know? Mostly, these students are future research mathematicians, statisticians, actuaries, computer scientists, software engineers, programmers, teachers, and everything else UW claims our math graduates become. That's a wide variety of students, with a wide range of needs, isn't it?

Let's step back for a second: why, again, have we decreed that these students must learn how to prove things? It's because we believe that more than just knowing how to think critically in general, these students need to know how to use the tools of logic and proof to, given axioms, verify facts and make conclusions (or inferences) about various things (numbers, functions, computer systems, statistical samples, etc). And, in general, those people above really do use those skills, if implicitly. Maybe not all of them need to be able to work with epsilons and deltas, but all of them need to be able to understand that an if-then statement can be true, but its converse can be false.

How do we teach this? How do we help students understand how to prove things? I feel that this breaks down into six parts, which are stated separately but are, of course, connected. There are probably more things that I'm forgetting, currently.

1. **Use examples, and more examples, while drawing focus away from the specific facts used in favour of highlighting the general method.** The idea here is that students often are seeing formal proofs for the first time, and it can be overwhelming to be learning all of this while also learning a new subject (in most cases, number theory, which isn't often a strong suit of incoming students). The specific use of examples that do not require material with which students are uncomfortable can help avoid this. Some intro-to-proofs courses use language-based examples; these can be good, if the students are comfortable with the language. Many students do not speak English as their first language, and so this can be just as

daunting, if not moreso. Inter-university collaboration might be useful, here, to see if we can find some examples of things that are within comfortable grasp of the majority of students. Requiring a strong English ability, or else providing the opportunity to work on it, might also be worth a try. Requiring high schools to teach their mathematics better would be nice, but of course highly unlikely.

2. **Build up the foundations with which to talk about proofs in mathematics.** Of course, the course should transition, in some reasonable way, from comfortable examples at the very beginning of the course to not-so-comfortable examples. The point of an intro-to-proofs course is to provide students an opportunity to acquire the skills necessary to write useful proofs; that is, proofs of mathematical facts, etc. After students become comfortable with the notion of rigorous proof, we can (slowly!) start to get them to prove things in specific areas of mathematics, with particular techniques for different situations. This, of course, involves teaching foundations of math, like vocabulary, basic set theory, quantifiers, logical notation, and so on. At times, I've had the thought that maybe this can be dispensed with, but now I don't think this is true. These are the basic building blocks of mathematics, and without them you cannot do very much at all.
3. **Show students how logic can be useful in atypical situations, not just as a tool in strictly mathematical pursuits.** If I'm reading a study that gives some data and reports statistical results, what conclusions can I make? I use logic to understand that no, correlation does not imply causation, and that no, just because I have some data that seems to show that something is one way, I have to keep in mind that it's not a guarantee, simply an inference. If I'm designing an algorithm, I use logic to help justify its correctness; I don't just run the algorithm a couple times (maybe with some edge cases) and say it's good to go. Testing and proof go hand-in-hand, in a practical-yet-theoretical discipline. Students often need a bit of convincing in order to be fully on-board with learning something; giving interesting examples can help. This can aid students who might otherwise not enjoy the course experience (here's looking at you, Riley Metzger!).
4. **Emphasize good communication of mathematics: not just correctness, and not just completion.** At its heart, a proof is a formalization of explaining why something is true. If I write a proof of something for you, I am attempting to show you why it is true, and I hope to leave you without a shadow of doubt that it is indeed true. Moreover, I don't want you to have to work very hard to understand the proof; I want to write my

proof in such a way that you read each step and say "oh, of course", or "hm, I didn't know that, but it makes sense!" The best proofs are those which are clear and illuminating. Of course, we can't expect novice proof-writers to write perfect proofs every time, but with solid feedback and the expectation that communication of ideas is worth something, students may be able to improve, in that regard. Examples of the difference between good and not-so-good communication in proofs would be incredibly helpful.

5. **Offer the opportunity to, and focus on the importance of, practice.** Becoming proficient at proving things does not come easily. It requires practice; lots and lots of practice, with varied subject matter. Students need good questions to practice with, and they need to be encouraged to do those questions, not just try unsuccessfully. Smaller tutorial sizes, or small group work, or more low-stress practice environments, can help encourage this, as can some of the points in the final subsection, here.
6. **Support students in their learning; don't just claim to.** This has multiple facets. The biggest thing is to encourage them. Students at a university for a program that takes such a course as this are not unintelligent; they're just untrained. If they run into trouble with material, it's okay; encourage them to work at it, provide resources, and publicize those resources! There are very few people who are naturals in terms of proof-writing, at this point in their lives/careers; students are almost always not alone. The next thing is to build on this course in future courses, and indicate this to the students before they finish the current course. Students often take a course, forget everything after the final, then get to the next course and struggle, especially after a co-op term or a long break. Perhaps courses after an intro-to-proofs course can, early on, make mention of the techniques in the proofs they do, or post a "you should know this stuff from your intro-to-proofs course" review sheet/package. This can help both those who've forgotten material, and those who were fine with the prior material but are struggling to see it in play in this new material. Finally, the last thing I want to bring up is the immense workload that students often take on, and the pressure they're almost always under to do so. It is challenging for most students to take on a "standard" course load and both succeed, and remain mentally healthy. Why do we then call it "standard"? As a graduate student who works with undergraduates in a drop-in tutoring help centre regularly, I experience on a daily basis students who are stressed out, both about their midterms for which they've only started studying recently, and about their assignments which come weekly and in bunches. Engineering advisors at the

University of Victoria have admitted (or at least, I've heard that they have) that almost no one is "on schedule" to complete their degrees on time; maybe you shouldn't be asking them to take six courses a term! Almost no one does, because it's not feasible to do so in a healthy manner. Maybe we shouldn't be recommending students to pack more courses in than they can handle. Maybe we should be working on coordinating classes as a whole to avoid certain types of stress. Maybe we should be advising students to spend more time on fewer courses, and making more bursaries available for those who need them to do enact this plan. If you're interested in the well-being of your students, and interested in helping them successfully leave your university with skills that will help them be valuable members of society, in whatever they choose to do, you should think long and hard about setting them up to succeed, rather than running them into the ground and celebrating those who manage to get up.

All of these things can help, but in the end, it is up to the students themselves to take advantage of their opportunities. In the face of increasing commercialization of university education, we have to somehow convince students that they need to work for their skills. As the old adage goes, you can lead a horse to water, but you can't make it drink. You can give students more opportunities to succeed, but if they don't take advantage of them, you cannot let it rest on your conscience. But we cannot just rest on our attempts, and say we tried: we must continue to strive to connect with students, and help them understand that we are trying to teach them an invaluable skill: the ability to see why something is true, and to communicate the reasons for it. In today's world, where critical thinking is a highly-sought-after but also rarely-publicly-utilized tool, this advanced skill elevates them, so that they can make more of a difference. For them, for their families, for their friends, for everyone.

I hope this helps, modulo the slight melodrama at the very end. At the very least, the fact that there exist people who care about this to the extent that they are actively working at trying to improve the status quo is important. It means that we aren't just letting the issue sit and become a fixed way of doing thing. Good luck.

SCYTHE MARSHALL

1. The title is a Tragically Hip reference, to "Courage (For Hugh MacLennan)", itself a reference to a twentieth-century Canadian author.

Send more profQUOTES.

THE mathNEWS EDITORS

WHO SHOULD LEARN HOW TO PROVE THINGS?

APPENDIX TO *HOMEWORK FOR STEVE FURINO*, BY SCYTHE MARSHALL

Let's not bury the lede: not everyone in the world needs to know how to prove things. Artists and writers, biologists and chemists, physicists and engineers: none of them have to know how to prove mathematical facts. Philosophers and lawyers, too. It's simply unnecessary, in the strict sense that whether or not they can prove things in mathematics with a sufficient amount of rigour is irrelevant to their ability to successfully perform their jobs.

However, what is important for all of these people is the ability to think critically about the world. Artists and writers must be able to assess the qualities of their creative works, in an objective fashion, and recognize when there are subjective qualities to their works that others may observe differently, and accept (or celebrate!) those differences. Biologists and chemists must be able to avoid correlation/causation errors, work with scientific evidence and hypotheses without bias, and build experiments that are able to isolate the important aspects of a situation. Physicists and engineers must be able to both correctly apply physical laws and manage best practices to develop new technologies, and learn more about our universe; in particular, avoiding the improper utilization of mathematics is an important facet of this. Their work also includes correct application of statistical principles, like for all scientists. Philosophers and lawyers, who often focus explicitly on proof in the real world, must think critically about how to correctly interpret language with respect to both intent and literal meaning.

All of these are examples of critical thinking at play, in specific situations. In a more general sense, people need to be able to think critically about their finances ("does it make sense to purchase a vehicle now, if I don't have a steady income stream?"), their politics ("should I be supporting a political party or leader whose policies hurt significant groups of people in my country?"), their health ("what can I do to improve my health, and how can I stick to that plan?"), and many other things. Critical thinking is a universally important skill: would there be this "alternative facts" bullshit if people would just think critically about what they're reading, for once? But being able to write down a mathematically correct proof that the limit of x^2-4 as x approaches 3 is 5, using epsilons and deltas, is probably not necessary.

As a last note, why do students take math past an elementary school level? Is it to teach them how to factor polynomials, which no one does outside of a university setting? Or is to help them work on problem solving and critical thinking skills? Presumably it's the latter, but in that case, does that mean students don't learn enough critical thinking in their other classes? How can we better teach people to think critically? Hopefully we can figure it out, and soon.

SCYTHE MARSHALL

N THINGS I WOULD BUY IF I HAD THE MONEY

- Marble school supplies because all the study bloggers have a thing for marble.
- Fancy food that no one really eats unless they have money.
- Since I have the money, I'd assume I have free time so I could read again.
- Fancy-looking notebooks that I would probably forget about and not write in.
- An up-to-date phone.
- A really old flip phone because I have the money, so why not!! Plus I would be mysterious with my second phone.
- More things like Netflix but that aren't Netflix.
- A pug.
- A cat.
- A house and furniture. I would really like to re-enact the scene from the Princess Diaries where Anne Hathaway slides down the fancy stairs with a mattress.
- Maybe a car?
- My university textbooks.
- Wine and cheese.
- A book on wine and cheese so I know the best wine to go with different cheeses.
- A newspaper subscription.
- Fancy coffee beans.
- Anything that's slightly mediocre but sounds infinitely better when you put the word fancy in front of it.
- My OSAP debt.
- University tuition.
- Food from chain restaurants that I've never eaten from before.
- A tutor to help me pass my courses.
- A good and reliable oven.
- A HE washer and dryer. I'm so done with my dryer at home NOT WORKING!!

BLOSSOM

Production Nights are every other Monday. We meet at 6:30 in the MathSoc Office.

Please come...

A LONELY mathNEWS EDITOR

I'M STILL HUMAN

Game began at the midnight hour, in the dark of the night
Can't be alone, it's risky on my own
I survived

I wanted to survive to Friday more
Kick some zombie ass outside
I brought Nerf guns and sock whips for war
And I survived

I had a six shot Nerf gun and a squad so they could watch my
ass
Though their team might change and maybe all of us will die
en masse
Just hope, hold tight and you'll learn to fight the zombies back
And we'll survive

I'm still human, I'm still fighting
I'm still human, I'll keep fighting
I'm alive, I'm alive
I'm alive, I'm alive

I fought zombies and gained bold stories
We won the main mission, yay!
I kept my life through all risks with ease
Oh God
It's just Monday...

I got a real long sock whip and a squad so I could watch their
ass
Though my team might change and maybe all of us will die en
masse
Just swing, shoot right and you'll learn to fight the zombies
back
And we'll survive

I'm still human, I'm still fighting
I'm still human, I'll keep fighting
I'm alive, I'm alive
I'm alive, I'm alive

You killed my friends, but I'm still human
I stunned the rest, so I'm still human
Won the mission, but I'm still fighting
You're all around, so I'm still fighting

Humans've made every single mistake
That we could ever possibly make
They died and they died and zombie numbers grew
But I never gave up and fought my way through
I knew where our goals were; I went in and got 'em
Did all the things humans said that I couldn't
I promise those killed will never be forgotten
We live to fight again

And I'm still human, I'm still fighting
I'm still human, I'll keep fighting
I'm alive (You killed my friends, but I'm still human)
(I stunned the rest, so I'm still human)

I'm alive (Won the mission, but I'm still fighting)
(You're all around, so I'm still fighting)
I'm alive (You killed my friends, but I'm still human)
(I stunned the rest, so I'm still human)
I'm alive

I'm alive, I'm alive
I'm alive, I'm alive

YOURS IN FIGHTING ZOMBIES 'TIL THE END,
SHAY BLAIR

OPTIMIZING DISNEY

Moana was a good movie. Just a straight-up, feel-good, classic sort of thing. Having heard nothing but mediocre reviews for *Beauty and the Beast*, clearly the best way to get an ongoing Disney fix is to bring Moana to your own house.

Ever notice how people continue to refer to Dwayne “The Rock” Johnson as Dwayne “The Rock” Johnson, years after it’s been a relevant part of his name? That’s key. No one omits that middle title. Forgetting “The Rock” three times in a row will anger Dwayne “The Rock” Johnson. As a natural attrition hunter, he will begin running towards whoever forgot his honorific, chasing them until they can run no further. This is the most reliable way to summon him, but will cost you a friend unless you can trick an enemy into uttering his name incorrectly. Plus, you’ll have to get them to stay still while he runs over there, and that could take weeks if he’s filming in Europe.

If you’re unwilling to crack proverbial eggs, you’ll need to do some legwork. Gather an action figure of Dwayne “The Rock” Johnson, some eggs, a deliciously prepared cod, an alumni of the University of Miami, and a spork under the light of the waning moon. Shake the action figure at the alumni while screaming “WHERE DO I FIND HIM? TELL ME!” until they call the university’s faculty, who should be able to get a hold of their other alumni. Once Dwayne “The Rock” Johnson is on the line, offer to trade him the cod for his presence at your house. Guy eats an inhuman amount of cod; his food intake while he’s exercising reads like a grizzly bear’s shopping list. Next, cook the eggs and eat them with your fork so you aren’t tempted to eat the cod while he’s on the way. That would anger him.

Failing that, you could always hang out with Make-A-Wish staff until they get in touch with him again.

And that’s all you need! Enjoy watching Moana with its physically biggest star. You’re welcome.

WOODEN KOALA

#SPIDERTHEORIES

The WatSFic DnD Tournament (#SPIDERFIGHT2017) will be held tomorrow. As I'm participating in it, I have no idea what's coming, but here are a few theories, based entirely on the title:

1. All the player characters will be instantly transformed into spiders upon the start of the adventure, and the rest of the adventure will hinge on us attempting to transform ourselves back into humans/gnomes/orcs/whatever we were initially.
2. We will be freedom fighters breaking up an inhumane underground spider fighting ring.
3. There will be an ever-looming threat of a spider attack, but it will eventually be revealed that the spider was actually a bear in disguise all along.
4. At some point, it will be revealed that the true spider was inside you all along.
5. The village the adventure takes place in will be named Spider Fight.
6. No spiders at all. This will never be remarked upon.

VICEROY BUTTERFLY

OVERWATCH ORISA OVERVIEW

We all thought Doomfist would be Overwatch's new hero release. But, nope, Blizzard gave us Orisa.

Orisa is a robot-centaur-thing with a confident personality. Her playstyle is semi-support and tank — she buffs and protects teammates while displacing enemy targets.

Her main weapon is a mini gun similar to D.Va's weapon, but with just 150 bullets — shooting it delivers sustained damage while significantly slowing her movement speed. Compared to D.VA's weapon, Orisa's gun is more accurate and fires more rapidly.

Her three abilities are fortify, halt, and protective barrier. Fortify is a personal shield that reduces damage intake from all sources then becomes immobile. Halt fires a rapid moving ball that latches on to nearby enemies, pulling them towards it. Protective barrier is similar to Reinhardt's shield, but it allows Orisa to have more mobility as it is placed down on the ground as opposed to her holding it. This seems pretty similar to Symmetra's shield — Blizzard, creativity pls. Orisa's ultimate ability is called supercharger. This is a device that she places on the ground; it attaches damage-boosting beams to all allies within line of sight for a short period of time.

Overall, I think Orisa is a great addition to Overwatch — but she does have a steep learning curve, especially for those new to the game.

GENJI

N ARTICLES THAT SHOW THAT THE "ARTICLE OF THE ISSUE" IS CORRUPT

Last issue, I accidentally wrote an article that wasn't complaining about anything. I immediately got Article of the Issue! This is terrible and needs to be counteracted immediately.

You see, the thing is that of all the other articles, a lot of them are just objectively better than the filler content I thoughtlessly scribbled down. Among those are:

- *"You Suck At Crypto"* (by Couch), which successfully convinced me that I suck at crypto.
- *"Terrible Ideas For A Terrible Hack"* (by Vice Mitt), which won an honourable mention, but should have just won instead. One of the terrible hacks (Unrecipe) actually got built during TerribleHack!
- *"4 Things that Happened This Week"* (by HatOfChocolate), in which **mathNEWS** does actual journalism!
- *"Review The Gungeon"* by Paru-Paro
- *"N Things In Your Home That Might be Hacked"* (by Viceroy Butterfly), which was probably even less effort to write than mine, but waaaay funnier!
- *"Octopodes' Handy Prereq Chart"* (by, who would have guessed that, Octopodes), which is actually SUUPER USEFULLL!!! Maybe that article should have won two prizes at once.
- *"25 minutes left. We're 25 minutes in, too! I guess I never realized that 25 was half of 50 until now"* (by Jason Bell). This isn't, technically, an article, but I still really like this **profQUOTE**.

I don't actually know which one of those should have won instead of me, but I do know that this grave injustice indicates that the **mathNEWS** editors are irredeemably corrupt. As a temporary solution, I propose that for objectivity, the Article of the Issue should be picked by Imprint staff.

DANK

N REASONS UW IS OFFICIALLY FAMOUS

- Goose butt tattoo guy
- The Waterboys making ICCA's finals
- Having a video about our most recent Humans vs. Zombies game make trending on Youtube
- People sometimes mistake it for the University of Washington

APLAYEROFGAMES

PEOPLE'S NEWSLETTER

Nº1

In XXI century, Marxist and Neo-Marxist tendencies are likely to emerge from universities, as students explore the structural integrity of the current political system, and apply a skeptical view towards the policy making of their state. It is also likely that the non-conformist nature of youth is an operational aspect of non-traditional views (it is more likely that you'd meet an anarcho-syndicalist in a University than anywhere else, unless you go to the Republican Spain of 1936 and just take a walk around Madrid). Truth is, this generalised view meets the design interests of leftist liberal approach to the social structure of society, as the Marxists viewed workers and youth as the key aspect of cultural revolution.

But how does cultural revolution happen in University of Waterloo? Canada, a country characterised by its current neo-liberal tendencies, is arguably a champion of multiculturalism not only in North America, but in the modern world. This article is not attempting to criticize positive or negative aspects of it, but simply acknowledge that it is the multiculturalist neo-liberal approach that highlights key policy elements of the modern Canadian government. In an environment of a liberal evolution, it is not so surprising to see the university student body to borrow elements of the nationwide culture movements.

Comparatively speaking, Waterloo student body is very local when it comes to social issues. However, these responses are usually spoken from the socio-cultural and not political prism. The healthy skepticism towards general policy-making problems usually tries to avoid political connotations, which is a safe way to avoid political alienation. In United States, this problem is much more obvious, as certain political views are immediately ascribed certain elements that the activists don't want to identify with. Partisan division takes a fan-like approach, where people start identifying with their ideas just as they identify with their sports teams. In an ideal world, constant criticism is a necessary aspect of any political discourse.

Lax and casual political discussion that occurs in the political science classes demonstrates a very cautious approach, as students try to refrain from sharing their opinions and allow their teachers shape theirs. It is more commonplace for a Waterloo student who harbors very radical views to remain silent, rather than engage in polemic with their professors, abstaining from any possible conflict with the scholarly authority. After all, some think that they are paying to learn the opinions of scholars, who dedicated their lives to study their topics. There is certain danger in this, but nevertheless this is a characteristic trait of political discourse among young students, especially the ones born in the Southern Ontario (based on my observations, all of the politically vocal political science students were born outside of Ontario and did not live there prior to attending the UW, which presents an interesting pattern).

This is very different from the countries, where education is partially-free or state-funded and political issues are more entrenched in the lives of their citizens. In Central, Southern and Eastern Europe and in Western Asia, student bodies that deal with political science classes exhibit somewhat contrarian rhetoric towards their university professors, but it is also important to note that the professors in these regions are more likely to be more conservative in their political leanings. So, is it reasonable to assume that students in North America would eventually take up a conservative stand based on the liberal approach of their professors? In socialist states, there was a prevalent tactic of conducting nationwide surveys to identify patterns and predict future responses to current matters. That approach assumed that respondents will remain consistent and rational with their answers, which was arguably the failure of rationalist approach – humans turned out to be “not so rational” according to the Soviet, East German or Yugoslavian state surveys. Therefore, the key question will likely remain rhetorical, but feel free to take a rationalist or functionalist approach to figure out the future tendencies. Personally, I predict a stagnation for cultural evolution in Canada, which would likely occur in 20 years or so (and this is a natural part of the social progress). Understanding the societal evolution can be used to adapt and make profit, and if you plan on hardcore exploitation of the opportunity, it is never too late to start gathering forces to seize the means of production.

AUGUST MARAUDER

N LANGUAGES THAT WERE REJECTED FOR BEING INSUFFICIENTLY C-LIKE

- The lambda calculus¹
- LISP
- APL
- Forth
- Scheme
- Prolog
- ML
- Erlang
- Coq
- Haskell
- Racket
- Agda

ΔX.X

1. <http://james-iry.blogspot.ca/2009/05/brief-incomplete-and-mostly-wrong.html>



EVER WONDERED WHAT DATING MOTHMAN IS LIKE?

Most people know about Mothman. That strange half human, half moth creature from West Virginian folklore that has become a legend since her first appearance in 1996. These people might also know about the terror Mothman instills in the rare few people who see her. But there is one thing about Mothman not many people know about, and that is her sweet loving side.

You see, Mothman and I have been dating, going on two years now, and let me tell you, she is an absolute sweetheart. From supporting me through those difficult midterm weeks to making sure I don't accidentally forget to sleep when I'm working on assignments, there is nothing I love more than dating Mothman.

I mean, sure, sometimes there is an animal carcass laying in front of our apartment in the morning ,and sure, there may be times where she is off for days at a time stalking prey in the forest. But when you are in a relationship with someone, you learn to live with their quirks.

Overall, dating Mothman is one of the best things that could have ever happened to me. So if anyone out there is questioning whether they should date that cryptid they sometimes see scurrying just out of the corner of their eye, I say go for it. I mean really, what do you have to lose?

PRODUCTS OF AN INCORRECT SUM

You can calculate your death using math, but math can never compute its own destruction. Infinities stack upon infinities. Strings of patterns like the threads of life that Atropos could never cut. Math is more prevalent than kindness these days. You can find math in the lines of your palms, in the number of streetlights you pass, in how many people you let get close to you. Where's your closest kindness? Is it buried in your gut, Or could I smell it on your breath? Are there more equations beneath your skin than compassion? Do you divide up your time so you can turn a blind eye on those in need? So you can get too busy to hear their pleas?

Do you live your life like clockwork? Live paycheque to paycheque, sandwiched by the thing you need to survive? Do you live your life in chaos? Like a pattern that goes on forever but you can never make sense of? Something that can take up all of your thoughts yet you only get farther from the truth? Math is the chaos. Math is the order. Math is the destruction of everything except itself. Are you the opposite? Are you an oxymoron? How many memoirs have you sined and cosined? Do you only focus on your own struggles but not mine? ...Is that not a sine? Are you jealous of math? Are you jealous of how it remains? After rubble and ruin, it is there to measure the angles of the pillars that have toppled. Math is the destruction. Math is the resurrection. Math is the chaos. Math is the order. From flowers to atomic bombs how has math go so wrong? ...How have we gone so wrong? ...Nothing adds up.

ITSH



INTEGRATION VIA ERGODIC THEORY

In the last issue of **mathNEWS**, Beyond Meta asked a fantastic question to Riley Metzger: "What's a cool bit of math that more people should know about?" His response was "Crude Monte Carlo Integration." Basically, you can integrate a function over some domain by taking an average of the function over a random sample of points in the domain.

In a similar way, we can use some ergodic theory to approximate integrals. In a way, it captures the same sort of ideas as MC integration: it uses a sufficient amount of randomness to choose sample points well enough to give a good approximation of the integral. There is some technical math in the following; consider yourself warned. For those who didn't just flip the page...

Consider an ergodic measure-preserving transformation T of the unit interval $I = [0,1]$ equipped with Lebesgue measure m (the usual "length" on the real line, restricted to $[0,1]$). The "measure-preserving" part means that if you take some subset A of $[0,1]$, and you look at the set of points that map into A (notated $T^{-1}(A)$, also called the pre-image), then $m(T^{-1}(A)) = m(A)$; they have the same size. For example, take $R(x) = x + a \pmod{1}$, where a is some real number, rational or irrational. Then the pre-image of any set is just the translate of that set modulo 1 by $-a$; this has the same size as the original set (by, ahem, translation-invariance of Lebesgue measure).

T doesn't have to be invertible; $T(x) = 2x \pmod{1}$ is perfectly fine. You can see that it preserves Lebesgue measure because it stretches $[0, \frac{1}{2}]$ and $[\frac{1}{2}, 1]$ onto $[0,1]$, so the pre-image of any set is the disjoint union of two copies of that set, shrunk into each of the two halves of $[0,1]$. The copies have half the size of the original set, but there are two of them! So the total size is the same as that of the original set. (This could have been nicely made more formal, if we only had LaTeX support, ahem.)

The "ergodic" part means that there are no non-trivial invariant sets: if $A = T^{-1}(A)$, then $m(A) = 0$ or 1 . This means that the whole space is mixed up by the dynamics sufficiently well. The map T above is ergodic, and the map R is ergodic exactly when a is irrational. If a is rational, then we can always find non-trivial invariant sets. If, for example, a is $\frac{1}{3}$, then the union of $(0, \frac{1}{3})$, $(\frac{1}{3}, \frac{2}{3})$, and $(\frac{2}{3}, 1)$ is invariant, because each of those sets has as pre-image one of the other sets. This map doesn't mix the space up sufficiently well; in fact, every point is periodic. The proofs that T and R (for irrational a) are ergodic are slightly non-trivial.

Now, take an integrable function f on $[0,1]$; it can be complex-valued, but we'll keep it real for now. (Rimshot in the distance.) One of the first, and most important, theorems of ergodic theory is that of George Birkhoff:

THEOREM: (BIRKHOFF'S POINTWISE ERGODIC THEOREM, 1931)

In the above setup with Lebesgue measure m on $[0,1]$, an ergodic measure-preserving transformation T , and an integrable function f on $[0,1]$, we have, for almost every x in $[0,1]$:

$$\lim_{n \rightarrow \infty} \frac{1}{n} \sum_{i=0}^{n-1} f(T^i(x)) = \int_0^1 f(x) dx.$$

In the usual parlance of ergodic theory, the quantity on the left is the average of the function along the time-orbit of x , and the quantity on the right is the spatial average of the function on $[0,1]$. The theorem says that for almost every point you choose, the long time average of the function f along the orbit of x is the spatial average of f . In particular, it means that you've sampled points in the domain randomly enough to approximate the integral. This "randomly enough" notion is the ergodicity of the map T with respect to the measure m .

I highly recommend trying this out with a computer; MATLAB can handle this pretty well, for example. Create a vector whose entries are the orbit of some pre-chosen point x under T , apply the function f to each entry, and then take the average of the resulting vector. You can compare to the integral using a numerical integrator, if desired.

A word of warning: the theorem only says "for almost every x ". This means "for all x but those in some set of zero measure". Remember how the rational numbers are countable? Measure theory tells us that the set of rational numbers has measure zero, so it could be the case that it won't work for any rational number! It can be hard to tell, especially if you don't know the answer a priori. This matters because computers have machine precision, which means that any floating point number is stored only to some finite length of binary digits. But all finite binary expansion numbers are rational, so...

As a test case, try using the doubling map T , as above, and see what happens if you pick x to be $1/\sqrt{2}$, with a large number of time steps. You'll underestimate the integral, because at some point, x will be mapped to 0, and will stay there. The map R , for irrational a , doesn't typically have this problem, so you can see that the approximation is pretty good most of the time.

Note: the theorem above holds in much more generality; the measure space can be any sigma-finite measure space, and T doesn't have to be ergodic. In this case, the spatial average is replaced with a conditional expectation with respect to the sub-sigma-algebra of T -invariant sets. If T is ergodic and m is an infinite measure, the spatial average is 0.

The moral of this story? Integration is about sampling points in your domain effectively enough to capture all of the data in your domain. There are many ways to do it: (pseudo-) random sampling via probability theory (the MC integration didn't have to be with respect to the uniform distribution: that's only for integrals with respect to Lebesgue measure), sampling via ergodic measure-preserving transformations, and discrete time-step integrations (in numerical differential equations) are just a few of the ways. You just have to be a bit careful to make sure your computer is telling you the right thing.

Just don't think you can sample a few points to compute an integral on your Math 138 final.

SCYTHE MARSHALL

N THINGS ABOUT OUR LIBRARIES THAT ARE UNEXPECTEDLY AWESOME

1. The computers (practically) always work. They might not do what you want all the time, or be the best, but they work reliably.
2. They will (fairly) happily loan you a bunch of stuff, like those annoying adaptors that Macbooks need (<https://uwaterloo.ca/library/services/equipment-loans>)
3. DC even has phones (at least one non-exploding Galaxy Note 2) you can take out for 3 days. (Rumor has it at one time they loaned iPads.) No more emulators if you don't have an Android device!
4. DP has day use lockers that are a) free, and b) you don't need to bring your own lock for. (<https://uwaterloo.ca/library/services/study-spaces-and-lockers>)
5. You can book a study space just for yourself online (single study in DC), and you kick people out if they're still in the room because you officially booked it (<https://bookings.lib.uwaterloo.ca/sbs/day.php>)
6. If you're on co-op, you can request they scan and send you articles from a book (<https://uwaterloo.ca/library/services/library-services-co-op-students-work-term-and-distance>)
7. You can borrow stuff at pretty much any university library province wide — except (really!) UofT, and the Ontario College of Art & Design. (<http://www.curba.ca/>)



HAT OF CHOCOLATE

CHESS VARIANTS

I have recently been playing around with some chess variants and enjoy the twist they can add to a game I love. Here are 3 of the ones I tried and my thoughts on them, exact layouts and rules can be looked up if you want to play any.

CRAZYHOUSE

Captured pieces can be placed anywhere on the board instead of moving on your turn.

This variant is rather aptly named, the ability to drop pieces tosses most traditional strategy out the window and planning any sort of effective defense quickly becomes impossible. That said it is one of my personal favourites and allows for very dynamic games.

4 PLAYER CHESS

This one requires a special board and is played with adjacent teams, there are an extra three ranks on each side of the board to make room and you can't communicate with your partner about moves.

The best part of 4 player chess is the team dynamics, trying to cooperate without directly communicating can be difficult, but it feels rewarding when you work together on a great play. The more crowded board also leads to more complicated board states with frequently shifting balance between attack and defense. If you get a good group for this game it can be lots of fun!

CHESS960

Named this way due to the 960 possible starting positions this gives, invented by Bobby Fischer, this variant involves the starting positions of the back rows being random yet mirrored.

This isn't too much of a departure from traditional chess but what it does give you is lots of variation in the opening. It is particularly great if you tire of routine or fixed opening moves that tend to lead to similar board states — a good way to keep games fresh without shaking up the core of the game.

Grab a friend and give some of these a try or find your own favourite variant; some of these can even be found online. A new take on a classic game is a good way to generate interest and make you think in different ways.

POCKETS

Read mathNEWS.

A mathNEWS EDITOR WHO SUSPECTS
YOU'RE ONLY HERE FOR profQUOTES

gamesNEWS

Hey Mathies!

It's the final week of term, so we all know what's happening: 24-Hours Games Night! Come to the C&D over the weekend to and spend some time relaxing before exam season hits. We'll be there all day, from noon on Saturday¹ to noon on Sunday, so feel free to join us whenever during that period!

This will mark my last official event² as Games Director. It's been a fun few years--I unofficially started in Spring 2014, and officially in Winter 2015--but unfortunately, my time at university is coming to a close.

To my VPI's, past and present: thank you for representing Games at Council, and giving a helping hand where it's needed, whether it's for posters, budget, or behind-the-scenes things like event forms.

To my VPO's, past and present: thank you for making sure Games had the C&D (and Comfy) booked whenever it was needed, and letting me get away with encroaching on office space to store food for Games.

To my fellow Games Directors, past and present: thank you for putting up with me, and for helping me out whenever I needed it. The events would definitely not have run as smoothly without someone organising things I didn't (want to) do or covering for me when I had midterms or other events that coincided with Games Nights

To VPI's, VPO's, and Games Directors in my off terms: thank you for making sure Games kept running, so that I had something to look forward to when I returned.

To everyone else who helped out: thank you for your contributions, whether it's driving to and from the store, tagging along on food runs to carry things, or suggesting items to purchase. All your help has made my job a lot easier.

And last but not least, to the rest of you, who just show up: thank you. You are what keeps our events running. Whether you showed up with a bunch of friends or by yourself; every week or once a month; for just an hour or for the entire evening; I hope the time you spent here was worth it, and that you enjoyed your time and made new friends.

One last message, before I head out forever³:

"Trust me, I'm a Cylon."

YOUR GAMES DIRECTOR,
A CRAFTY PLAYER

1. Yes, it's April Fools' Day. I do expect shenanigans to happen, and am fine as long as emergency services do not need to be contacted.
2. Unofficial events, on the other hand.... Something Thursdays something exam season something.
3. Or until I happen to be back in Waterloo.

N THING I WISH MY ROOMMATES WOULD DO

- Clean after themselves
- Stop yelling middle of the night
- Not to party till 6am twice a week
- Stop eating my food!!
- Wash their damn dishes
- Take the garbage out
- Clean after their friends' mess
- Take their shoes off before waling into my room

GREEN BAY FAN

AN IMPORTANT QUESTION

Would you eat a bee?

Okay, no, think about it seriously. It's not a live bee. The stinger has been taken out, and it's been prepared by a trained bee chef. Expertly seasoned, of course. It's a delicacy in several countries. How about then?

What if I pay you \$100? Or give you free tutoring in that class you're failing? Or buy you a sweet pair of shoes?

Maybe revenge will motivate you? What if I tell you this bee killed a really nice guy? Or it's just super racist and is, well, was, the head of a bee supremacist movement?

Okay, what if you could avert WWII by eating this bee? You eat this bee, Joe Biden becomes president of the USA. You eat this bee, no one ever dies from preventable childhood illnesses ever again.

Still no? You monster.

DIMINUTIVE REX

Here at mathNEWS,
we're not afraid to ask
your toughest questions.

Of course, that doesn't
stop us from posing
your idiotic ones, too.

THE mathASKS AMBASSADOR

N THINGS TO DO INSTEAD OF WRITING A REAL mathNEWS ARTICLE

- Decide what kind of pizza you want to eat at **mathNEWS** Production Night.
- Read old issues of **mathNEWS**.
- Stare hopelessly at an empty document.
- Eat free pizza at **mathNEWS** Production Night.
- Watch YouTube videos in an effort to forget the pain of a blinking typing indicator on an empty document.
- ~~Study for finals~~ Who are we kidding?
- Give up and write an "n things" article.

MATH/ARTS/SANS/ART



NATURE KNOWS ITS MATH

Spring is finally here, so have this poem by Joan Graham about spring and math.

Divide
the year
into seasons,
four,
subtract
the snow then
add
some more
green,
a bud,
a breeze,
a whispering
behind
the trees,
and here
beneath the
rain-scrubbed
sky
Orange poppies
multiply.

JOAN BRANSFIELD GRAHAM,
"NATURE KNOWS ITS MATH" FROM
MARVELOUS MATH. COPYRIGHT © 1997 BY
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UW'S BASTION OF ERUDITE THOUGHT SINCE 1973

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gridCOMMENT

PRESENTED IN FABULOUS, READABLE PLAINTEXT

A mainstay of **mathNEWS** is its **gridWORD**, and it is quite the shame that a paper dedicated to devotees of mathematics do so much with words as opposed to the abstract notions beginning with numbers. It is high time to correct that, and with that i present to you this puzzle which i have laboriously assembled.

The rules of this puzzle is no different from your usual **gridWORD**: there are clues, and there are boxes in which the answers to the clues are to be filled. As always, solutions to the puzzle will be accepted in the usual manner: online at our email or physically under the door to our office on the third floor of MC. And also as always, the group which submits the most correct solution shall be awarded a prize, where in the event of a tie for most correct, the tiebreaker shall be my favourite answer to the **gridQUESTION** of the issue, "what is your favourite bit of mathematics that you would like to share?"

I do wish solvers the best of luck; it did take me a while to get everything together, for hopefully obvious reasons. Someone save me from digitopolis so I do not have to continue doing this, please.

ZETHAR

OVERHEARD AT mathNEWS

TOBEDETERMINED

- “ It tastes like Fruit Gusher made out of wood.
- “ Just rub the George pizza on your face. That might help.
- “ Just sit down on these train tracks and write us an article. Now.

EXTROVERTED

- “ I'm impressed with how you fit that whole thing in your mouth.

ITORED

- “ Lets vote for all three options and hope that everyone does not vote for VR Arcade.
- “ Vegetarian George? How about... George in the Jungle.
- “ I was once a colony of Germany; Qingdao!

THE EDITORS **mathNEWS**, WINTER 2017

OCTOPODES' HANDY PREREQ CHART

CO EDITION

Okay, I must admit, this one is slightly less handy than the last one. The CO courses just don't map as nicely, probably because so many of them have just MATH 239/ 249 (Intro to Combinatorics) or CO 250/ 255 (Intro to Optimization) as a prerequisite. There's also the matter of the handful of courses that have PMATH courses as prereqs. These traits mean the chart wants to be wide — very, very wide — and I had to do quite a bit of work to squish it down so it would actually be readable.

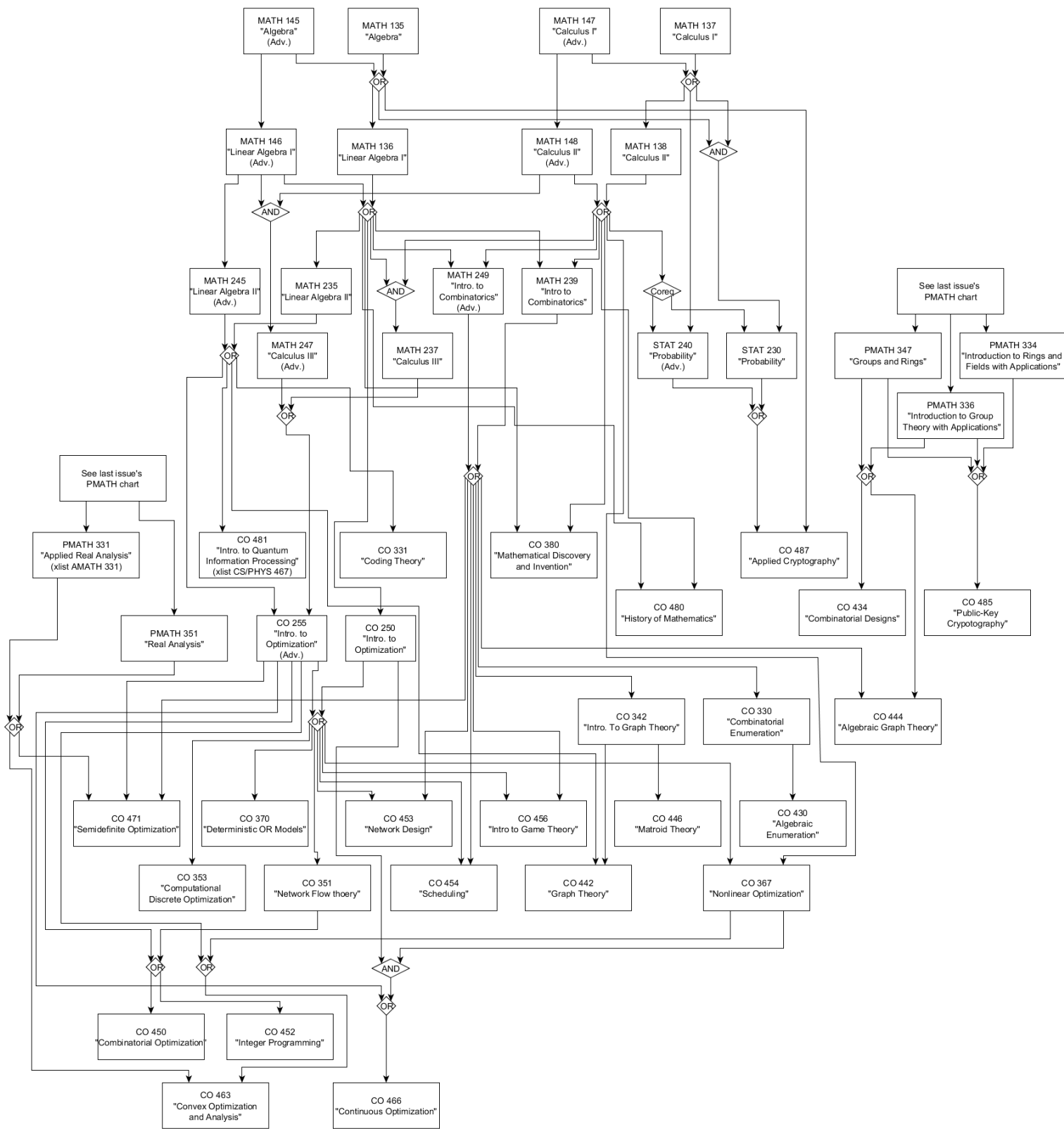
That said, this is something of a blessing in disguise. Taking just MATH 239 and CO 250, as well as your basic 100-level math courses, gives you access to more than half of the 300 and 400-level courses in CO right off the bat. Taking CO 255 instead of 250 opens up 4 more options — CO 450, 452, 463, and 466 — and 255 is also required for CO 471. If you're interested in taking any of these courses, I'd advise taking CO 255 as soon as possible (the next offering seems to be Winter 2018).

Unlike PMATH, CO doesn't break down into subdisciplines very cleanly. The two topics indicated by the name, combinatorics and optimization, are much more intertwined than algebra and analysis in PMATH. For every course like "Nonlinear Optimization" and "Combinatorial Enumeration", which fall cleanly into these categories, there's another like "Combinatorial Optimization" which draws from both.

I'll keep publishing these until I run out of math departments, so check out the next issue of **mathNEWS** for the next one!

OCTOPODES





I wrote for mathNEWS → I get free pizza

A mathNEWS EDITOR WITH SOMETHING TO PROVE

gridWORD gridNUMBER

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		37					38	39	
			40						
							41		

Drop your gridWORD solutions off at MC 3030. And yes, we do award points for creativity.

A PERPETUALLY BORED mathNEWS EDITOR

haltingPROBLEMS

BECAUSE THIS WORKS FOR A THROWAWAY PAGE

This week we launch the last of the new **mathNEWS** features planned for this term, **haltingPROBLEMS!** Simply put, from here on out, the back of each issue's **lookAHEAD** will feature the previous week's **gridSOLUTION**, along with an activity whose completion is both self-verifiable, and doesn't offer a prize. This week it's a nonogram, but the next might be a colouring page, or a connect-the-dots, or something else of that nature. I'd planned to do it last issue, but thanks to midterms and stuff, I didn't have time to make the puzzle. I warn you, though, I don't know how difficult this thing is. It shouldn't be a Zetharian-scale problem, but I just drew a picture and then made a puzzle out of it, so I can't tell you if

it's easy, either. If we do a nonogram again next issue, I'll try to keep it from being too much of a challenge, but for now, enjoy this entirely disposable puzzle I've made for you.

Anyways, that's it for **mathNEWS** 133.6. Keep an eye out for our next issue, where President Feridun Hamdullahpur will answer questions for us in **mathASKS**, and maybe write an article for **profpresidentTHOUGHTS**. Until then, good luck on finals! If anyone needs me, I'll be on the **mathNEWS** couch.

GEORGE LAMBROU,
EDITOR-ASLEEP, **mathNEWS**

LAST WEEK'S gridSOLUTION:

R	E	M	I	T		A	D	M	E	N		E	A	T						
E	V	A	D	E		L	I	E	G	E		F	L	U						
E	I	G	E	N	V	E	C	T	O	R		F	I	N						
F	L	E	A		A	R	E	A		V	O	L	G	A						
				T	I	N	T		D	A	E	M	O	N	S					
E	S	T	E	R		S	P	A	R	S	E	R								
T	H	E	S	I	S		A	T	E		N	E	W	T						
N	I	L		S	O	P	R	A	N	O		S	H	E						
A	P	E	D		N	O	S		A	B	A	C	U	S						
				V	O	C	A	L	I	C		I	N	E	P	T				
S	E	I	Z	U	R	E		O	N	T	O									
A	P	S	E	S		A	B	L	E		D	E	E	P						
P	O	I		H	E	X	A	D	E	C	I	M	A	L						
I	D	O		A	R	E	T	E		A	Z	U	R	E						
D	E	N		T	A	S	E	R		T	E	S	L	A						

lookAHEAD

SUN APR 2

Lectures/Classes End

MON APR 3

TUE APR 4

Pre-examination Study Days

WED APR 5

Pre-examination Study Days

THU APR 6

Pre-examination Study Days

FRI APR 7

On-campus Examinations Begin

SAT APR 8

SUN APR 9

mathNEWS 133.7 Production Night

MON APR 10

The mathNEWS Editors Love Cheddar-Flavoured Popcorn (Hint Hint) Day

TUE APR 11

Your Name (Kimi No Na Wa) Playing in theaters at Conestoga Mall day [Ed: Not actually a holiday, but still an important date]

WED APR 12

THU APR 13

mathNEWS 133.7 is Published

Good Friday (Christianity)

FRI APR 14

SAT APR 15

ARTICLES OF THE ISSUE

This week's articles of the issue most definitely do not include "N articles that show that the "Article of the Issue" is corrupt". Anyways, on to the winners!

The Informative Article of the Issue goes to "Octopodes' handy prereq chart: CO edition" by, you guessed it, Octopodes! It is a chart that will surely come in handy for all wannabe CO majors/minors/options/course-takers.

The Funny Article of the Issue goes to "You Have Now Subscribed to Goose Facts" by GooseChaser. A short yet amusing and lighthearted (ED: Like the geese mentioned in the article, *heh*) article, it is made even better by the author-penned self-portrait that accompanies it.

Congratulations to Octopodes and GooseChaser!
Come by MC 3030 to grab your prizes.

ITORED



otherNEWS is made technically possible by club executives of the Math Faculty. I say "technically" because if they had sent us more news this week, this box wouldn't be here.

THE mathNEWS EDITOR WHO PUTS THE "NEWS" IN mathNEWS