Developing the QL Habit of Mind in Multiple Contexts: Geoscience Education Modules

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1. Spreadsheet modules – Vacher
   a. In geological-mathematical problem solving.
   b. Across the curriculum.
2. Resources for spreadsheets in education – Fratesi

Creating and Strengthening Interdisciplinary Programs in QL
PREP Workshop, Macalester College, St. Paul, MN
6/15/05

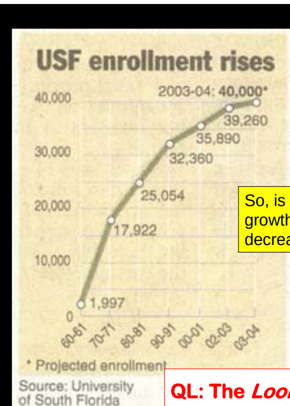
Vacher's part

1. General comments.
2. NSF DUE-0126500 (5/15/02 – 4/30/03): Modules for geological-mathematical problem solving. Proof of concept.
3. NSF DUE-0442629 (7/05 – 6/08): Spreadsheets across the curriculum. Full development.

Another idea – Saturday, 4 pm, NNN meeting

Hands-on math as a lab course – a perspective from introductory geology.

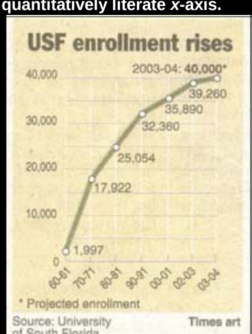
Where I'm coming from



So, is the rate of enrollment growth increasing or decreasing?

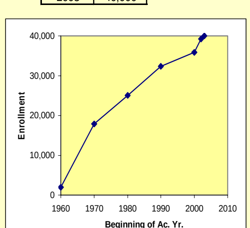
QL: The ***Look at the Axes!*** Problem

QL: Create SS to redraw graph with a quantitatively literate *x*-axis.



USF Enrollment Data

Fall	*N*
1960	1,997
1970	17,922
1980	25,054
1990	32,360
2000	35,890
2002	39,260
2003	40,000

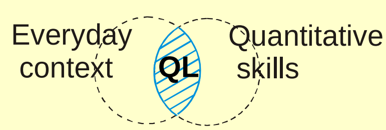


Key fact: Every course that uses tables and graphs is an opportunity to enhance QL.

QUANTITATIVE LITERACY (NUMERACY)

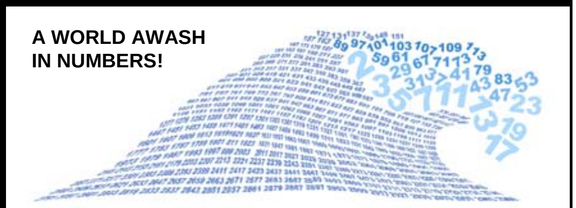
Voltaire: If you want to converse with me define your terms.

QL: A habit of mind in which one engages numbers in everyday context.



QL ⟷ **Math phobia**, **Math anxiety**, **Math avoidance**

A WORLD AWASH IN NUMBERS!



Are our students being prepared to handle numbers?
- A workplace issue.
- A citizenship issue.

See *Mathematics and Democracy* at www.math.dartmouth.edu/~nnn

Attitudes of Full-Time Faculty Members (1998-1999)

Goals for undergraduates noted as essential or very important

Develop ability to think clearly.	99.4%
Prepare students for employment after college.	70.7
Enhance students' self-understanding.	61.8
Prepare students for responsible citizenship.	60.0
Help students develop personal values.	59.7
Enhance s... for racial/e...	57.8
Develop m...	57.5
Prepare s... on.	56.0
Enhance the out-of-class experience of students.	41.2
Provide f... dents' emotional development.	38.2
Instill in... a commitment to community service.	36.2
Teaching ... nts the classic works of Western civilization.	28.4
Prepare students for family living.	17.8

Note: Fully 130.7% of full-time faculty members are in-step with the goals of QL!

CHE Almanac, 8/31/2001, p. 29

On designing new courses →

Barbara J. Tewskbury, R. Heather Macdonmald, Cathryn A. Manduca, and David W. Mogk, 2004: On the Cutting Edge: Improving Faculty Ability to Design Innovative Courses.

The method that faculty use most frequently for designing new courses and developing course syllabi involves making a list of the most important topics in a discipline, culling topics until the list is of reasonable length, arranging the topics in a logical order, and developing syllabus, lectures, labs, assignments and exams around the list of topics….

As part of a workshop program for faculty development in the geosciences, (we have) … developed and offered workshops … that guide participants … (to) articulate goals and design effective and innovative courses that both meet those goals and assess outcomes. The process begins, not with a list of content items, but with setting goals by answering the question, "**What do I want my students to be able to do on their own when they are done with my class?**", rather than the question, "**What do I want my students to know in this subject?**"

NSF and AAAS, Invention and Impact: Building Excellence in Undergraduate Science, Technology, Engineering and Mathematics, A Conference of the Course, Curriculum and Laboratory Improvement (CCLI) Progam, April 16-18, 2004, Crystal City, Virginia. , p. 39.

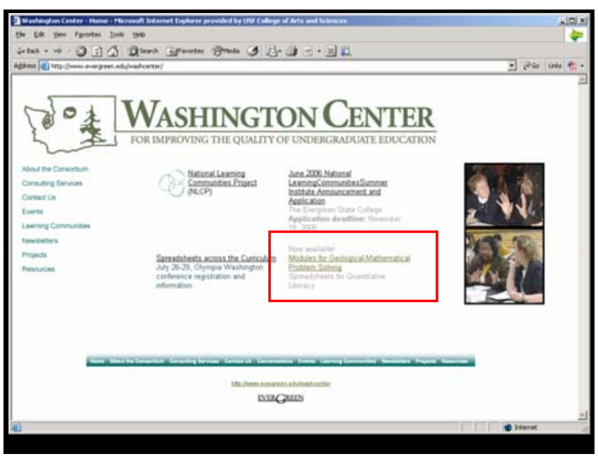
What do I want my students to be able to do on their own when they are done with my class?

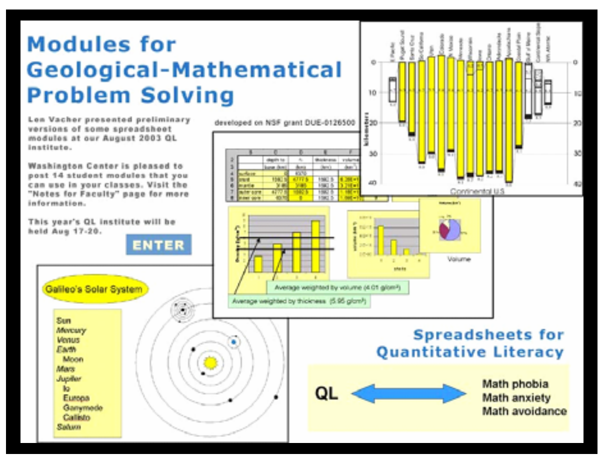
Solve problems.

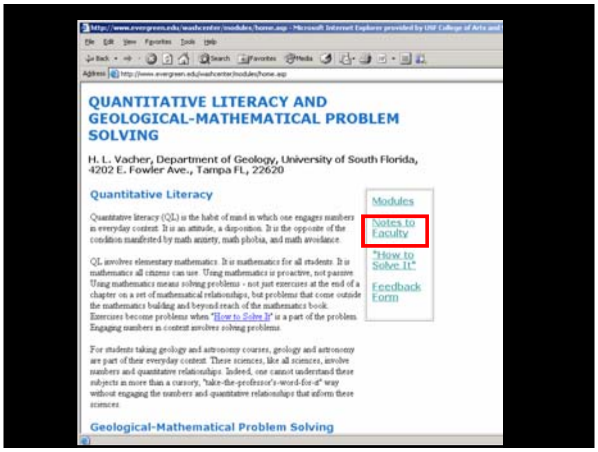
Polya.

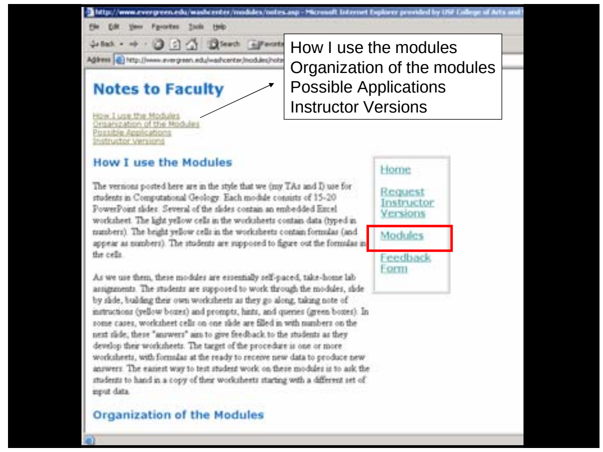
Our knowledge about any subject consists of *information* and of *know-how*. If you have genuine *bona fide* experience of mathematical work on any level, elementary or advanced, there will be no doubt in your mind that, in mathematics, **know-how is much more important than mere possession of information.**
What is know-how in mathematics? The ability to solve problems -- **not merely routine problems but problems requiring some degree of independence, judgment, originality, creativity.** (p. vii-viii)
A problem is a 'great' problem if it is very difficult, it is just a 'little' problem if it is just a little difficult. Yet some degree of difficulty belongs to the very notion of a problem: **where there is no difficulty, there is no problem.** (p. 117)

Mathematical Discovery: On Understanding Learning, and Teaching Problem Solving (Wiley, v. 1, 1962, 216 pp; v. 2, 1965, 191 pp.









CONTENTS

1. Density of the Earth
- 1.1A. Density of the Earth - How to Solve It
- ~~1.1B. Density of the Earth - Using some field data~~
- 1.2A. Density of rocks - How large is a ton of rock?
- ~~1.2B. Density of rocks - Some applications~~
- 1.3A. The Earth's shells - Densities and thicknesses
- 1.3B. The Earth's shells - Density vs. depth

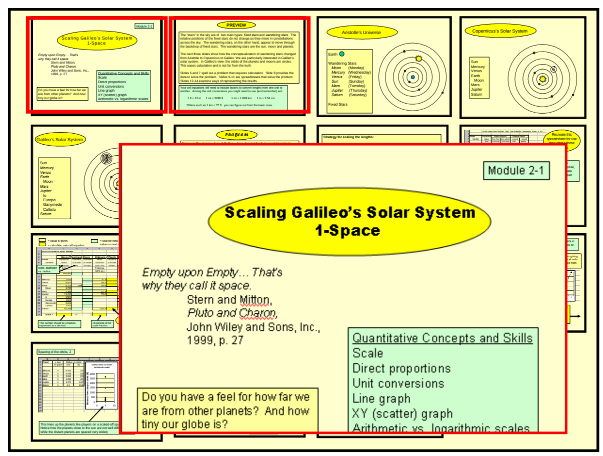
2. Scaling Galileo's Solar System
- 2.1. Space
- 2.2. Size of the globes
- 2.3. Times
- 2.4. Locating the globes

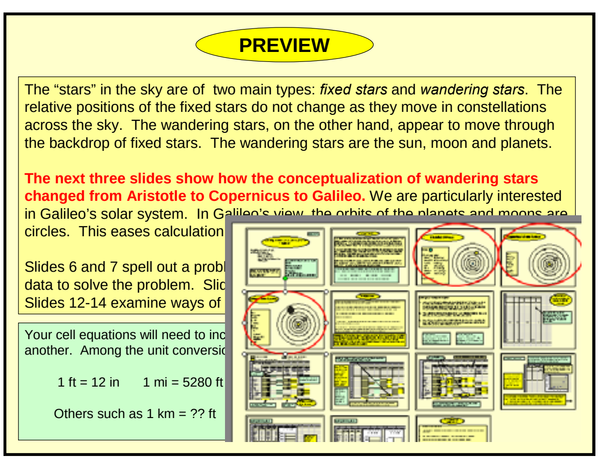
3. Kepler's Third Law
- 3.1. The Equation
- 3.2. Masses and densities (being prepared)
- 3.3. Little *g* (being prepared)

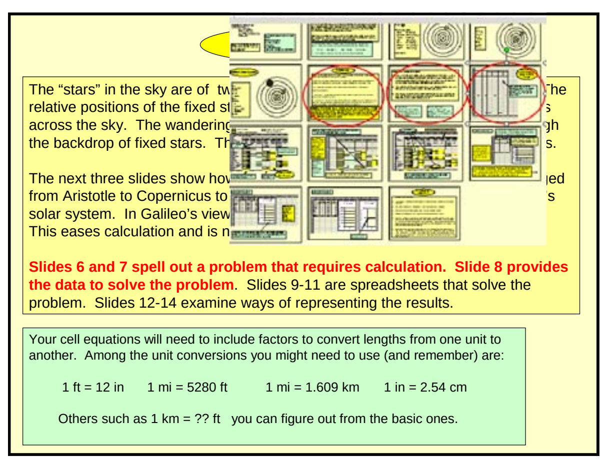
4. The Floating Lithosphere
- 4.1. Isostasy
- 4.2. Eureka!
- 4.3. Cross section of North America

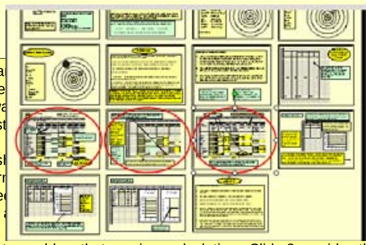
2. First module in class

1. My favorite









The “stars” in the sky a … The
relative positions of the … s
across the sky. The wa … gh
the backdrop of fixed st … ts.

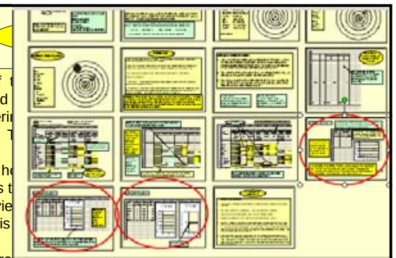
The next three slides sl … ged
from Aristotle to Coperr … ’s
solar system. In Galile … .
This eases calculation a …

Slides 6 and 7 spell out a problem that requires calculation. Slide 8 provides the data to solve the problem. **Slides 9-11 are spreadsheets that solve the problem.** Slides 12-14 examine ways of representing the results.

Your cell equations will need to include factors to convert lengths from one unit to another. Among the unit conversions you might need to use (and remember) are:

1 ft = 12 in 1 mi = 5280 ft 1 mi = 1.609 km 1 in = 2.54 cm

Others such as 1 km = ?? ft you can figure out from the basic ones.



The “stars” in the sky are of …
relative positions of the fixed …
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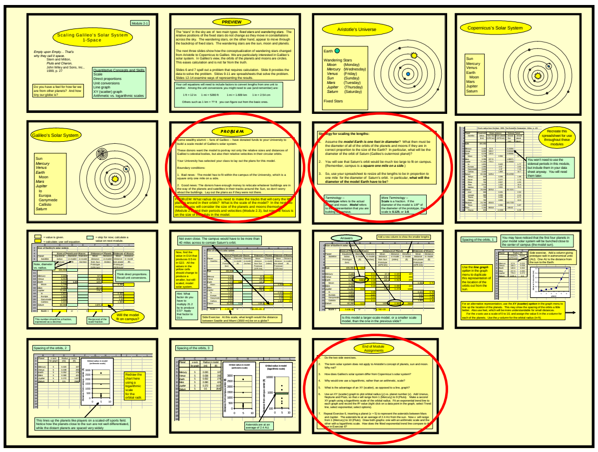


PROBLEM

Some wealthy alumni -- fans of Galileo -- have donated funds to your University to build a scale model of Galileo’s solar system.

These donors want the model to portray not only the relative sizes and distances of Galileo’s celestial bodies, but also their relative velocities in their circular orbits.

Your University has selected your class to lay out the plans for this model.

Boundary conditions:

1. Bad news: The model has to fit within the campus of the University, which is a square only one mile on a side.

2. Good news: The donors have enough money to relocate whatever buildings are in the way of the planets and satellites in their tracks around the Sun, so don’t worry about the buildings. Lay out the plans as if they were not there.

PROBLEM: What radius do you need to make the tracks that will carry the little planets around in their orbits? What is the scale of the model? In the next two modules, you will consider the size of the planets and moons themselves (Module 2.2) and their periods and velocities (Module 2.3), but now the focus is on the size of the orbits in the model.

Strategy for scaling the lengths:

1. Assume the ***model Earth is one foot in diameter***? What then must be the diameter of all of the orbits of the planets and moons if they are in correct proportion to the size of the Earth? In particular, what will be the diameter of the orbit of Saturn (Galileo’s outermost planet)?

2. You will see that Saturn’s orbit would be much too large to fit on campus. (Remember, campus is a ***square one mile on a side***.)

3. So, use your spreadsheet to resize all the lengths to be in proportion to one mile for the diameter of Saturn’s orbit. In particular, **what will the diameter of the orbit for the model Earth have to be**?

Terminology --
Prototype refers to the actual planet and moon. ***Model*** refers to the representation that you are building on campus.

More Terminology --
Scale is a fraction. If the diameter of the model is 1/8th of the diameter of the prototype, the scale is **0.125**, or **1:8**.

End of Module Assignments

1. Do the two side exercises.
2. The term solar system does not apply to Aristotle’s concept of planets, sun and moon. Why not?
3. How does Galileo’s solar system differ from Copernicus’s solar system?
4. Why would one use a logarithmic, rather than an arithmetic, scale?
5. What is the advantage of an XY (scatter), as opposed to a line, graph?
6. Use an XY (scatter) graph to plot orbital radius (*y*) vs. planet number (*x*). Add Uranus, Neptune and Pluto, so that *x* will range from 1 (Mercury) to 9 (Pluto). Make a second XY graph using a logarithmic scale of the orbital radius. Fit an exponential trend line to each graph and record the R^2 value (right click on a data point in the graph, select Trend line, select exponential, select options).
7. Repeat Exercise 6, inserting a planet ($x = 5$) to represent the asteroids between Mars and Jupiter. The asteroids lie at an average of 2.4 AU from the sun. Now *x* will range from 1 (Mercury) to 10 (Pluto). Draw both graphs: one with an arithmetic scale and the other with a logarithmic scale. How does the fitted exponential trend line compare to the one in Exercise 6?

CONTENTS

2. First module in class

Module 1-2A

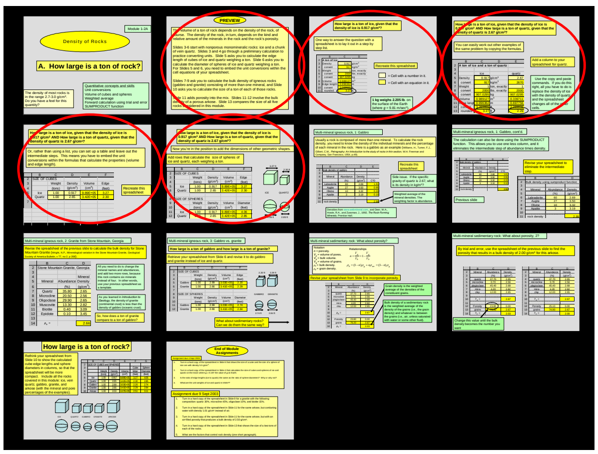
Density of Rocks

A. How large is a ton of rock?

The density of most rocks is in the range 2.7-3.0 g/cm³. Do you have a feel for this quantity?

Quantitative concepts and skills
Unit conversions
Volume of cubes and spheres
Weighted average
Forward calculation using trial and error
SUMPRODUCT function

1



PREVIEW

The volume of a ton of rock depends on the density of the rock, of course. The density of the rock, in turn, depends on the kind and relative amount of the minerals in the rock and the rock's porosity.

Slides 3-6 start with nonporous monomineralic rocks: ice and a chunk of vein quartz. Slides 3 and 4 go through a preliminary calculation to practice converting units. Slide 5 asks you to calculate the edge length of cubes of ice and quartz weighing a ton. Slide 6 asks you to calculate the diameter of spheres of ice and quartz weighing a ton. For Slides 5 and 6, you need to embed the unit conversions within the cell equations of your spreadsheet.

Slides 7-9 ask you to calculate the bulk density of igneous rocks (gabbro and granite) consisting of more than one mineral, and Slide 10 asks you to calculate the size of a ton of each of those rocks.

Slide 11 adds porosity into the mix. Slides 11-12 involve the bulk density of a porous arkose. Slide 13 compares the size of all five rocks considered in this module.

Slide 14 gives the assignment to hand in.

2

How large is a ton of ice, given that the density of ice is 0.917 g/cm³?

One way to answer the question with a spreadsheet is to lay it out in a step by step list.

	B	C	D
2	**A ton of ice**		
3	Density	0.917	g/cm³
4	convert	917	kg/m³
5	Weight	1	ton, exactly
6	convert	2000	lbs, exactly
7	convert	907.0295	kg
8	Volume	0.989127	m³
9	Edge length	0.996362	m
10	convert	3.269065	ft
11	rounded	3.27	ft

Recreate this spreadsheet

= Cell with a number in it.

= Cell with an equation in it.

1 kg weighs 2.205 lb. on the surface of the Earth (where g = 9.81 m/sec²).

3

How large is a ton of ice, given that the density of ice is 0.917 g/cm³ AND How large is a ton of quartz, given that the density of quartz is 2.67 g/cm³?

You can easily work out other examples of the same problem by copying the formulas.

	B	C	D	E
2	**A ton of ice and a ton of quartz**			
3				
4		ice		quartz
5	Density	0.917	g/cm³	2.67
6	convert	917	kg/m³	2670
7	Weight	1	ton, exactly	1
8	convert	2000	lbs, exactly	2000
9	convert	907.0295	kg	907.0295
10	Volume	0.989127	m³	0.339711
11	Edge lengt	0.996362	m	0.697756
12	convert	3.269065	ft	2.289336
13	rounded	3.27	ft	2.29

Add a column to your spreadsheet for quartz.

Use the copy and paste commands. If you do this right, all you have to do is replace the density of ice with the density of quartz, and the spreadsheet changes all of the other cells.

4

How large is a ton of ice, given that the density of ice is 0.917 g/cm³ AND How large is a ton of quartz, given that the density of quartz is 2.67 g/cm³?

Or, rather than using a list, you can set up a table and leave out the intermediate steps. This means you have to embed the unit conversions within the formulas that calculate the properties (volume and edge length).

	B	C	D	E	F
2	SIZE OF CUBES				
3		Weight	Density	Volume	Edge
4		(tons)	(g/cm^3)	(cm^3)	(feet)
5	Ice	1.00	0.917	9.89E+05	3.27
6	Quartz	1.00	2.65	3.42E+05	2.30
7					

Recreate this spreadsheet

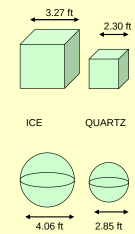
5

How large is a ton of ice, given that the density of ice is 0.917 g/cm³ AND How large is a ton of quartz, given that the density of quartz is 2.67 g/cm³?

Now you're in the position to add the dimensions of other geometric shapes.

Add rows that calculate the size of spheres of ice and quartz, each weighing a ton.

	B	C	D	E	F
2	SIZE OF CUBES				
3		Weight	Density	Volume	Edge
4		(tons)	(g/cm^3)	(cm^3)	(feet)
5	Ice	1.00	0.917	9.89E+05	3.27
6	Quartz	1.00	2.65	3.42E+05	2.30
7					
8	SIZE OF SPHERES				
9		Weight	Density	Volume	Diameter
10		(tons)	(g/cm^3)	(cm^3)	(feet)
11	Ice	1.00	0.917	9.89E+05	4.06
12	Quartz	1.00	2.65	3.42E+05	2.85



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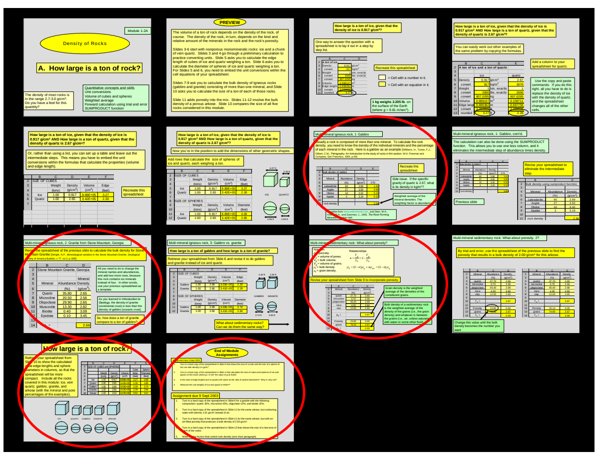


Multi-mineral igneous rock, 1: Gabbro

Usually a rock is composed of more than one mineral. To calculate the rock density, you need to know the density of the individual minerals and the percentage of each mineral in the rock. Here is a gabbro as an example (Williams, H., Turner, F.J., Gilbert, C.M., *Petrography: An Introduction to the study of rocks in thin section*, W.H. Freeman and Company, San Francisco, 1954, p.49).

Recreate this spreadsheet

	B	C	D	E
2	Bulk density of gabbro			
3				
4	Mineral	Abundance	Density	
5		(%)	(g/cm^3)	C*D
6	Labradorite	60	2.69	1.61
7	Augite	27	3.50	0.95
8	Olivine	10	3.32	0.33
9	Apatite	3	3.19	0.10
10				
11	rock density			2.99

Side issue. If the specific gravity of quartz is 2.67, what is its density in kg/m³?

Weighted average of the mineral densities. The weighting factor is abundance.

Densities from www.webmineral.com., and Deer, W.A., Howie, R.A., and Zussman, J., 1992, *The Rock-Forming Minerals*, Prentice Hall.

7

Multi-mineral igneous rock, 2: Granite from Stone Mountain, Georgia

Revise the spreadsheet of the previous slide to calculate the bulk density for Stone Mountain Granite (Wright, N.P., Mineralogical variation in the Stone Mountain Granite, Geological Society of America Bulletin, v 77, no 2, p 208).

	B	C	D
2	Stone Mountain Granite, Georgia		
3			
4			Mineral
5	Mineral	Abundance	Density
6		(%)	(g/cm^3)
7	Quartz	35.80	2.65
8	Microcline	20.50	2.56
9	Oligoclase	29.90	2.65
10	Muscovite	13.30	2.82
11	Biotite	0.40	3.09
12	Epidote	0.10	3.45
13			
14	ρ_b =		2.66

All you need to do is change the mineral names and abundances, and add two more rows, because this rock contains six minerals instead of four. In other words, use your previous spreadsheet as a template.

As you learned in *Introduction to Geology*, the density of granite (continental crust) is less than the density of gabbro (oceanic crust).

So, how does a ton of granite compare to a ton of gabbro?

9

Multi-mineral sedimentary rock: What about porosity?

Notation
n = porosity.
V_p = volume of pores.
V_b = bulk volume.
V_g = volume of grains.
ρ_b = bulk density.
ρ_g = grain density.

Relationships

$$n = \frac{V_p}{V_b} = 1 - \frac{V_g}{V_b}$$

$$\rho_b = (1-n)\rho_g + n\rho_{air} = (1-n)\rho_g$$

Revise your spreadsheet from Slide 9 to incorporate porosity.

	B	C	D
2	Mineral	Abundance	Density
3		(%)	(g/cm^3)
4	quartz	37.70	2.65
5	microcline	0.70	2.56
6	plagioclase	45.40	2.68
7	mica	4.20	2.82
8	clay	12.00	2.65
9			
10	ρ_g =		2.67
11			
12	Porosity	23.80	0.00
13	grains	76.20	2.67
14	ρ_b =		2.03

Grain density is the weighted average of the densities of the constituent grains.

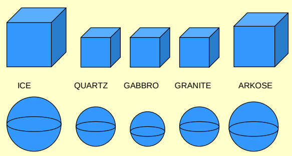
Bulk density of a sedimentary rock is the weighted average of the density of the grains (i.e., the grain density) and whatever is between the grains (i.e., air, unless saturated with water or some other fluid).

11

How large is a ton of rock?

Rethink your spreadsheet from Slide 10 to show the calculated cube edge lengths and sphere diameters in columns, so that the spreadsheet will be more compact. Include all the rocks covered in this module: ice, vein quartz, gabbro, granite, and arkose (with the mineral and pore percentages of the examples).

	B	C	D	E	F	G
2	SIZE OF CUBES and SPHERES					
3					Cube	Sphere
4		Weight	Density	Volume	Edge	Diameter
5		(tons)	(g/cm^3)	(cm^3)	(feet)	(feet)
6	Ice	1.00	0.917	9.89E+05	3.27	4.06
7	Quartz	1.00	2.65	3.42E+05	2.30	2.85
8	Gabbro	1.00	2.99	3.03E+05	2.20	2.74
9	Granite	1.00	2.66	3.41E+05	2.29	2.84
10	Arkose	1.00	2.03	4.47E+05	2.51	3.11



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End of Module Assignments

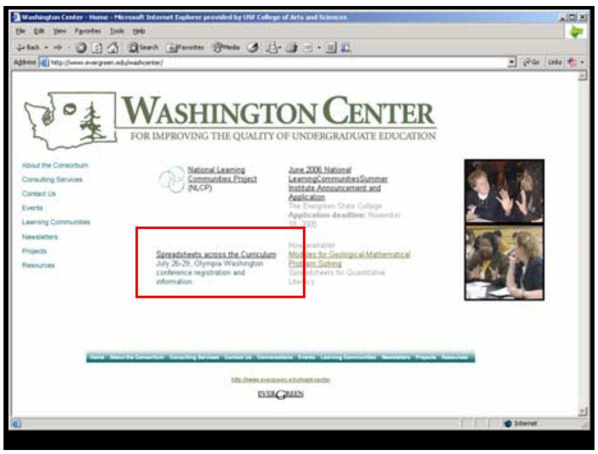
Assignment due 4 Sept 2003

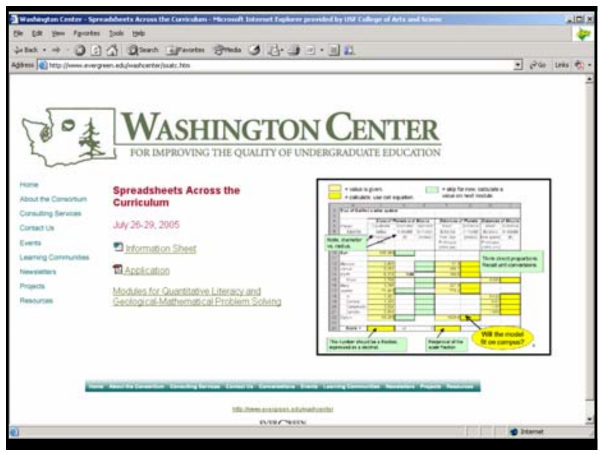
1. Turn in a hard copy of the spreadsheet in Slide 6 that shows the size of a cube and the size of a sphere of iron ore with density 5.5 g/cm^3.
2. Turn in a hard copy of the spreadsheet in Slide 4 that calculates the size of cubes and spheres of ice and quartz on the moon where g = 0.167 the value of g on Earth.
3. Is the ratio of edge lengths (ice to quartz) the same as the ratio of sphere diameters? Why or why not?
4. What are the unit weights of ice and quartz in kN/m^3?

Assignment due 9 Sept 2003

1. Turn in a hard copy of the spreadsheet in Slide 9 for a granite with the following composition: quartz 30%, microcline 45%, oligoclase 10%, and biotite 15%.
2. Turn in a hard copy of the spreadsheet in Slide 11 for the same arkose, but contianing water with density 1.01 g/cm^3 instead of air.
3. Turn in a hard copy of the spreadsheet in Slide 11 for the same arkose, but with an air-filled porosity that produces a bulk density of 2.50 g/cm^3.
4. Turn in a hard copy of the spreadsheet in Slide 13 that shows the size of a *two* tons of each of the rocks.
5. What are the factors that control rock density (one short paragraph).

14





BROADER IMPACTS

QL is a Human Resources Development Issue

Human Resource Managers:
Goal: To increase employee productivity.
Mission: Increase employees' ability to produce.

Educators in academia:
Goal: To increase student learning.
Mission: Increase students' ability to learn.

The Case for Spreadsheets:
→ HR: Spreadsheets increase employees' ability to produce.
→ QL: Spreadsheets increase students' ability to learn.

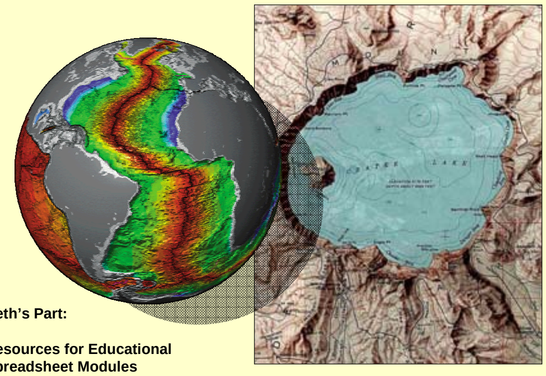
In the Mind's Eye

Polya

Spreadsheets make it happen.

Not just enter-and-watch spreadsheets, but spreadsheets that students create to solve problems.

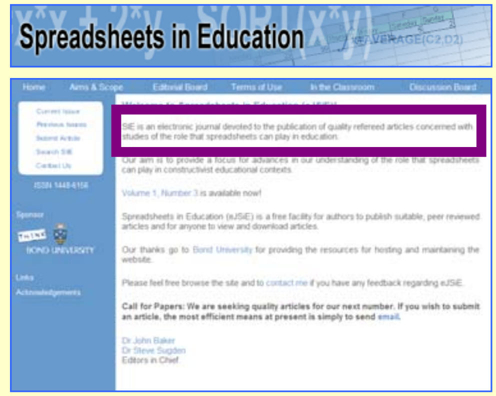
The more spreadsheets the better.



Beth's Part:

Resources for Educational Spreadsheet Modules Examples in the Geosciences

Images: NOAA, USGS



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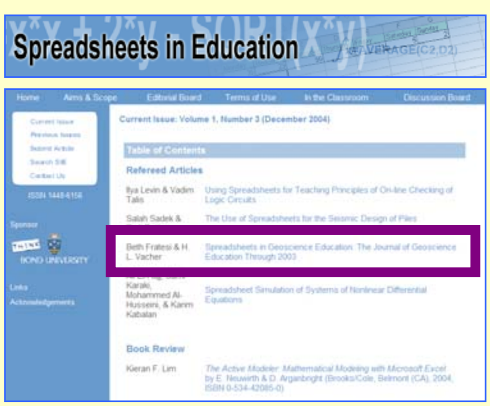
Geological education can be served by using spreadsheets:

- Spreadsheets allow educators to move away from instructivist teaching: they "**promote more open-ended investigations, problem-oriented activities, and active learning** by students".
- Spreadsheets "**provide insights into the ... context** without necessitating attention to extraneous distractions".
- Spreadsheets, or more accurately, the building of spreadsheets, **promotes abstract reasoning** by the learner.
- Spreadsheets "are interactive; they **give immediate feedback** to changing data or formulae; they enable data, formulae and graphical output to be available on the screen at once; they give students a large measure of control and ownership over their learning".
- Spreadsheets **save time**. "The time gained can then be spent on investigating ... the so-called **what-if scenarios**. There is huge scope for investigation of dependence on parameters in almost any spreadsheet model....".



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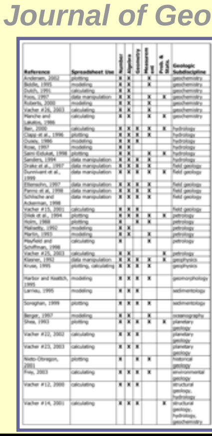
Journal of Geoscience Education



From 1980 to 2004, there were 212 articles that included mathematics in some form. 38 of them included spreadsheet exercises.

"We are biased, of course, but we are happy to argue that earth and space science offers hugely interesting **context**. As illustrated by these 38 papers, the range is tremendous. If mathematics educators are looking for examples, case histories, and ideas to adapt to their own uses, then check out the articles in the following annotated bibliography and watch for more as the JGE continues to publish spreadsheets in geoscience education."

In other words, we don't have to force QL upon geologists:

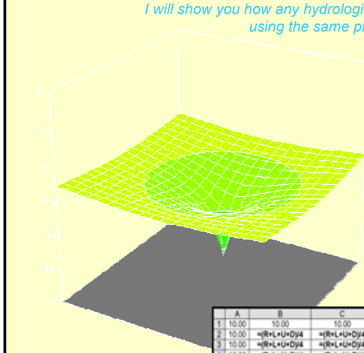
If geology, then calculus

Understanding geology can lead to an understanding of rates of change and other mathematical concepts.

Groundwater Flow

I will show you how any hydrologist can build groundwater models using the same piece of general software that one may use to do the bookkeeping for the golf club.

- Olsthoorn

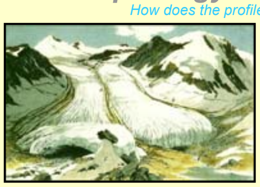


A map of the water table in the vicinity of a pumping well exhibiting a "cone of depression".

	A	B	C	D	E	F	G
1	10.00	10.00	10.00	10.00	10.00	10.00	10.00
2	10.00	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	10.00
3	10.00	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	10.00
4	10.00	=(R+L+U+D)/4	=(R+L+U+D)/4	5.00	=(R+L+U+D)/4	=(R+L+U+D)/4	10.00
5	10.00	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	10.00
6	10.00	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	=(R+L+U+D)/4	10.00
7	10.00	10.00	10.00	10.00	10.00	10.00	10.00

Geomorphology

How does the profile across a glacial valley change over time?

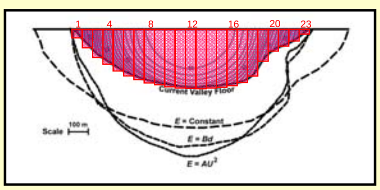


Three hypotheses:

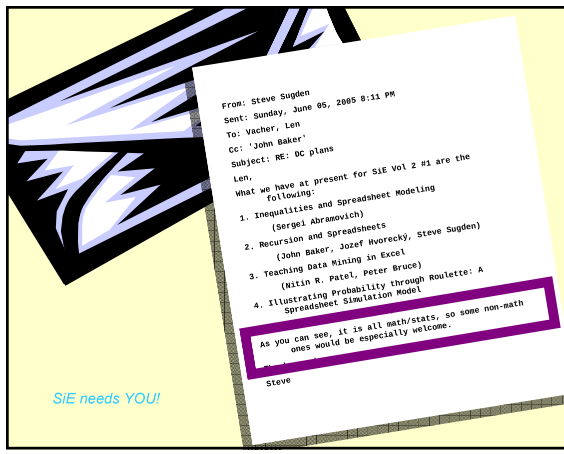
E = C

E = AU²

E = Bd



	A	B	C	D	E	F
1	Section	U	U^2	10^3AU^2	d	10^3Bd
2	1	12	144	30	27	26
3	2	16	256	54	80	77
4	3	20	400	84	121	115
5	4	24	576	121	168	160
6	5	27	729	153	208	198
7	6	31	961	202	235	224
8	7	35	1225	257	255	243
9	8	37	1369	287	281	269
10	9	39	1521	319	302	288
11	10	40	1600	336	308	294
12	11	41	1681	353	322	307
13	12	42	1764	370	322	307
14	13	41	1681	353	322	307
15	14	39	1521	319	315	301
16	15	37	1369	287	302	288
17	16	33	1089	229	281	269
18	17	30	900	189	241	230
19	18	29	841	177	188	179
20	19	25	625	131	134	128
21	20	18	324	68	101	96
22	21	14	196	41	74	70
23	22	10	100	21	27	26
24	23	Sum	21080	Sum	4614	



From: Steve Sugden
Sent: Sunday, June 05, 2005 8:11 PM
To: Vacher, Len
Cc: 'John Baker'
Subject: RE: DC plans

Len,

What we have at present for SiE Vol 2 #1 are the following:

1. Inequalities and Spreadsheet Modeling (Sergei Abramovich)
2. Recursion and Spreadsheets (John Baker, Jozef Hvorecký, Steve Sugden)
3. Teaching Data Mining in Excel (Nitin R. Patel, Peter Bruce)
4. Illustrating Probability through Roulette: A Spreadsheet Simulation Model

As you can see, it is all math/stats, so some non-math ones would be especially welcome.

Steve

SiE needs YOU!

Google

Try a Google search for "spreadsheets in education."

Spreadsheets, Mathematics, Science, and Statistics Education

Quite a Lot of What You always wanted to know

This page tries to collect some information about spreadsheets with an emphasis on mathematics and statistics education. If you have some more information which you think should be offered through this page please send information to Erich Neuwirth.

Currently we have the following topics:

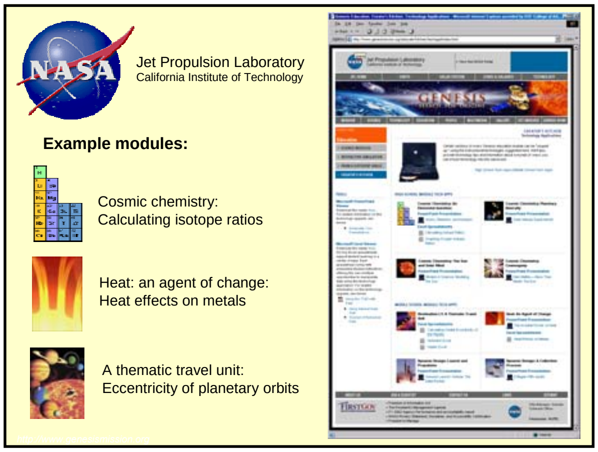
- Spreadsheets in Education
  - Recommended Books and Journals
  - Papers about Spreadsheets in Scientific Journals and Books
  - Example Spreadsheets and Projects (mostly Excel 5.0)
  - Further Resources for Spreadsheets in Education on the Internet
- General Resources for Spreadsheets on the Web
  - Web Documents explaining Spreadsheet Concepts
  - Support Information, Utility Programs, and Add-Ins
- Mathematical Learning Resources on the Internet

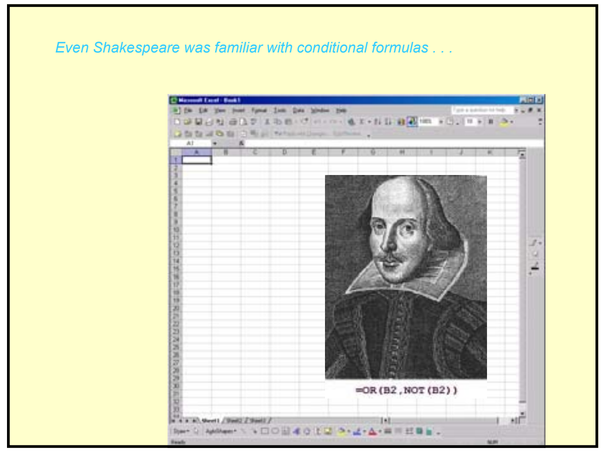
The University of Wisconsin - Madison
Materials Research Science and Engineering Center (MRSEC)

Interdisciplinary Education Group (IEG):

· uses examples of nanotechnology and advanced materials to explore science and engineering concepts at the college level
· brings the "wow" and potential of nanotechnology and advanced materials to the public.

Example module:
Graphing surfaces we can't see


Jet Propulsion Laboratory
California Institute of Technology
Example modules:
Cosmic chemistry:
Calculating isotope ratios
Heat: an agent of change:
Heat effects on metals
A thematic travel unit:
Eccentricity of planetary orbits


Even Shakespeare was familiar with conditional formulas . . .
=OR(B2,NOT(B2))