# CONDENSED MATTER

VOL 1. ISSUE 4. MATERIALS ENGINEERING NEWSLETTER NOVEMBER 13, 2009


## SWEET STEEL MELODY

**By SHIRIN KABOLI**

Graduate students, faculty members and staff in various departments throughout campus receive a couple of emails per week regarding upcoming university events. The way we choose to handle these emails differs from person to person. Some of us may ignore an email based remotely on the subject title, some may open it up curiously for a quick browse and some may save it to read in the future - which never actually comes! However, when the subject of the e-mail is "Ice Cream Social and Farewell", few people can ignore it. This particular subject was sent to all faculty and staff by the Vice-President three months ago. The proof that few people could resist reading the e-mail was the presence of more than 700 people at Hamilton Hall at noon, August 12th, waiting for free ice cream.

On that wonderful warm and sunny day, people enjoyed a pleasant time socializing among friends while indulging in as many ice cream portions as physically possible. What's more, our kind president provided us with beautiful live music which spread from a strange looking creature called a traditional African instrument, or simply the "Steel Pan". The history of this musical instrument may be interesting particularly to Materials & Music Lovers since it indicates the direct contribution of materials science to the construction of a musical instrument.

As the name recalls, the steel pan is made of steel. It was originally invented on the Kitt Nevis islands in the US back in the 1930s when bands started to use discarded oil barrels to make their pans. Today, steel pans are still made out of those same barrels using similar techniques people used to make them in the past.

Steel Drum at McMaster

First, the pan maker draw circles on the surface of the barrel to follow the gradual shape changes during the next steps few staps, this is called marking. To lower the bottom of the barrel into a concave shape, the maker uses a sledgehammer, this is called sinking. Then a pan tuner marks the notes on the surface and lowers down the surface between the notes further with a backing hammer (backing). In the next step, notes are separated by hitting the surface along each note border with a steel punch (grooving). Finally the barrel is cut into proper pan length using an electrical jigsaw. To ensure good sound and surface quality, the pans usually undergo a number of post heat treatment processes such as homogenization, annealing and tempering. Temperature and time during each cycle differ from one pan to another due to the desired characteristics and types (i.e. soprano, tenor, bass). Also in order to protect the pan from corrosion, a thin layer of zinc or chromium is often electroplated on its surface. Finally the surface is covered with wax to protect it from moisture and to make it shiny. Voila, the drum is ready! But what if instead of using a mild steel, one was to us a a high carbon steel which during the heat treatment cycle formed a martensite in the pan? What would happen to Chopins nice waltz for example? Who knows? It is the Materials Engineer's responsibility never let this happen.

# Solving the Quintic Polynomial

**By DR. JEFFREY J. HOYT**

In a recent issue of "Condensed Matter" David Rossouw described the intriguing mathematical construct known as a Cantor set, which establishes the rather non-intuitive idea that some infinities are actually larger than other infinities. The article reminded me of one of my favorite stories from the history of mathematics. In high school, and even earlier, we all learn the quadratic equation.

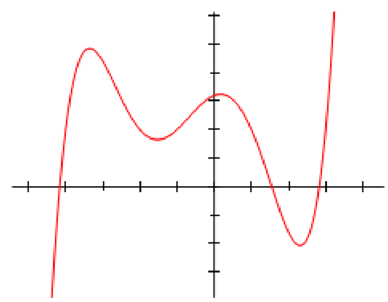
$$x = -b \pm \frac{\sqrt{b^2 - 4ac}}{2a} \qquad (1)$$

Which, of course, defines the two, not necessarily real, roots of a second order polynomial equation. With a little more work we can also write down the analytic solution to a cubic polynomial and with considerably more effort we can also formulate the lengthy analytic solution to the fourth order, or quartic, polynomial. In the past, and over a period of centuries, mathematicians attempted the next logical step, the solution to the quintic, but every attempt was unsuccessful. In the early 1800s the matter was finally put to rest by the French mathematician Evariste Galois. It turns out nobody will ever derive an analytic solution to the roots of a fifth order (or higher) polynomial because it cannot be done.

To find the five roots of a quintic you will have to do something else, like Newton-Raphson iteration. Galois' work set the stage for this remarkable and again non-intuitive finding. Proving the impossibility of something is a delicate and challenging task, think of Ferma's last theorem, and to do so Galois had to first invent an entire branch of mathematics. The field of study that will always be associated with Galois is called group theory.

But that's not the interesting part of the story. On May 30, 1832 Galois was involved in a duel to the death. Certain details, such as who the challenger was and who challenged whom, are lost to history, but there is some evidence that the unrequited love of a young woman was the root cause. Legend has it that, prior to the duel, Galois did the math (so to speak) and concluded there was a good chance he would not survive. Thus, on the eve of the duel Galois scribbled furiously through the night, recorded the entire fundamental underpinnings of group theory, and mailed his extensive notes to a friend. The next day Galois was shot and killed. Evariste Galois was just 20 years old.

The tragic death of Galois was needless to say a terrible loss for mathematics. Fortunately his stunning achievement was preserved and the influence of Galois is felt to this day in many fields of study such as crystallography and the renormalization group theory analysis of critical phenomena.



A graph of the quintic

## Condensed Matter Survey Results

| Question Asked | Average Result | Number of Respondants |
|---|---|---|
| Will **grads** get the H1N1 Vaccine? [5-For sure 1-No Way] | 3 | 18 |
| How many hours/day do **grads** spend on school work? | 8.12 | 18 |
| Will **undergrads** get the H1N1 Vaccine? [5-For sure 1-No Way] | 2.15 | 27 |
| How many hours/day do **undergrads** spend per day on school work? | 7.15 | 27 |
| Will **staff** get the H1N1 Vaccine? [5-For sure 1-No Way] | 2 | 3 |
| How many hours/day does **staff** spend per day on work? | 6.2 | 3 |

*Dr. Provatas answered all questions as well. See "Interview with Department Chair" article.*

## Seeing the Invisible

**By DAVID ROSSOUW**

In 1986 the Nobel prize for physics was awarded to the German born engineer Ernst Ruska. [1] He was awarded the prize for the design of the first electron microscope.

The electron microscope is quite different from the common optical microscope which we are all familiar with. The optical microscope uses visible light to illuminate an object, and lenses to focus light in such a way that very small objects, invisible to the naked eye, are enlarged and visible to the observer. However, there is a upper limit to the attainable magnification. A light microscope can only reveal objects larger than the light wave itself. White light ranges in length (wavelength) from 0.2 to 0.7 thousandths of a millimetre (0.2 $\mu$m to 0.7$\mu$m). Thus objects smaller than 0.2 $\mu$m cannot be resolved. This is not a limitation due to the quality of the microscope, but a fundamental limitation of the light source.

Well that's easy to fix you say, why not use a smaller light wave for higher magnification, such as xrays? The trouble with smaller light waves is that they are more energetic, xrays smash through objects, breaking bonds and significantly altering materials during exposure. This is obviously undesirable. There is another way, but a small digression is required. Louis de Broglie proposed in 1924 that matter, not just light, exhibits wave properties. It was not until 1927 however, that the wave properties of matter were accepted in the scientific community. George Thomson (son of J.J. Thomson) conducted an experiment that demonstrated the diffraction of electrons by a regular crystal lattice, for which he was awarded the Nobel prize in 1937. It is one of the great ironies in physics, that the great physicist J.J. Thomson received the Nobel prize in 1906 for proving that electrons behave like particles, and 31 years later, his son George was awarded the Nobel prize for proving that electrons behave like waves. To this day, much of the scientific community is troubled by the wave-particle duality of matter.

Now returning to the problem of limited magnification with light. With de Broglies discovery of 'electron waves', it was realised that electrons could be used instead of light for imaging small objects. Glass lenses could be replaced with electric and magnetic fields, and light sources could be replaced with electron emitting filaments. Electron waves are no larger than xrays, but without the destructive side effects.

In 1931, seven years after the discovery of electron waves, Ernst Ruska and Max Knoll built the first electron microscope at the Technical University of Berlin. Ruska found that the a magnetic coil could serve as a lens for electrons, and irradiating an object with an electron beam could produce a useful image. In 1931, he built the very first electron microscope, and subsequently helped commercialize the technology.

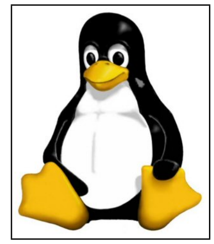
Ernst Ruska and Max Knoll

In his instrument, electrons were passed through a very thin slice of an object and were then deflected onto photographic film, producing an image that could be greatly magnified. Todays electron microscopes are capable of resolving individual atoms, with magnifications up to a million times. We are fortunate to have two recently installed world class electron microscopes here at McMaster, capable of resolving features down to 0.6 Angstroms, that is, over three thousand times more powerful than the best optical microscope.

## To Stop Windows from Crashing, Simply Stop Using it.

**By PAUL OKRUTNY**

I am sure you've heard about Linux, you've heard how great it is, and you've heard how secure it is, the free price tag sure sounds enticing but you still will not change over because of those incompatibilities you hear about. Surely you're too busy to learn a new operating system and go through the setup and customization of the hundreds of programs you use on a daily basis, it just makes sense to buy windows and buy a virus scanner to make it secure.



Linux Logo

E-mail, Word Processing, Spreadsheet Calculation, Presentations and Surfing the Web are probably all the things you currently do on your computer. If you're slightly more then just a user, you'll probably be familiar with some form of image editing software, instant messaging and perhaps music management and distribution. But be honest with yourself, do you really venture far beyond this form of computer complexity?

Most people do not even venture far beyond e-mail and word processing as even with those they have problems. If that is the case, then why does everyone stick with Windows? Where is this incompatibility that everyone is talking about? E-mail is the same on all systems, word processing and spreadsheet calculations have little differences between Linux and Windows and they work interchangeably between systems, image editing and music software exist for both operating systems and obviously the Web is the same on any computer.

So when we teach new users how to use computers, what is the difference between them learning, Click 'Start' then 'Programs' then 'Microsoft Word' vs.

[1] Actually the Nobel Prize was shared amongst three scientists, of which half the prize was credited to Ernst Ruska.

Click 'Applications' then 'Office' then 'Open Office Word Processor' while being taught how to word process a document?

The only difference is marketing. Microsoft spends billions on marketing to teachers, to CTO's and to the average user so its believed to be superior. It crept its way into society, into schools and into businesses showing itself hundreds of times per day to unprepared computer users who eventually became conditioned to regard it as the ultimate operating system; Remember, *a lie becomes the truth if told often enough*.

I realize there is nothing I can say to actually convince everyone to use Linux, as my words stand little chance against the billions spent on Microsoft's promotion. So do not simply take my word for it, look through the following data and be your own judge.

First, lets take a look at cost. Cybersource Pty Ltd, an Australian Consulting company endorsed by the Australian Government published a study [1] of cost between Windows and Linux. Their numbers summarized in Table 1 are based on a typical Windows XP installations including Microsoft Office, an Anti Virus program for all users and two out of the total computers being equipped with Adobe Photoshop. The numbers also include software updates, downtime due to viruses and the much more powerful hardware necessary to handle the poorly coded Windows software. A single purchase of Linux already comes bundled with Word Processing software, requires no anti virus software, can be installed on many machines and comes with a great Photoshop alternative, the $80 covers 2 months of telephone support and 3 months of further e-mail support and can actually be skipped altogether saving the $80.

Table 1: Cost Comparison Summary

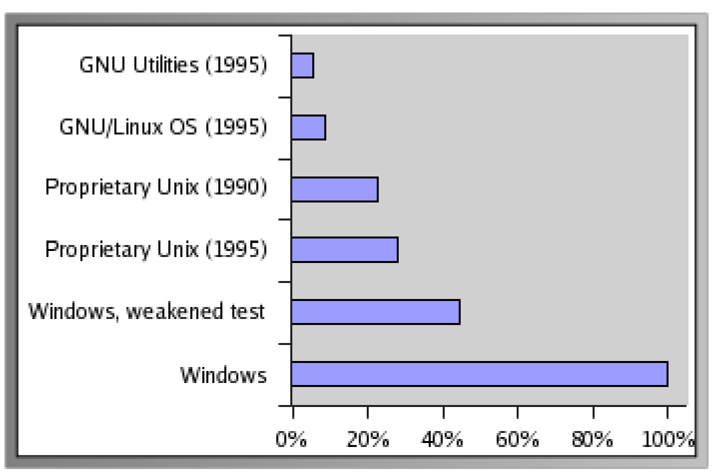
| Case | Microsoft Solution | Linux Solution | Savings |
|---|---|---|---|
| Company A (50 Users) | $69,987 | $80 | $69,907 |
| Company B (100 Users) | $136,734 | $80 | $136,654 |
| Company C (250 Users) | $282,974 | $80 | $282,894 |

Next, lets discuss security.

Virus infection has been a disaster to the financial accounts of Microsoft Windows users in both business and the non-profit sector. The LoveLetter virus alone is estimated to have cost $960 million in direct costs and **$7.7 billion** in lost productivity. It is not surprising that the anti-virus software industry sales total nearly $1 billion annually[2]. Makes one think that if you were in the anti virus industry and business was slow, it would be in your favour to sit down and write a few viruses.

Many have noted that Windows is attacked by viruses more often because there is a larger number of Windows systems in use. A counter argument is that Microsoft has made many design choices over the past few years that have rendered its products less secure, and this has made their products a much easier target than many other systems. [3] Microsofts Chief Technology Officer Craig Mundie admitted that Microsofts products were, less secure than they could have been because they were, designed with features in mind rather than security – even though most people didnt use those new features. [4] Several examples of these insecure features include executing start-up macros in Word, executing attachments in Outlook, and the lack of write protection on system directories in Windows 3.1/95/98.

Finally, stability.




Fuzz Test Failure Rate

My favourite way to demonstrate this is to use the Fuzz Test performed by the University of Wisconcin. Fuzz testing is a simple technique consisting of feeding random input to applications, if the application cannot handle the input, it crashes. The results are displayed in the Fuzz Test Figure above.

If Linux wins over microsoft in security, stability and price, then why are so many people using it, why is McMaster's administration using it, and why are we so stubborn to change? I urge everyone to at least read up on this subject further. By changing over we gain stability, versatility, the concept of open source as well as free education and best of all, we save money which can otherwise be put in towards research. Next time you ask your professor for a Vista Serial Number, think twice about what else could that $200 buy you. A conference fee? A few Textbooks? You get the point, its not a difficult switch, I promise.

[1] www.cyber.com.au/cyber/about/linux_vs_windows_pricing_comparison.pdf

[2] www.dwheeler.com/oss_fs_why.html

[3] www.dwheeler.com/oss_fs_why.html

[4] www.v3.co.uk/vnunet/news/2120337/microsoft-outlines-security-strategy

[5] www.pages.cs.wisc.edu/ bart/fuzz/fuzz.html

# ALGAE FUEL

**By MARIANA BUDIMAN**

The real cost of transport, whether it be car, train or aircraft, is highly influenced by the price of fuel. With rising fuel prices, will oil powered transport be affordable in the near future? Algae power generation was predicted as one of the top ten unusual green technologies to power the future in an article entitled The Energy Roadmap [1]. Other technologies listed included food power, bacteria power, trash power, weather power and pollution power [2].

Algae are simple, photosynthetic organisms which, in the presence of water, efficiently transform carbon dioxide and sunlight into energy [3,4]. As a result of photosynthesis, algae produces oil similar to the petroleum products available in todays market [4]. This oil can be converted into gasoline and diesel using existing refineries.

Research into algae for oil mass production is focused mainly on microalgae (cyanobacteria and diatoms) as it has a relatively simple structure, fast growth rate and high oil content [6]. Some research is also being performed on using seaweed (macroalgae) for biofuels, due to the high abundance of this resource [7,8].

Some advantages of using algae as a potential fuel include:
1. Algae can grow in salt water, fresh water, ponds, contaminated water and even on land that is not ordinarily suitable for production. Thus algae can serve the dual purpose of producing biofuel whilst cleaning up contaminated land area [3,9].
2. Algae can produce more oil per area than many crops because almost the entire algae organism can use sunlight to produce lipids, or oil (see table below) [10].

Some large companies and many research institutions around the world have put serious efforts and capital into algae research, including Exxon Oil [4], NASA [11], and Algae Biomass Organization (ABO) and Boeing Commercial Airplanes [12]. In the near future, algae fuel stations may exist, where algae farms and refineries reside on site, ready to provide petroleum to a the new generation.

Table 2: Algae Oil per Area Comparison

| Crop | Oil Yield (Gallons/Acre) |
|---|---|
| Corn | 18 |
| Cotton | 35 |
| Soybean | 48 |
| Mustard seed | 61 |
| Sunflower | 102 |
| Rapeseed | 127 |
| Jatropha | 202 |
| Oil palm | 635 |
| Algae | 10000 |

References

[1] http://www.thetakeaway.org/stories/2009/feb/03/ten-unusual-alternative-technologies-could-change-way-we-use-energy/

[2] http://theenergyroadmap.com

[3] "Algae: Biofuel Of The Future?." http://www.sciencedaily.com/releases/2008/08/080818184434.htm

[4] http://www.guardian.co.uk/environment/2009/jul/14/green-algae-exxon-mobil

[5] http://www.pure-energy-fuels.com/Algae.html

[6] "Microalgal Production SARDI AQUATIC SCIENCES" (PDF)

[7] "Seaweed to breathe new life into fight against global warming". The Times Online. 2005.

[8] Seaweed Biofuels: Production of Biogas and Bioethanol from Brown Macroalgae

[9] "Biofuels from industrial/domestic wastewater"". Retrieved 2008-06-11.

[10] "Why Algae?". Solix Biofuels. Retrieved 2008-06-11.

[11] http://www.scientificamerican.com/article.cfm?id=nasa-fuel-algae-sewage

[12] http://www.boeing.com/commercial/index.html

# An Interview with the Department Chair

**By VARIOUS**

**Question from Undergrad:** What do you think makes a good graduate student?

**Nik Provastas:** A graduate student reaches excellence by climbing a complex ladder of achievement and maturing in the 4 years it typically takes to complete a Ph.D. The general path a student takes can vary but here is a summary of my general philosophy on the matter. Following a discussion of their topic with their supervisor, a graduate student should begin their journey by making a serious and exhaustive study of the literature in their field. This step will go on throughout the duration of graduate study but is most difficult at the beginning. It often involves the difficult task of scouring books and papers from many journals, both in their own field but perhaps also in more distant areas. It also involves having frequent discussions with other professors and students. Only through this process can a student begin to piece together the open questions in a field. This is crucial since, as a graduate student you are expected to advance the field in a novel way, as determined by the process of peer review. Re-inventing the wheel is of no use, regardless of how much work you put into it. The following step of a successful thesis includes developing a students own view of their topic and what they feel they can contribute to the topic. This step will be where a student begins to develop their own theory, experiment, model, or all of these, in order to explain or address what they have determined as the interesting open question whose solution can advance their field in a novel way. I often call this step taking ownership. Like a child leaving home for the first time, a successful graduate student is expected to start developing independence from their supervisor, and an expertise in the particular and esoteric aspects of their field. In the best of cases this expertise will often also surpass that of their supervisor, a professor who is intended only to mentor them through their journey of study and discovery. In fact, I believe that only when a graduate student is able to educate the supervisor is that student ready to graduate.

**Question from Grad:** How do you plan on improving the reputation and awareness of Materials Engineering at McMaster among industry, especially now that many previously major employers are enduring financial hardships?

**Nik Provastas:** The department takes very seriously the issue of sensitizing industry about materials science and engineering. One of the reasons our undergraduates have a good success rate in securing co-op positions stems in part from the strong relationship our professors have with local industry. I plan to build on this strength and further promote our department to industry. This will be done via several routes. These include approaching industries that employ former graduates of our department, as well as collaborating closely with the Associate Deans office to promote our department more aggressively to industries that look to recruit engineering students.

**Question from Grad:** Does the department have plans to extend their field of research into emerging fields such as composites?

**Nik Provastas:** Several of our professors presently publish work in the area of composites. In fact, one of Dr. Wilkinsons Ph.D students, Juan Kong, recently had a paper accepted that deals specifically with creep deformation in fibre reinforced composites. Moreover, a recent student of mine, Tao Wu, recently finished a Ph.D study on the xerographic properties of paper, one of Canadas most important composites. There are other examples as well. You are encouraged to read web sites of individual professors and find out more about their various research areas. On the topic of web sites, I would like to add at this point that we would value your feedback on how informative you find our web site(s) and any suggestions you may have about how to improve them. Please send your comment to me or to Diana Maltese who will be maintaining our web pages.

**Question from Undergrad:** Why did you to choose Materials Science over other subjects?

**Nik Provastas:** What makes materials so cool to me is that it is one of those fields that sit at the intersections of engineering and fundamental science. For example, nearly all aspects of engineering function relay intimately on developing materials whose properties carry that functionality. On the other hand, to do so more often than not requires a detailed understanding of the physical and chemical phenomena that endow a material with a specific functionality or property. As a researcher, this duality appeals to me because it is a little like having your cake and being able to eat it too.

**Question from Undergrad:** Why wasnt́ there a Materials Graduate Studies table at the Graduate fair in the student center?

**Nik Provastas:** From our previous experience, turnout at this even has consistently been abysmal. We thus felt that our resources and time could be better spent on promoting materials science and engineering in other forms. For example, our department now hosts our own annual graduate studies night, where our professors give final year undergraduate students an overview of our research projects and upcoming gradate student availability. This even will run again this year and we strongly encourage students to participate.

**Question from Undergrad:** What is your favorite movie franchise and why?

**Nik Provastas:** As a kid I loved Star Trek. It provided a great escape to a world where science and engineering ruled supreme, and of a world of unlimited possibilities. Most recently, the Matrix Trilogy. I loved the movies ominous message about the consequences of a complacent society that has become too involved with superficialities to reflect on the true nature of things.