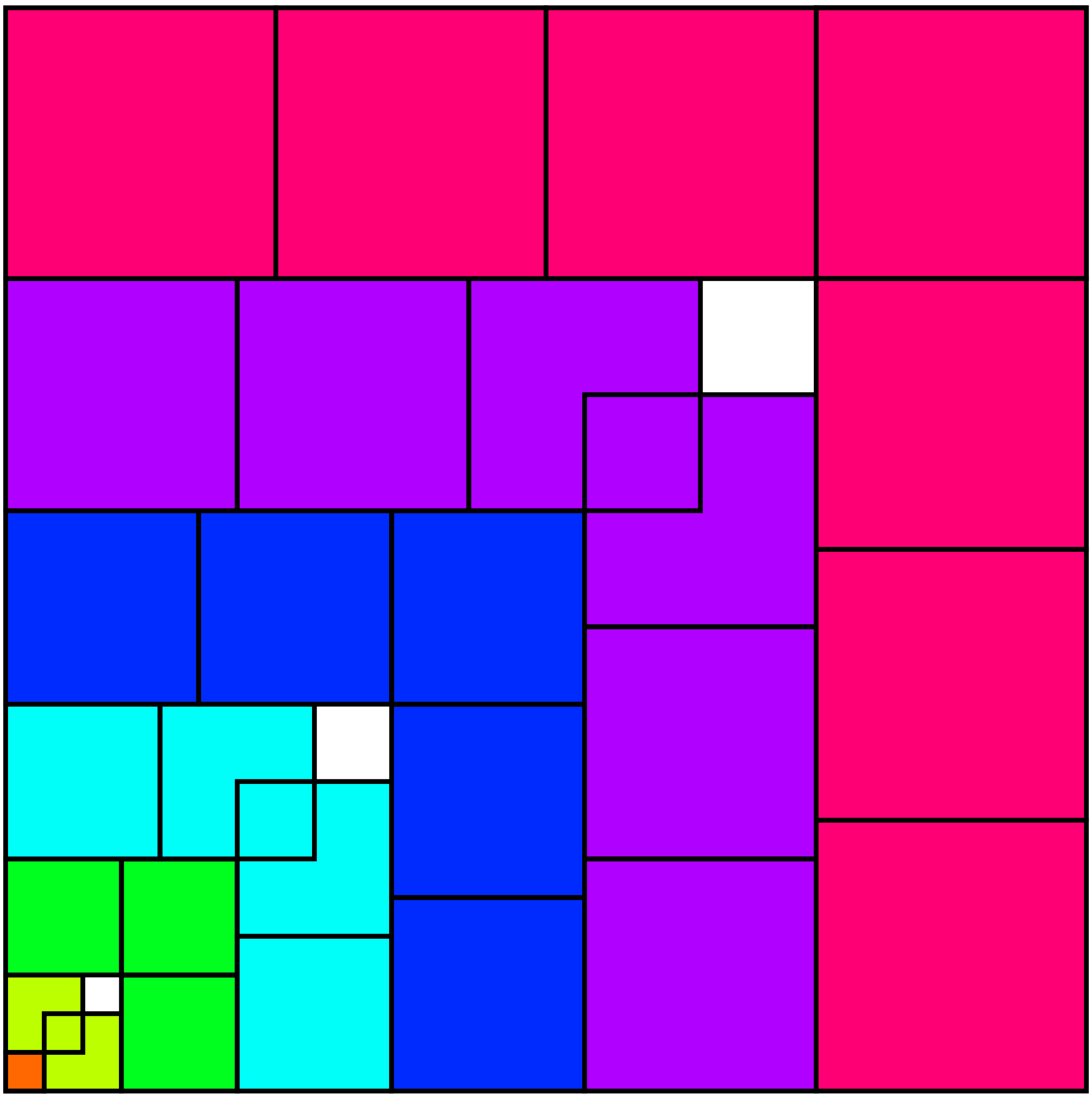
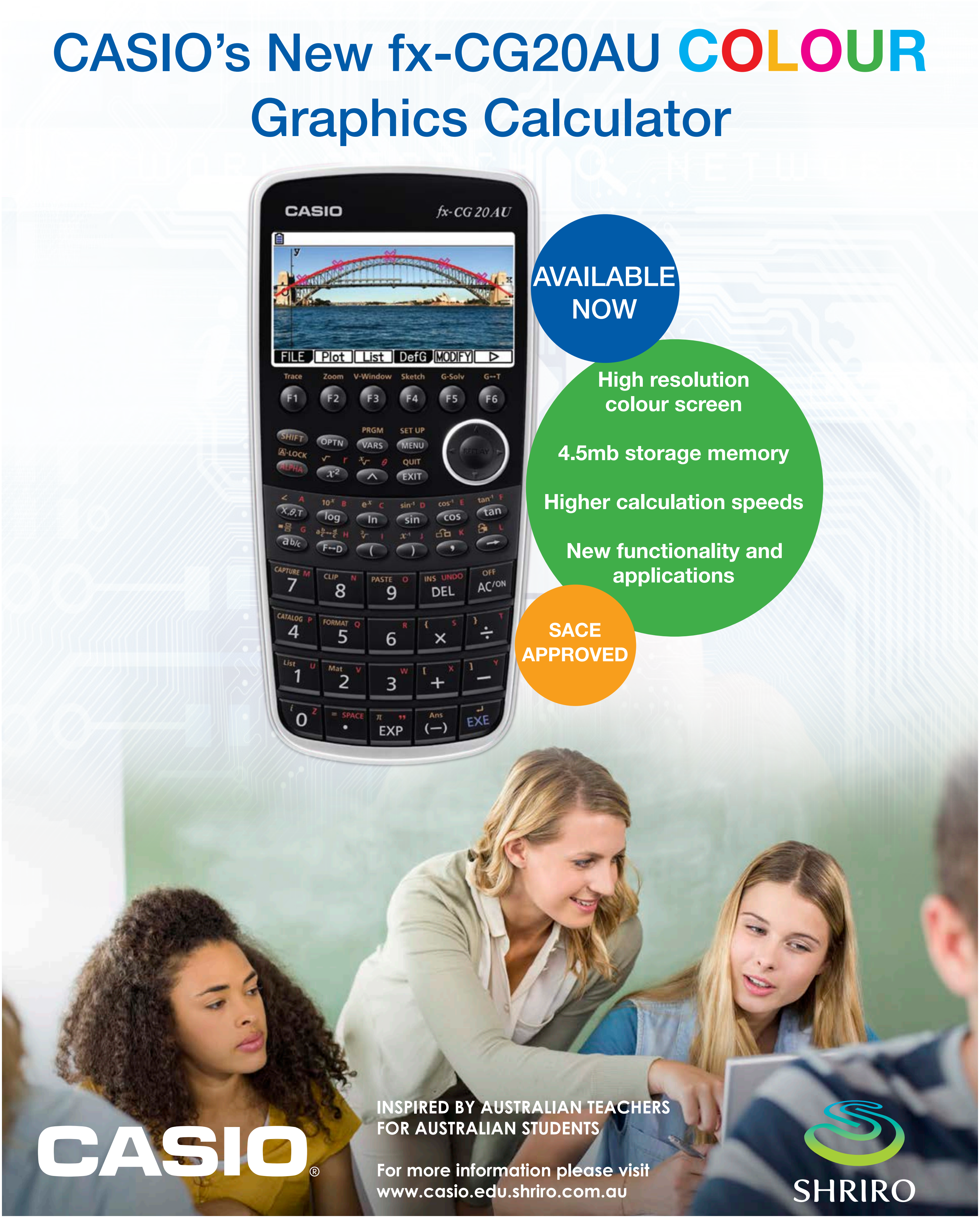
TEACHING MATHEMATICS

Volume 41 Number 4 November 2016



The Journal of the Queensland Association of Mathematics Teachers Inc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November 2016 Volume 41 No. 4

TEACHING MATHEMATICS

Regulars

Features

Teaching Ideas

Front Cover

The cover shows a continuation of the sequence on Page 27, illustrating that the square of the sum of the first n whole numbers is equal to the sum of the first n cubes.

QAMT Executive & Committee

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Teaching Mathematics is the official journal of the Queensland Association of Mathematics Teachers Inc. The journal is published four times a year (March, June, September and November) and is provided as a right to all members of the association.

The aims of the journal reflect, put into effect, and communicate the objectives of the association:

- to promote interest in mathematical education at all levels;
- to encourage and promote research in the teaching of mathematics;
- to speak and act on matters related to mathematical education.

Advertising material published in and accompanying this journal does not imply endorsement by the association.

Educators, administrators, parents and students are invited and encouraged to contribute articles which relate to the teaching of mathematics at any level. These may be of any length from interesting 2-line snippets, through short letters concerned with topical issues to longer in-depth articles. Critical comments and advice about the future directions of the journal are always welcome.

Materials should be sent to the Editor, Rodney Anderson. The preferred way is by email. Contact details are as follows:

Rodney Anderson
Moreton Bay College

Phone: 07 3390 8555
Fax: 07 3390 8919
Email: andersonr@mbc.qld.edu.au

Microsoft Word is the preferred format. All receipts will be acknowledged - if you haven't heard within a week, e-mail Rodney to check. Copy dates are: mid-February; mid-May; mid-August; mid-October.

The views expressed in articles contained in Teaching Mathematics belong to the respective authors and do not necessarily correspond to the views and opinions of the Queensland Association of Mathematics Teachers.

If you have any questions regarding Teaching Mathematics, contact Rodney Anderson. Publications sub-committee members are listed below. Feel free to contact any of these concerning other publication matters.

Rodney Anderson (Convenor)	Moreton Bay College	07 3390 8555
Gaynor Johnson (Newsletter)	QAMT Office	07 3365 6505

Books, software etc. for review should be sent to Rodney Anderson; information to go in the newsletter should be sent to Gaynor Johnson at the QAMT Office. Newsletter copy dates are the beginning of each term.

Contact the QAMT office for advertising enquiries.

Advertising Rates	1 Issue	2 Issues	3 Issues	4 Issues
Quarter page	$44	$88	$110	$132
Half page	$66	$132	$176	$220
Full page	$110	$220	$308	$396
Insert (single A4 or folded A3)	$220	$440	$660	$770

QAMT also now offers a colour advertising service for the covers.

From the President

Greg Bland

I don't know about you, but over the last year or so I have noticed a marked increase in advertisements for low-value, short-term loan products, or "payday loans" as they are often called. These advertisements focus on the simplicity of applying for such a loan and the speed at which the loans are approved and the cash is deposited in your account. These companies' websites feature nifty tools that allow you to adjust the loan amount using a slider, and provide reassuring information about the low repayments involved. You need to read a little further down the page to see the interest rate and fee information. And if you're getting ready to apply for one of these loans… well, maybe it's best that you just don't look.

In an era when the official cash rate is a measly 1.5%, the typical interest rate you will pay to one of these payday lenders is around 40% per annum. In my research, I have seen some slightly lower than this, and some slightly higher. But wait, there's more! An establishment fee, typically 20% of the principal, is also added on, not to mention other fees you may incur if you cannot meet payments along the way. When the establishment fee is factored in, the comparison rate jumps to around 65% to 70% per annum. These loans may be easy, but they are certainly not cheap.

It would be unfair, however, to single out payday lenders as the only rogues in the consumer finance industry. Another of my personal favourites is the magical "interest free finance" available in some major department stores. These seductive offers allow you to buy large-ticket items today in exchange for an agreement to make regular repayments over the next few years. If you do repay the full amount within the interest-free period, then everything will be just fine. However, here's the catch. Each month, you will receive an invoice for a minimum repayment, the dollar value of which is *lower* than the average amount you would need to repay to meet your debt obligation within the interest-free period. You need to do your own calculations to work out how much extra you ought to be paying. And if your loan period extends past the interest-free period by even a single day, you will be charged the full exorbitant rate of interest, backdated to the purchase date. All of a sudden, that computer you bought for $2 000 a couple of years ago, which is now obsolete, will have ended up costing you two or three times the purchase price.

As mathematics teachers, I'm sure that none of this is news to you. However, I've found over the years that most high school students are not only unaware of these issues, but when they investigate them, they are genuinely shocked. Consumer finance provides some great examples like these to investigate mathematics in a genuine context and, just as importantly, decrease the chances of students making expensive mistakes as they become more independent.

I'd like to thank you for your support of QAMT over the year, and I'd also like to take this opportunity to extend a big thank-you to Rodney Anderson, former President, and the entire QAMT Executive for their continued hard work. We have some exciting events lined up for 2017 and I look forward to welcoming as many of you as possible to our Annual Conference in Toowoomba. After the hot days and balmy nights in Cairns for QAMTAC 2016 earlier in the year, I can guarantee a much cooler climate for next year's event!

Have a safe and happy Christmas holiday and I look forward to seeing you in 2017.

Greg Bland
President, QAMT

From the Editor

Rodney Anderson

A reminder that we encourage contributions from members for the Journal, since after all, it is your Journal. This is a chance to share your ideas and practices with other members. We also welcome suggestions for particular topics that you would like to read about.

E-mail suggestions and submissions to andersonr@mbc.qld.edu.au

Incentive to contribute articles/teaching ideas to the journal

QAMT MEMBERSHIP DRAW

1 For every article/teaching idea contributed, the author will receive a ticket in a Membership Draw.

2 If you are contributing an article/teaching idea for the first time, the author will receive two tickets in a Membership Draw.

3 The winner of the Membership Draw is Miles Ford.

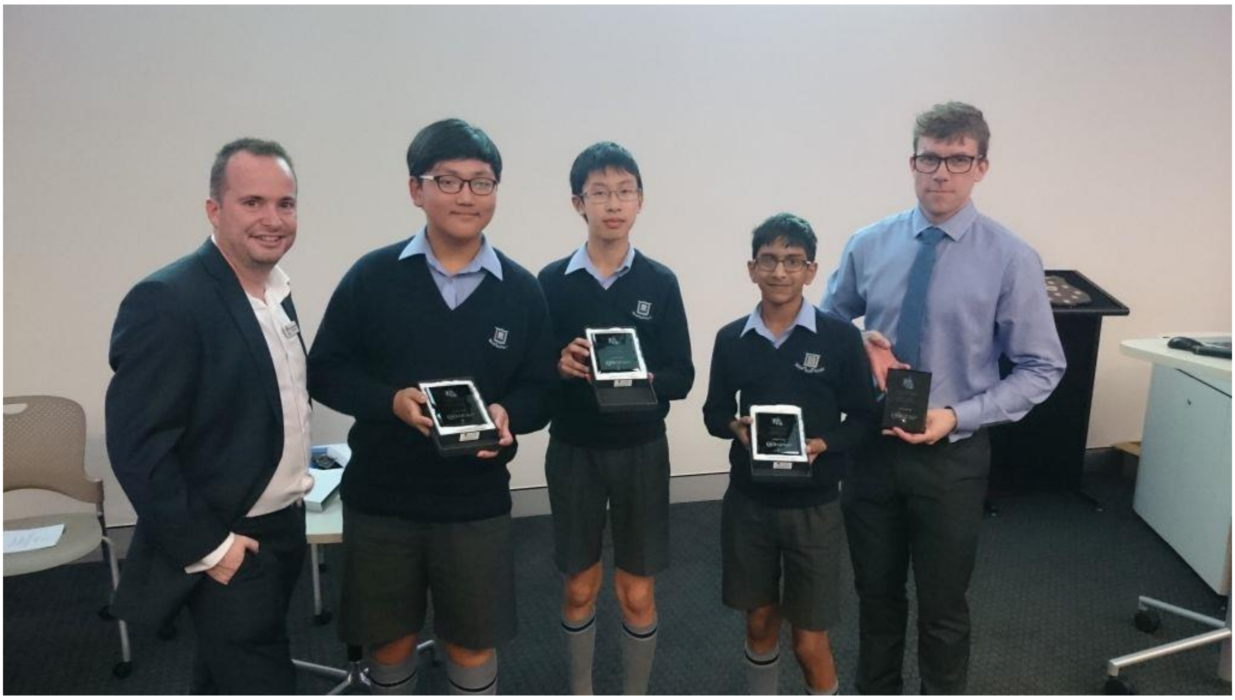
Please contact Gaynor Johnson at qamt@qamt.qld.edu.au

At the August Forum QAMT bestowed Life Membership to Peter Cooper. He has been an Executive Committee member for many years, Treasurer and Organiser of the Year 7/8 Quiz.

2016 Year 7&8 Quiz State Final
Sponsored by QT Mutual Bank

Congratulations to Brisbane Grammar School, winners of the 2016 QAMT Year 7&8 Quiz State Final
Thanks are extended to schools, students, teachers, parents, co-ordinators and the host school, Brisbane Grammar School.

Finalist schools included All Saints Anglican School, Brisbane Boys College, Brisbane Grammar School, Cavendish Road SHS, Centenary Heights SHS, Chinchilla SHS, Fraser Coast Anglican College, Gregory Terrace, Hillbrook Anglican School, Immanuel Lutheran College, Ipswich Girls' Grammar School, Matthew Flinders Anglican College, North Lakes State College, Redlands College, Rockhampton Grammar School, Somerset College, St Andrews Catholic College Cairns and The Cathedral School Townsville.



QAMT Dates
Professional Development
Planning for 2017

Middle School Teaching
Helping Children Learn
Saturday 18th February

Venue:	The University of Queensland
Cost:	$55 Presenters and Students
	$85 Members
	$150 Non-Members

New to Teaching Night
Pi Night
Friday 10th March

Time:	4:30pm – 7:15pm
Venue:	The University of Queensland
Cost:	Free

Problem Solving Competition
Saturday, 11th March
Pi Day

The UQ/QAMT PSC is open to all students of secondary schools in Queensland. Students may sit the exams at school or at UQ on Saturday morning.

Cost:	$5 per student
Contact:	Michael Bulmer - m.bulmer@uq.edu.au
	www.maths.uq.edu.au/qamt
	$10 administration fee for non-member schools

Early Years Conference
Saturday 6th May

Venue:	To be confirmed
Cost:	$55 Presenters and Students
	$85 Members
	$150 Non-Members

Annual Conference

Conference:	Saturday 24th and Sunday 25th June
Venue:	Toowoomba
Cost:	tba Presenters and Students
	tba Members
	tba Non-Members (with membership)

Visit qamt.org for updates.

Thursday, 27th July
Australian Mathematics Competition
Australian Mathematics Trust
Details www.amt.canberra.edu.au

QAMT Year 7/8 Quiz – Sponsored by QT Mutual Bank
A quiz style competition with 3 members to a team suggested dates are

Round 1:	July
Round 2:	Early August
State Grand Final:	19th October
Entry fee:	$22 per team
	$10 administration fee for non-member schools

Mathematics/STEM

Conference:	Wednesday, 30th November
Venue:	The University of Queensland
Cost:	tba Presenters and Students
	tba Members
	tba Non-Members

Friday Night Mathematics
24th March, 28th April, 28th July
The University of Queensland

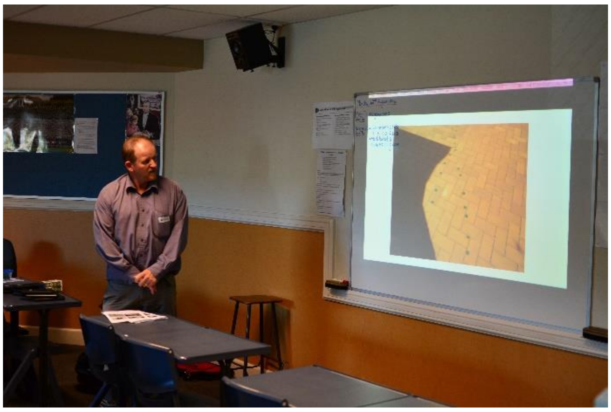
Professional Discussion and Engagement

Emmanuel College on the Gold Coast is seeking to improve its Mathematics teaching and learning. They are interested in building connections with schools who are teaching mathematics in a conceptually rich way to students in Years 4 - 6.

If you would like to share your journey and allow them to observe your practice, please contact Helen Boyes

hboyes@emmauel.qld.edu.au

2016 August Forum



International Mathematical Modelling Challenge

Peter Galbraith
The University of Queensland

Introduction

This short paper is designed to provide further information about the international mathematical modelling challenge that is outlined in the accompanying document from the sponsoring organisation: see (IM^2C 2016). As indicated on the website:

The purpose of the IM^2C is to promote the teaching of mathematical modelling and applications at all educational levels for all students. It is based on the firm belief that students and teachers need to experience the power of mathematics to help better understand, analyse and solve real world problems outside of mathematics itself – and to do so in realistic contexts. The Challenge has been established in the spirit of promoting educational change.

Linking this initiative to our own context, the very first aim for the Australian Mathematics Curriculum (ACARA 2016), reads as follows:

Mathematics aims to ensure that students: are confident, creative users and communicators of mathematics, able to investigate, represent and interpret situations in their personal and work lives and as active citizens.

We could also note that such purposes link closely with STEM priorities. It is a sentiment echoed in similar statements from an increasing number of countries. Interestingly one of these is Singapore, which, despite excelling in international testing regimes, knows that there are important mathematical abilities that cannot be tested by individual items, or formal examinations. The above goal is a clear statement of one of these.

A succinct summary of desired attributes to be developed in learners is usefully summarised in the USA core standards description of a mathematically proficient student. (CCSSI 2012).

Mathematically proficient students can apply what they know, are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using (mathematical) tools… They can analyse those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

In Australia, as in other places, lip service has been paid to such aims for many years, but the support necessary for their actualisation has been sadly lacking. Some states have taken the opportunity, within their own jurisdictions, to include a component on applications and mathematical modelling – others not at all. As readers will know, a number of schools in Queensland continue to provide students with outstanding abilities to apply their mathematical knowledge to problems derived from genuine real life situations. The assessment of some of those responsible for achieving such outcomes, is that quality tends to be uneven across the state, despite moderation processes.

As elaborated on their website, the IM²C believes that an important way to influence secondary school culture, and teaching and learning practices is to institute a high-level, prestigious secondary school contest – one that will have both national and international recognition. It has therefore founded the International Mathematical Modelling Challenge. This is a true team competition, held over a number of days, with students able to use any inanimate resources, such as books, technology of any kind, and internet resources. Real problems require a mix of different kinds of mathematics for their analysis and solution. And real problems take time and teamwork. The IM²C provides students with a deeper experience both of how mathematics can explain our world and what working with mathematics looks like.

Several Australian schools participated in the 2016 competition – including some from Queensland - although a short time line meant that publicity could not be as extensive as desired. In coming years, the Challenge, following the style of other major international contests, will consist of two rounds of competition. In the first round, national teams will work on a common problem and submit their solutions to an expert panel. This will be followed by a second round hosted each year by a different country, in which the national teams present their solutions in person and engage in additional modelling experiences together.

Australia is represented on the international organising committee of the IM²C, but additionally has constituted its own reference group. This group, hosted through ACER, has a role in facilitating the Australian component of the Challenge.
https://www.immchallenge.org.au/registration/rules

However, it has in mind a wider purpose in facilitating and supporting the teaching of mathematical modelling across the country. To that purpose it is producing *Support Materials* that will provide ideas, examples, and methods for teachers and students to access and use. While the materials will contain information directly relevant for those intending to participate in the Challenge, it is recognised that many may wish to enhance the teaching of applications and modelling without such participation. For example, to meet more completely, the ideals set out in curriculum statements. Consequently, the materials are being constructed in modular form, encompassing different layers of treatment and example. This means that individuals can select stand–alone material for the level and purpose that suits them and/or their students. The materials cover the range from introductory modelling (suitable for Primary school education) to advanced modelling such as is featured within the IM²C.

In addition to use by individual schools and teachers for curriculum purposes, the materials are being designed as resources suitable for use in teacher education programs, both pre-service and in-service.

A word of warning: Looking at some of the examples provided by the IM²C can be startling, when it is seen what extraordinary mathematics can be produced by students when they are enabled to run free, guided by an authentic understanding of what it means to apply mathematics, and to evaluate outcomes. Not all can reach the highest standards obtained, but on the basis of past initiatives, it can be confidently claimed that students are capable of far more than they have been allowed to achieve in the past. It is not the intention here to elaborate on the detail contained in support materials, but the following outline will indicate the type of approach that characterises the kind of mathematical modelling that is being promoted.

Mathematical Modelling as real world problem solving

Children are natural modellers. For example, they know that often '1 = 2' provides an equitable solution to the problem of sharing lollies of different sizes (one big lolly equals two smaller ones). Yet formal schooling so often robs initiative in the name of conformity. Modelling as real world problem solving begins from an assumption that mathematics is everywhere in the world around us – a challenge is to identify its presence, access it, and apply it productively. As noted above, international and national educational bodies increasingly avow that students should have a mathematical preparation which equips them to use their acquired mathematical knowledge in their personal lives, as citizens, and in the workplace.

Such a purpose implies two intersecting goals. Firstly, to develop a systematic and successful approach to addressing individual problems located in real world settings, and secondly through this means, to enable students cumulatively to become real world problem solvers. Ultimately, the latter means that they not only can productively address problems set by others, but become able to identify and address problems that matter to them.

A Framework for Mathematical Modelling

Over many years a cyclic process has been developed and refined as a scaffolding aid for those learning and applying a modelling process to solve real problems. It is an authentic process – in the sense that it is consistent with the way professional modellers approach problems in their field. One representation of the process is shown below.

1. Identify a (real world) problem
2. Specify a related mathematical question(s)
3. Formulate a mathematical model to address the question (involves making assumptions, choosing variables, estimating magnitudes of inputs etc.)
4. Solve the mathematics
5. Interpret the mathematical results in terms of their real world meanings
6. Make a judgment as to the adequacy of the solution to the original question(s)
7. Either report on success or make adjustments and try for a better solution.

The cyclic nature of the process can be understood by considering the circumstance where a first solution is deemed inadequate in terms of criteria applied in 6. As 7 indicates, the problem then needs to be re-addressed, which involves revising the solution through revisiting earlier stages of the process (e.g. 3, 4, 5, and 6), and this may need to be carried out several times. Sometimes an extension or refinement of the original problem is suggested by the outcome of a first modelling endeavour, and further cycles of activity are then conducted. Of particular importance is the realisation that it is the problem and its solution that drives the modelling processes, and the choices that the modellers consequently make. For the modeller the activity is usually anything but smoothly cyclic, because checking, testing and evaluating means that there is frequent movement within and between intermediate stages of the total process. Various versions of the modelling cycle exist, but they all contain the same essentials and ordering of stages as the above.

Report Writing

Every modelling project needs to be communicated coherently and comprehensively to an audience. While reports may vary in style and detail they should always contain information that gives a complete picture of what the modelling has achieved. In debates about assessment one common and relevant theme seems to involve arguments which set timed examinations against assignment work. It needs to be emphasised that modelling report writing is not ‘busy work’ it is highly targeted and mathematics intensive, as illustrated in the reports of student teams included on the IM^{2}C website.

In an Olympic year we might consider the quite different attributes required in different events, and the different methods needed for assessing performances in them. For track events put everyone eligible on the track at the same time, and use one simple measure – time to complete the event. Not too different from the idea of a common examination.

For events such as diving and gymnastics assessment is more complex – involving the application of agreed criteria and based on the combined opinion of knowledgeable experts. This is much more in the vein of mathematical modelling. Something is lost when debates on assessment practices try to impose simplistic generalisations across different types of learning, especially when based on personal preference rather than considered validity. In terms of modelling report writing the following gives an idea of what is required, and what has been displayed in the work of student teams included on the Challenge website.
Since models are designed to address particular problems, in specific situations, they must be capable of being evaluated and used by others, and so need to be communicated clearly and fully. This involves:

- Describing the real-world problem being addressed.
- Specifying the resulting mathematical questions precisely
- Listing all assumptions and their justification
- Indicating sources of imported information (e.g. websites)
- Indicating how numerical values used in calculations were decided on
- Showing and justifying all mathematical working
- Setting out all mathematical working, graphs, tables, etc.
- Interpreting mathematical results in terms of the real world problem
- Evaluating the result – does your answer make sense? Does it help to answer the problem?
- Dealing with refinements to the original problem
- Are there qualifications you want to make about your solution?
- What recommendations arise from the work? What further work is needed?

In practice several of these activities can occur at the same time. For example, obtaining a mathematical result, interpreting it, and evaluating its correctness or relevance, are aspects that are often dealt with together.

This short summary is intended to provide some reference points from which to understand the purpose and substance of the modelling initiative. In that respect the dates on the flier refer only to the 2017 Challenge – other development and support activity from within the parallel Australian initiative is ongoing. At a later date a more expansive paper on the Australian initiative and support materials is envisaged.

Spelling as 'modeling' occurs when quoting from a US source document.

References

ACARA. (2016). *Australian Curriculum: Mathematics Aims.* Retrieved 27 October 2016 from http://www.australiancurriculum.edu.au/mathematics/aims

CCSSI. (2012). *Mathematics: Standards for Mathematical Practice - Model with Mathematics*. http://www.corestandards.org/Math/Practice/MP4

IM^{2}C. (2016). *International Mathematical Modeling Challenge*. http://immchallenge.org/

(IM²C international mathematical modeling challenge)

An opportunity for senior secondary students to work as part of a team to solve a genuine, real-world problem using mathematics.

14 March – 7 April 2017

Completely free to enter, and open to all Australian schools, the International Mathematical Modeling Challenge (IM²C) exists to support the real-world application of learning, build proficiency, encourage collaboration, and challenge students to use mathematics to make a real difference to the world around them.

Operating in teams, comprising up to four students from the same school, the IM²C challenges students around the world to work together to solve a common real-world problem by devising and applying an original mathematical model.

By mobilising students in teams, the IM²C replicates real-world conditions, requiring proficiency in mathematics alongside collaboration and contributions from different skill sets, perspectives and methodologies to achieve overall success.

Working together under the supervision of a team advisor (usually a teacher) for up to five consecutive days between March and May, teams will unpack the given problem, hypothesise, test, and develop a working solution, before preparing and submitting a report on their solution to the Australian judging panel.

Two teams will be chosen to represent Australia in the International phase of the competition, with their solutions competing against others from countries around the world.

For further information and to register, please visit

www.immchallenge.org.au

ACER

The International Mathematical Modelling Challenge (IM²C) in Australia is organised and implemented by the Australian Council *for* Educational Research (ACER), and under the guidance of a national advisory group.

About reSolve: Maths by inquiry

Peter Cooper
reSolve Outreach Officer, Qld
pcooper@aamt.edu.au

Many of you by now will have heard something about project 'reSolve: Maths by inquiry'. So what's it all about?

ReSolve is a federally funded initiative which sets out to build teaching quality in the 'fraught' area often referred to as 'problem solving' or 'thinking mathematically'. Recent reports have shown that mathematics programs across Australia are not delivering enough of the innovative problem solving thinkers need to come up with solutions to the many challenging problems and research initiatives which Australia now faces. The project, which is managed by the Australian Academy of Science (AAS) and delivered by the Australian Association of Mathematics Teachers (AAMT), aims to provide teachers with the resources and professional knowledge to build real, relevant, and quality mathematical thinking in and with their students. The protocol used to ensure the materials are authentic and of high quality states that reSolve learning experiences are

- purposeful
- challenging and engaging, yet accessible, and
- promoting a supportive, knowledge-building culture

The fact that all reSolve learning experiences are 'purposeful' means not only that they provide teaching and learning opportunities directed to stated ACARA descriptors but also that they can be built into your existing maths programs in the units where these descriptors are targeted. Because the lessons do target identified descriptors they are not delimited like many of the existing 'Inquiry' approaches you may be familiar with. To emphasise the purposeful nature of the reSolve lessons, we use a lower-case 'i' to describe our approach.

If you would like to read more about the reSolve protocols, structure and materials, an informative newsletter has just been produced (Newsletter #2, November; link below). The project is funded in its current form until the middle of 2018.

How do you get involved with reSolve?
The project is federally funded so there are no charges to teachers or schools for the materials and support offered through the project. Teachers, curriculum co-ordinators and HoDs can engage with the project either as individuals or as part of a group. To get started, teachers should register with the project by completing an Expression of Interest (EoI; link below) – this is a non-binding agreement which is used to let the project officers know to contact you, and also for the Federal bean counters to get an idea of how many people are linking to the materials. Once this is done, you will be invited to join the reSolve wikispace so that you can access all the reSolve materials and also be contacted by the Queensland project officer (that's me! - contacts below).

So what happens?
The first step is for you to choose a lesson or sequence of lessons to trial with your classes. I can help with this if needed. The lessons are extremely well designed around the descriptors, detailed, and clearly scripted by the project program writers (who are all very competent teachers). The preparation needed to deliver a lesson is really only reading through and understanding the lesson plan and collecting the resources. The resources and manipulatives are those available in pretty well all schools and do

not require the purchase of special 'one-offs' or software. Since the lessons are really engaging they can be used as stand-alone or included in your program. You can trial the lessons on your own or (if distance and time permits) ask me to come along to your class so that we can then debrief about your experience and the materials and consider what you might do next. Either way, once you and your students have had a couple of good experiences with the materials we can look at how you might embed the existing and new materials in your program and explore how to use the Professional Learning Modules (PLMs) to enable you to design or share your own 'inquiries' and experiences.

Will you and your students enjoy the inquiry lessons available from reSolve?
Almost certainly you will. I have been in many classrooms trialling the reSolve materials over the past two months and in every case there has been a positive outcome. Teachers and students do enjoy these lessons and as a result you can expect the students to be meaningfully engaged and behave much better than in a 'normal' class. Students want to complete and explore the activities, and will often bring new solutions to the teachers later in the day, or after homework. They will also tell you that they enjoyed the lesson, and chatter happily to parents and school administrators about what it was they enjoyed.

.. and in the longer term, how is this sustainable?

The project will deliver eight distinct inquiry sequences (more than eight lessons in many cases) for each year level from F – 10. Teachers may use these as they see fit in their programs. Eight inquiry lessons in a year (two per five-week unit, perhaps) while being a substantial contribution is unlikely to meet all the needs of a year level maths program. From the start of next year, the project managers will identify and train up to thirty teachers in each State to be 'reSolve Champions'. The 'champions' will be offered at least four days professional development (most likely at ANU). The reSolve champions will support a local 'reSolve community' and network which will encourage the sharing and trialling of resources, deliver the PLMs and work with teachers to improve the pedagogy around 'inquiries'. They will also act as a clearing house to develop and share modified and new materials.

So where do you find all the materials and information?

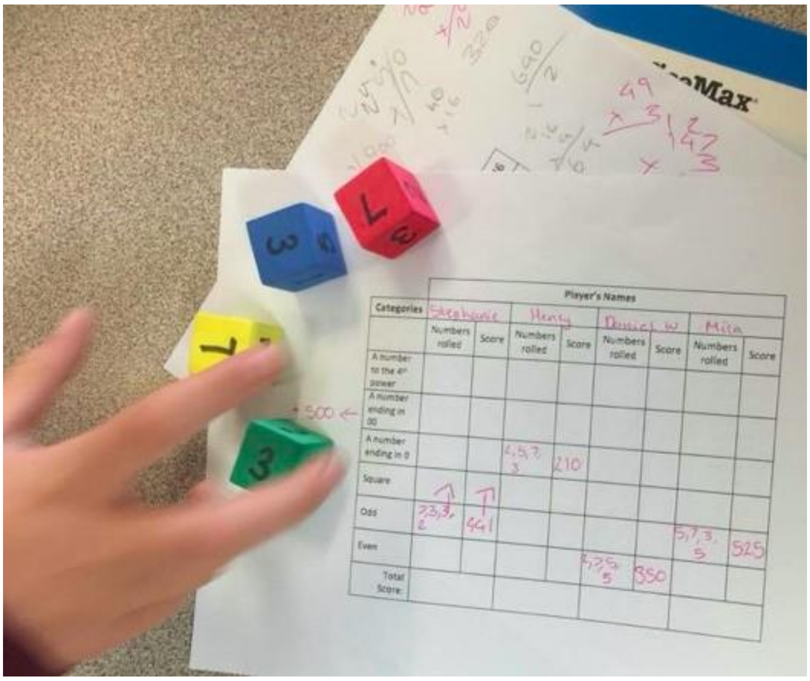
More information; the November Newsletter:
https://www.science.org.au/resolve-newsletter/resolve-newsletter-issue-2
Note: searching for 'resolve MBI' on the web will link to many other reSolve articles

Joining the project through the EoI process: http://tiny.cc/mbi-eoi-trialling, or:
https://docs.google.com/a/aamt.edu.au/forms/d/e/1FAIpQLSfjY3j3rGM0LPake0RL-Op-mCk1XrpB-LDS7d_FHh1RcdF-zQ/viewform

For any further help with registering or for more information, please contact me.
Please note: the EQ network is unhappy with connecting to wikispace, google docs, or dropbox – to access many of these links and most materials you may have to use your home computer or tablet, or use you CFT on a public or home internet.

Other opportunities to share your ideas and experiences with reSolve:

reSolve Facebook group
follow @resolveMBI on Twitter
pcooper@aamt.edu.au



Stephanie who rolls 3, 7, 3, 7 with the dice, moving her score from the space that says odd to the one that says square. Danielle, who was in Stephanie's group, got really excited later when she managed to roll four 7s and score 2401 in the space that says "A number to the fourth power".

The students were given the challenge of expressing the numbers from 1 to 120 as the sum of squares.

Positive Mathematics for Indigenous Students

Conference 2017

Mount St Bernard College
Herberton
2nd-3rd March 2017

MOUNT ST BERNARD COLLEGE

Mercy traditions • Spirited learning • Building futures

Keynote Speakers

Emeritus Profesor Alan Bishop

Monash University (Education)

Professor Robyn Jorgensen

University of Canberra (Education - STEM)

A series of workshops that focus on:

- Sharing success criteria
- Classroom walkthroughs
- Algebra with Indigenous students
- Using data, assessment and feedback
- Nurturing a positive attitude to learning
- Differentiation in the Mathematics classroom
- Teachers networking with teachers about teaching
- Strategies to accelerate progress in order to help **Close the Gap**
- Inclusive pedagogical strategies for delivering mathematics curriculum

Further information may be found at:

www.maths446.wixsite.com/pm4is-2017

maths@msb.qld.edu.au

Teaching Ideas

Programming in Mathematica®

Miles Ford
St Johns Anglican College

The following excerpts are from an assignment set for Year Twelve Mathematics B students in Semester Two. The assessment is part of the unit on the application of geometric progressions to financial contexts. It is an open task, but has at its core the requirement for students to write a program to produce their own finance calculator.

> Finance Calculator
>
> Using *Mathematica*, build your own financial calculator tool.
>
> It can focus on any particular context you wish to consider, be it loans (home, car, credit cards, etc…), investments (share market, superannuation, etc…), comparisons of options (rent vs buy, saving vs loaning, etc…) or other. The scope of your calculator can be broad or specific, performing a number of different functions or focusing on analysing one context in depth.
>
> **Examine other calculators** freely available online (a short list to get you started is on the following page) to consider existing products. Choose a type you want to focus on and **comment on what factors similar calculators do and don't account for**. You will develop your calculator with the focus on improving on these existing products with regard to their calculations, not necessarily their appearance.
>
> **Develop *Mathematica* code** to implement your equations and compare its results to hand calculations using test data to confirm it works.

With this assessment as the background we will now investigate how to composite basic functions in order to teach students how to write programs in *Mathematica*.

Consider the following simple calculation:

1. What is the effective interest rate of 5% p.a. compounding monthly?

All operations performed in *Mathematica* are done using functions. This makes it an incredibly useful platform for helping to show students how composite functions work. As such I have deliberately emphasised the composition of the functions used, using the form $f[g[x]]$.

Mathematica has a function called $EffectiveInterest[r,c]$, which calculates the effective interest given the interest rate (r), as a decimal, and the compounding term (c), as a fraction of a year:

In[6]:= EffectiveInterest$\left[\frac{5}{100}, \frac{1}{12}\right]$

Out[6]= $\frac{1\,868\,450\,286\,128\,943\,065\,061\,084\,481}{36\,520\,347\,436\,056\,576\,000\,000\,000\,000}$

An important thing to note about *Mathematica* is that it uses exact value. To round off, take the $EffectiveInterest$ function and put that inside the $Round[x, n]$ function, where x is the value to be rounded and it is rounded to the nearest multiple of n; creating the composite function $Round[EffectiveInterest[r, c], n]$:

```
In[12]:= Round[EffectiveInterest[5/100, 1/12], 0.0001]

Out[12]= 0.0512
```

This is a more easily understood solution.

Now consider a calculation that would use the former calculation:

2. Gene has $1000 that she invests at 5% p.a. compounding monthly. How much will she have after 8 years?

Mathematica's $TimeValue[p, r, t]$ function determines the future value of a principal (p), at a given interest rate (r), over a number of years (t). To again keep the numbers recognisable round the value off to the nearest hundredth. This process creates the composite function: $Round[TimeValue[p, EffectiveInterest[r, c], t], n]$.

```
In[14]:= Round[TimeValue[1000, EffectiveInterest[5/100, 1/12], 8], 0.01]

Out[14]= 1490.59
```

So far *Mathematica* is basically operating as a calculator. To solve a problem with a principal of $300 at 3% p.a. compounding weekly for 5 years the values can be changed and the function re-executed.

But by using parameters instead of specific values the code can be easily converted to solve for any values within a specified range.

The function $Manipulate[e, p]$ allows us to add parameters (p) to a specific expression (e).

1. Composite our existing calculation (e) within a $Manipulate[]$ function
2. Change the constant values to parameters with relevant names (in blue)
3. State what the range of possible values are for each parameter

```
Manipulate[Round[TimeValue[principal, EffectiveInterest[rate/100, 1/cterm], years], 0.01],
 {principal, 100, 100 000, 100, Appearance → "Labeled"},
 {rate, 0, 10, 0.5, Appearance → "Labeled"},
 {years, 1, 20, 0.5, Appearance → "Labeled"},
 {cterm, {1, 12, 26, 52, 365}, ControlType → Setter}]
```

There are rules around choosing names and different conventions in different programming circles. Avoid spaces and start with a lower case letter in most cases.

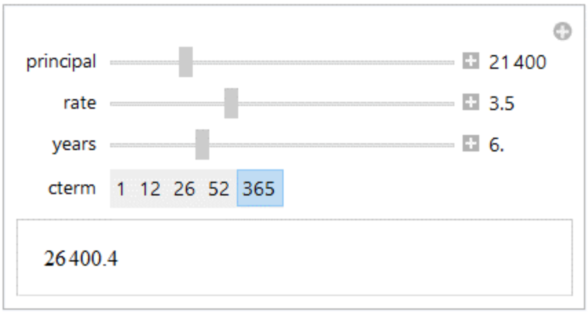
Most of the parameters are of the form: {name, lowest value, highest value, step size, other options}

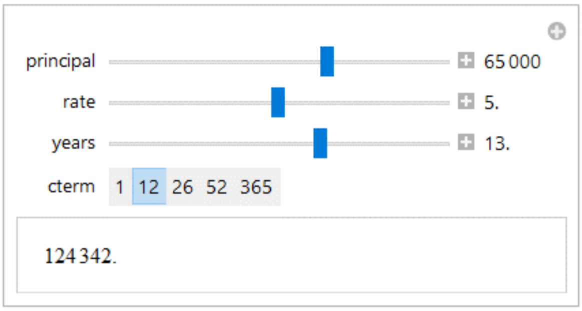
For example: `{principal, 100, 100 000, 100, Appearance → "Labeled"},`

This can be read as "a parameter called principal that can range from 100 to 100 000, increasing in lots of 100, with the current value visible".

$cterm$ is different in that it doesn't have lowest, highest and step values, but instead has a specified list of possible values: {1, 12, 26, 52, 365}. It also doesn't use a sliding bar to choose the current value but instead presents the set list of options.

This program can accept a range of values for each parameter and can perform the calculation with live updating as changes are made.

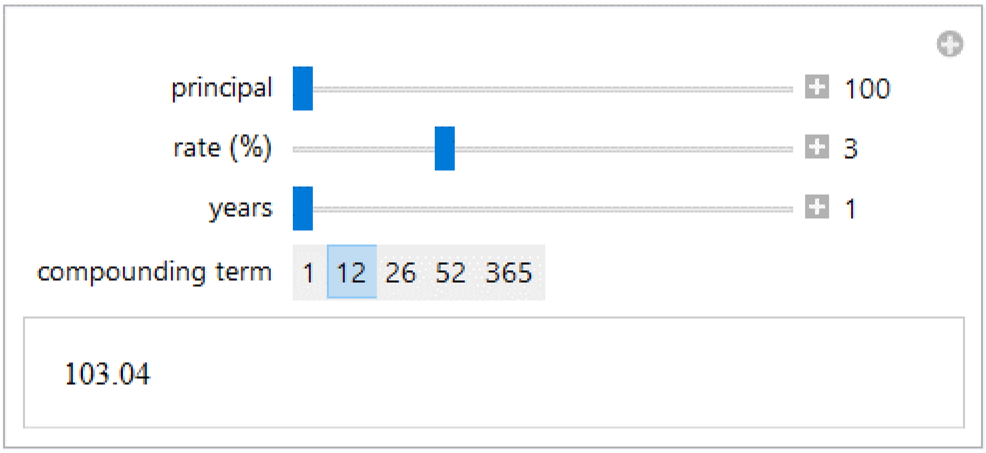




The user interface can be improved by giving the parameters more informative headings, rather than just the name, and setting starting values, rather than defaulting to the lowest value.

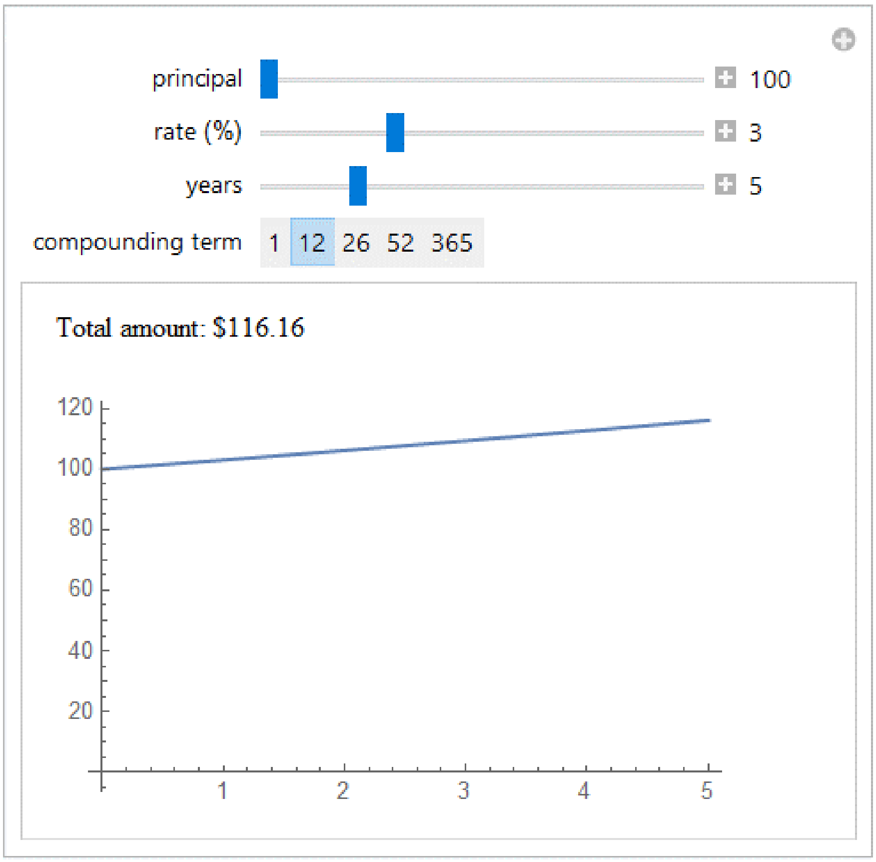
```
Manipulate[Round[TimeValue[principal, EffectiveInterest[rate/100, 1/cterm], years], 0.01],
 {principal, 100, 100 000, 100, Appearance → "Labeled"},
 {{rate, 3, "rate (%)"}, 0, 10, 0.5, Appearance → "Labeled"},
 {years, 1, 20, 0.5, Appearance → "Labeled"},
 {{cterm, 12, "compounding term"}, {1, 12, 26, 52, 365}, ControlType → Setter}]
```

These changes set the starting interest rate to 3 and give it the title "rate (%)" and set the starting compounding term to 12 and give it the title "compounding term".



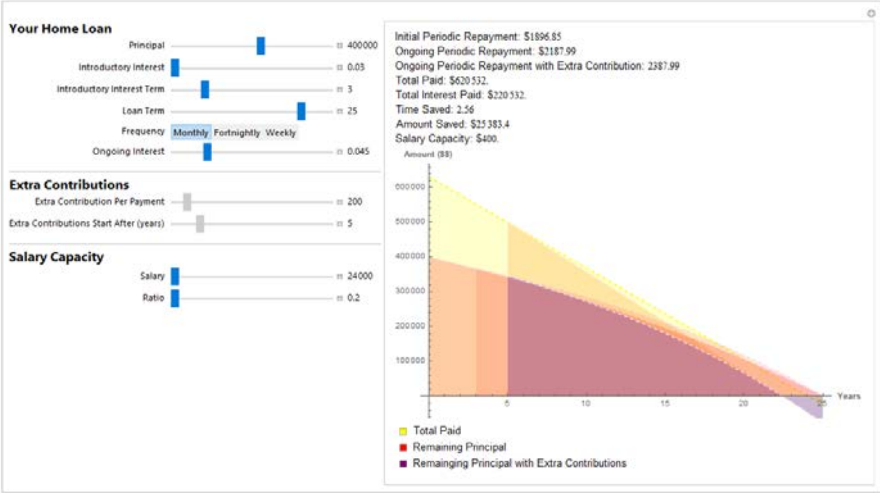
Further adjustments can be made to make the calculator more useful and visually appropriate. The following code adds in a graph of the compound growth and adds some formatting code, in the form of $Column$[] and Row[], to better present the output. It also includes code comments, marked with (* and *) within the program to assist with understanding the code.

```
Manipulate[ (* future value calculator *)
 Column[{
   Row[{
     (* calculate future value *)
     "Total amount: $",
     Round[TimeValue[principal, EffectiveInterest[rate/100, 1/cterm], years], 0.01]}],

   (* add a blank line between the calculation and plot *)
   "",

   (* plot of future value over time *)
   Plot[TimeValue[principal, EffectiveInterest[rate/100, 1/cterm], time],
    {time, 0, years}, AxesOrigin → {0, 0}, ImageSize → 300]}],

  (* manipulate variables *)
  {principal, 100, 100 000, 100, Appearance → "Labeled"},
  {{rate, 3, "rate (%)"}, 0, 10, 0.5, Appearance → "Labeled"},
  {{years, 5}, 1, 20, 0.5, Appearance → "Labeled"},
  {{cterm, 12, "compounding term"}, {1, 12, 26, 52, 365}, ControlType → Setter}]
```

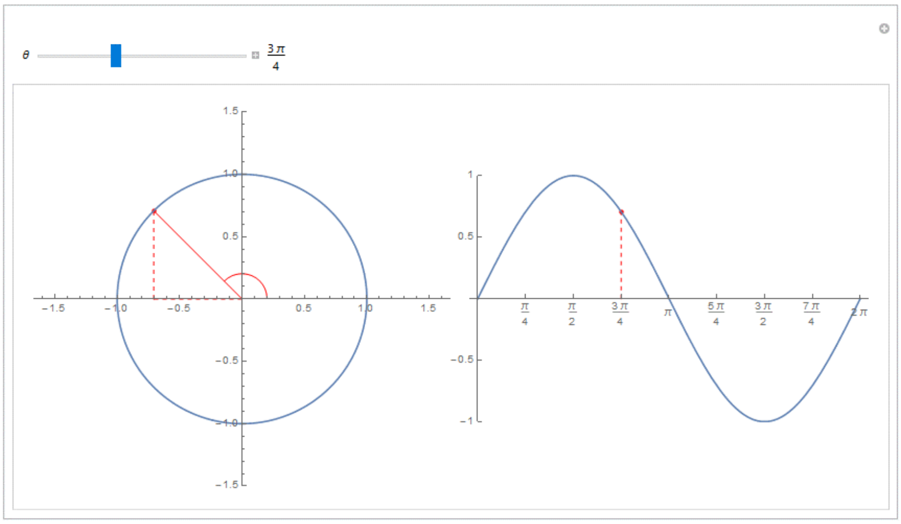


These same basic principles can be applied to any mathematical process; enabling students to develop dynamic representations across a range of different concepts.

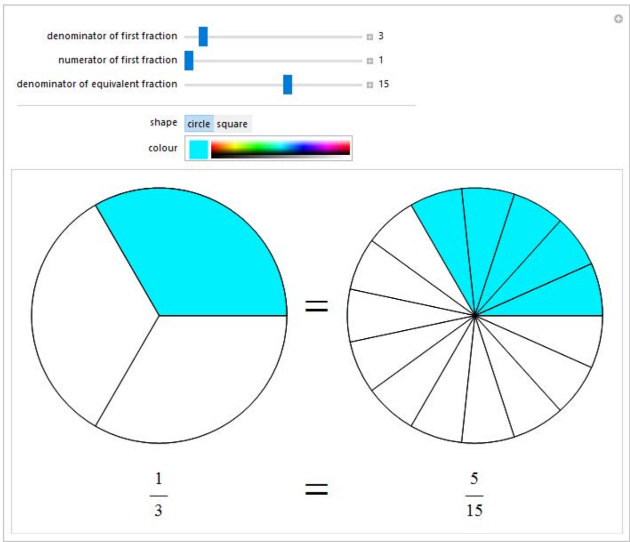
Home loan calculator



Trigonometric graphs



Fraction equivalence



Squares and Cubes

Peter Fox
Texas Instruments Australia

A great question to ask students: "What is the sum of the first 100 numbers?" The question becomes relatively trivial when students have a formula in front of them. It is a much more powerful question when students have to work it out for themselves. There are so many ways for students to work out a solution to this problem. At the same time, teacher can use this opportunity to highlight that 'working out' is at least as important as the answer. If I was only interested in the answer then I could have used a calculator, spreadsheet or the internet to work it out.

In year 7 students will often add the first 10 numbers to arrive at 55 and then multiple the answer by 10 to erroneously arrive at 550 as the sum of the first 100 numbers. To help convince these students that their approach doesn't work, ask them to add up the first 20 numbers and multiply the answer by 5. Does this produce the same answer? The student's original line of thinking however can be used to identify a strategy (Option 3), although somewhat more complicated than Option 1 or 2 below. If the emphasis is on *student* thinking then students should be encouraged to continue to work out their answer using their own methods. The 'answer' is only being used to verify that the student is using a *successful* strategy. To ensure the strategy is successful, students may be asked to find the sum of the first 200 numbers or perhaps more complicated; the sum of the first 150 numbers.

Students should be encouraged to generalise their approach using 'words' such as: "Square the biggest number, add on the biggest number to this amount and then half the result. …". The purpose of writing their formula in words is to then help students realise that the 'algebraic' representation is much simpler to express their procedure. Students should also be encouraged to share their strategies and identify if any of them are the same.

A range of grouping strategies for adding up the numbers from 1 to 100 are provided here
Grouping – Option 1:

$1 + 2 + 3 + 4 \dots 49 + 50 + 51 + 96 + 97 + 98 + 99 + 100$
$= (1 + 99) + (2 + 98) + (3 + 97) + (4 + 96) \dots + (49 + 51) + 100 + 50$
$= 50 \times 100 + 50$
$= 5050$

Grouping – Option 2:

$1 + 2 + 3 + 4 \dots 49 + 50 + 51 + 96 + 97 + 98 + 99 + 100$
$= (1 + 101) + (2 + 99) + (3 + 98) + \dots (50 + 51)$
$= 50 \times 101$
$= 5050$

Grouping – Option 3:

$1 + 2 + 3 + 4 \dots 49 + 50 + 51 + 96 + 97 + 98 + 99 + 100$
$= (1 + 2 + \dots 9) + (10 + 10 + \dots 10) + (1 + 2 + \dots 9) + (20 + 20 + \dots 20) \dots$
$= 10 \times (1 + 2 + 3 + 4 \dots 9) + 10 \times (10 + 20 + 30 + 40 \dots 90) + 100$

Grouping – Option 4:

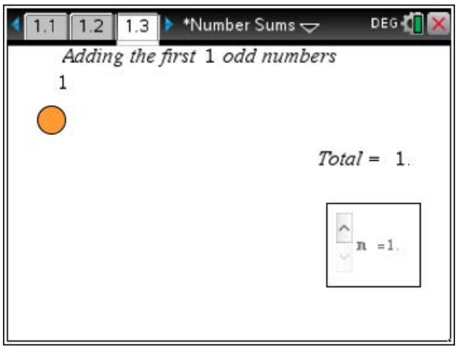
$1 + 2 + 3 + 4 \dots 49 + 50 + 51 + 96 + 97 + 98 + 99 + 100$
$= 1 + 3 + 5 + 7 + 9 \dots 99 + 2 + 4 + 6 + 8 + \dots 100$
$= 50^2 + 50^2 + 50$

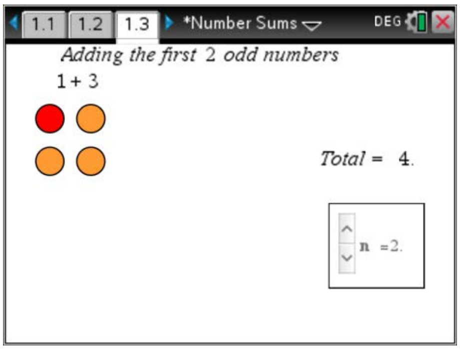
There are other ways to help students *see* how to find the sum of the first *n* whole numbers. Consider the sequence of patterns below:

Start by adding up all the odd numbers.

Visually these can construct a square.

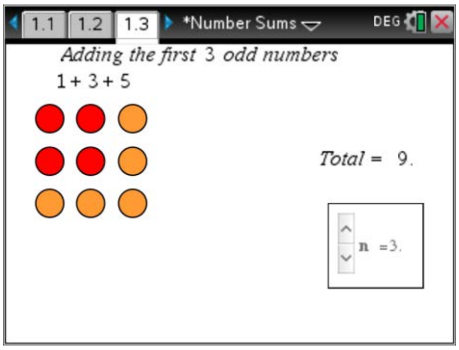
The first 3 odd numbers is 3^2.

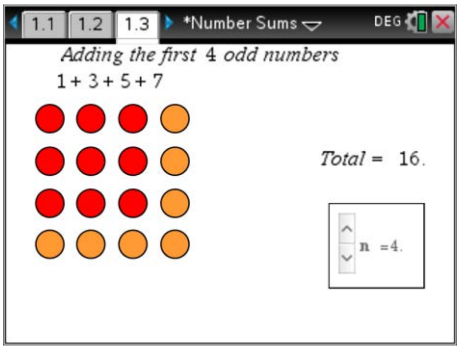




The sum of the first n odd numbers is n^2.

This pattern is very obvious from the diagrams.





Using this approach the sum of the first *n* odd numbers is n^2. The sum of the first *n* even numbers can be found using the following comparison:

1 + 3 + 5 + 7 + …
2 + 4 + 6 + 8 + …

Notice that each even number is just one more than the corresponding odd number. So the sum of the first *n* even numbers is *n* more than the sum of the first *n* odd numbers. The sum of the first *n* even numbers is therefore $n^2 + n$. Now compare this to the sum of the first *n* whole numbers:

2 + 4 + 6 + 8 + …

1 + 2 + 3 + 4 …

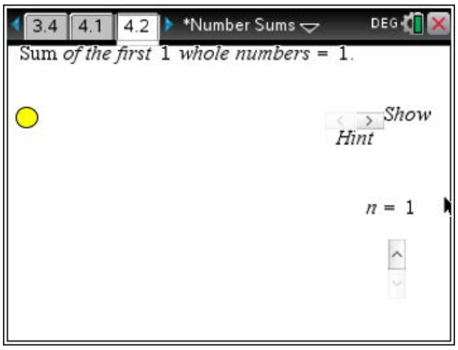
It follows that the sum of the first *n* whole numbers is half the sum of the evens, resulting in the formula:

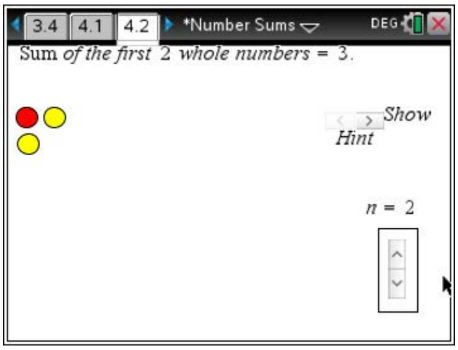
$$\sum_{x=1}^{n} x = \frac{n^2 + n}{2}$$

Another option here is to start with a rectangle.

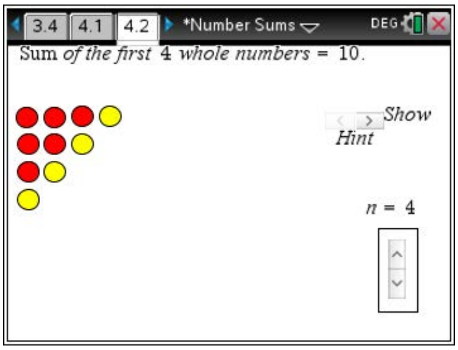
In this example a triangle is gradually formed on the left hand side.

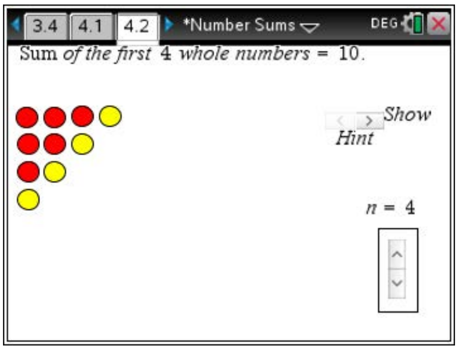
This problem may also be familiar as the ‘stacking problem’, just turned on its side.



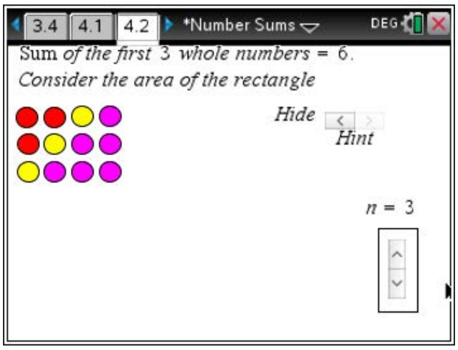


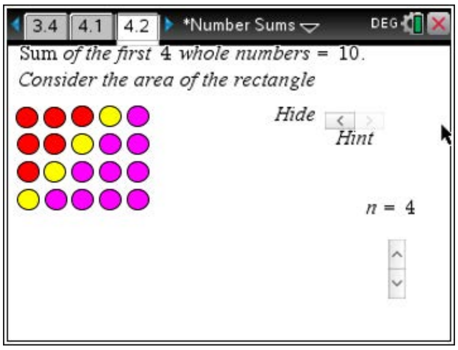
This approach is not obvious until the ‘hint’ is displayed using the slider on the right.





The hint shows a rectangle that is twice the size of the amount we are trying to compute.





The dimensions of the rectangle are n by (n+1) so the ‘area’ of the shape is:

$$\frac{n(n+1)}{2}$$

The visual approach to this problem is very powerful, it also helps students reconstruct the formula when they are encouraged to create links between the image and the formula.

It must be clear that the evidence presented so far does not constitute a proof, this can be left to students in Years 11 and 12 where proof by induction is relatively straight forward method of *proving* the result.

Show true for n = 1

$$\frac{1\times(1+1)}{2}=1$$

Assume true for n:

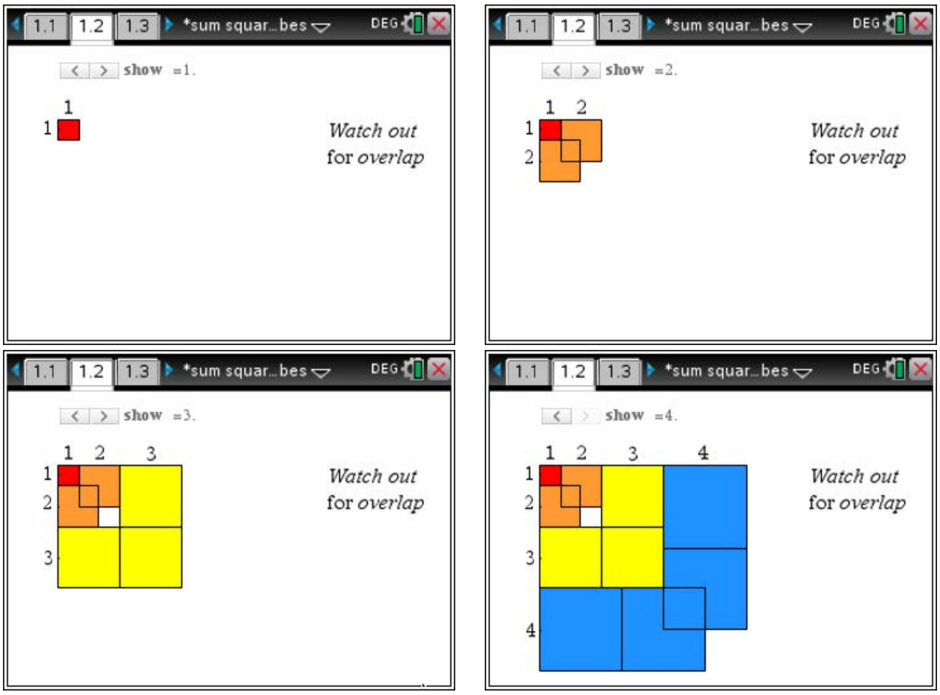
$$\sum_{x=1}^{n} x = \frac{n(n+1)}{2}$$

Show true for n + 1:

$$\sum_{x=1}^{n+1} x = \frac{(n+1)(n+2)}{2} = \frac{n(n+1)}{2} + (n+1) \quad \text{[RHS = Original sum plus next number } n+1 \text{]}$$

$$= \frac{n(n+1)}{2} + \frac{2(n+1)}{2}$$

$$= \frac{(n+2)(n+1)}{2}$$



In the second diagram imagine the 2 x 2 squares as being 2 pieces of paper. The overlap would fit nicely into the 'gap' to form a 3 x 3 square.

In the third diagram there are 3 pieces of paper that have been added, each one is a 3 × 3 square.

In the fourth diagram there are four more pieces of 4 × 4 papers added. Once again the small gap left over could be filled using the overlap of the 4 × 4 squares.

Study the diagrams carefully. Consider the overall dimensions of the shape. The area of the overall shape can be determined in two ways:

Option 1:

$$\left(\sum_{x=1}^{n} x\right)^2$$ … This represents the overall dimensions being the sum 1 + 2 + 3 … then squared.

Option 2:

$\sum_{x=1}^{n} x^3$ ... Consider the successive shapes 1 × (1 × 1), then 1 × (1 × 1) + 2 × (2 × 2) , and the

third shape: 1 × (1 × 1) + 2 × (2 × 2) + 3 × (3 × 3) which can be summarised as: $1^3 + 2^3 + 3^3$ ..

This means that:

$$\left(\sum_{x=1}^{n} x\right)^2 = \left(\sum_{x=1}^{n} x^3\right)$$

Since we have already computed the sum of the first *n* whole numbers then we can write the sum of the first *n* cubed numbers as:

$$\left(\sum_{x=1}^{n} x^3\right) = \left(\frac{n(n+1)}{2}\right)^2 = \frac{n^2(n+1)^2}{4}$$

[Readers are encouraged to check this formula or perhaps prove by induction!]

Of course if you're not convinced about the beauty of mathematics just yet, consider the following:

$$\sum_{x=1}^{n} x = \frac{n(n+1)}{2} = \frac{1}{2}n^2 + \frac{1}{2}n$$

$$\sum_{x=1}^{n} x^2 = \frac{n(n+1)(2n+1)}{6} = \frac{1}{3}n^3 + \frac{1}{2}n^2 + \frac{1}{6}n$$

$$\sum_{x=1}^{n} x^3 = \frac{n^2(n+1)^2}{4} = \frac{1}{4}n^4 + \frac{1}{2}n^3 + \frac{1}{4}n^2$$

$$\sum_{x=1}^{n} x^4 = \frac{n(n+1)(6n^3+9n^2+n-1)}{30} = \frac{1}{5}n^5 + \frac{1}{2}n^4 + \frac{1}{3}n^3 - \frac{1}{30}n$$

What do all the factorised expressions have in common? Why?

Calculate the sum of the coefficients in each polynomial. What do you get? Why?

Could you write down the first two terms of the next sum?

So we have seen a simple 'sum of the first n whole numbers', a problem for years 7 and 8 turn into a lovely introduction to polynomials for students in year 11 including proofs by induction. The task also highlights how different representations of a polynomial reveal different patterns or information about the problem.

If you like the visual approach, try asking your students produce a visual approach for the sum of the first n^2 numbers.

Note - These activities, and more, can be downloaded for free from Texas Instruments website http://education.ti.com/australia

Look for the "Senior Nspired Curriculum" and "Australian Nspired Curriculum" activity pages. Teachers can also see how these problems are produced and solved by tuning into the free webinars.

EARLY QLD WRITERS

H K POWELL

223. *The Inverses of Stewart's Theorem.*

If A^1 and B^1 are the inverse points of A and B respectively with respect to a circle, centre O, raduis k, the formulae for converting lengths are :

$$OA = \frac{k^2}{OA^1}\ ;\quad OB = \frac{k^2}{OB^1}\ ;$$

$$AB = \frac{k^2}{OA^1.OB^1}\ .A^1B^1.$$

If A, B, C are three points taken in order on a straight line, and if P is any other point either on the line or not on the line,

$$PA^2.BC-PB^2.AC+PC^2.AB=AB.BC.AC.$$

(This theorem is also true whether A, B, C are taken in order or not, provided directed lengths are used, and is generally referred to as Stewart's theorem.)

(i) Take P not on the line and invert with respect to P. Using the conversion formulae, we get the following : P, A, B, C are four points taken in order around a circle. Then

$$PB.PC.BC+PA.PB.AB=PA.PC.AC+AB.BC.AC.$$

(This is easily proved by writing down the area of the quadrilateral as the sum of the areas of two triangles and using $\frac{a}{\sin A} = 2R$

(ii) Invert with respect to any point O not on the line. Then we get the following complicated theorem :

O, A, B, C are four points taken in order around a circle. P is any other point either on or not on the circle. Then

$$PA^2.OB.OC.BC+PC^2.OA.OB.AB$$
$$=PB^2.OA.OC.AC+OP^2.AB.BC.AC.$$

(To prove this (without inversion) is not simple. A proof using coordinate geometry and determinants is given in Charles Smith's "Conic Sections", p. 99, Ex. 7, for the case when P is in the plane of the circle. This may be easily extended to the case when P is not in the plane of the circle, by taking the plane of the circle as the XY plane.)

(iii) If the centre of inversion O is on the line AB, the formulae for converting the length AB is

$$AB= \frac{k^2}{OA^1.OB^1}\ B^1A^1,$$

where the lengths are directed lengths.

(a) In Stewart's theorem, take P on the line ABC and use directed lengths. Invert with respect to P.
This if P, A, B, C are any four points on a line, (i) holds provided all the lengths are directed lengths.

(b) Invert with respect to any point O on the line. Then if O, P, A, B, C are any five points on a line, (ii) holds provided all the lengths are divided lengths.

Use of Vectors for the Nine Points Circle Property.

In what follows, the reader will easily supply his own figure. Let ABC be a triangle, O the circumcentre, H the orthocentre; D,E,F the middle points of BC, CA, AB respectively, and X the middle point of AH. Let the position vectors of A,B,C referred to O as origin be α, β, γ respectively. For shortness we shall say that the point whose position vector referred to O is μ is the point μ. Then D,E,F are the points $\frac{\beta+\gamma}{2}$, $\frac{\gamma+\alpha}{2}$, $\frac{\alpha+\beta}{2}$ respectively.
If N is the centre of the circle through D,E,F, the vectors ND, NE, NF must have equal magnitudes, Since the magnitudes of α,β,γ are all equal to the radius of the circumcircle (R), it is evident that N is the point $\frac{\alpha+\beta+\gamma}{2}$ and the radius of the circle is $\frac{R}{2}$.
H is the point $\alpha+\beta+\gamma$, for the distance from a vertex to the orthocentre is twice the distance from the circumcentre to the opposite side. (Alternatively, we may show that the point $\alpha+\beta+\gamma$ is H by dot products. For the join of A to this point is $\beta+\gamma$ and the dot product of this with BC is $\gamma^2-\beta^2$, i.e. zero, and there are similar results for the other sides.) The mid-point of AH , namely X, is the point $\alpha+\frac{\beta+\gamma}{2}$.

$\therefore NX$ is the vector $\frac{\alpha}{2}$, and since ND is the vector $-\frac{\alpha}{2}$, it follows that XD is a diameter of the circle $\therefore$ The circle passes through X and through the foot of the perpendicular from A to BC. By similar reasoning it passes through the middle points of BH and CH and through the feet of the other two perpendiculars

Answers to Student Problems

Volume 41, Number 2

1. $b^{x^2+5} - (b^{10})^3 = 0$

$b^{x^2+5} = (b^{10})^3$

$b^{x^2+5} = b^{30}$

Equate indices

$x^2 + 5 = 30$

$x^2 = 25$

$x = 5 \;\; or \; x = -5$

2. $0.\dot{0}\overline{5} + 0.\dot{7} \qquad = \frac{5}{99} + \frac{7}{9} \qquad = \frac{5}{99} + \frac{77}{99} \qquad = \frac{82}{99}$

3. Volume of water that evaporates = Area of Base × Height

$= 50 \times 16 \times 0.0083$

$= 6.64\, m^3$

$= 6\,640\, L$

Time to refill = $\frac{6\,640}{23}$

= $288.695 \ldots min$

= $4.81159 \ldots hours$

$4h\ 48min\ 42seconds$

4. $f(x) = 2x + 3 \qquad f\left(f\left(f(\mathrm{x})\right)\right) = 5$

$f(f(2x + 3)) = 5$

$f(2(2x + 3) + 3) = 5$

$f(4x + 6 + 3) = 5$

$f(4x + 9) = 5$

$2(4x + 9) + 3 = 5$

$8x + 18 + 3 = 5$

$8x + 21 = 5$

$x = -2$

5. $speed = \frac{d}{t}$

$1\ 236 \frac{km}{h} = \frac{d}{7\ seconds}$

$1\ 236 \frac{km}{h} = \frac{d}{\frac{7}{3\ 600} hours}$

$d = 1\ 236 \times \frac{7}{3\ 600}$

$d \approx 2.4\ km$

Entries
Solutions for the student Problems were submitted by Moreton Bay College, Northside Christian College, St Joseph's College Gregory Terrace.

Winners
Congratulations are extended to Matt Cho of St Joseph's College Gregory Terrace and Toiné Smit of Northside Christian College.

Prizes are provided by our generous sponsor, The University of Queensland.

Submitting Solutions
Students are invited to submit solutions to the Student Problems.

Please photocopy the problem page and clearly print your name, your school, and your year level.

Write your solutions (with full working) for each question.

Send your solutions to:

"QAMT Student Problems"
C/- Rodney Anderson
Moreton Bay College
PO Box 84
WYNNUM QLD 4178

Closing date is Friday, 24th February, 2017

Student Problems

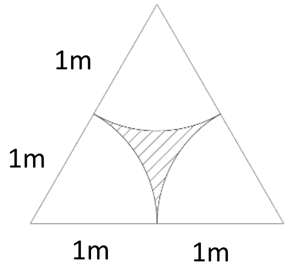
Name: .... **School:** .... **Year:** ....

Write your solutions (with working) next to each question or on a separate sheet of paper or by filling in the appropriate boxes.

A pdf copy of the student problems is on www.qamt.org/resources.

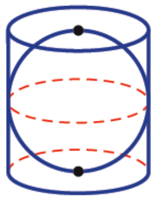
Question 1. By only using diagrams and the use of Pythagorean Triples determine which triangle has the greatest area, the 10cm, 13cm, 13cm isosceles triangle or the 10cm, 10cm, 16cm isosceles triangle.

Question 2. Determine the exact area of the shaded region.



Question 3. Without using a calculator evaluate $\dfrac{8\,888^2 - 1\,111^2}{7\times 11\times 101}$

Question 4. A sphere that has a surface area of $100\pi\ cm^2$ is inscribed in a cylinder. What is the exact volume of the cylinder?



Question 5. Rearrange $\dfrac{ax+b}{cx+d} = e$ to make x the subject.

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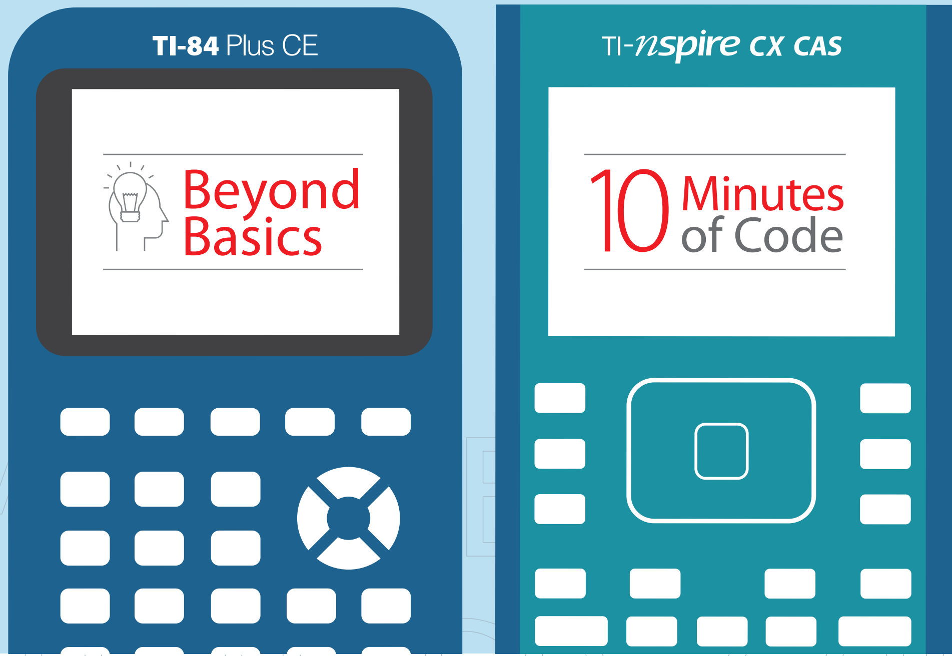

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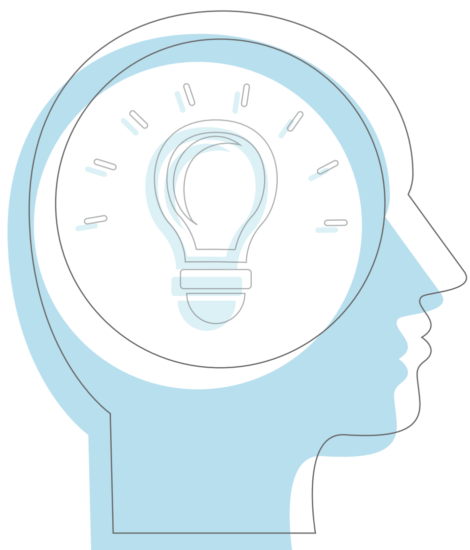

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