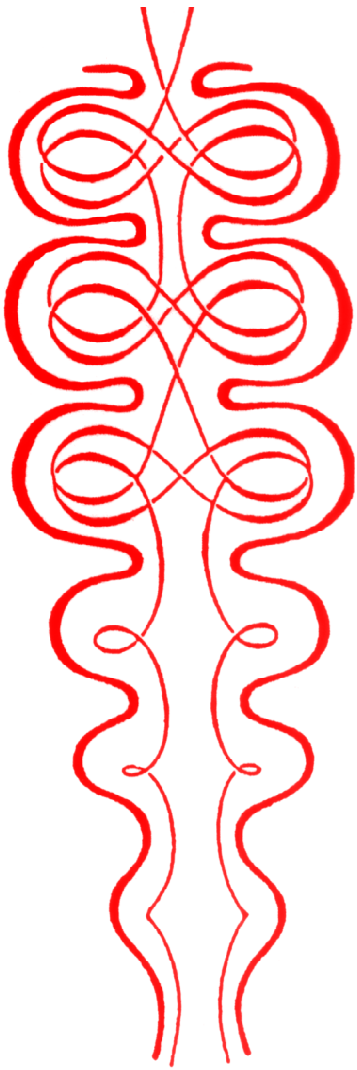


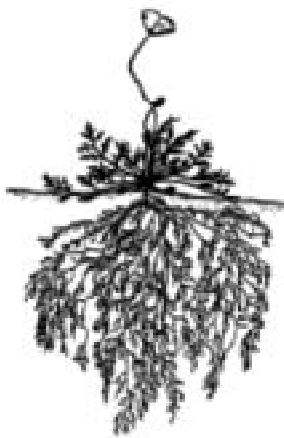
Volume 10, #20
Spring 2004



WALDORF SCIENCE

NEWSLETTER

*Editors: David Mitchell & John Petering
1158 Quince Ave.
Boulder, CO 80304
FAX 303 / 541-9244
E-Mail: davidm@awsna.org*



Waldorf Science

Explorations in Phenomenology as Practiced in Waldorf Schools

A Science News Roundletter

Editors: John Petering & David Mitchell

1158 Quince Ave.

Boulder, CO 80304

FAX 303/ 541-9244

E-mail – davidm@awsna.org

© Copyright 2004 by Mitchell & Petering

All materials may be reproduced for individual use in Waldorf/Steiner Schools but not published without permission of the editors.

VOL. 10, #20

Spring 2004

NOTE FROM THE EDITORS

For the past ten years, the editors have brought out two *Waldorf Science Newsletters* each year. This current edition represents number twenty and will be the final regular newsletter. We hope that we have provided some helpful materials to teachers at every level in the Waldorf school and that we have strengthened the understanding of phenomenological science.

Now that we are not burdened by a deadline, we will send future newsletters as we accumulate adequate material. Hopefully, this will result in one per year. We invite your participation and contributions.

At the recent 75th Anniversary Celebration of Waldorf Education in North America at the Rudolf Steiner School of New York City, Douglas Gerwin and David Mitchell presented an hour long program celebrating phenomenological science. The intention was to illustrate the difference between a hypothetical and a phenomenological approach by taking the example of color shadows.

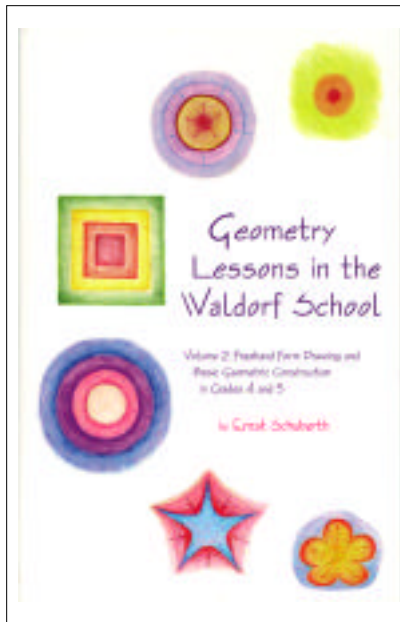
They began by recalling—and reenacting—the story of Goethe sitting in a tavern and appreciating the ar-

rival of a dark-haired beauty. Goethe stared at her while she stood motionless in front of a blank wall. When she moved he was startled to see an image of her on the wall where she has been standing. Goethe considered the optical illusion to be optical truth, and it propelled him on a lifelong study.

David and Douglas initially tried to “explain” the effect Goethe experienced by offering up the hypothesis of the “tired retina” becoming saturated with light. They then proceeded to demonstrate several color shadow experiments that undermined the hypothesis. In this manner they contrasted two teaching methods, one empirical using hypothesis, the other phenomenological, or Goethean, based on observation, analysis, and the determination of the law revealed by the phenomena. The audience commented on the more pastel, soft-bounded qualities of the colored shadow experiment and were also able to experience the moral implications of this investigation.

The group—some hundred plus in number—seemed willing to forget the lack of air and stifling heat in the overpacked room and enjoyed the exploration and discussion.

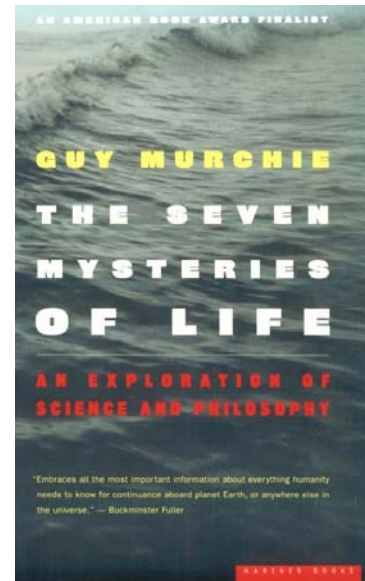
Books of Note



*Geometry Lessons in the Waldorf School
Volume 2
Freehand Form Drawing and Basic Geometric
Construction in Grades 4 and 5*

by Ernst Schuberth
86 pages plus attached CD Rom
AWSNA Publications, 2004
ISBN #1-888365-52-8

This new release from AWSNA Publications presents the essence of the geometry lessons in Grades 4 and 5. It has clear illustrations and progressively builds the concepts necessary for a strong foundation needed for the upper grades. Dr. Schuberth is passionate about his subject and his clear developmental approach will be a good resource for all teachers. The attached CD Rom offers specific exercises for the fourth and fifth grade teacher, emphasizes how color can be used to enhance the understanding, and offers examples of knot forms and geometric page design.



The Seven Mysteries of Life

by Guy Murchie
704 pages
Mariner Books, 1999 (paperback edition)
ISBN #035957915

If you don't believe that the physical world we live in is incredibly fascinating, complex, and heart-breakingly beautiful, you need to read this book.

Guy Murchie is interested in the interconnectedness of all forms of life on earth. This book is the object of his seventeen-year quest for knowledge and discovery. Here we plummet the essence of science, philosophy, and inspiration. The editor [DSM] considers this one of his favorite titles.

Imagine a book that could explain practically everything in the natural world—how the various senses work, how sand is deposited on beaches, how sonar in bats works, how closely related we all are to other humans, to chimpanzees, to everything, how different creatures reproduce, how a tree is constructed, what a muscle is made out of, why the moon appears the way it does on the horizon—and yet somehow be an incredibly fascinating page turner at the same time. This book will leave you with with an impression of awe at the organization of nature..

Teachers and parents might be interested in two projects by AWSNA Publications. These essays are available gratis at www.waldorflibrary.org or you can purchase a spiral bound copy of either from AWSNA at www.awsna.org or by calling 916-961-0927.

Waldorf Journal Project #2

The Making of a Teacher by Henry Barnes

Child Development—Conception to Birth:

Embryology from an Anthroposophical Perspective by Bruno Callegaro, M.D.

Early Childhood Today: Wish and Reality by Walter Riethmüller

The Kindergarten Child by Peter Lang

Creating a Meadow for Childhood: Education for a New Millennium, What Do Young Children Need Today? by Sally Schweizer

Psychology and Early Years Learning:

Affirming the Wisdom of Waldorf by Richard House

Children's Questions by A. C. Harwood

Non-Verbal Education: A Necessity in the Developmental Stages by Michaela Glöckler, M.D.

Child Observation and Study by Michaela Glöckler, M.D.

Some Aspects of Child Study Work in Faculty Meetings, Points for Observation in Child Study by Magda Lissau

Overview of Childhood Characteristics by David Mitchell

Encountering the Individuality of a Child by Walter Riethmüller

Tell Me a Story: The Narrative of Active Learning by Martyn Rawson

Sleep as a Task of Waldorf Education by Peter Loebell

The Effect of Lunar Nodes on Human Biography: Our Hidden Plan by Susanne Donato

The Adolescent Years by L. Francis Edmunds

Waldorf Journal Project #3

Life's Anxieties – Life's Opportunities: Anxiety and Its Importance to Inner Development

Two Essays by Pietro Archiati and Felicitas Vogt

Sleep Disturbances and Healthy Sleep by Christa-Johanna Bub-Jachens

Nutrition: Modern Food, Is It Really Future-Oriented? by Petra Kühne

Food and Nutrition: What Nourishes Our Children? by Petra Kühne

The Feet Reveal the Human Will by Norbert Glas

Hearing: Door to the Soul and Spirit Around Us, with a Look at Technological Media by Heinz Buddemeier

The Unfolding of Sexuality by Mathias Wais

Puberty and Its Crisis: Educational Help in Overcoming Difficulties by Dr. Johannes Bockemühl

Drug Addiction: The Wake-up Call of Our Times by Felicitas Vogt

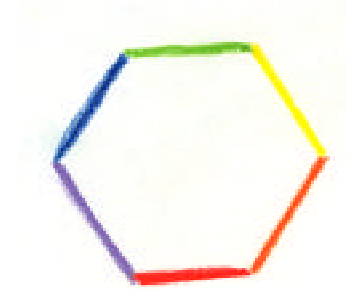
Education Seen as a Problem Involving the Training of Teachers by Rudolf Steiner

A Number Story For the Six table

(as done in the Second Grade)

Reprinted from *Math Lessons for Elementary Grades* by Dorothy Harrer
revised and reprinted 2004 by AWSNA Publications.

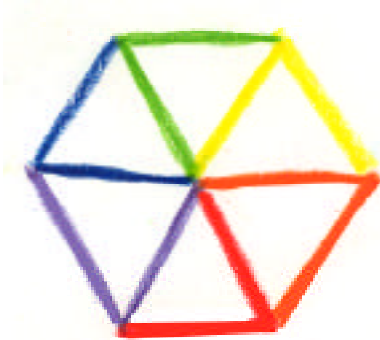
This story accompanies the drawing of the hexagon, free hand, in steps I through VII



Step I

There was once a King whose shining palace was right in the center of his six-sided kingdom. At each side of the kingdom rose a high wall, and each of the six walls was one of six beautiful colors, violet, blue, green, yellow, orange and red.

Although these six beautiful walls protected him from all enemies, they limited his kingdom to what they enclosed and beyond them the King had no power nor did he know what lay beyond them.

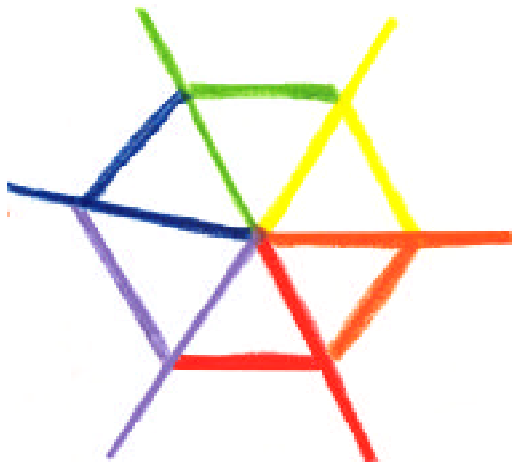


Step II

Strangely enough, the King had exactly six sons. When they had grown to become noble knights, they rode out from the King's palace in six different directions in order to explore the kingdom.

At length each reached a corner between each of the six walls and each looked to his right to see a wall built of violet, blue, green, yellow, orange, or red. But beyond that they could not go. Whereupon they returned to the King and asked him what lay beyond the walls of the kingdom.

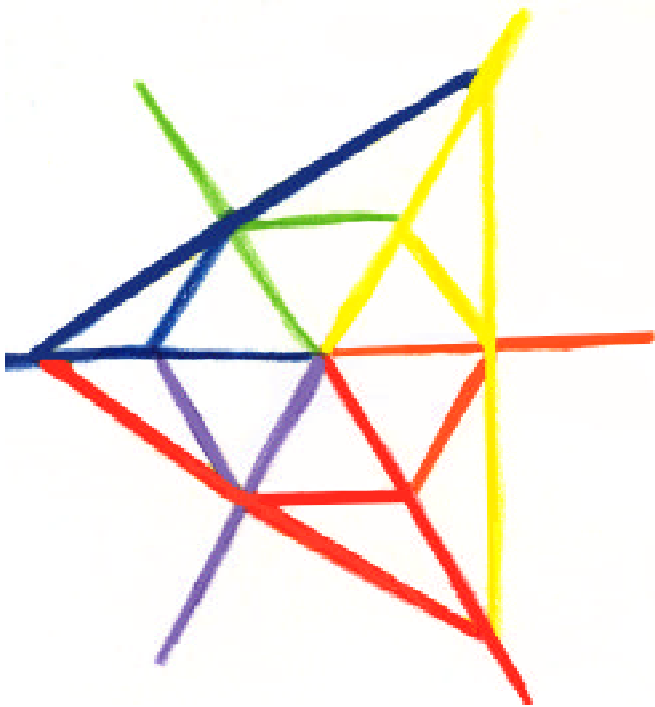
The King answered, "I know not for although the six walls protect me from my enemies, they do not permit me to see what lies beyond them. I have had enough to do to rule my kingdom wisely, and well within its six walls, and here I must stay. Now you have my blessing to find your way beyond the walls and to carry my good will to all that lives without."



Step III

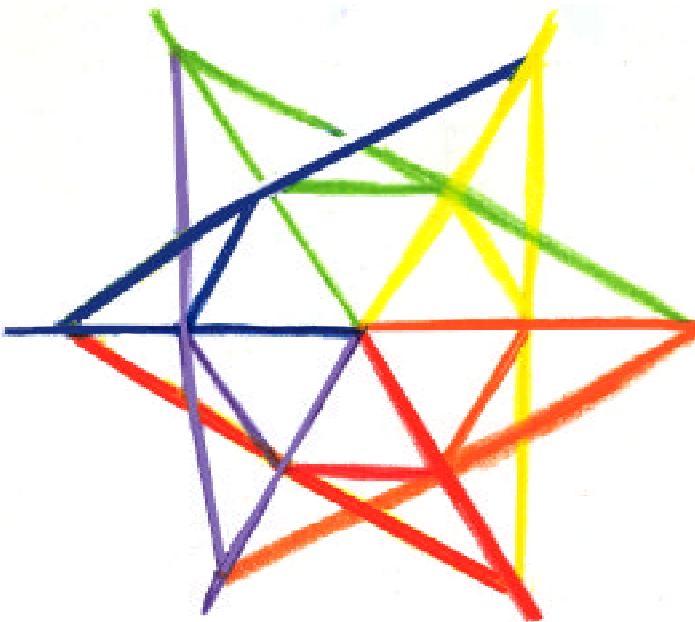
Thereupon, each knight chose a banner of a color to match the wall he had seen and each set out with fluttering banner and sound of trumpet to breach the wall.

Upon reaching the corner, each young knight with the help of his trusty men broke through the walls and marched forth into the world beyond his father's kingdom.



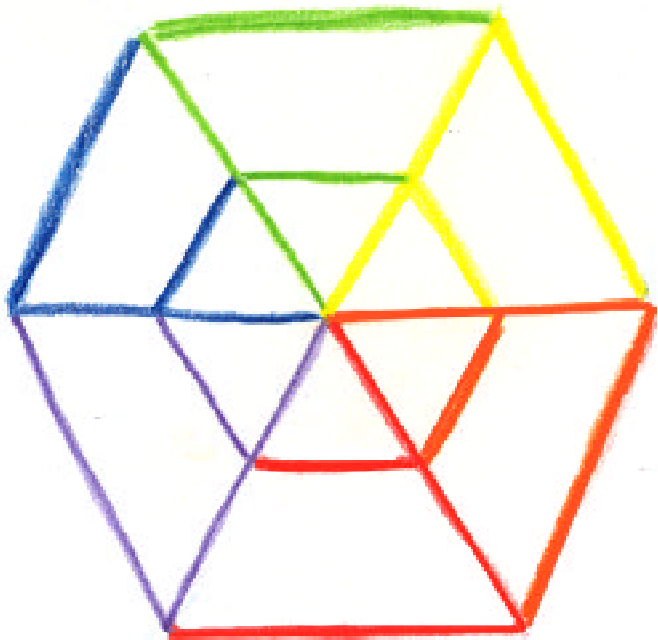
Step IV

The yellow knight traveled as far outside the walls as it was from the palace to the walls. He found himself in a desert blazing with hot sun and sand, no living being, no plant nor animal in sight. So he returned to the wall and looked to the right and to the left. Seeing, in the distance, his red and blue brothers, he went straight to meet the red then back to meet the blue who likewise had journeyed beyond their corners then returned to the old walls. The blue knight had found himself facing a deep, blue ocean which he could not cross and the red knight was turned back by a sea of red fire. Yellow, Red and Blue each built a new wall, straight and sure, touching at three points on the old. Along the new walls they set up lines of their trusty henchmen to guard their father's kingdom against blinding light, bottomless ocean and searing fire.



Step V

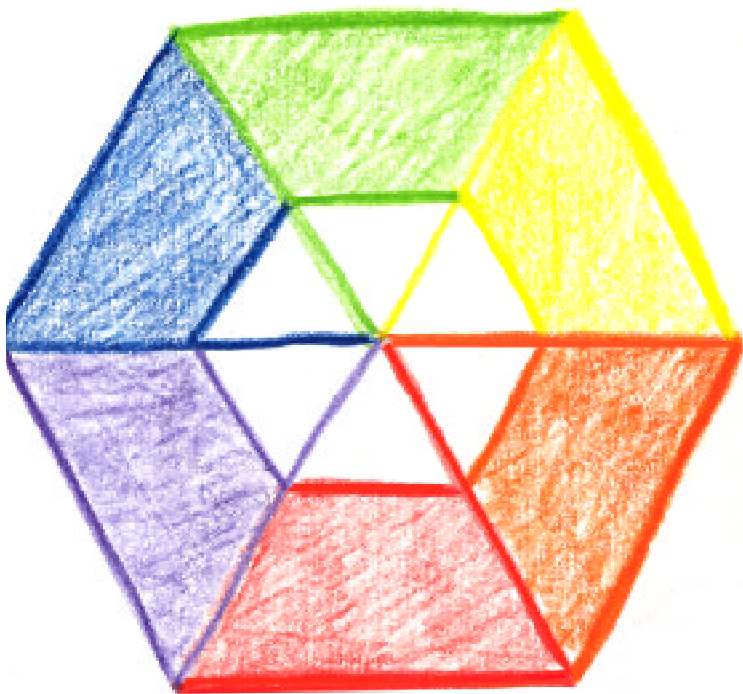
In the meantime the orange, violet, and green knights had each journeyed out from the corners where the walls of the kingdom met. They too went as far out as their brothers. The orange faced a shimmering heat, the violet a bottomless pit, and the green an endless sea of green grass. They too returned to build new walls which touched upon the old.



Step VI

Now all six knights gained courage and joined forces. The red set up a defense and built a Red wall from the Violet to the Orange to better guard the kingdom against the burning fire. Now he, especially, felt great courage within his own being. The violet knight built a wall from Red to Blue. From its ramparts he prayed and found the endless reaches of eternity where he could look beyond the bottomless pit to realms where there were never any endings. Blue stretched his ramparts from Violet to Green and built his wall deep and strong against the deep, blue ocean. Once done, he felt calm, peaceful, and sure that no storm could enter his father's kingdom. Green built his new wall from Blue to Yellow. Outside that wall great grasses and jungles crowded toward the inner kingdom but could not enter through the wall.

But from his wall, Green could look far in understanding how all life was linked together. Yellow built a wall of golden light against the blinding desert sun. It was a wall of wisdom that guarded his father's kingdom against all that dazzles, and dizzies those who have no wisdom. It made the outer light dim in the strength of an inner light. And lastly, Orange built a wall that guarded the kingdom from the heat that flickered between the desert and the fire. The orange wall established, within the kingdom, a power of warm-hearted love in everyone of the subjects of the King.



Step VII

Each knight, having had his part in enlarging the old kingdom to become four times its original size, allowed each color enter the spirit of the realm:

with yellow came wisdom
(knowing what to do)—

with red came courage
(doing what is hard)—

with blue came peace
(a feeling of God's love for mankind)—

with green came understanding
(of others)—

with violet came a sense of eternity
(timelessness)—

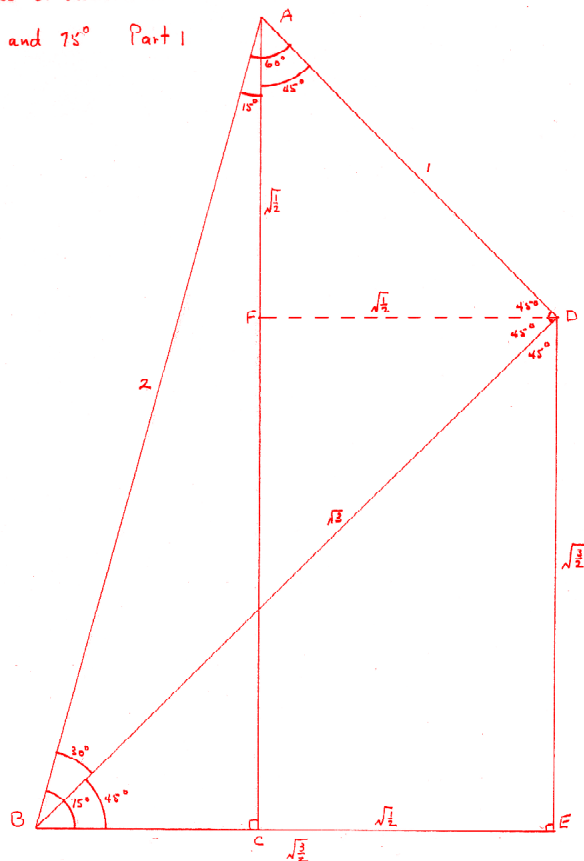
with orange came love
(for all that is good).

Novel Entries for a Trig Table

In trigonometry, it is common to begin simply and build up the values for the sine function by evaluating simple, regular geometric forms such as 30°–60° and 45° right triangles (see also the article on another approach to trigonometry in this issue). In this way, we can evaluate the entries for the sine 30°, sine 45°, and sine 60°. However it would be nice to have further entries to use to solve some simple, introductory trigonometry problems with our “own trig table.” The classic way to compute further angle values is to use the very elaborate half-angle and double-angle formulae as they were applied by Ptolemy in producing his complete table. However, these formula are difficult to introduce and prove to a novice class.

Harry Kretz has found a way to determine two additional angles using simple geometric relationship within the grasp of a 10th grade beginning trigonometry. His novel approach is explained in his forthcoming book on trigonometry. However, until it appears in print, we were given permission to share this gem with our readers.

Values of functions of
15° and 75° Part 1



Part 2

Values of functions of 15° and 75°

$$a = \sqrt{\frac{3}{2}} - \sqrt{\frac{1}{2}} = 1.2247 - 0.7071 = 0.5176$$

$$b = \sqrt{\frac{3}{2}} + \sqrt{\frac{1}{2}} = 1.2247 + 0.7071 = 1.9318$$

$$\sin 15^\circ = \frac{0.5176}{2} = 0.2588$$

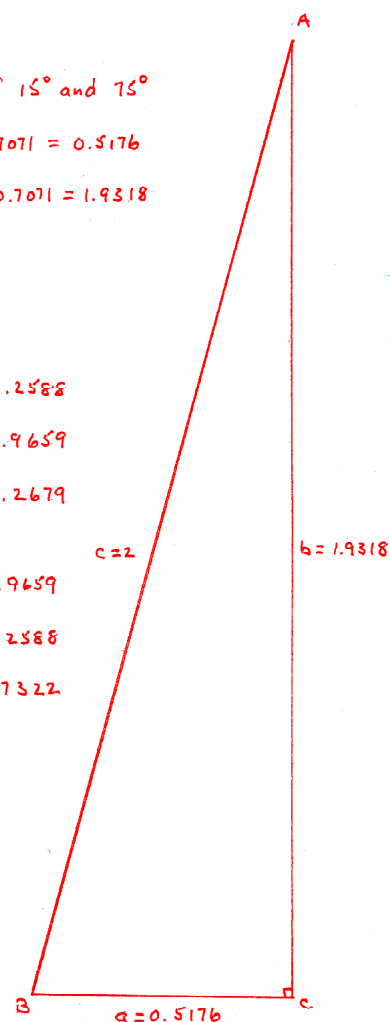
$$\cos 15^\circ = \frac{1.9318}{2} = 0.9659$$

$$\tan 15^\circ = \frac{0.5176}{1.9318} = 0.2679$$

$$\sin 75^\circ = \cos 15^\circ = 0.9659$$

$$\cos 75^\circ = \sin 15^\circ = 0.2588$$

$$\tan 75^\circ = \frac{1.9318}{0.5176} = 3.7322$$



The first step is to lay out the hypotenuse of a 45° triangle congruent to the short side of a 30°–60° triangle (as shown in the figure “Part 1”). This forms a small 15°–75° triangle and a rectangle. We can now work out the length of the rectangle.

Given the short side of the 30°–60° triangle = 1, its long side = $\sqrt{3}$; then, the side of the small 45° triangle forms the top of the rectangle, and = $\sqrt{1/2}$. There is also formed a large 45° triangle, whose hypotenuse is congruent to the long leg of the 30°–60° triangle and = $\sqrt{3}$; thus, its sides must be = $\sqrt{3/2}$.

So (as shown in the second illustration “part 2”) by addition or subtraction of the known values, the long leg of the 15°–75° triangle must be $\sqrt{1/2} + \sqrt{3/2} = 1.9318$, and its short leg $\sqrt{3/2} - \sqrt{1/2} = 0.5176$.

An introduction to the Sine and Tangent

by

Uwe Hansen

excerpt from

Mathematics Themes for 10th Grade

Developed on the Basis of Waldorf School Teaching

Kassel 2002

Trigonometry arises out of the question: What is the relationship between curved and straight lines? This relationship can be studied in a simple case: A straight line g which touches a circle tangent at point B , now moves a certain angle α around B , so that a chord of length s arises.

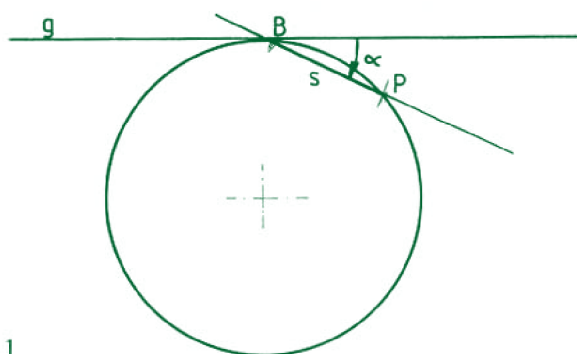


Fig. 1

The length of the chord changes. Initially, the chord will grow as the angle α grows larger, until with $\alpha = 90^\circ$, it will be equal to the diameter of the circle. Then, it will grow smaller, and with an angle of $\alpha = 180^\circ$, it will again (as with $\alpha = 0^\circ$) become zero.

We examine a few special angles:

1. Case $\alpha = 30^\circ$

The central angle is 60° , and we have an equilateral triangle. The chord is equal to the radius, and also to the sides of a regular hexagon: $s = r$.

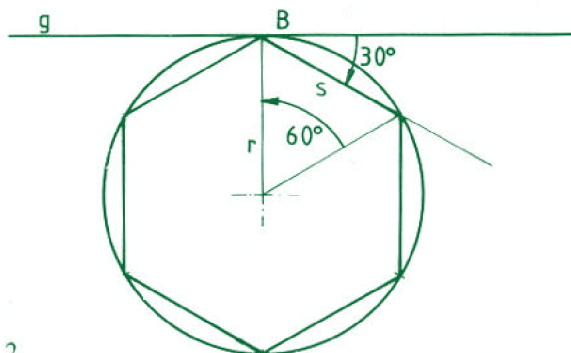


Fig. 2

2. Case $\alpha = 45^\circ$

The central angle is now 90° in this case. The chord is the side of a square inscribed in the circle.

it is:

$$s^2 = r^2 + r^2 \quad \text{law of Pythagoras}$$

$$s^2 = 2r^2$$

$$s = r \cdot \sqrt{2}$$

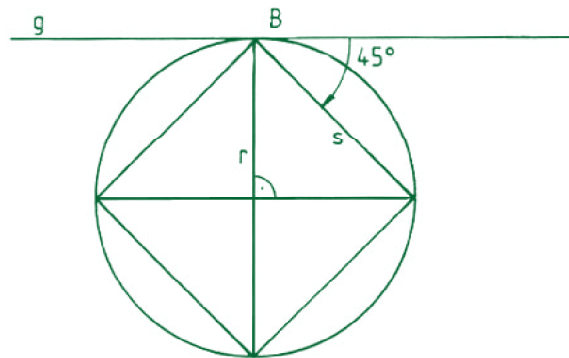


Fig. 3

3. Case $\alpha = 60^\circ$

The central angle is 120° . The chord is the side of an equilateral triangle inscribed in the circle.

$$s^2 + r^2 = (2r)^2 \quad \text{law of Pythagoras}$$

$$s^2 + r^2 = 4r^2$$

$$s^2 = 3r^2 = r\sqrt{3}$$

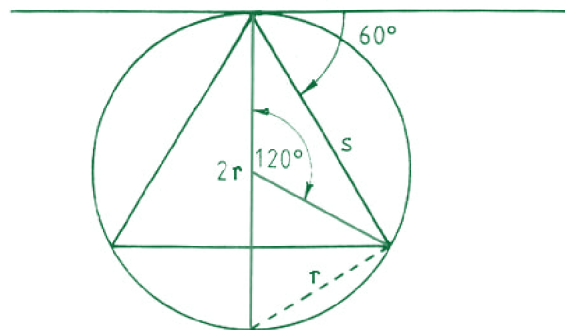


Fig. 4

Overview:

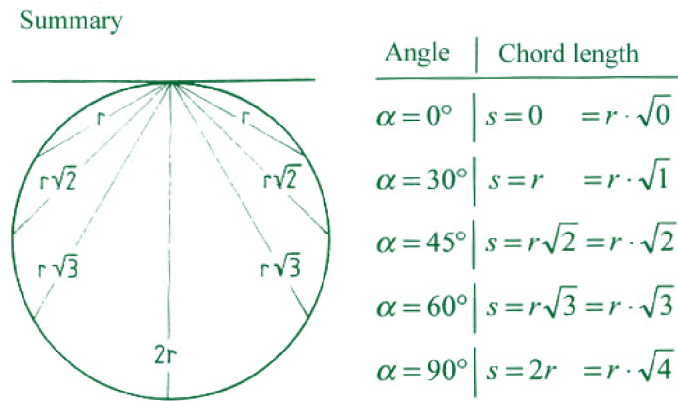


Fig. 5

The rule applies: The chord for the angles α and $180^\circ - \alpha$ have the same length.

In addition it holds true that: all “inscribed” (peripheral) angles, which lie on one side of the chord s of the circle, are all equal to each other.

The inscribed angles β on the other side of the chord are larger and also equal to each other, decreasing from 180° .

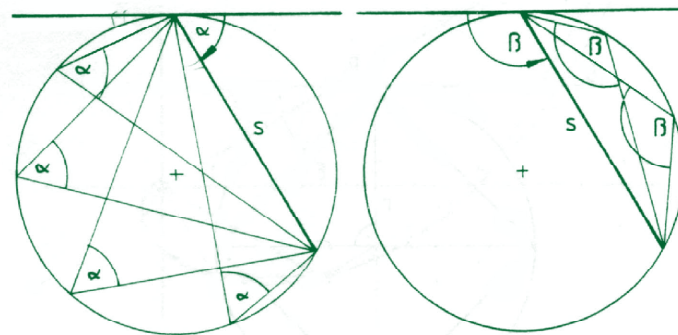


Fig. 6a

Fig. 6b

Some properties of chords and angles

Since $\alpha + \beta = 180^\circ$, the inscribed (peripheral) angles are all equal to the tangent angle (α or β) of the corresponding chord.

The central angle is twice the size (2α) of the inscribed angle α .

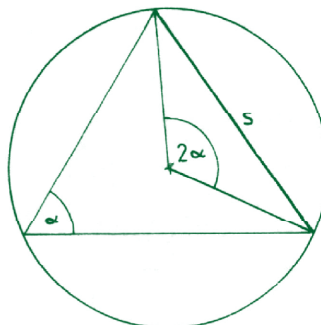


Fig. 7

All chords, formed by a inscribed angle α on the circumference of a circle, have the same length.

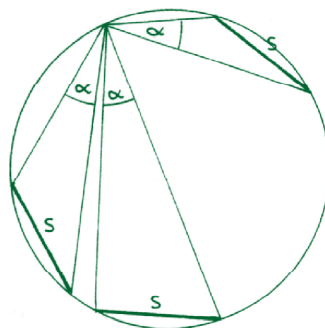


Fig. 8

This leads to the definition of the sine: The sine of an angle α is the relationship of the chord length s to the circle's diameter, where the chord belongs to inscribed angle α

$$\begin{aligned}\sin \alpha &= \frac{\text{chord of peripheral angle } \alpha}{\text{circle diameter}} \\ &= s/2r\end{aligned}$$

In particular, it is true: $\sin \alpha = \sin(180-\alpha)$. This definition also has the advantage that for angles $\alpha > 90^\circ$ up to 180° the sine is immediately clear—the usual introduction of the sine for these obtuse angles is not transparent enough for the students.

We can extend the previous table to:

inscribed angle	chord length	chord = $s/2r$ diam	in short
0°	0	$0/2r = 0$	$\sin 0^\circ = 0$
30°	r	$r/2r = 1/2$	$\sin 30^\circ = 0.5$
45°	$r\sqrt{2}$	$r\sqrt{2}/2r = \sqrt{2}/2$	$\sin 45^\circ = 0.7071$
60°	$r\sqrt{3}$	$r\sqrt{3}/2r = \sqrt{3}/2$	$\sin 60^\circ = 0.866$
90°	$2r$	$2r/2r = 1$	$\sin 90^\circ = 1$
120°	$r\sqrt{3}$	$r\sqrt{3}/2r = \sqrt{3}/2$	$\sin 120^\circ = 0.866$
135°	$r\sqrt{2}$	$r\sqrt{2}/2r = \sqrt{2}/2$	$\sin 135^\circ = 0.7071$
150°	r	$r/2r = 1/2$	$\sin 150^\circ = 0.5$
180°	0	$0/2r = 0$	$\sin 180^\circ = 0$

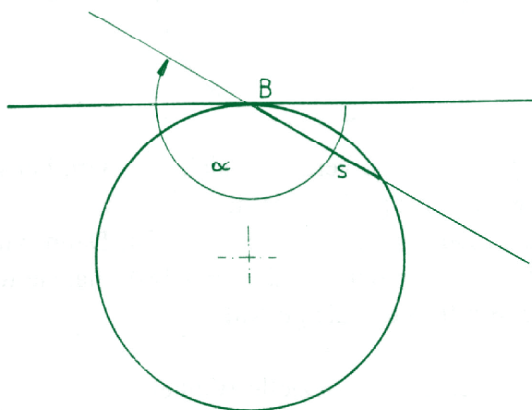


Fig. 9

This approach leads to the correct idea that the sine produces *negative* values for obtuse angles (see Fig. 9, above)

$\alpha > 180^\circ$.

For example, with, $\alpha = 210$ ($180 + 30$), it must be that the $\sin 210 = -\frac{1}{2}$, since the chord must now be measured in the direction (to the *right*) *opposite* to the angle side (going upper *left*, from vertex, along leg) for these obtuse angles.

Further, the *Law of Sines* is now also a direct outcome of our chosen definition, as follows:
 since $\sin \alpha = \alpha/2r$ $\sin \beta = \beta/2r$ $\sin \gamma = \gamma/2r$

then: $2r = a/\sin \alpha = b/\sin \beta = c/\sin \gamma$

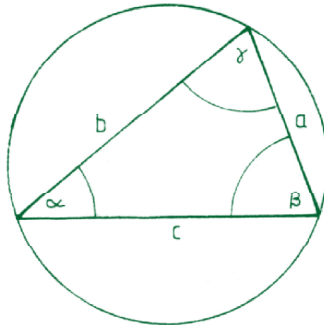


Fig. 10

So, we have in this simple way developed the important *Law of Sines*!

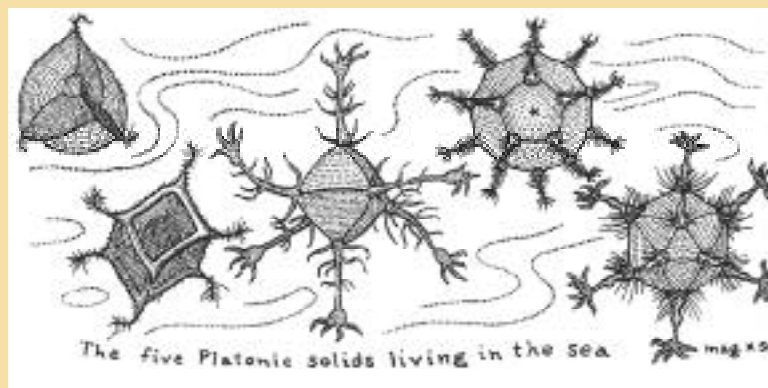
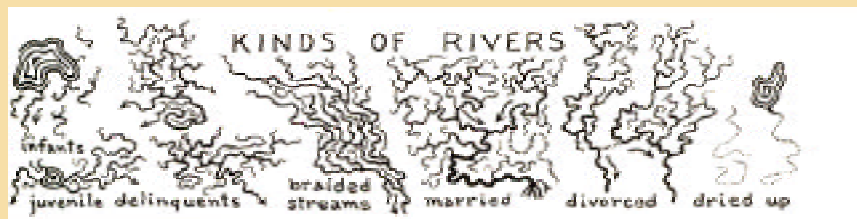


Illustration taken from *The Seven Mysteries of Life*
 by Guy Murchie, reviewed in this newsletter.

Toss Out the Toss-Up: Bias in Heads-or-Tails

by

Erica Klarreich

If you want to decide which football team takes the ball first or who gets the larger piece of cake, the fairest thing is to toss a coin, right? Not necessarily.

A new mathematical analysis suggests that coin tossing is inherently biased: A coin is more likely to land on the same face it started out on.

"I don't care how vigorously you throw it, you can't toss a coin fairly," says Persi Diaconis, a statistician at Stanford University who performed the study with Susan Holmes of Stanford and Richard Montgomery of the University of California, Santa Cruz.

In 1986, mathematician Joseph Keller, now an emeritus professor at Stanford, proved that one fair way to toss a coin is to throw it so that it spins perfectly around a horizontal axis through the coin's center.

Such a perfect toss would require superhuman precision. Every other possible toss is biased, according to an analysis described on Feb. 14 in Seattle at the annual meeting of the American Association for the Advancement of Science.

The researchers' logic goes like this. At the opposite extreme from Keller's perfect toss is a completely biased toss, in which the coin stays flat while in the air. Since the coin never actually flips, it is guaranteed to land on the same face that it started out on.

Between the perfectly spinning toss and the flat toss lies a continuum of other possibilities, in which the coin spins around a tilted axis, precessing like an old-fashioned children's top. Each of these possibilities is biased, the team found. The bias is most pronounced when the flip is close to being a flat toss. For a wide range of possible spins, the coin never flips at all, the team proved.

In experiments, the researchers were surprised to find that it's difficult to tell from watching a coin whether it has flipped. A coin toss typically takes just half a second, with the circumference of the coin

whizzing around at three meters per second. What's more, the coin's spin makes it wobble, often creating the illusion that the coin has flipped.

"Sometimes we had the complete impression that the coin had turned over when it really hadn't," Holmes says.

Magicians and charlatans may take advantage of this illusion. Keller observes, "Some people can throw the coin up so that it just wobbles but looks to the observer as if it is turning over." To see whether the predicted bias shows up in actual coin tosses, the team made movies of tossed coins and then calculated the axes of spin.

Their preliminary data suggest that a coin will land the same way it started about 51 percent of the time. It would take about 10,000 tosses before a casual observer would become aware of such a small bias, Diaconis says. "Maybe that's why society hasn't noticed this before," he says.

This slight bias pales when compared with that of spinning a coin on its edge. A spinning penny will land as tails about 80 percent of the time, Diaconis says, because the extra material on the head side shifts the center of mass slightly.

During World War II, South African mathematician John Kerrich carried out 10,000 coin tosses while interned in a German prison camp. However, he didn't record which side the coin started on, so he couldn't have discovered the kind of bias the new analysis brings out.

Says David Aldous, a statistician at the University of California, Berkeley, "This is a good lesson that even in simple things that people take for granted, there may be unexpected subtleties."

References:

Diaconis, P. 2004. The search for randomness. American Association for the Advancement of Science annual meeting. Feb. 14. Seattle.

Further Readings:

Keller, J.B. 1986. The probability of heads. *American Mathematical Monthly* 93(March):191-197.

Peterson, I. 2004. Heads or tails? *Science News Online* (Feb. 28). Available at: <http://www.sciencenews.org/articles/20040228/mathtrek.asp>.

Sources:

David Aldous
Department of Statistics
University of California, Berkeley
367 Evans Hall
Berkeley, CA 94720-3860

Persi Diaconis
Department of Statistics
Stanford University
Stanford, CA 94305-4065

Susan P. Holmes
Department of Statistics
Stanford University
Stanford, CA 94305-4065

Joseph B. Keller
Stanford University
Department of Mathematics
Stanford, CA 94305-2125

Richard Montgomery
Department of Mathematics
University of California , Santa Cruz
1156 High Street
Santa Cruz, CA 95064

Taken from <http://www.sciencenews.org/articles/20040228/fob2.asp>
Science News, Week of Feb. 28, 2004;, Vol. 165,
No. 9 , p. 131, "Toss Out the Toss-Up: Bias in heads-or-tails" reported by Erica Klarreich.

Phlogiston Theory

According to the phlogiston theory, propounded in the 17th century, every combustible substance consisted of a hypothetical principle of fire known as phlogiston, which was liberated through burning, and a residue. The word phlogiston was first used early in the 18th century by the German chemist Georg Ernst Stahl. Stahl declared that the rusting of iron was also a form of burning in which phlogiston was freed and the metal reduced to an ash or calx. The theory was superseded between 1770 and 1790 when the French chemist Antoine Lavoisier showed that burning and rusting both involved oxygen and concluded that both ash and rust were compounds of oxygen. Lavoisier's oxidization theory has been accepted by scientists from about 1800 to the present day.

Bibliography: Conant, James B., ed., *Overthrow of the Phlogiston Theory: The Chemical Revolution of 1775-1789* (1950); Partington, J.R., and McKie, D., *Historical Studies on the Phlogiston Theory* (1981).

Humor

“After being interviewed by the school administration, the eager teaching prospect said: “Let me see if I’ve got this right.

“You want me to go into that room with all those kids, and fill their every waking moment with a love for learning. And I’m supposed to instill a sense of pride in their ethnicity, modify their disruptive behavior, observe them for signs of abuse, and even censor their T-shirt messages and dress habits.

“You want me to wage a war on drugs and sexually transmitted diseases, check their backpacks for weapons of mass destruction, and raise their self esteem. You want me to teach them patriotism, good citizenship, sportsmanship, fair play, how to register to vote, how to balance a checkbook, and how to apply for a job.

“I am to check their heads for lice, maintain a safe environment, recognize signs of antisocial behavior, offer advice, write letters of recommendation for student employment and scholarships, encourage respect for the cultural diversity of others, and oh, make sure that I give the girls in my class 50 percent of my attention.

“My contract requires me to work on my own time after school, evenings, and weekends grading papers. Also, I must spend my summer vacation at my own expense working toward advance certification and a Masters degree. And on my own time you want me to attend committee and faculty meetings, PTA meetings, and participate in staff development training. I am to be a paragon of virtue, larger than life, such that my very presence will awe my students into being obedient and respectful of authority.

“And I am to pledge allegiance to family values and this current administration. You want me to incorporate technology into the learning experience, monitor web sites, and relate personally with each student. That includes deciding who might be potentially dangerous and/or liable to commit a crime in school. I am to make sure all students pass the mandatory state exams, even those who don’t come to school regularly or complete any of their assignments.

“Plus, I am to make sure that all of the students with handicaps get an equal education regardless of the extent of their mental or physical handicap.

“And I am to communicate regularly with the parents by letter, telephone, newsletter, and report card.

“All of this I am to do with just a piece of chalk, a computer, a few books, a bulletin board, a big smile, AND on a starting salary that qualifies my family for food stamps! You want me to do all of this and yet you expect me. . .

. . . NOT TO PRAY?”

Song of the Rain

—by Howard Schrager

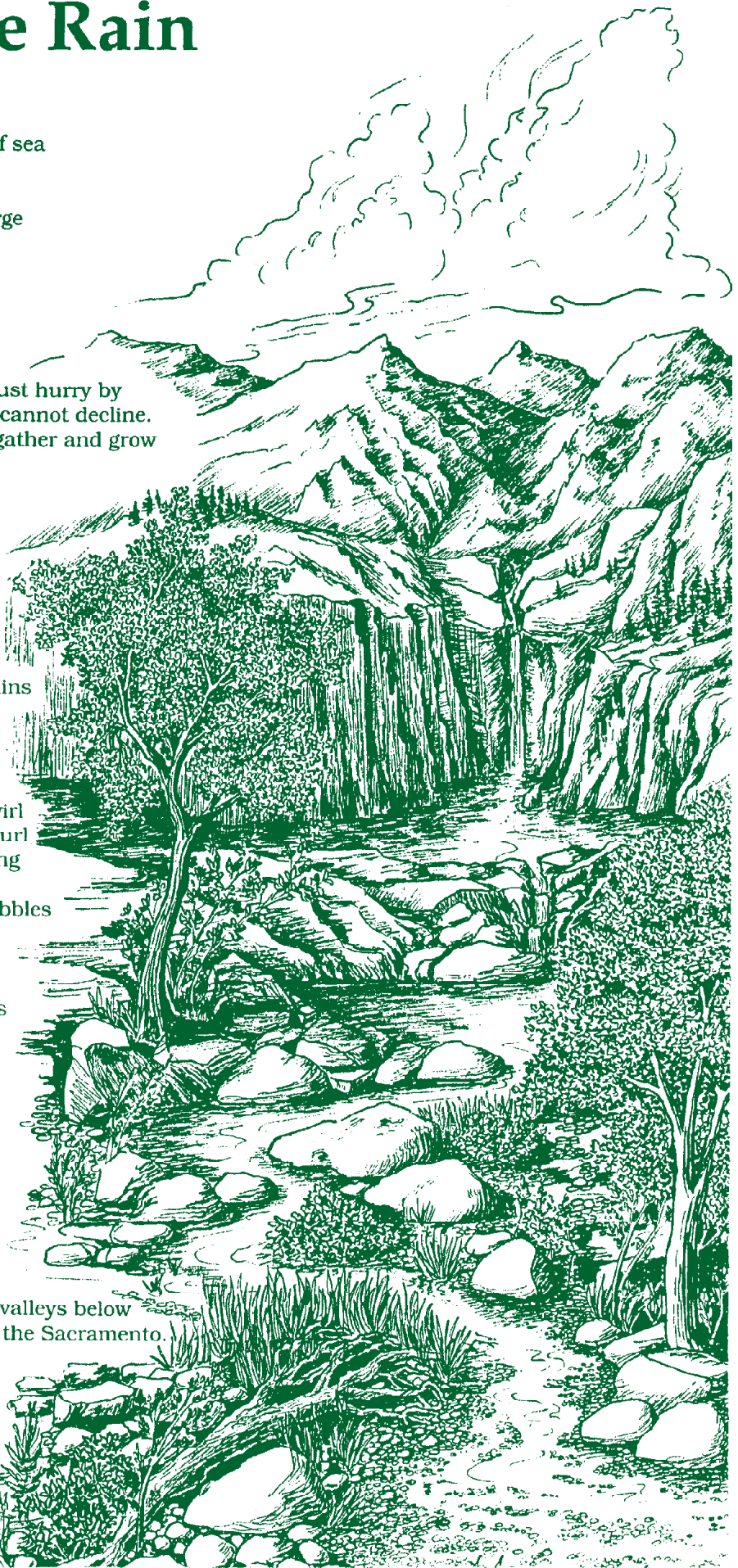
Masses of air and surges of sea
In unsurpassing time
Mingle ceaselessly.
Over the Pacific huge clouds emerge
By the hand of the wind
Landward they are urged.
Reaching first the sandy shores
They cross the coastal hills
Hurrying past the valleys wide
They tumble up foothills.
Fueled by the breeze they would just hurry by
But to climb the High Sierra they cannot decline.
Higher, ever higher, stormclouds gather and grow
Colder, ever colder
Rain droplets, or snow.

First a pitter then a patter
Little drops begin to splatter
All about the High Sierra.
Every dimple in the granite
Catches water, then it scatters
Then the scores of tiny droplets
As if scared run down the mountains
Then the trickles turn to ripples
As they scamper ever downward
Thrilling over stone and gravel
Meet like playmates as they travel
Forming creeks they skate and swirl
Down cascades they plunge and curl
Bubbling, gurgling, roaring, purring
Over rock and root they wheel
Sweeping twigs and leaves and pebbles
And then pausing in the eddies.

All these swiftly moving streams
From their own self-carved ravines
Now they join the booming tide
In deep gorges trenched in time
Of the mighty thundering rivers
On the floor of their own canyons.

Kings and Kern, Mokelumne
Stanislaus, Tuolumne
Feather, Bear, American
Merced and Yuba surge ahead
Through the Mother Lode
With its horde of gold
Downward, ever downward to the valleys below
Joining now the San Joaquin and the Sacramento.
Slower now, and broader
Past the Delta, rich, the flow
Through the Straits, into the Bay
Out the Golden Gate and home.

© 1991 Howard Schrager



Refrigeration in Physics – Heat Studies

by

Paolo Carini, Ph.D.
San Francisco Waldorf High School

After a discussion of heat, boiling phenomena, and latent heat, a refrigerator is brought into class. This is not a common refrigerator, however! This is a refrigerator-bike, see Fig. 1, right! The students like to ride the bike, but instead of turning a wheel they crank a compressor.

It is hard work! The result, however, is rewarding. The condenser (the thinner tube coiled around one side of the handle bar—see Figs. 2 and 3, below), runs from the compressor (Figs. 4–7) to the handle bar, and becomes quite warm; meanwhile the evaporator (the large tube coiled around the other side of the handle bar in the Fig. 3, below), which is connected to the condenser through a capillary valve and then runs back to the compressor, starts to cool down till frost appears on it!

It is a beautiful application of the concepts of heat and latent heat we have discussed in class, and at the same time is a real experience of the *work* needed to reverse the natural direction of heat flow.



Fig. 1



Fig. 2

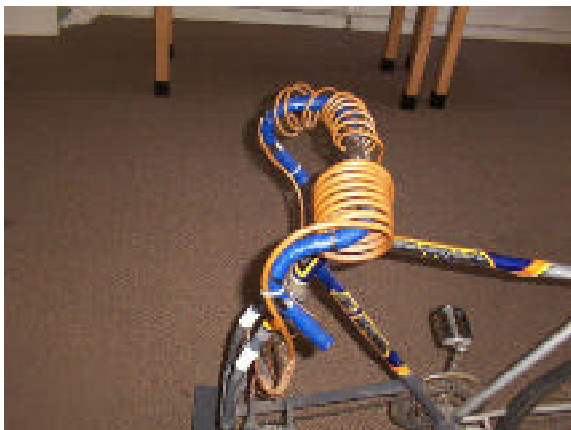


Fig. 3



Fig. 4



Fig. 6



Fig.5



Fig. 7

The Poetry Of Astronomy

Here is a lovely website, just packed with information about astronomy, links to resources, and an appreciation of poetry about the stars!

<http://www.celestialnavigation.net/wayfinding.html>



Celestial Navigation is the art and science of finding your way by the sun, moon, stars, and planets, and, in one form or another, is one of the oldest practices in human history. This webpage is an attempt to bring together all of the best Celestial Navigation resources on the internet, with pointers to other resources as well. Find out why we should study Celestial Navigation in the age of GPS; get an introduction to Celestial Navigation's history, then take a look at the navigational astronomy page as a background for the theory and practice; teachers, discover how celestial navigation can enliven the classroom, whether your field is earth science, astronomy, math, history, or literature, with special links about Vikings; learn about navigational instruments, including sextants, astrolabes, nocturnals, and planispheres; learn about nonwestern, non-instrument Polynesian starpaths and Wayfinding; read quotations about navigation; check out some schools; or just go directly to the list of resources that lists the sources from other pages.

“The heavens call to you and circle about you, displaying to you their eternal splendors....”

— Dante, *Purgatorio*, Canto XIV



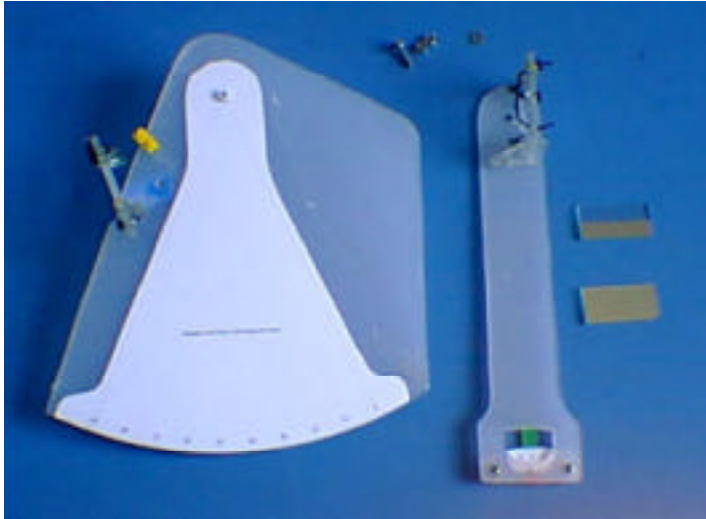
This astrolabe can be ordered from Celestaire Corp. at <http://www.celestaire.com/catalog/products/1701.html>

The Xtant Project

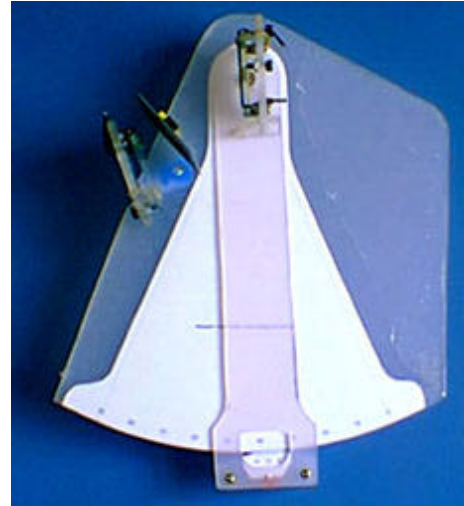
Build your own sextant

From time to time I get tired of writing abstract computer programs. This time I decided to do a more concrete project: a sextant (actually, an octant). I'm not a very experienced craftsman and don't have an equipped shop. The design is simple and can be reproduced with hand tools. I used a small jigsaw and a belt sander. I have made no blue prints.

In tests, when compared to a Davis plastic sextant, this octant did agree within six inches (see test results in the at the end of the article).



My octant parts ...

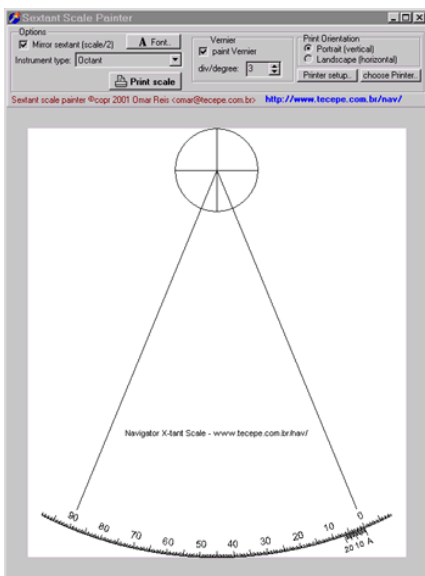


... assembled

Printing the scale

The scale is probably the most difficult sextant component to do using traditional techniques. It must be very precise and allow reading degrees and minutes, with accuracy at least within five feet of arc.

Fortunately, most of us have a precise printing equipment right on our desktop: an inkjet or laser printer. These machines can print 300 dots per inch (1,200 for laser), with enough precision to print a good sextant scale.



To the left, you see a screenshot of my XtantScalePrinter program. I used the default options in my project, but you may experiment with other designs (sextant types, ticks per degree etc.).

Laser or inkjet?

Laser printouts are more resistant to water than inkjet ones, and they have better resolution. Use a laser printer, if available.

But an inkjet printer will also do the work. If using an inkjet scale, protect it from water spray, either by adding a thin layer of transparent plastic or by taking extreme care with the instrument.

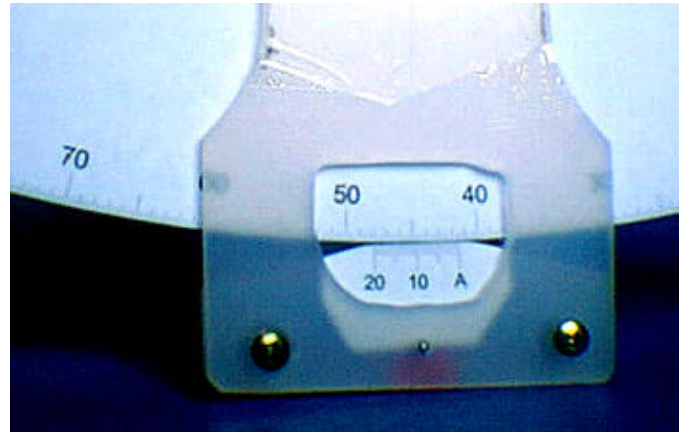
Sextant scale printer program

In order to achieve the best results, I wrote a small scale printing program. Please go to the web page to download this material.

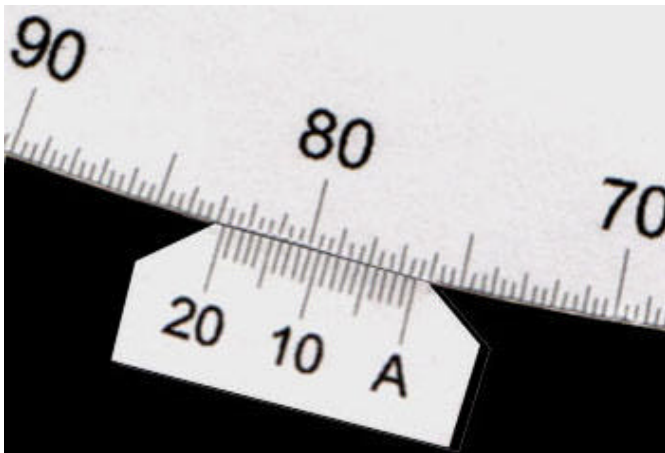
Since I didn't have the sophisticated machining equipment required, I discarded the idea of a drum sextant and went on to build a vernier scale sextant. Vernier sextants appeared before the modern drum sextants. In the vernier scale sextant, each degree in the scale is divided in three ticks (20' wide).

Access the complete article at:

<http://www.tecepe.com.br/nav/XTantProject.htm>



The Vernier scale

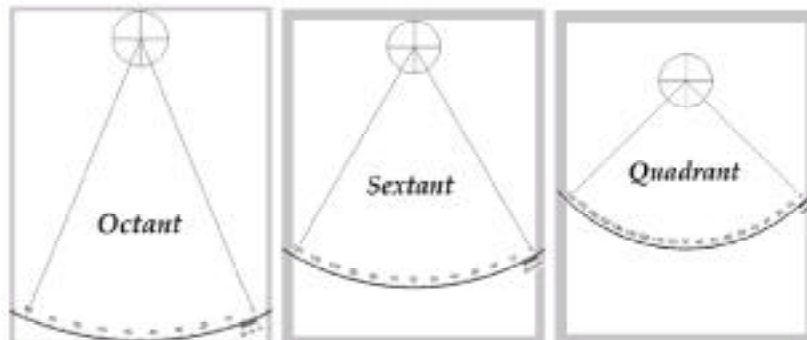


Vernier scale

The vernier scale precision can be as good as a drum scale. The only difference is that the vernier scale requires a much more delicate handling of the sextant arm while trimming.

Reading the vernier scale is easy, once you get used to it. In the scale to the left, the index reads 76° with minutes between 20' and 40' (tick A). In the vernier, we can see that the sixth vernier tick coincides with the index tick, so the reading is 76°26'.

Below are the three basic X-tant types. The octant can measure up to 90°, the sextant up to 120°, and the quadrant up to 180° (see below). I choose to build an Octant, since this design fits better in a A4 printer page, giving the largest possible degree size in the scale, for best detail. And the 90° scale is enough for most observations.



X-tant types

I used A4 inkjet sticker paper to print the scale (the ones used for printing labels). Choose a paper with no cuts. After printing the scale, check your printer's quality, using a compass to see if the index is a perfect circle segment.

Scale Transfer – An alternative way to print the scale was suggested by Mr. Schmit by email: “When you print documents with laser printers or photocopiers, it is done by fusing the toner on the paper. You can transfer the print on any solid heat resistant material by refusing the toner with a very hot clothing iron. Place the laser-printed document on the cleaned material (printed side facing the surface) then apply the iron on the paper back just long enough to melt the toner. I used that to make gratings and reticules on glass or metal sheets, and it works fine if your print is strong enough—but the print must be reversed!”

While this reversed print is not directly supported by the scale printer program, most printer drivers (e.g.: HP) offer this as an option. Open the “Printer Setup” dialog, click “Properties” and check the “reverse horizontally” checkbox.

Another way was suggested by Mr. Kunnar, “I used inkjet iron transfer paper. It is a kind of plastic that can be transferred to clothes using a hot iron. Since the ink ends up trapped between the sextant frame and the plastic layer, this scale is water proof.”

Instrument frame

I used a three mm thick acrylic board for the instrument frame. This material is easy to machine and relatively rigid. Acrylic boards are usually sold in large sizes, so you might want to search for someone who works with this material, in order to get the small piece you need with minimum expense.

The size of the sextant will depend on the printed scale size (that's why there is no blue print). So, you will only “design” the instrument after you have stuck the scale on the acrylic board.

The acrylic board comes with plastic layers in both sides for protection. It's a good idea to keep this protection as long as possible, because the acrylic will be easily scratched. I carefully lifted the plastic protection (see below), stuck the scale and put the plastic back in place, so the sextant scale was also protected while machining the frame.



Lift the plastic protection, adhere the scale, and put the protection back in place.

After printing, cut around the scale, leaving like three mm around the outside line.

Sticking the printed scale in the board is a critical operation. It must be perfectly stuck, free of air bubbles or ripples. Otherwise the scale will not be correct.



Remove the paper backing completely. Hold it with the two hands and gently place in the acrylic board, the arm axis circle first. Then use one hand to spread the scale, while holding the other side. Keep the paper slightly tensioned, but not so much as to distort it. If you make a mistake, you probably will have to print another scale and start again.

Frame, arm, and vernier, with cut lines.

After this, you can use a marker pen to draw the parts (frame, arm and vernier).

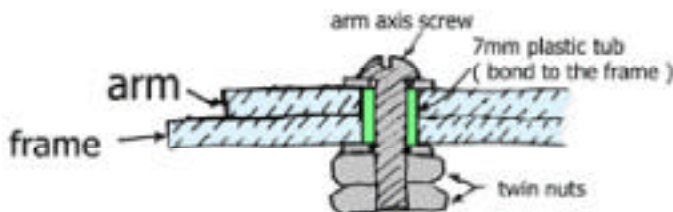
The arm window (where the scale is read) must be sized and positioned so that you can see both the scale and the vernier touch point (that will define the arm radius). My octant arm is about 40 mm wide.

When designing the arm, measure the scale radius and add 10mm on either side (towards and away from the arm axis). My arm window is 30 mm wide.

The image to the left shows the three frame parts, marked, and ready to be cut.

I cut the parts with a jigsaw with a thin-toothed blade. Take care when cutting along the scale ticks. Never cut across the scale line. If you are careful, you can cut as close as 0.5 mm from the scale. Then you will have little trouble sanding out the rest, until you precisely reach the fine scale line. Use fine sanding paper for finishing the scale arc.

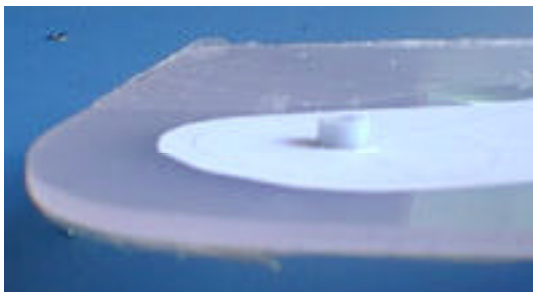
Also carefully cut and sand the vernier contact point, testing frequently against the scale arc. The vernier and scale contact must be as close as possible.



To drill the arm axis hole, first mark it with a hard point. Drill a two mm lead hole and then a seven mm hole. Use sharp drills. Do the same in the frame and make sure the hole center is precisely positioned.

I inserted a seven mm hard plastic tube in the axis, so there is no contact between the arm and screw as the arm is moved (only between the tube and arm). Bond the tube to the frame.

The axis screw goes in the middle, with twin nuts. Make sure there is no slack in the arm axis setup.



After cutting, drilling, and sanding, you can assemble the arm and frame for the first time. Then you can position and bond the vernier in the arm, using a couple small drops of loctite (Cyanoacrylate glue). Use small self-tap screws to secure the vernier.



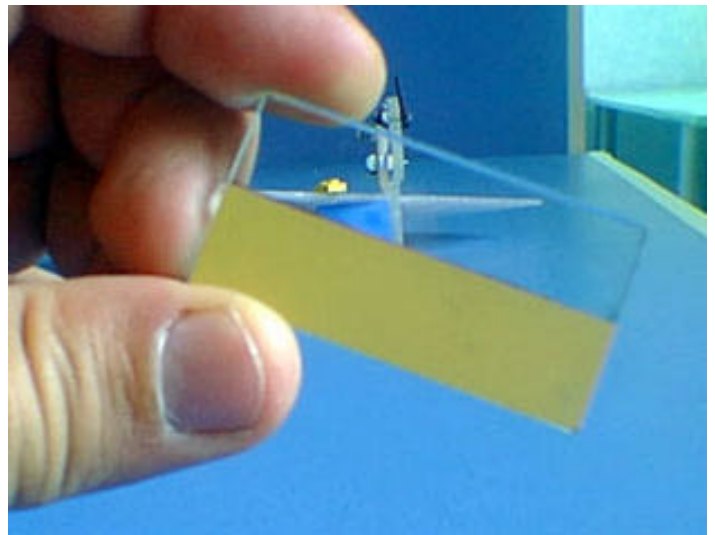
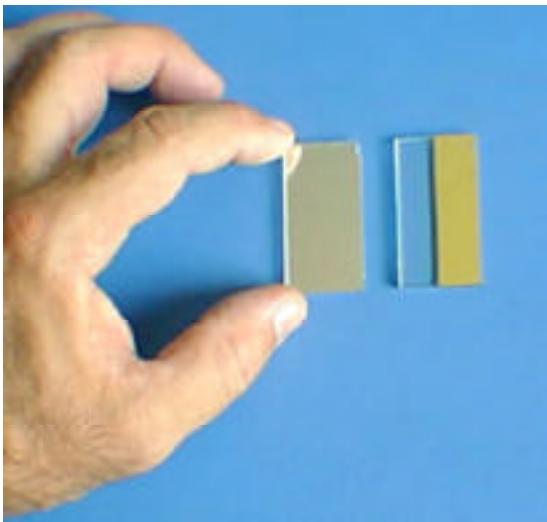
If you did these steps right, the vernier should be in smooth, close contact with the index, as you slide the arm along the arc.

Add a plastic device in the back of the arm to press it against the frame (the green part on the left image). It is important to have some friction between the arm and frame, so the instrument will hold the reading if left alone (i.e., the arm will not move by itself). This is also important for fine trimming.

Mirrors

I used two equally sized glass mirrors (46 mm x 24 mm, 3 mm thick). Any glass shop will cut these for you. As you know, one of the mirrors must be half silvered. So you must remove half of the mirror silver backing. I used a paper cutter blade for this job (Olfa cutter).

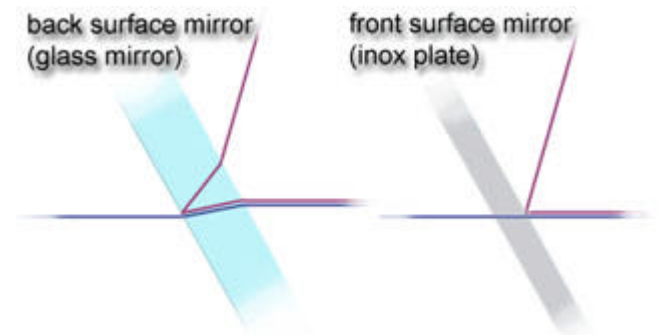
First make a sharp longitudinal cut along the middle of the mirror. Then scratch half of the epoxy protective layer from the back of the mirror, with the blade inclined. The epoxy backing is a hard material, but will come out with patience. Don't use any abrasive material or the blade point, to avoid scratching the glass. Once the epoxy is gone, the silver is easy to remove, rubbing hard with a wet cloth. In the end, the glass must be clear and scratch free (see Fig. below).



Mirrors

You may be tempted at this point to use a thinner mirror and eliminate the transparent part altogether. Don't do that. This would introduce a refraction error. The direct (horizon) light ray must pass thru the glass, as the light ray from the star does.

This can only be done if you use a front mirrored surface, such as a polished inox plate.



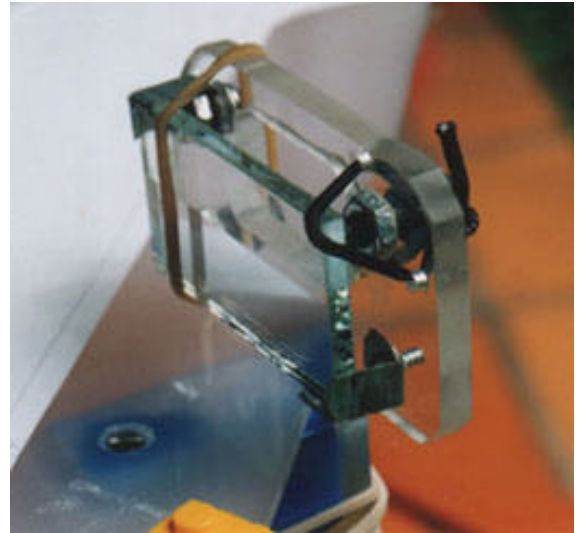
Mirror holders

I used a thicker acrylic for the mirror holders (4mm), as these parts are sometimes subjected to abuse. They will also have to be fixed with self-tap screws so a thicker material is better.

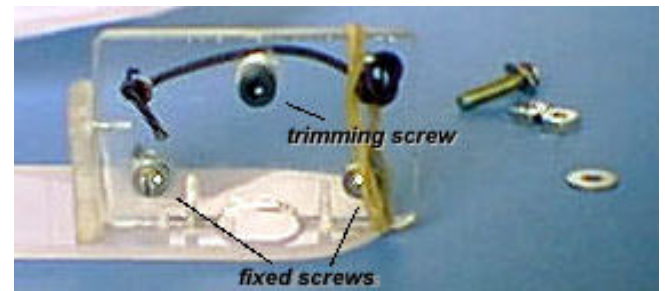
Both mirrors must be supported by three contact points (from geometry, we know that three points are required to define a plane). I used three supporting screws to position each mirror. Some of the screws are adjustable, for mirror trimming, and some are fixed. For the adjustable screws, I used Allen screws, which have large heads and are easy to turn by hand. The fixed points are regular inox nut screws.

Make a point in all screw tips, to reduce the contact area between mirror and screw to a point. I also added thin metal plates to prevent the mirrors from moving sideways while trimming.

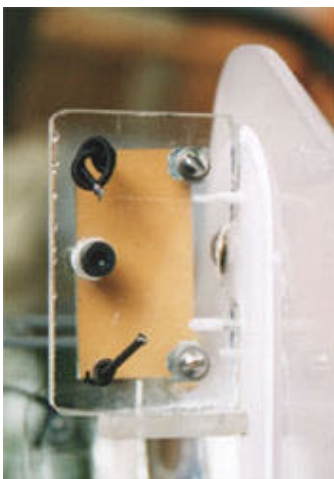
To ensure a perfect contact between the three screws and mirror, I used rubber bands. These press the mirrors against the screws. Commercial sextants use metal springs for this function, but I could not find any suitable part in my junk collection.



Arm mirror setup

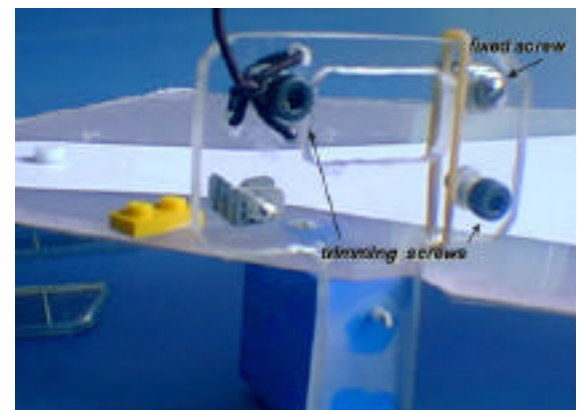


Backview



The *arm mirror holder* is basically a rectangle with a side supporting plate. The arm mirror has one adjustable screw (top screw in the figure above). Make a 1 mm deep housing for the adjustable screw nut and bond it to the acrylic, so it won't move when you trim the screw.

The *frame mirror holder* is a T shaped part, with two adjustment screws. Cut a window, so that the sight thru the glass part of the frame mirror is clear.



After completing the two mirror holder setups (i.e., after drilling, cutting, sanding, and securing the mirror screws), you can bond them to the frame and arm. Start with the arm mirror.

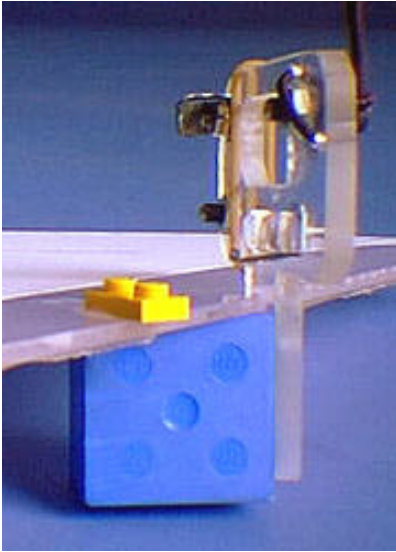
The arm mirror assembly must be positioned so that the center of the mirrored surface (the back surface of the mirror) is over the arm axis center. This way the center of the mirrored surface (i.e. the back of the mirror) remains fixed while the arm is moved.

Make sure you have space to introduce and remove the arm axis screw, or you won't be able to assemble and disassemble the arm. After bonding with Loctite, use small flathead self-tap screws to secure the assembly to the arm. Make a housing for the screw head to avoid interfering in the arm movement.

After securing the arm mirror assembly, set the arm to $0^{\circ}00'$ reading and place the frame mirror assembly parallel to the arm mirror. I used a Lego Duplo block (the large blue piece) to support the frame mirror assembly. This way the right angle between the frame mirror and instruments plane is guaranteed.

I like to use Lego parts because they are widely available (at least in my house floor), have good dimensional precision and include all sorts of blocks and devices.

Make sure both mirror holders are firm by bonding and securing with screws. Having reached this point, you already have a sextant to take twilight sights. But you still need shades to take sun sights.



Shades

As shades for sun and moon sights, I used 35 mm dark negative photography film (there is one in the end of every film roll). The negatives were mounted in slide frames. I used double negatives for the sun frame and single for the moon.

Both slide frames are removable and are attached to the instrument frame using Lego blocks (the yellow one in the pictures above). I must say I'm not happy with this fixation solution. A more skilled (less lazy) craftsman would probably do a better job with some pivoting design.

The thing to watch here is the shade position. The filter surface must be orthogonal to the line connecting both mirror centers. This is to avoid introducing a refraction error. Try to position the slide center in the line connecting the two mirror centers.



Sun shade

Don't make the same mistake I did, letting the shade support interfere with the arm at large angles. The arm must go at least up to 90° (for the octant).

No eyepiece?

I was looking for a good 2x or 3x small telescope that I could use as an eyepiece for my sextant. I played with small toy telescopes, but results were poor. In the end, I decided to use no eyepiece. This actually gives a lot of freedom handling the sextant.

When taking a sight, remember to hold the instrument so that your eye is on a plane parallel to the instrument's and containing the fixed mirror silver-glass division. This is easy to find: Turn the instrument up until you face the fixed mirror. In this position, you should see half of your eye in the silvered part of the mirror. Move it sideways until you see it. Then turn the instrument back down to observation position.

Trimming the mirrors

Trimming this octant is no different than any other sextant. First trim the arm mirror adjustment screw. The arm mirror must be perpendicular to the arm/frame plane. This may be checked by looking at the index scale reflected in the arm mirror. The reflected index must be perfectly aligned with the index part you see directly (green arrow on the right).

Then trim the frame mirror. This is a little trickier, because two screws have to be trimmed simultaneously. Set the arm to 0°00' and point the instrument to a far object (like a star or boat far away). Then trim the two screws until the object remains a single image while you swing and rock about the instrument axis.



Sun sight

As future improvements, I would change to a better shade positioning system, add a nice handle and a case (I'm currently using a cardboard box). The case is probably the most important of the three, for a sextant – like a violin – is not be left hanging around if it is to last long.

There are many materials, design ideas, and garage junk devices that can be used to build a sextant. If you build such an instrument – using these ideas or not – I would like to hear about it. I would also be happy to publish other design solutions here.

A sextant is a fun thing to build, and getting a precise reading from your own instrument is one thing that will make you feel good.

Sextant field test

I did some tests comparing the same vertical angles, measured by three different instruments:

1. A Kern theodolite
2. A Davis MK15 plastic sextant
3. My Octant

The theodolite (a survey instrument) is presumably more precise than the sextants and was used as a benchmark. Sextant angles were corrected for index error. I measured four vertical objects, obtaining the following results:

Object #	Kern theodolite	Davis sextant		My Octant	
1	7°41'	7°42'	+1	7°42'	+1'
2	22°24'	22°19.5'	-5'	22°25'	+1'
3	41°37'	41°44.5'	+7'	41°42'	+5'
4	56°42'	57°01'	+19'	56°55'	+13'

Highlights from Recent Science-teaching Periodicals

from *The Physics Teacher*

— summaries available on-line at: <http://scitation.aip.org/tpt/>

“The Sparking Chaotic Pendulum: Trajectories of a Chaotic Pendulum Revealed” by Fabio Cássaro, et.al. Previously, *The Physics Teacher* articles described an easy way to create, using magnets, a pendulum that exhibits chaotic behavior. Another paper showed how a spark generator coupled to a spherical pendulum could be used to “trace” and study two-dimensional trajectories such as Lissajous patterns, ellipses, and circles.

In this paper, those two ideas were joined to develop an experimental apparatus, the “chaotic sparking pendulum,” that reveals chaotic two-dimensional orbits of a pendulum sliding over a set of magnets.

—Jan. 2004, Volume 42, Issue 1, pp. 47–48.

“Wheelies and Headers” by William M. Wehrbein

Where we determine the conditions required in order to keep both tires touching the ground at all times.

— Feb. 2004, Volume 42, Issue 2, pp. 27–30.

“Centrifugal Icicles and an Inertial Paradox” by Donald F. Collins

During a North Carolina ice storm, as freezing rain fell freezing on the perimeter of the spinning toy windmill, it formed unusual icicles radiating radially outward from the perimeter of the wheel (Fig. 1). “Although easy to understand from a conceptual standpoint” — centrifugal force, explanations from an inertial perspective prove to be very difficult, especially if one is reminded of the tendency of water drops to actually follow tangential trajectories when the water breaks away from a spinning wheel.



— Feb. 2004, Volume 42, Issue 2, pp. 79-81.

“Rollover of Sport Utility Vehicles” by Desmond Penny

Despite their rugged image, SUV’s have caused persistent safety concerns about rollovers. In light of recent documentaries on the issue of SUV rollover accidents, this article examines types of rollovers (tripped and untripped) and the physics of Static Stability Factor (SSF), and although the US-DOT rating system is a good first step, it is insufficient. The NHTSA has been charged with developing and implementing a dynamic on-road handling test to gauge and score rollover propensity.

— Feb. 2004, Volume 42, Issue 2, p. 86-91.



“Trick of the Trade—Conservation of Angular Momentum with a Plastic Dish” by Adolf Cortel

How to demonstrate conservation of angular momentum—the fact that the direction of the axis of rotation does not change—using only a thin and flexible rod, an ordinary dish, and a cheap fan

— Feb. 2004, Volume 42, Issue 2, p. 122.

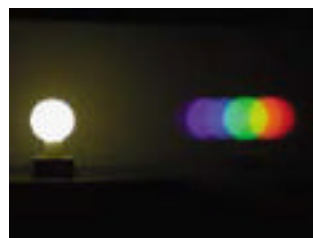
“Outdoor Vector Lab” by Paul Erdman

A vector lab that focused on reinforcing the concept of length and direction of vectors, Erdman describes an outdoor lab exercise that forces students to use vectors in the solution of a location problem that is more challenging than it first appears (finding distance between two points that are on opposite sides of a building).

— March 2004 Vol. 42, No. 3, p. 146–148.

“Compact Fluorescent Lamp Observed Through a Diffraction Grating” by L. M. Gratton, M. Perini, and V. Zanetti

This article examines interesting and unexpected color phenomena from a compact fluorescent lamp observed through a diffraction grating. Viewed close to the lamp, some of the different colored images become superimposed. Colors seen in the overlapping areas are quite different from those of the original disks. The appearance of these new colors has to do with how we perceive color.



— May 2004, Vol. 42, No. 5, pp. 270–271.

“A Big Sunbird” by J. Güémez, R. Valiente and C. Fiolhais, M. Fiolhais

After explaining how to construct a bobbing ‘drinking bird’ toy apparatus, its thermal physics and the work done while bobbing is analyzed.

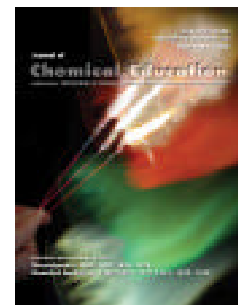
— May 2004, Vol. 42, No. 5, pp. 307–309.

In *Physics Today* July 2003, we have a fascinating account of the life and work of Marie Curie, from the Journal of Chemical Education on-line at: <http://jchemed.chem.wisc.edu/>

“The Chemistry of Photographic Color Dye Formation by Bruce E. Kahn “

This piece describes laboratory activities converting black and white photographs to color images in a variety of ways, involving a number of chemical concepts such as oxidation/reduction, stoichiometry, acids and bases, pH, nucleophilic reactions, conjugation, complexation, solubility, and reversibility.

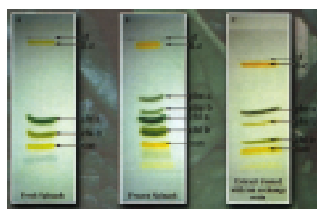
— May 2004, Vol.81, No 5, p 693.



“Quantitative Assay for Starch by Colorimetry Using a Desktop Scanner”

A procedure to produce a standard curve for quantification of starch concentration using colorimetry. The colorimetry is performed by image analysis of a picture of solutions obtained using a desktop scanner. The analysis is performed using a Visual Basic computer program (COLORS.EXE) that measures red, green, and blue pixel intensities from the image.

— May 2004, Vol.81, No 5, p702.



“Chromatography of Spinach Extract” Plant Pigments in Spinach. Three thin-layer chromatography plates show the separation of plant pigments in various spinach extracts. The separated pigments are xanthophyll, chlorophyll a and b, pheophytin a and b, and β -carotene. A direct method of extracting plant pigments from spinach leaves into a dry organic solvent and the subsequent chromatographic separation of the pigments is described in the article “An Improved Method for the Extraction and Thin-

Layer Chromatography of Chlorophyll a and b from Spinach” by Hao T. Quach, Robert L. Steeper, and G. William Griffin.

— March 2004, Vol.81, No 3, p385.

“Water, Arsenic, electrochemical removal of metal cations”

— Feb. 2004, Vol.81, No 2.

“Chemistry Perfumes Your Daily Life” by Anne-Dominique Fortineau, at Quest International (one of the big fragrance companies).

A very readable summary of the basics of fragrance and perfumes (relevant to grade 9 block topic on: chemistry of natural products).

— Jan. 2004, Vol. 81, No 1, p 45.

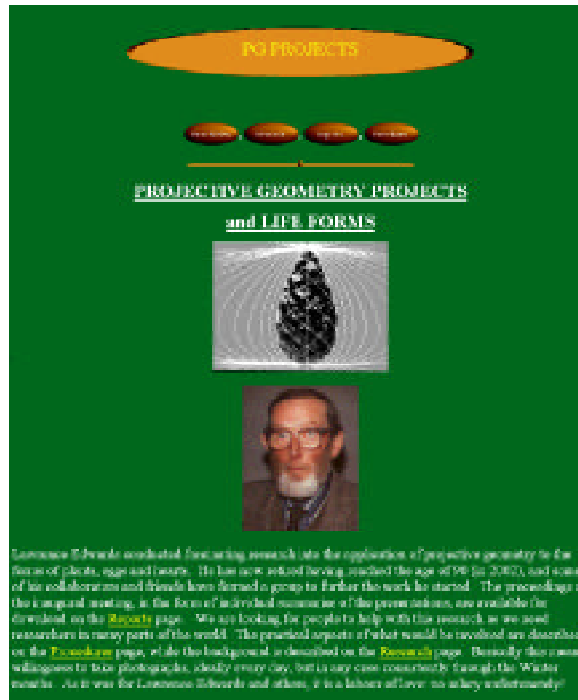


Websites of Interest

The Vortex of Life website

This web-site ><http://www.anth.org.uk/vortexoflife>< has a wealth of information on the Path Curves—mathematical forms investigated by Lawrence Edwards and published in his book “The Vortex of Life” (formerly “Field of Form”) by Floris Books (1993) ISBN: 0-86315-148-5. Unfortunately, it is now out of print—perhaps some copies are still available in your local anthroposophical bookshop.

The web pages include a brief but clear introduction to path curves, as well as the fascinating ongoing research work of several people investigating how path curves occur in Nature.



Some very useful resources available on this web site include:

Instructions on “Photographing

Instructions on “Photographing Leaf Buds” by Graham Calderwood—these documents are available for download (in Microsoft Word-6 format):

Practical Bud Observation, Measurement and Analysis Part 1 (63k); Part 2 (128k)

Software

Graham Calderwood has developed a sophisticated “Bud Workshop” program which can be used to analyze the scanned photographs, as well as saving results in a data archive (for later trends analysis). This software program is available for download by interested researchers. Until now, he was the only one using it for bud path-curve analysis, but it is hoped this tool will be used by more researchers to do their own analyses. If we increase the number of researchers—as we hope—it will become too much for one part time person! However, the purpose of the whole exercise would be lost if these results were not consolidated with those of other people, as the “Aggregate-Graphs” of phase-shifts (time-trends) which have proved so informative, depend upon that. More on that if you join us!

Download basic bud workshop at:

<http://www.anth.org.uk/vortexoflife/Procedures.htm#Software>

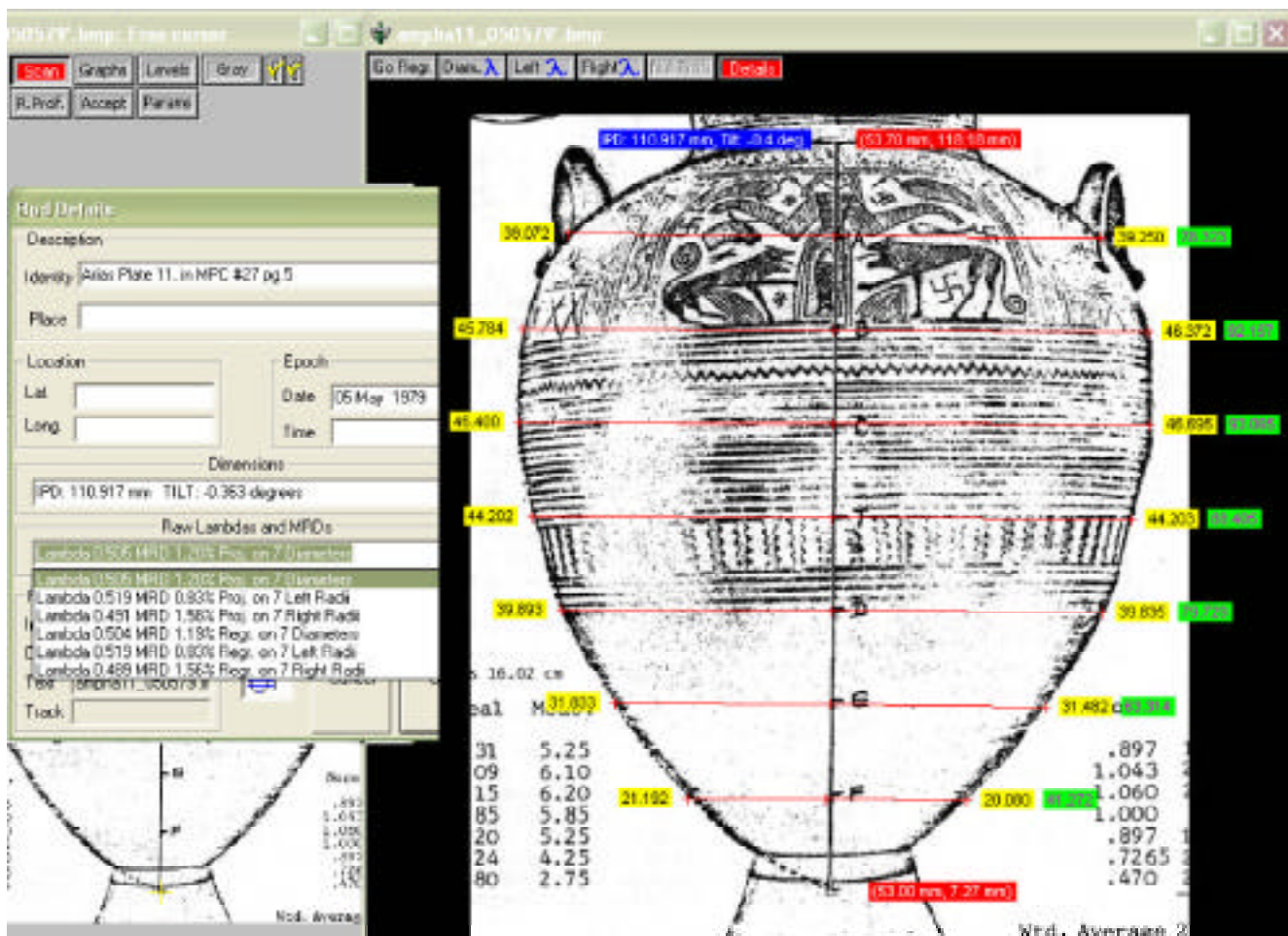
Windows Program (582Kb); optional help files (159Kb) optional WAV files (1.1Mb)

The above are ZIP files which need expanding. The WAV files are for verbal advice/comment

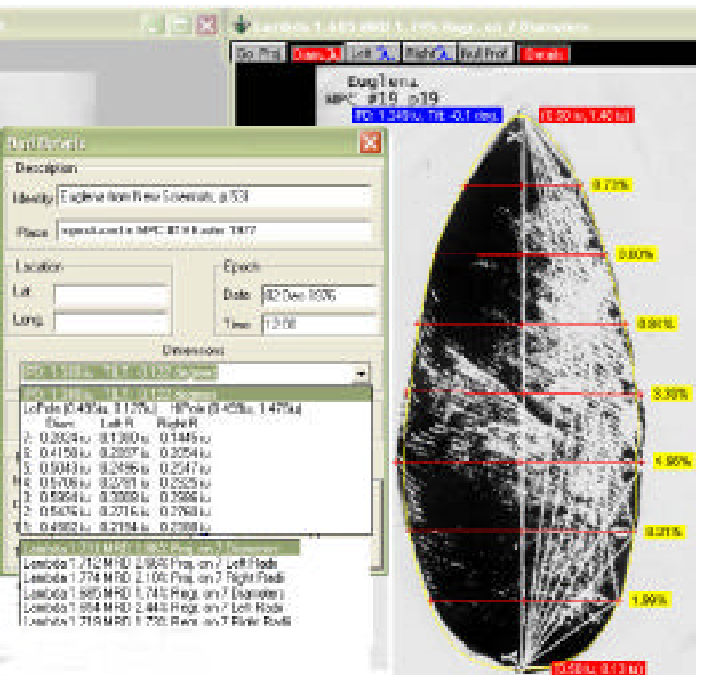
*Note: the EXE file available at present is an older Oct-2002 interim version; if you intend to use it regularly, contact G. Calderwood for a more recent version if for no other reason than to get the complete help files <graham@gcalderwood.freemove.co.uk> .

The BUD-WORKSHOP program will load TIFF or JPEG graphic images, and allow one to easily analyze the dimensions of the form, calculating the path curve lambda-value (by the L. Edwards' original "projective method" as well as the "least squares" method developed by Barry Christian). Some examples of its results are shown in the illustrations below.

The duck egg-forms are taken from illustrations in Lawrence Edwards book. Analysis using BUDWORKSHOP shows similar results to ones Edwards reported in his book.



The interesting analysis of Greek amphora that was described in Steven Eberhardt's Mathematical Physical Correspondences, (see the back issue from May 1979) is shown (right). Again, the analysis is very easy in BUDWORKSHOP, and yields results corresponding to the ones reported in MPC.



Index of Past Issues

Waldorf Science Newsletter: edited by David Mitchell & John Petering

This newsletter is published twice each year and is dedicated to developing science teaching in the Waldorf schools. Teachers are invited to pose questions, seek resource material, discuss experiments, write about their classes (successful and not very successful), and investigate phenomena. The editors also translate relevant science articles from Waldorf periodicals from around the world. The following past editions are available from:

AWSNA Publications	e-mail awsna@awsna.org
3911 Bannister Road	fax: 916/ 961-0715
Fair Oaks, CA 95628	phone: 916/ 961-0927

Available from www.awsna.org on-line at: http://www.awsna.org/books_sciencenews.htm

Volume 1, #1

Partial contents – Acoustics in Grade 6; Teaching about Alcohol in Grade 8 Chemistry; The Chemistry Curriculum: The Debate over Teacher Demonstration vs. Student Experimentation; Spiritual Aspects of 20th Century Science; Overview of the Waldorf Science Curriculum; Water; Characteristics of the Major Sugars; Goethe's Meditation on Granite; Book Reviews; Humor; Poetry; Conferences; and Sample Experiments

Volume 1, #2

Partial contents – The Characteristics of Drugs; Eratosthenes Revived; The Golden Number; Educational Guidelines for a Chemical Formula Language; The Properties of Acids and Bases; Walter Lebedörfer on Chemistry; Biology in the 11th Grade; What Is Home?; the Waldorf Environmental Curriculum; Environmental Education; Women in Science; Book Reviews; Humor; Poetry; Conferences; and Sample Experiments

Volume 2, #3

Partial contents – Grade 12 Physics – Von Mackensen; Biology Teaching in the 11th Grade; Euclid's Algorithm; The Logos and Goethean Observation; Nature Education; Aristotle's Taste Spectrum; Book Reviews; Humor, Poetry; Conferences; and Sample Experiments

Volume 2, #4

Partial contents – Current Research; Strange Theories; Science Education and Wonder; The Human Earth; Steiner's Counterspace Examined; The Cow; Language and the Book of Nature; Book Reviews; Humor; Poetry; Conferences; and Sample Experiment

Volume 3, #5

Partial contents – Book Reviews; First Lessons in Astronomy; Steps in the Development of Thinking (Power of Judgment); Computer Science and Computers in the Waldorf School; Technology; Computers in Education; Some Characteristics of the Computer; Computers and Consciousness; Experiments

Volume 3, #6

Partial contents – Space and Counter Space; New Eyes for Plants; Experiments of Academia dell Cement; Physics and Chemistry in the Grades; Goethean Science Credits; Chemistry Workshop; Table of Important Salts; Goethe's Scientific Imagination; To Infinity and Back in Class 11; π and Trigonometry; Science in the Waldorf Kindergarten; A Note on Pascal's Triangle; Experiments

Volume 4, #7

Partial contents – The Message of the Sphinx; Honey; Cell Cosmology; Einstein's Question; What is Goethean Science?; Prototype Computer Program; River Watch as a Classroom Activity; Thoughts on Curriculum Standards; Comments on Building a Waldorf School; Experiments

Volume 4, #8

Partial contents – Towards Holistic Biology; How DNA Computers Work; Solar System Facts; What is Goethean Science?; Human Movement and the Nervous System; What Is Science?; What Is Meant by “Teaching the Children to Breathe?”; Experiments

Volume 5, #9

Partial contents – The Globe Inside our Planet; Music, Blood and Hemoglobin; Standards in Science; Cognitive Channels—the Learning Cycles and Middle School Students; 8th Grade Physics, From Dividing to Extracting Roots; What is Lambda?; Waldorf Science Kits

Volume 5, #10

Partial contents – Reading the Rocks; Why the Arts are Important to Science; The Three Groups of Rocks; Introduction to Geology; The Rock Cycle; Mineralogy for Grade 6; Metals and Minerals, Precious Stones—Their Meaning for Earth, the Human Being, and the Cosmos; Experiments

Volume 6, #11

Partial contents – A Chemistry of Process; Sponges and Sinks and Rags; How to Read Science; Experiences and Suggestions for Chemistry Teaching; Experimentation as an Art; Biographies—Dmitri Mendeleev, Joseph Priestley, Marie Curie; Destructive Distillation; Experiments

Volume 6, #12

Partial contents – Light and Darkness in 6th Grade Physics; The Relation of “Optical Elevation” to Binocular Vision; Description of Curves in Connection with Elevation Phenomenon; Water Treatment at the Toronto Waldorf School; A Lime Kiln that Can Be Assembled and Disassembled; Experiments

Volume 7, #13

Partial contents – Thoughts on Returning to an “Education Towards Freedom”; Pedagogical Motives for the Third Seven- Year Period; Social Education through Mathematics Lessons; A Vision for Waldorf Education; Our Approach to Math Doesn’t Add Up; International Mathematics Curriculum

Volume 7, #14

Partial contents – Conferences; Physiology, Update on Taste; Pictorial Earthquake; Boiling with Snow; Towards a Waldorf High School Science Curriculum for the 21st Century; The Thermal Decomposition of Calcium Carbonate; Crystal Reveals Unexpected Beginnings; Cosmic Ray Studies on Skis; Experiments

Volume 8, #15

Partial contents – Book Reviews; Arabic Science; Arabic Mathematics: Forgotten Brilliance; Making Natural Dyes; Exploring the Qualities of Iron; Von Mackensen Chemistry Conference; Oxalic and Formic Acid; Hydraulic Rams; What the Water Spider Taught Me

Volume 8, #16

Partial contents – Waldorf High School Research Papers; Inside the Gulf of Maine; How Do Atomistic Models Act on the Understanding of Nature in the Young Person?; The House of Arithmetic; Origami Mathematics; Sixth Grade Acoustics; Sixth Grade Kaleidoscopes; Tricks with Mirrors; The Flour Mill and the Industrial Revolution; Web Gems; Understanding Parabolic Reflectors; The Capacitor; Oscillation and Waves; Crystal Radio; Qualifications for High School Mathematics Teaching

Volume 9, #17

Partial contents – Book Reviews; Acknowledgement from a Waldorf Parent; Raising Money for Science; the Twelve Year-old Child and Orpheus; Towards a Sensible Kind of Chemistry, Part One ; The Lightning Bug; The Ladybug; Exploratory Experimentation: Goethe, Land, and Faraday; Faraday’s Synthetic Investigation of Solenoids; Faradays Analytic Investigation of Induction; Geometric Addition Table: A Curious Configuration;

Volume 9, #18

Partial contents – Book Reviews; Towards a Sensible Kind of Chemistry, Part Two; The Evolution of the Fast Brain; Professors Vie with Web for Class Attention; The Teenage Edge; Oscillator Coil Demonstration Using an Ultra-Low Frequency LC- “Tank” Circuit; Thermodynamic Experiments for the Middle School.

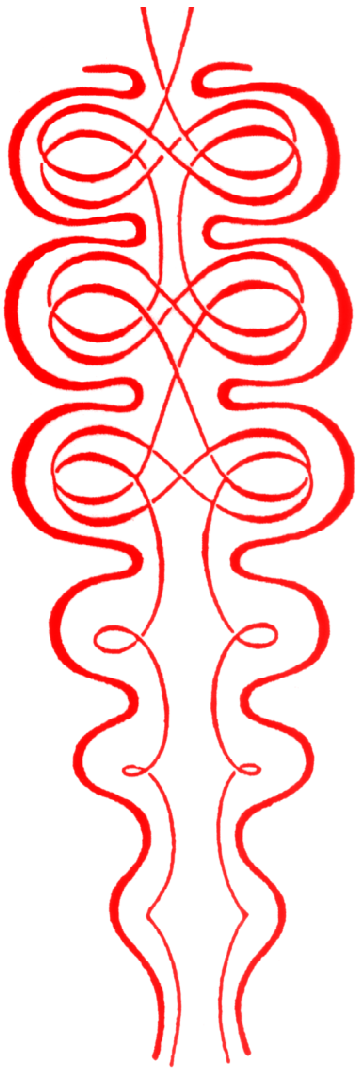
Volume 10, #19

Partial contents – Book Reviews; The Beaver; Nature in the Human Being; Astronomy Verses for the Middle School; Child Development and the Teaching of Science; Bibliography for Middle School Teachers; What is Phenomenology?; The Design of Human and Animal Bodies; The Brain and Finger Dexterity; Observations of a Neurophysiologist

Volume 10, #20

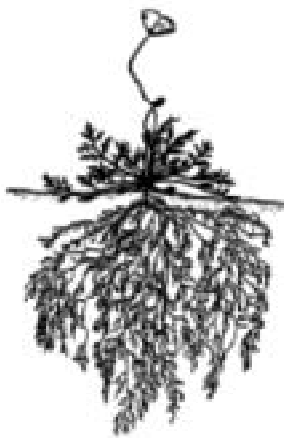
Partial contents – Book Reviews; A Number Story for the Six table; Trigonometry; An Introduction to Sine and Tangent; Toss Out the Toss-Up: Bias in Heads-or-Tails; Phlogiston Theory; Song of Rain; Refrigeration in Physics – Heat Studies; The Poetry of Astronomy; Build Your Own Sextant; Highlights from Science Periodicals, Websites of Interest

Volume 10, #20
Spring 2004



WALDORF SCIENCE NEWSLETTER

*Editors: David Mitchell & John Petering
1158 Quince Ave.
Boulder, CO 80304
FAX 303 / 541-9244
E-Mail: davidm@awsna.org*



Waldorf Science

Explorations in Phenomenology as Practiced in Waldorf Schools

A Science News Roundletter

Editors: John Petering & David Mitchell

1158 Quince Ave.

Boulder, CO 80304

FAX 303/ 541-9244

E-mail – davidm@awsna.org

© Copyright 2004 by Mitchell & Petering

All materials may be reproduced for individual use in Waldorf/Steiner Schools but not published without permission of the editors.

VOL. 10, #20

Spring 2004

NOTE FROM THE EDITORS

For the past ten years, the editors have brought out two *Waldorf Science Newsletters* each year. This current edition represents number twenty and will be the final regular newsletter. We hope that we have provided some helpful materials to teachers at every level in the Waldorf school and that we have strengthened the understanding of phenomenological science.

Now that we are not burdened by a deadline, we will send future newsletters as we accumulate adequate material. Hopefully, this will result in one per year. We invite your participation and contributions.

At the recent 75th Anniversary Celebration of Waldorf Education in North America at the Rudolf Steiner School of New York City, Douglas Gerwin and David Mitchell presented an hour long program celebrating phenomenological science. The intention was to illustrate the difference between a hypothetical and a phenomenological approach by taking the example of color shadows.

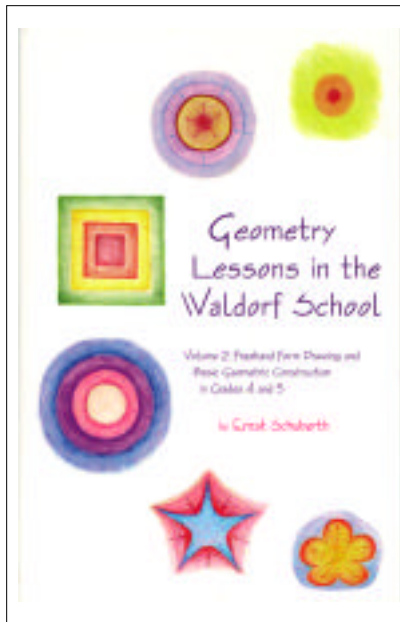
They began by recalling—and reenacting—the story of Goethe sitting in a tavern and appreciating the ar-

rival of a dark-haired beauty. Goethe stared at her while she stood motionless in front of a blank wall. When she moved he was startled to see an image of her on the wall where she has been standing. Goethe considered the optical illusion to be optical truth, and it propelled him on a lifelong study.

David and Douglas initially tried to “explain” the effect Goethe experienced by offering up the hypothesis of the “tired retina” becoming saturated with light. They then proceeded to demonstrate several color shadow experiments that undermined the hypothesis. In this manner they contrasted two teaching methods, one empirical using hypothesis, the other phenomenological, or Goethean, based on observation, analysis, and the determination of the law revealed by the phenomena. The audience commented on the more pastel, soft-bounded qualities of the colored shadow experiment and were also able to experience the moral implications of this investigation.

The group—some hundred plus in number—seemed willing to forget the lack of air and stifling heat in the overpacked room and enjoyed the exploration and discussion.

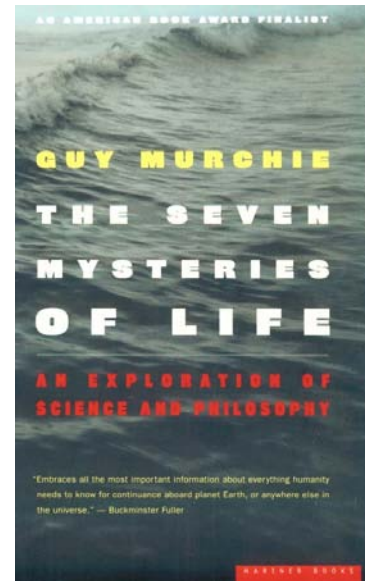
Books of Note



*Geometry Lessons in the Waldorf School
Volume 2
Freehand Form Drawing and Basic Geometric
Construction in Grades 4 and 5*

by Ernst Schuberth
86 pages plus attached CD Rom
AWSNA Publications, 2004
ISBN #1-888365-52-8

This new release from AWSNA Publications presents the essence of the geometry lessons in Grades 4 and 5. It has clear illustrations and progressively builds the concepts necessary for a strong foundation needed for the upper grades. Dr. Schuberth is passionate about his subject and his clear developmental approach will be a good resource for all teachers. The attached CD Rom offers specific exercises for the fourth and fifth grade teacher, emphasizes how color can be used to enhance the understanding, and offers examples of knot forms and geometric page design.



The Seven Mysteries of Life

by Guy Murchie
704 pages
Mariner Books, 1999 (paperback edition)
ISBN #035957915

If you don't believe that the physical world we live in is incredibly fascinating, complex, and heart-breakingly beautiful, you need to read this book.

Guy Murchie is interested in the interconnectedness of all forms of life on earth. This book is the object of his seventeen-year quest for knowledge and discovery. Here we plummet the essence of science, philosophy, and inspiration. The editor [DSM] considers this one of his favorite titles.

Imagine a book that could explain practically everything in the natural world—how the various senses work, how sand is deposited on beaches, how sonar in bats works, how closely related we all are to other humans, to chimpanzees, to everything, how different creatures reproduce, how a tree is constructed, what a muscle is made out of, why the moon appears the way it does on the horizon—and yet somehow be an incredibly fascinating page turner at the same time. This book will leave you with with an impression of awe at the organization of nature..

Teachers and parents might be interested in two projects by AWSNA Publications. These essays are available gratis at www.waldorflibrary.org or you can purchase a spiral bound copy of either from AWSNA at www.awsna.org or by calling 916-961-0927.

Waldorf Journal Project #2

The Making of a Teacher by Henry Barnes

Child Development—Conception to Birth:

Embryology from an Anthroposophical Perspective by Bruno Callegaro, M.D.

Early Childhood Today: Wish and Reality by Walter Riethmüller

The Kindergarten Child by Peter Lang

Creating a Meadow for Childhood: Education for a New Millennium, What Do Young Children Need Today? by Sally Schweizer

Psychology and Early Years Learning:

Affirming the Wisdom of Waldorf by Richard House

Children's Questions by A. C. Harwood

Non-Verbal Education: A Necessity in the Developmental Stages by Michaela Glöckler, M.D.

Child Observation and Study by Michaela Glöckler, M.D.

Some Aspects of Child Study Work in Faculty Meetings, Points for Observation in Child Study by Magda Lissau

Overview of Childhood Characteristics by David Mitchell

Encountering the Individuality of a Child by Walter Riethmüller

Tell Me a Story: The Narrative of Active Learning by Martyn Rawson

Sleep as a Task of Waldorf Education by Peter Loebell

The Effect of Lunar Nodes on Human Biography: Our Hidden Plan by Susanne Donato

The Adolescent Years by L. Francis Edmunds

Waldorf Journal Project #3

Life's Anxieties – Life's Opportunities: Anxiety and Its Importance to Inner Development

Two Essays by Pietro Archiati and Felicitas Vogt

Sleep Disturbances and Healthy Sleep by Christa-Johanna Bub-Jachens

Nutrition: Modern Food, Is It Really Future-Oriented? by Petra Kühne

Food and Nutrition: What Nourishes Our Children? by Petra Kühne

The Feet Reveal the Human Will by Norbert Glas

Hearing: Door to the Soul and Spirit Around Us, with a Look at Technological Media by Heinz Buddemeier

The Unfolding of Sexuality by Mathias Wais

Puberty and Its Crisis: Educational Help in Overcoming Difficulties by Dr. Johannes Bockemühl

Drug Addiction: The Wake-up Call of Our Times by Felicitas Vogt

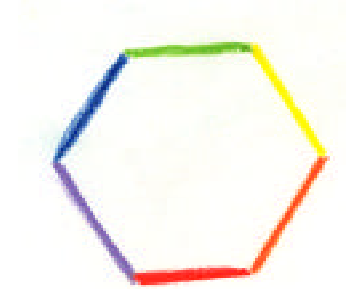
Education Seen as a Problem Involving the Training of Teachers by Rudolf Steiner

A Number Story For the Six table

(as done in the Second Grade)

Reprinted from *Math Lessons for Elementary Grades* by Dorothy Harrer
revised and reprinted 2004 by AWSNA Publications.

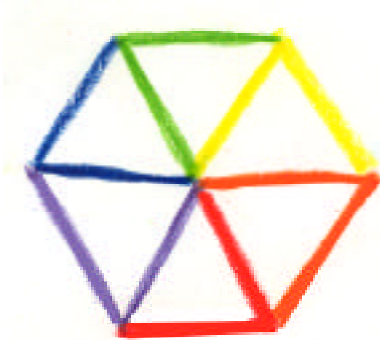
This story accompanies the drawing of the hexagon, free hand, in steps I through VII



Step I

There was once a King whose shining palace was right in the center of his six-sided kingdom. At each side of the kingdom rose a high wall, and each of the six walls was one of six beautiful colors, violet, blue, green, yellow, orange and red.

Although these six beautiful walls protected him from all enemies, they limited his kingdom to what they enclosed and beyond them the King had no power nor did he know what lay beyond them.

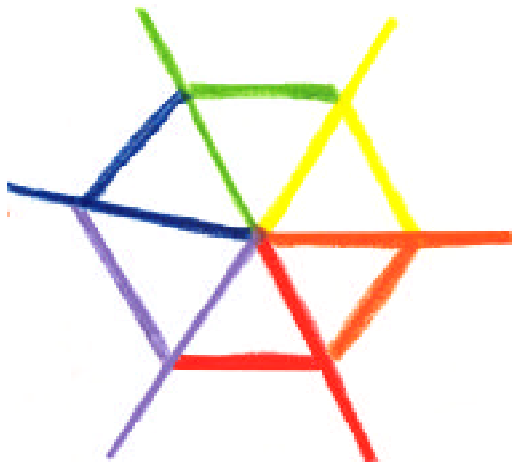


Step II

Strangely enough, the King had exactly six sons. When they had grown to become noble knights, they rode out from the King's palace in six different directions in order to explore the kingdom.

At length each reached a corner between each of the six walls and each looked to his right to see a wall built of violet, blue, green, yellow, orange, or red. But beyond that they could not go. Whereupon they returned to the King and asked him what lay beyond the walls of the kingdom.

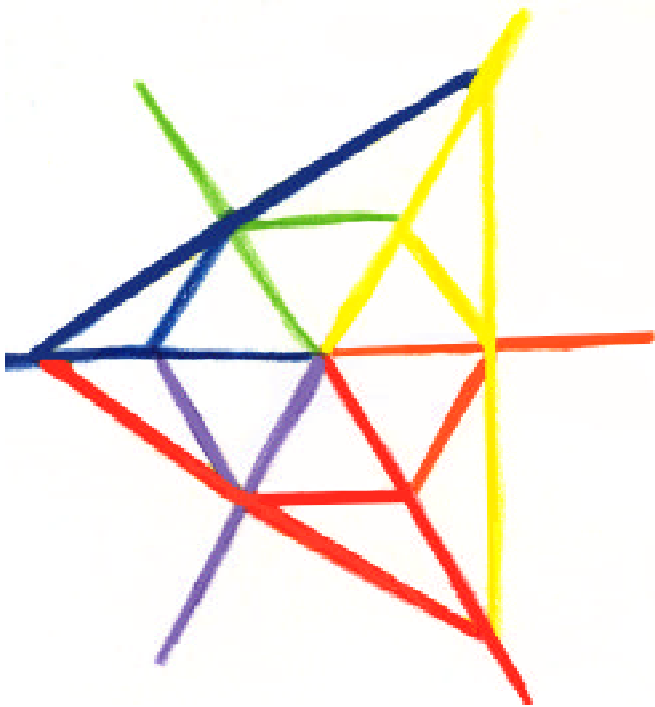
The King answered, "I know not for although the six walls protect me from my enemies, they do not permit me to see what lies beyond them. I have had enough to do to rule my kingdom wisely, and well within its six walls, and here I must stay. Now you have my blessing to find your way beyond the walls and to carry my good will to all that lives without."



Step III

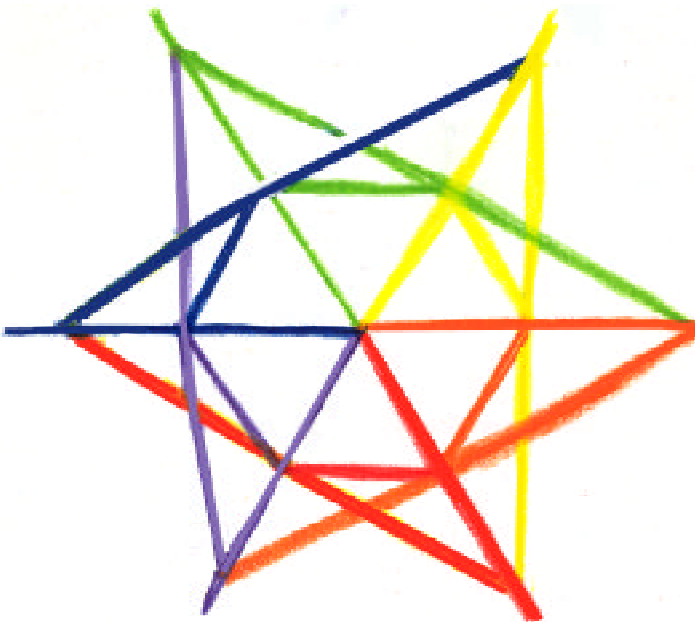
Thereupon, each knight chose a banner of a color to match the wall he had seen and each set out with fluttering banner and sound of trumpet to breach the wall.

Upon reaching the corner, each young knight with the help of his trusty men broke through the walls and marched forth into the world beyond his father's kingdom.



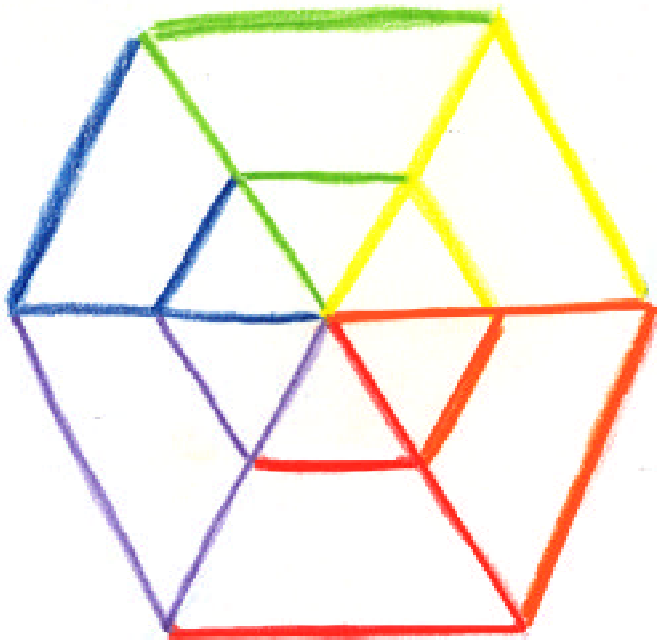
Step IV

The yellow knight traveled as far outside the walls as it was from the palace to the walls. He found himself in a desert blazing with hot sun and sand, no living being, no plant nor animal in sight. So he returned to the wall and looked to the right and to the left. Seeing, in the distance, his red and blue brothers, he went straight to meet the red then back to meet the blue who likewise had journeyed beyond their corners then returned to the old walls. The blue knight had found himself facing a deep, blue ocean which he could not cross and the red knight was turned back by a sea of red fire. Yellow, Red and Blue each built a new wall, straight and sure, touching at three points on the old. Along the new walls they set up lines of their trusty henchmen to guard their father's kingdom against blinding light, bottomless ocean and searing fire.



Step V

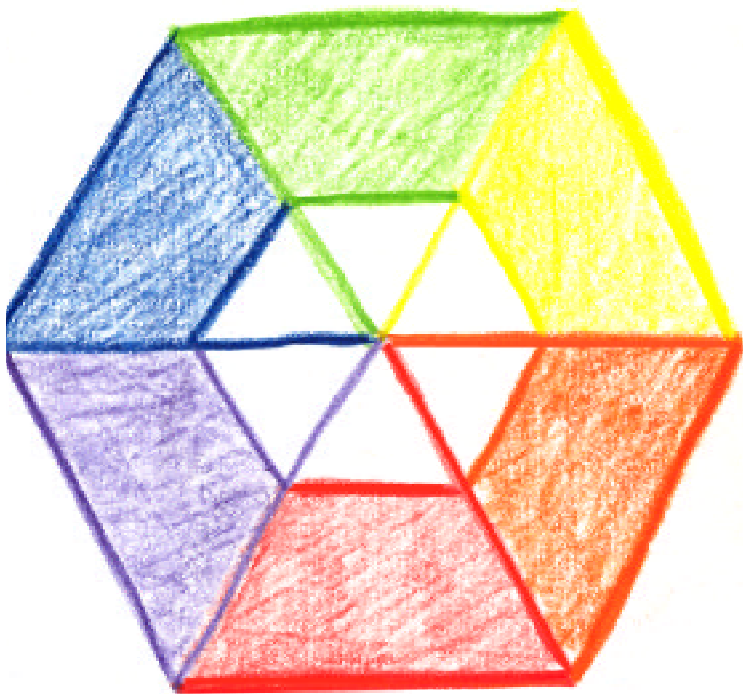
In the meantime the orange, violet, and green knights had each journeyed out from the corners where the walls of the kingdom met. They too went as far out as their brothers. The orange faced a shimmering heat, the violet a bottomless pit, and the green an endless sea of green grass. They too returned to build new walls which touched upon the old.



Step VI

Now all six knights gained courage and joined forces. The red set up a defense and built a Red wall from the Violet to the Orange to better guard the kingdom against the burning fire. Now he, especially, felt great courage within his own being. The violet knight built a wall from Red to Blue. From its ramparts he prayed and found the endless reaches of eternity where he could look beyond the bottomless pit to realms where there were never any endings. Blue stretched his ramparts from Violet to Green and built his wall deep and strong against the deep, blue ocean. Once done, he felt calm, peaceful, and sure that no storm could enter his father's kingdom. Green built his new wall from Blue to Yellow. Outside that wall great grasses and jungles crowded toward the inner kingdom but could not enter through the wall.

But from his wall, Green could look far in understanding how all life was linked together. Yellow built a wall of golden light against the blinding desert sun. It was a wall of wisdom that guarded his father's kingdom against all that dazzles, and dizzies those who have no wisdom. It made the outer light dim in the strength of an inner light. And lastly, Orange built a wall that guarded the kingdom from the heat that flickered between the desert and the fire. The orange wall established, within the kingdom, a power of warm-hearted love in everyone of the subjects of the King.



Step VII

Each knight, having had his part in enlarging the old kingdom to become four times its original size, allowed each color enter the spirit of the realm:

with yellow came wisdom
(knowing what to do)—

with red came courage
(doing what is hard)—

with blue came peace
(a feeling of God's love for mankind)—

with green came understanding
(of others)—

with violet came a sense of eternity
(timelessness)—

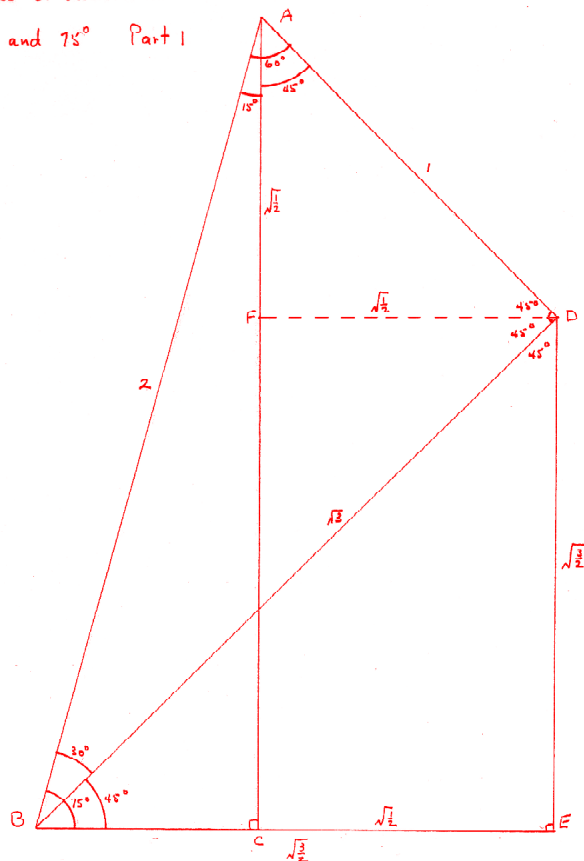
with orange came love
(for all that is good).

Novel Entries for a Trig Table

In trigonometry, it is common to begin simply and build up the values for the sine function by evaluating simple, regular geometric forms such as 30°–60° and 45° right triangles (see also the article on another approach to trigonometry in this issue). In this way, we can evaluate the entries for the sine 30°, sine 45°, and sine 60°. However it would be nice to have further entries to use to solve some simple, introductory trigonometry problems with our “own trig table.” The classic way to compute further angle values is to use the very elaborate half-angle and double-angle formulae as they were applied by Ptolemy in producing his complete table. However, these formula are difficult to introduce and prove to a novice class.

Harry Kretz has found a way to determine two additional angles using simple geometric relationship within the grasp of a 10th grade beginning trigonometry. His novel approach is explained in his forthcoming book on trigonometry. However, until it appears in print, we were given permission to share this gem with our readers.

Values of functions of
15° and 75° Part 1



Part 2

Values of functions of 15° and 75°

$$a = \sqrt{\frac{3}{2}} - \sqrt{\frac{1}{2}} = 1.2247 - 0.7071 = 0.5176$$

$$b = \sqrt{\frac{3}{2}} + \sqrt{\frac{1}{2}} = 1.2247 + 0.7071 = 1.9318$$

$$\sin 15^\circ = \frac{0.5176}{2} = 0.2588$$

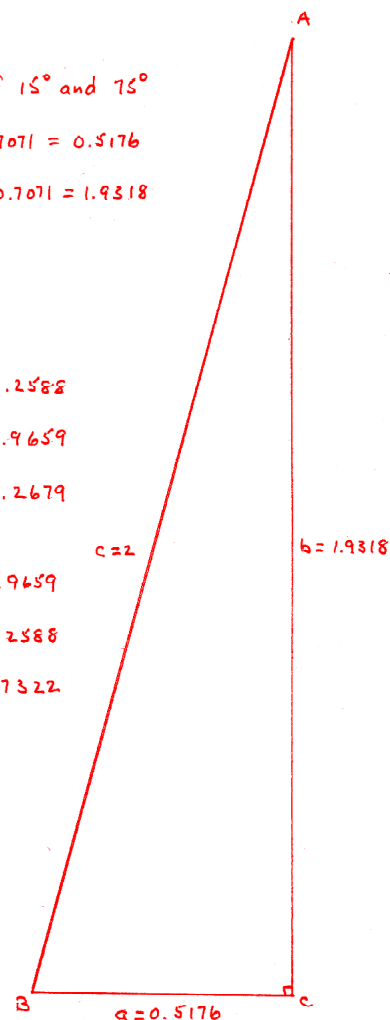
$$\cos 15^\circ = \frac{1.9318}{2} = 0.9659$$

$$\tan 15^\circ = \frac{0.5176}{1.9318} = 0.2679$$

$$\sin 75^\circ = \cos 15^\circ = 0.9659$$

$$\cos 75^\circ = \sin 15^\circ = 0.2588$$

$$\tan 75^\circ = \frac{1.9318}{0.5176} = 3.7322$$



The first step is to lay out the hypotenuse of a 45° triangle congruent to the short side of a 30°–60° triangle (as shown in the figure “Part 1”). This forms a small 15°–75° triangle and a rectangle. We can now work out the length of the rectangle.

Given the short side of the 30°–60° triangle = 1, its long side = $\sqrt{3}$; then, the side of the small 45° triangle forms the top of the rectangle, and = $\sqrt{1/2}$. There is also formed a large 45° triangle, whose hypotenuse is congruent to the long leg of the 30°–60° triangle and = $\sqrt{3}$; thus, its sides must be = $\sqrt{3/2}$.

So (as shown in the second illustration “part 2”) by addition or subtraction of the known values, the long leg of the 15°–75° triangle must be $\sqrt{1/2} + \sqrt{3/2} = 1.9318$, and its short leg $\sqrt{3/2} - \sqrt{1/2} = 0.5176$.

An introduction to the Sine and Tangent

by

Uwe Hansen

excerpt from

Mathematics Themes for 10th Grade

Developed on the Basis of Waldorf School Teaching

Kassel 2002

Trigonometry arises out of the question: What is the relationship between curved and straight lines? This relationship can be studied in a simple case: A straight line g which touches a circle tangent at point B , now moves a certain angle α around B , so that a chord of length s arises.

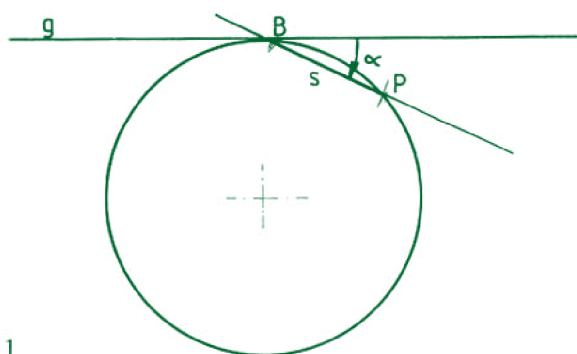


Fig. 1

The length of the chord changes. Initially, the chord will grow as the angle α grows larger, until with $\alpha = 90^\circ$, it will be equal to the diameter of the circle. Then, it will grow smaller, and with an angle of $\alpha = 180^\circ$, it will again (as with $\alpha = 0^\circ$) become zero.

We examine a few special angles:

1. Case $\alpha = 30^\circ$

The central angle is 60° , and we have an equilateral triangle. The chord is equal to the radius, and also to the sides of a regular hexagon: $s = r$.

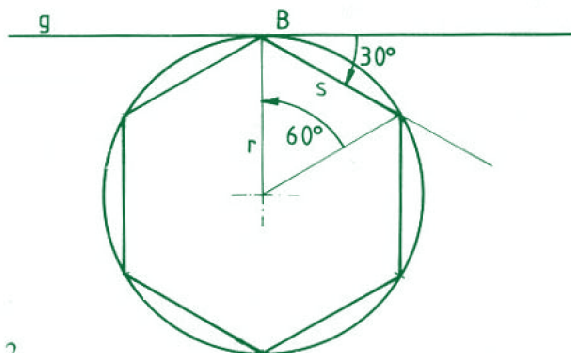


Fig. 2

2. Case $\alpha = 45^\circ$

The central angle is now 90° in this case. The chord is the side of a square inscribed in the circle.

it is:

$$s^2 = r^2 + r^2 \quad \text{law of Pythagoras}$$

$$s^2 = 2r^2$$

$$s = r \cdot \sqrt{2}$$

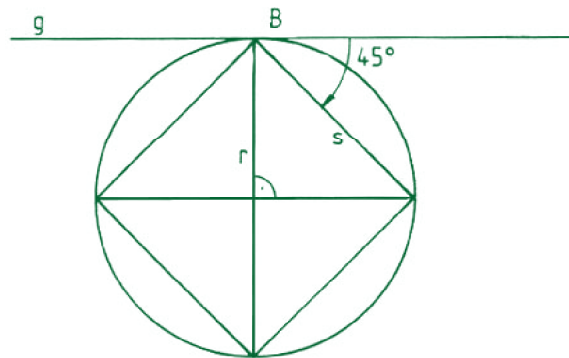


Fig. 3

3. Case $\alpha = 60^\circ$

The central angle is 120° . The chord is the side of an equilateral triangle inscribed in the circle.

$$s^2 + r^2 = (2r)^2 \quad \text{law of Pythagoras}$$

$$s^2 + r^2 = 4r^2$$

$$s^2 = 3r^2 = r\sqrt{3}$$

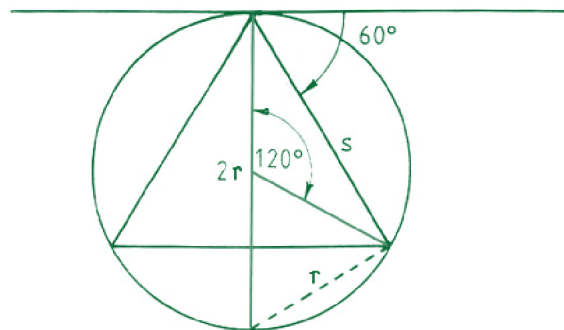


Fig. 4

Overview:

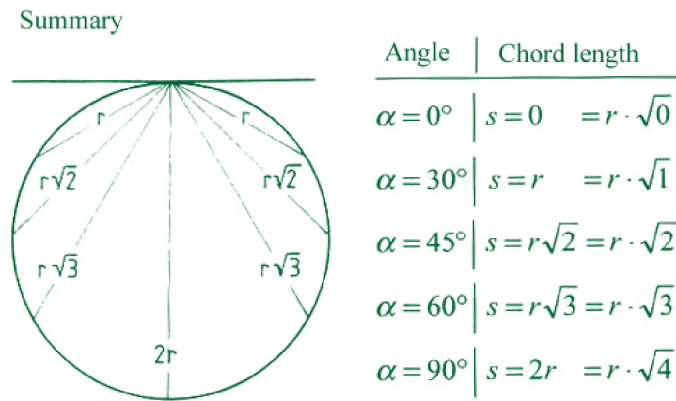


Fig. 5

The rule applies: The chord for the angles α and $180^\circ - \alpha$ have the same length.

In addition it holds true that: all “inscribed” (peripheral) angles, which lie on one side of the chord s of the circle, are all equal to each other.

The inscribed angles β on the other side of the chord are larger and also equal to each other, decreasing from 180° .

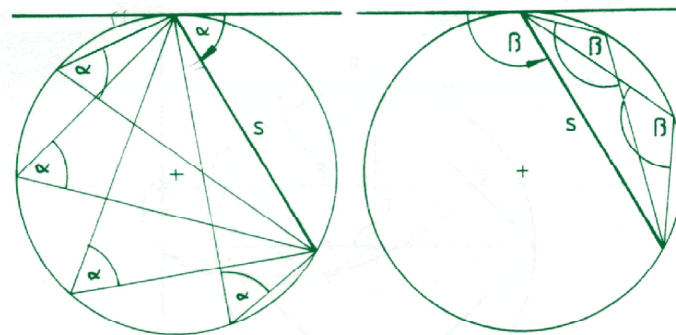


Fig. 6a

Fig. 6b

Some properties of chords and angles

Since $\alpha + \beta = 180^\circ$, the inscribed (peripheral) angles are all equal to the tangent angle (α or β) of the corresponding chord.

The central angle is twice the size (2α) of the inscribed angle α .

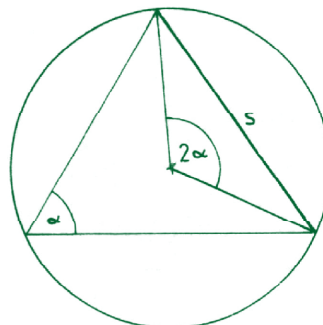


Fig. 7

All chords, formed by a inscribed angle α on the circumference of a circle, have the same length.

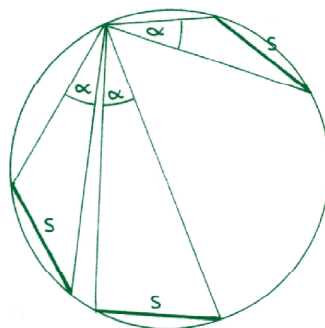


Fig. 8

This leads to the definition of the sine: The sine of an angle α is the relationship of the chord length s to the circle's diameter, where the chord belongs to inscribed angle α

$$\begin{aligned}\sin \alpha &= \frac{\text{chord of peripheral angle } \alpha}{\text{circle diameter}} \\ &= s/2r\end{aligned}$$

In particular, it is true: $\sin \alpha = \sin(180-\alpha)$. This definition also has the advantage that for angles $\alpha > 90^\circ$ up to 180° the sine is immediately clear—the usual introduction of the sine for these obtuse angles is not transparent enough for the students.

We can extend the previous table to:

inscribed angle	chord length	chord = $s/2r$ diam	in short
0°	0	$0/2r = 0$	$\sin 0^\circ = 0$
30°	r	$r/2r = 1/2$	$\sin 30^\circ = 0.5$
45°	$r\sqrt{2}$	$r\sqrt{2}/2r = \sqrt{2}/2$	$\sin 45^\circ = 0.7071$
60°	$r\sqrt{3}$	$r\sqrt{3}/2r = \sqrt{3}/2$	$\sin 60^\circ = 0.866$
90°	$2r$	$2r/2r = 1$	$\sin 90^\circ = 1$
120°	$r\sqrt{3}$	$r\sqrt{3}/2r = \sqrt{3}/2$	$\sin 120^\circ = 0.866$
135°	$r\sqrt{2}$	$r\sqrt{2}/2r = \sqrt{2}/2$	$\sin 135^\circ = 0.7071$
150°	r	$r/2r = 1/2$	$\sin 150^\circ = 0.5$
180°	0	$0/2r = 0$	$\sin 180^\circ = 0$

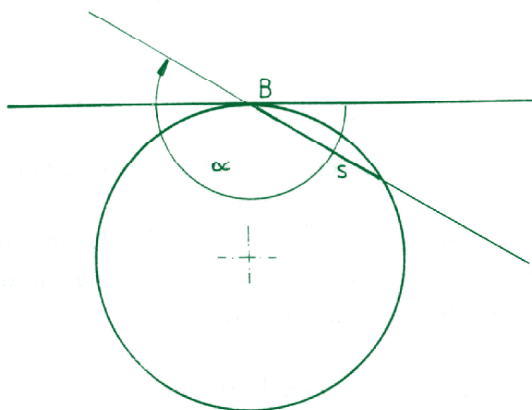


Fig. 9

This approach leads to the correct idea that the sine produces *negative* values for obtuse angles (see Fig. 9, above)

$\alpha > 180^\circ$.

For example, with, $\alpha = 210$ ($180 + 30$), it must be that the $\sin 210 = -\frac{1}{2}$, since the chord must now be measured in the direction (to the *right*) *opposite* to the angle side (going upper *left*, from vertex, along leg) for these obtuse angles.

Further, the *Law of Sines* is now also a direct outcome of our chosen definition, as follows:
 since $\sin \alpha = \alpha/2r$ $\sin \beta = \beta/2r$ $\sin \gamma = \gamma/2r$

then: $2r = a/\sin \alpha = b/\sin \beta = c/\sin \gamma$

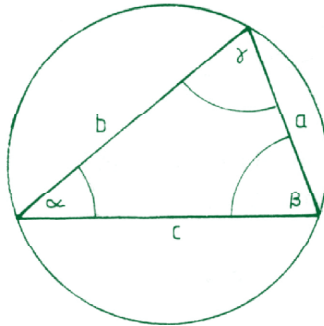


Fig. 10

So, we have in this simple way developed the important *Law of Sines*!

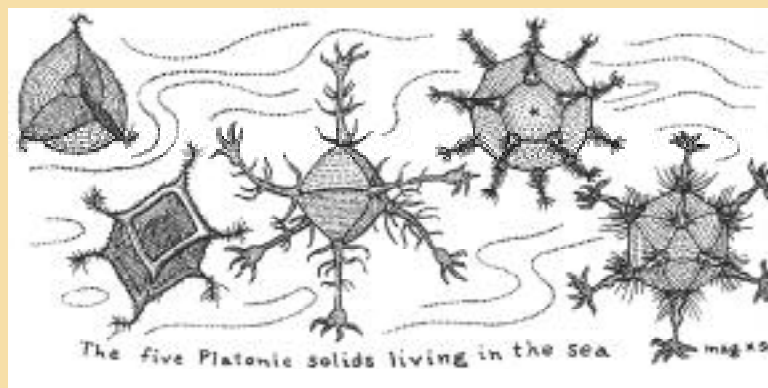
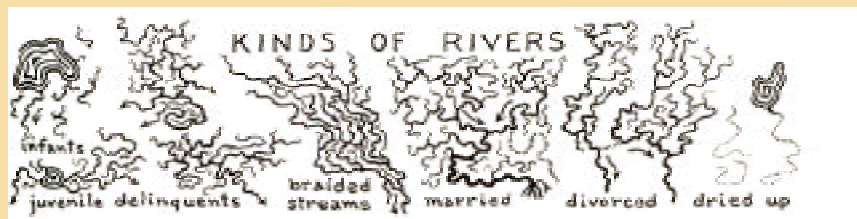


Illustration taken from *The Seven Mysteries of Life*
 by Guy Murchie, reviewed in this newsletter.

Toss Out the Toss-Up: Bias in Heads-or-Tails

by

Erica Klarreich

If you want to decide which football team takes the ball first or who gets the larger piece of cake, the fairest thing is to toss a coin, right? Not necessarily.

A new mathematical analysis suggests that coin tossing is inherently biased: A coin is more likely to land on the same face it started out on.

"I don't care how vigorously you throw it, you can't toss a coin fairly," says Persi Diaconis, a statistician at Stanford University who performed the study with Susan Holmes of Stanford and Richard Montgomery of the University of California, Santa Cruz.

In 1986, mathematician Joseph Keller, now an emeritus professor at Stanford, proved that one fair way to toss a coin is to throw it so that it spins perfectly around a horizontal axis through the coin's center.

Such a perfect toss would require superhuman precision. Every other possible toss is biased, according to an analysis described on Feb. 14 in Seattle at the annual meeting of the American Association for the Advancement of Science.

The researchers' logic goes like this. At the opposite extreme from Keller's perfect toss is a completely biased toss, in which the coin stays flat while in the air. Since the coin never actually flips, it is guaranteed to land on the same face that it started out on.

Between the perfectly spinning toss and the flat toss lies a continuum of other possibilities, in which the coin spins around a tilted axis, precessing like an old-fashioned children's top. Each of these possibilities is biased, the team found. The bias is most pronounced when the flip is close to being a flat toss. For a wide range of possible spins, the coin never flips at all, the team proved.

In experiments, the researchers were surprised to find that it's difficult to tell from watching a coin whether it has flipped. A coin toss typically takes just half a second, with the circumference of the coin

whizzing around at three meters per second. What's more, the coin's spin makes it wobble, often creating the illusion that the coin has flipped.

"Sometimes we had the complete impression that the coin had turned over when it really hadn't," Holmes says.

Magicians and charlatans may take advantage of this illusion. Keller observes, "Some people can throw the coin up so that it just wobbles but looks to the observer as if it is turning over." To see whether the predicted bias shows up in actual coin tosses, the team made movies of tossed coins and then calculated the axes of spin.

Their preliminary data suggest that a coin will land the same way it started about 51 percent of the time. It would take about 10,000 tosses before a casual observer would become aware of such a small bias, Diaconis says. "Maybe that's why society hasn't noticed this before," he says.

This slight bias pales when compared with that of spinning a coin on its edge. A spinning penny will land as tails about 80 percent of the time, Diaconis says, because the extra material on the head side shifts the center of mass slightly.

During World War II, South African mathematician John Kerrich carried out 10,000 coin tosses while interned in a German prison camp. However, he didn't record which side the coin started on, so he couldn't have discovered the kind of bias the new analysis brings out.

Says David Aldous, a statistician at the University of California, Berkeley, "This is a good lesson that even in simple things that people take for granted, there may be unexpected subtleties."

References:

Diaconis, P. 2004. The search for randomness. American Association for the Advancement of Science annual meeting. Feb. 14. Seattle.

Further Readings:

Keller, J.B. 1986. The probability of heads. *American Mathematical Monthly* 93(March):191-197.

Peterson, I. 2004. Heads or tails? *Science News Online* (Feb. 28). Available at: <http://www.sciencenews.org/articles/20040228/mathtrek.asp>.

Sources:

David Aldous
Department of Statistics
University of California, Berkeley
367 Evans Hall
Berkeley, CA 94720-3860

Persi Diaconis
Department of Statistics
Stanford University
Stanford, CA 94305-4065

Susan P. Holmes
Department of Statistics
Stanford University
Stanford, CA 94305-4065

Joseph B. Keller
Stanford University
Department of Mathematics
Stanford, CA 94305-2125

Richard Montgomery
Department of Mathematics
University of California , Santa Cruz
1156 High Street
Santa Cruz, CA 95064

Taken from <http://www.sciencenews.org/articles/20040228/fob2.asp>
Science News, Week of Feb. 28, 2004;, Vol. 165,
No. 9 , p. 131, "Toss Out the Toss-Up: Bias in heads-or-tails" reported by Erica Klarreich.

Phlogiston Theory

According to the phlogiston theory, propounded in the 17th century, every combustible substance consisted of a hypothetical principle of fire known as phlogiston, which was liberated through burning, and a residue. The word phlogiston was first used early in the 18th century by the German chemist Georg Ernst Stahl. Stahl declared that the rusting of iron was also a form of burning in which phlogiston was freed and the metal reduced to an ash or calx. The theory was superseded between 1770 and 1790 when the French chemist Antoine Lavoisier showed that burning and rusting both involved oxygen and concluded that both ash and rust were compounds of oxygen. Lavoisier's oxidization theory has been accepted by scientists from about 1800 to the present day.

Bibliography: Conant, James B., ed., *Overthrow of the Phlogiston Theory: The Chemical Revolution of 1775-1789* (1950); Partington, J.R., and McKie, D., *Historical Studies on the Phlogiston Theory* (1981).

Humor

“After being interviewed by the school administration, the eager teaching prospect said: “Let me see if I’ve got this right.

“You want me to go into that room with all those kids, and fill their every waking moment with a love for learning. And I’m supposed to instill a sense of pride in their ethnicity, modify their disruptive behavior, observe them for signs of abuse, and even censor their T-shirt messages and dress habits.

“You want me to wage a war on drugs and sexually transmitted diseases, check their backpacks for weapons of mass destruction, and raise their self esteem. You want me to teach them patriotism, good citizenship, sportsmanship, fair play, how to register to vote, how to balance a checkbook, and how to apply for a job.

“I am to check their heads for lice, maintain a safe environment, recognize signs of antisocial behavior, offer advice, write letters of recommendation for student employment and scholarships, encourage respect for the cultural diversity of others, and oh, make sure that I give the girls in my class 50 percent of my attention.

“My contract requires me to work on my own time after school, evenings, and weekends grading papers. Also, I must spend my summer vacation at my own expense working toward advance certification and a Masters degree. And on my own time you want me to attend committee and faculty meetings, PTA meetings, and participate in staff development training. I am to be a paragon of virtue, larger than life, such that my very presence will awe my students into being obedient and respectful of authority.

“And I am to pledge allegiance to family values and this current administration. You want me to incorporate technology into the learning experience, monitor web sites, and relate personally with each student. That includes deciding who might be potentially dangerous and/or liable to commit a crime in school. I am to make sure all students pass the mandatory state exams, even those who don’t come to school regularly or complete any of their assignments.

“Plus, I am to make sure that all of the students with handicaps get an equal education regardless of the extent of their mental or physical handicap.

“And I am to communicate regularly with the parents by letter, telephone, newsletter, and report card.

“All of this I am to do with just a piece of chalk, a computer, a few books, a bulletin board, a big smile, AND on a starting salary that qualifies my family for food stamps! You want me to do all of this and yet you expect me. . .

. . . NOT TO PRAY?”

Song of the Rain

—by Howard Schrager

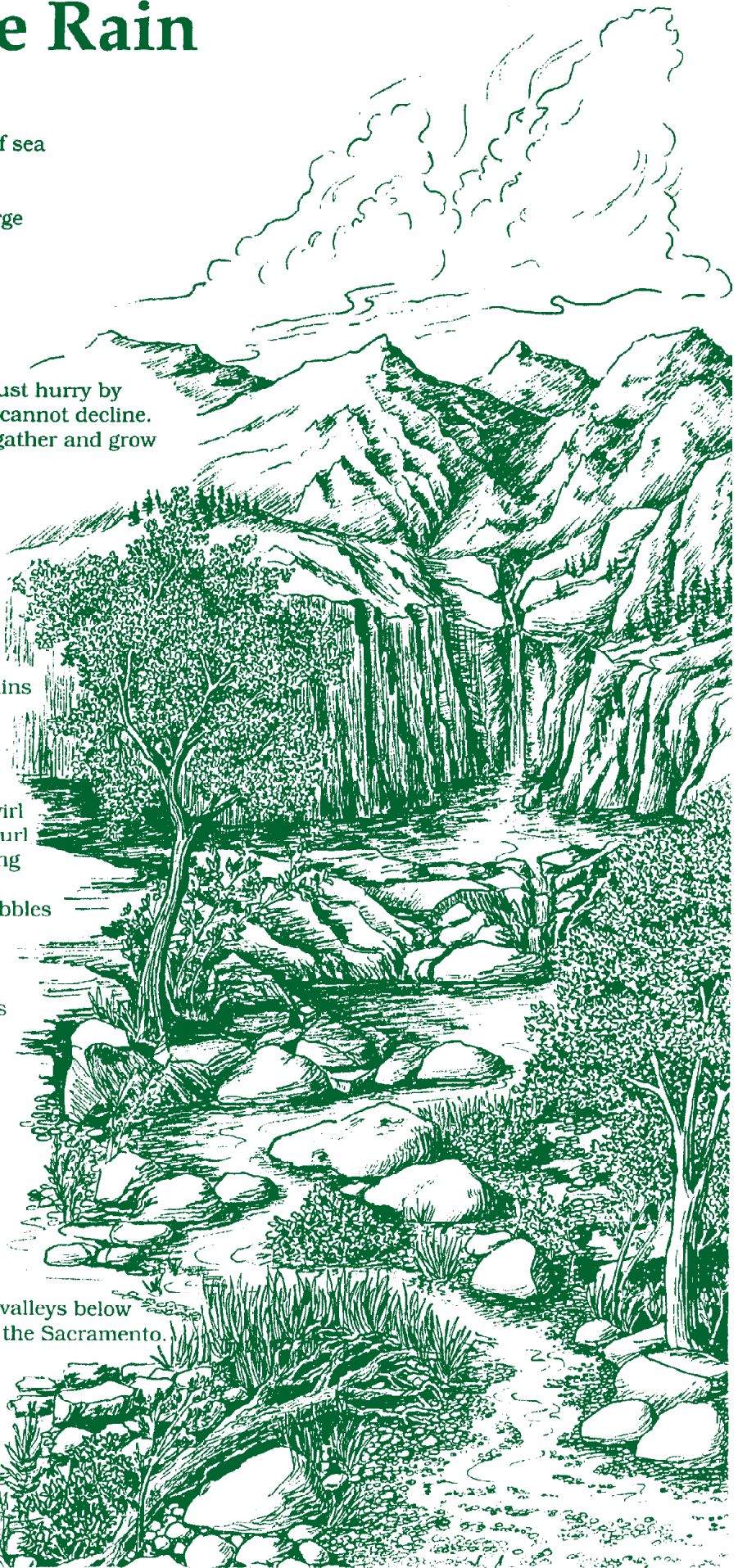
Masses of air and surges of sea
In unsurpassing time
Mingle ceaselessly.
Over the Pacific huge clouds emerge
By the hand of the wind
Landward they are urged.
Reaching first the sandy shores
They cross the coastal hills
Hurrying past the valleys wide
They tumble up foothills.
Fueled by the breeze they would just hurry by
But to climb the High Sierra they cannot decline.
Higher, ever higher, stormclouds gather and grow
Colder, ever colder
Rain droplets, or snow.

First a pitter then a patter
Little drops begin to splatter
All about the High Sierra.
Every dimple in the granite
Catches water, then it scatters
Then the scores of tiny droplets
As if scared run down the mountains
Then the trickles turn to ripples
As they scamper ever downward
Thrilling over stone and gravel
Meet like playmates as they travel
Forming creeks they skate and swirl
Down cascades they plunge and curl
Bubbling, gurgling, roaring, purring
Over rock and root they wheel
Sweeping twigs and leaves and pebbles
And then pausing in the eddies.

All these swiftly moving streams
From their own self-carved ravines
Now they join the booming tide
In deep gorges trenched in time
Of the mighty thundering rivers
On the floor of their own canyons.

Kings and Kern, Mokelumne
Stanislaus, Tuolumne
Feather, Bear, American
Merced and Yuba surge ahead
Through the Mother Lode
With its horde of gold
Downward, ever downward to the valleys below
Joining now the San Joaquin and the Sacramento.
Slower now, and broader
Past the Delta, rich, the flow
Through the Straits, into the Bay
Out the Golden Gate and home.

© 1991 Howard Schrager



Refrigeration in Physics – Heat Studies

by

Paolo Carini, Ph.D.
San Francisco Waldorf High School

After a discussion of heat, boiling phenomena, and latent heat, a refrigerator is brought into class. This is not a common refrigerator, however! This is a refrigerator-bike, see Fig. 1, right! The students like to ride the bike, but instead of turning a wheel they crank a compressor.

It is hard work! The result, however, is rewarding. The condenser (the thinner tube coiled around one side of the handle bar—see Figs. 2 and 3, below), runs from the compressor (Figs. 4–7) to the handle bar, and becomes quite warm; meanwhile the evaporator (the large tube coiled around the other side of the handle bar in the Fig. 3, below), which is connected to the condenser through a capillary valve and then runs back to the compressor, starts to cool down till frost appears on it!

It is a beautiful application of the concepts of heat and latent heat we have discussed in class, and at the same time is a real experience of the *work* needed to reverse the natural direction of heat flow.



Fig. 1



Fig. 2

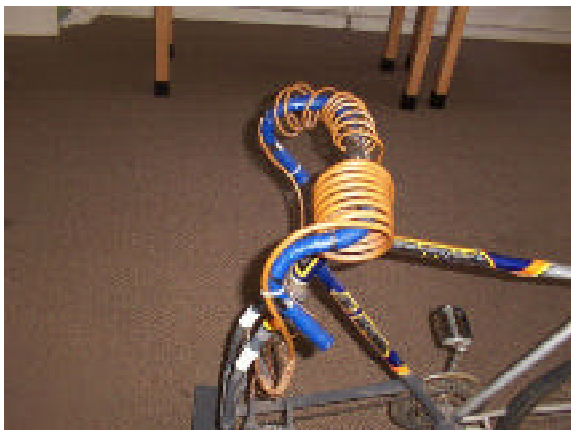


Fig. 3



Fig. 4



Fig. 6



Fig.5



Fig. 7

The Poetry Of Astronomy

Here is a lovely website, just packed with information about astronomy, links to resources, and an appreciation of poetry about the stars!

<http://www.celestialnavigation.net/wayfinding.html>



Celestial Navigation is the art and science of finding your way by the sun, moon, stars, and planets, and, in one form or another, is one of the oldest practices in human history. This webpage is an attempt to bring together all of the best Celestial Navigation resources on the internet, with pointers to other resources as well. Find out why we should study Celestial Navigation in the age of GPS; get an introduction to Celestial Navigation's history, then take a look at the navigational astronomy page as a background for the theory and practice; teachers, discover how celestial navigation can enliven the classroom, whether your field is earth science, astronomy, math, history, or literature, with special links about Vikings; learn about navigational instruments, including sextants, astrolabes, nocturnals, and planispheres; learn about nonwestern, non-instrument Polynesian starpaths and Wayfinding; read quotations about navigation; check out some schools; or just go directly to the list of resources that lists the sources from other pages.

“The heavens call to you and circle about you, displaying to you their eternal splendors....”

— Dante, *Purgatorio*, Canto XIV



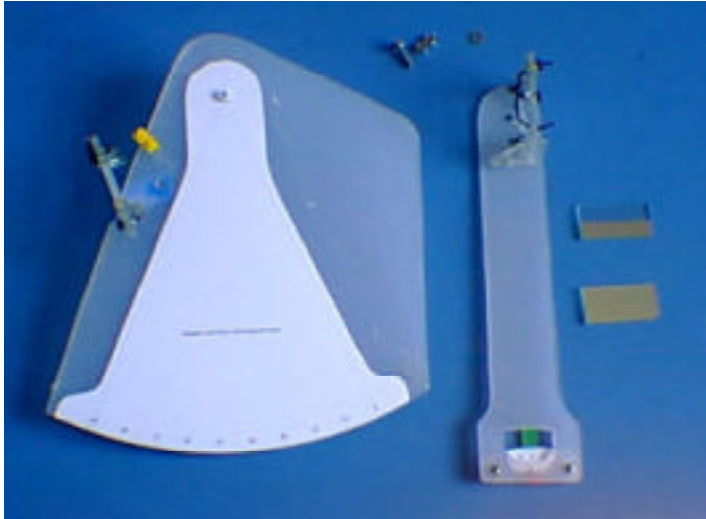
This astrolabe can be ordered from Celestaire Corp. at <http://www.celestaire.com/catalog/products/1701.html>

The Xtant Project

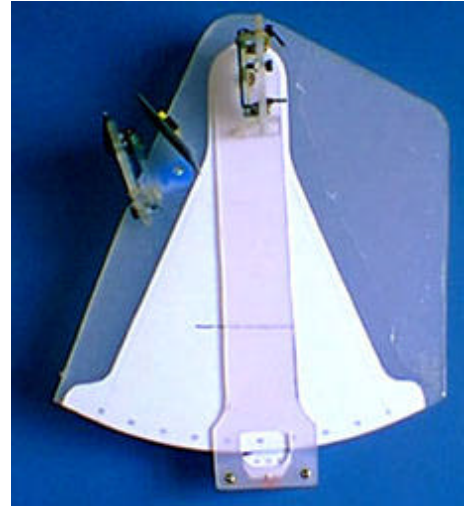
Build your own sextant

From time to time I get tired of writing abstract computer programs. This time I decided to do a more concrete project: a sextant (actually, an octant). I'm not a very experienced craftsman and don't have an equipped shop. The design is simple and can be reproduced with hand tools. I used a small jigsaw and a belt sander. I have made no blue prints.

In tests, when compared to a Davis plastic sextant, this octant did agree within six inches (see test results in the at the end of the article).



My octant parts ...

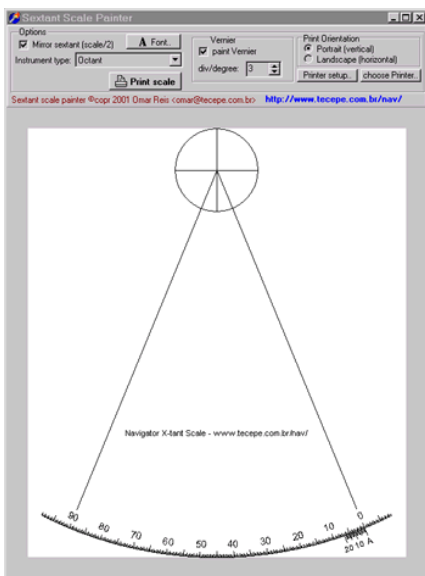


... assembled

Printing the scale

The scale is probably the most difficult sextant component to do using traditional techniques. It must be very precise and allow reading degrees and minutes, with accuracy at least within five feet of arc.

Fortunately, most of us have a precise printing equipment right on our desktop: an inkjet or laser printer. These machines can print 300 dots per inch (1,200 for laser), with enough precision to print a good sextant scale.



To the left, you see a screenshot of my XtantScalePrinter program. I used the default options in my project, but you may experiment with other designs (sextant types, ticks per degree etc.).

Laser or inkjet?

Laser printouts are more resistant to water than inkjet ones, and they have better resolution. Use a laser printer, if available.

But an inkjet printer will also do the work. If using an inkjet scale, protect it from water spray, either by adding a thin layer of transparent plastic or by taking extreme care with the instrument.

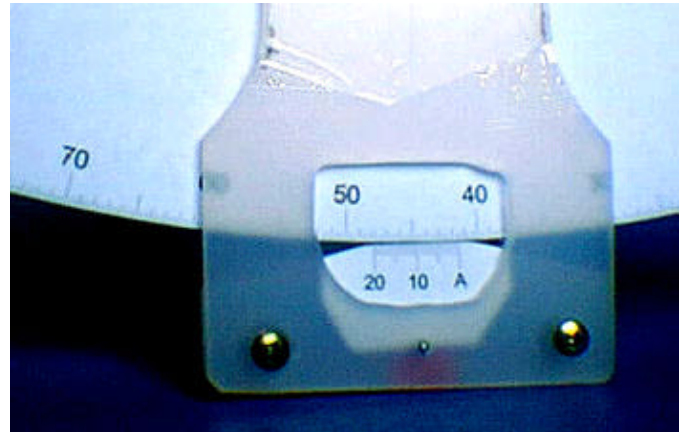
Sextant scale printer program

In order to achieve the best results, I wrote a small scale printing program. Please go to the web page to download this material.

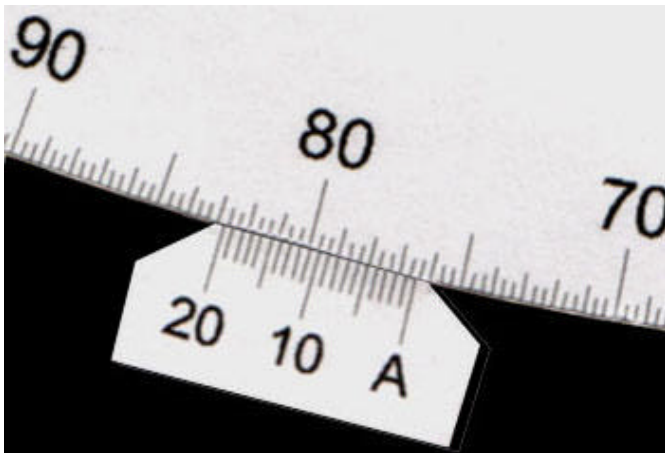
Since I didn't have the sophisticated machining equipment required, I discarded the idea of a drum sextant and went on to build a vernier scale sextant. Vernier sextants appeared before the modern drum sextants. In the vernier scale sextant, each degree in the scale is divided in three ticks (20' wide).

Access the complete article at:

<http://www.tecepe.com.br/nav/XTantProject.htm>



The Vernier scale

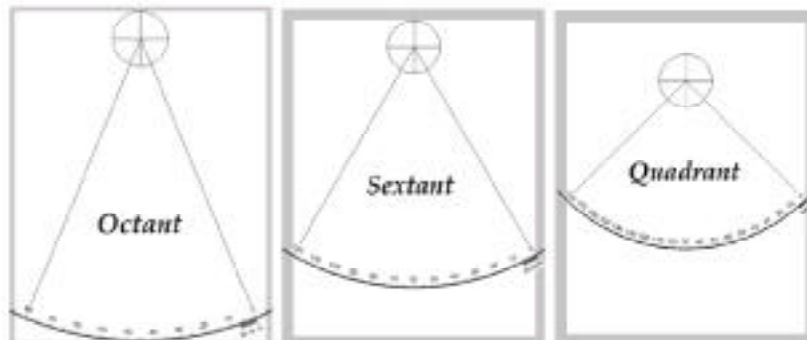


Vernier scale

The vernier scale precision can be as good as a drum scale. The only difference is that the vernier scale requires a much more delicate handling of the sextant arm while trimming.

Reading the vernier scale is easy, once you get used to it. In the scale to the left, the index reads 76° with minutes between 20' and 40' (tick A). In the vernier, we can see that the sixth vernier tick coincides with the index tick, so the reading is 76°26'.

Below are the three basic X-tant types. The octant can measure up to 90°, the sextant up to 120°, and the quadrant up to 180° (see below). I choose to build an Octant, since this design fits better in a A4 printer page, giving the largest possible degree size in the scale, for best detail. And the 90° scale is enough for most observations.



X-tant types

I used A4 inkjet sticker paper to print the scale (the ones used for printing labels). Choose a paper with no cuts. After printing the scale, check your printer's quality, using a compass to see if the index is a perfect circle segment.

Scale Transfer – An alternative way to print the scale was suggested by Mr. Schmit by email: “When you print documents with laser printers or photocopiers, it is done by fusing the toner on the paper. You can transfer the print on any solid heat resistant material by refusing the toner with a very hot clothing iron. Place the laser-printed document on the cleaned material (printed side facing the surface) then apply the iron on the paper back just long enough to melt the toner. I used that to make gratings and reticules on glass or metal sheets, and it works fine if your print is strong enough—but the print must be reversed!”

While this reversed print is not directly supported by the scale printer program, most printer drivers (e.g.: HP) offer this as an option. Open the “Printer Setup” dialog, click “Properties” and check the “reverse horizontally” checkbox.

Another way was suggested by Mr. Kunnar, “I used inkjet iron transfer paper. It is a kind of plastic that can be transferred to clothes using a hot iron. Since the ink ends up trapped between the sextant frame and the plastic layer, this scale is water proof.”

Instrument frame

I used a three mm thick acrylic board for the instrument frame. This material is easy to machine and relatively rigid. Acrylic boards are usually sold in large sizes, so you might want to search for someone who works with this material, in order to get the small piece you need with minimum expense.

The size of the sextant will depend on the printed scale size (that's why there is no blue print). So, you will only “design” the instrument after you have stuck the scale on the acrylic board.

The acrylic board comes with plastic layers in both sides for protection. It's a good idea to keep this protection as long as possible, because the acrylic will be easily scratched. I carefully lifted the plastic protection (see below), stuck the scale and put the plastic back in place, so the sextant scale was also protected while machining the frame.



Lift the plastic protection, adhere the scale, and put the protection back in place.

After printing, cut around the scale, leaving like three mm around the outside line.

Sticking the printed scale in the board is a critical operation. It must be perfectly stuck, free of air bubbles or ripples. Otherwise the scale will not be correct.



Remove the paper backing completely. Hold it with the two hands and gently place in the acrylic board, the arm axis circle first. Then use one hand to spread the scale, while holding the other side. Keep the paper slightly tensioned, but not so much as to distort it. If you make a mistake, you probably will have to print another scale and start again.

Frame, arm, and vernier, with cut lines.

After this, you can use a marker pen to draw the parts (frame, arm and vernier).

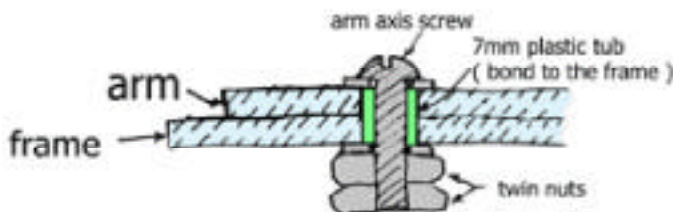
The arm window (where the scale is read) must be sized and positioned so that you can see both the scale and the vernier touch point (that will define the arm radius). My octant arm is about 40 mm wide.

When designing the arm, measure the scale radius and add 10mm on either side (towards and away from the arm axis). My arm window is 30 mm wide.

The image to the left shows the three frame parts, marked, and ready to be cut.

I cut the parts with a jigsaw with a thin-toothed blade. Take care when cutting along the scale ticks. Never cut across the scale line. If you are careful, you can cut as close as 0.5 mm from the scale. Then you will have little trouble sanding out the rest, until you precisely reach the fine scale line. Use fine sanding paper for finishing the scale arc.

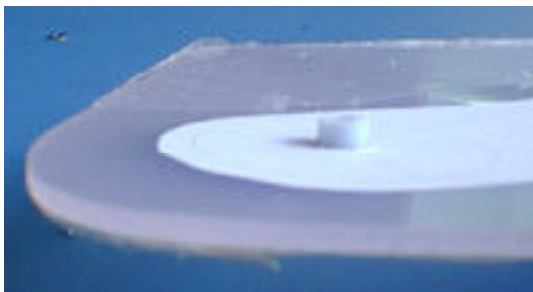
Also carefully cut and sand the vernier contact point, testing frequently against the scale arc. The vernier and scale contact must be as close as possible.



To drill the arm axis hole, first mark it with a hard point. Drill a two mm lead hole and then a seven mm hole. Use sharp drills. Do the same in the frame and make sure the hole center is precisely positioned.

I inserted a seven mm hard plastic tube in the axis, so there is no contact between the arm and screw as the arm is moved (only between the tube and arm). Bond the tube to the frame.

The axis screw goes in the middle, with twin nuts. Make sure there is no slack in the arm axis setup.



After cutting, drilling, and sanding, you can assemble the arm and frame for the first time. Then you can position and bond the vernier in the arm, using a couple small drops of loctite (Cyanoacrylate glue). Use small self-tap screws to secure the vernier.



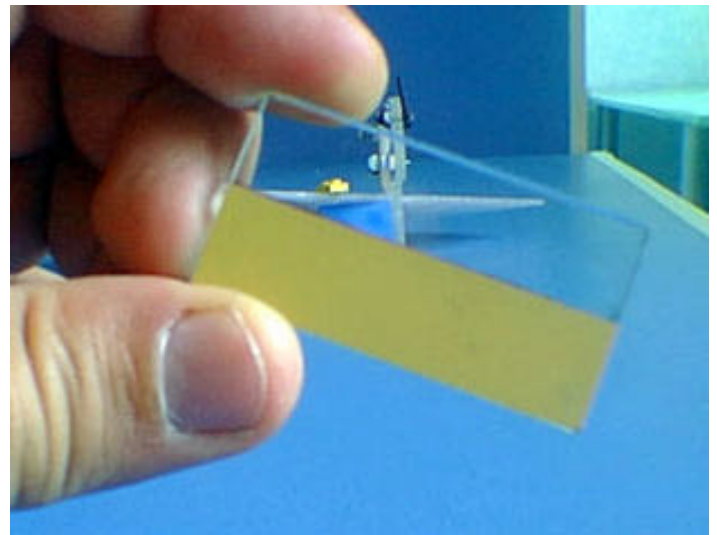
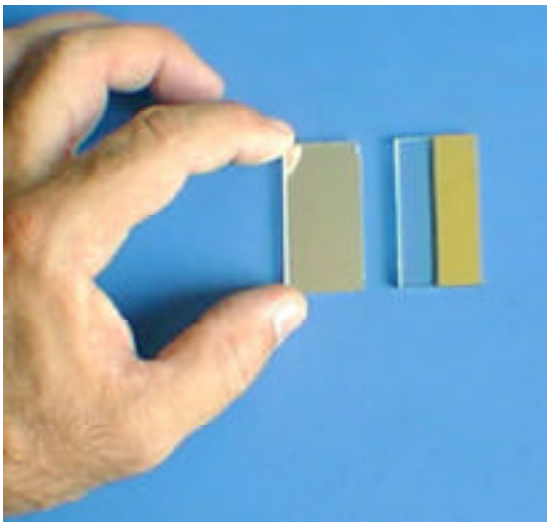
If you did these steps right, the vernier should be in smooth, close contact with the index, as you slide the arm along the arc.

Add a plastic device in the back of the arm to press it against the frame (the green part on the left image). It is important to have some friction between the arm and frame, so the instrument will hold the reading if left alone (i.e., the arm will not move by itself). This is also important for fine trimming.

Mirrors

I used two equally sized glass mirrors (46 mm x 24 mm, 3 mm thick). Any glass shop will cut these for you. As you know, one of the mirrors must be half silvered. So you must remove half of the mirror silver backing. I used a paper cutter blade for this job (Olfa cutter).

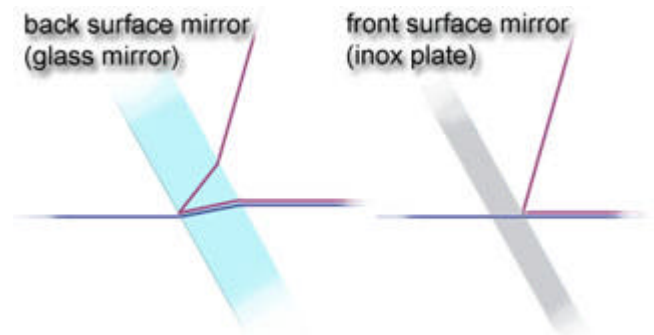
First make a sharp longitudinal cut along the middle of the mirror. Then scratch half of the epoxy protective layer from the back of the mirror, with the blade inclined. The epoxy backing is a hard material, but will come out with patience. Don't use any abrasive material or the blade point, to avoid scratching the glass. Once the epoxy is gone, the silver is easy to remove, rubbing hard with a wet cloth. In the end, the glass must be clear and scratch free (see Fig. below).



Mirrors

You may be tempted at this point to use a thinner mirror and eliminate the transparent part altogether. Don't do that. This would introduce a refraction error. The direct (horizon) light ray must pass through the glass, as the light ray from the star does.

This can only be done if you use a front mirrored surface, such as a polished inox plate.



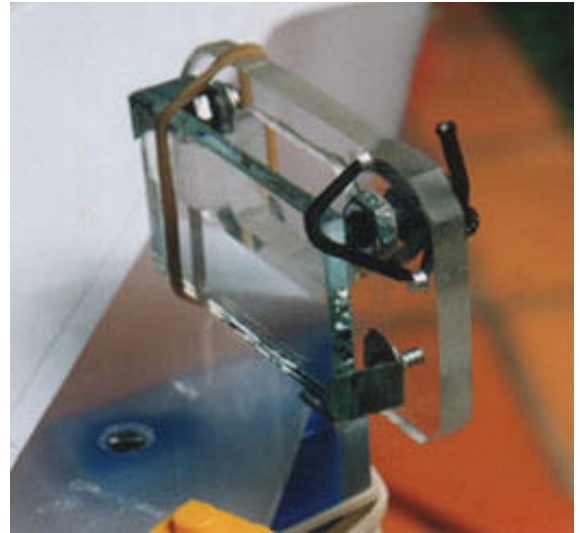
Mirror holders

I used a thicker acrylic for the mirror holders (4mm), as these parts are sometimes subjected to abuse. They will also have to be fixed with self-tap screws so a thicker material is better.

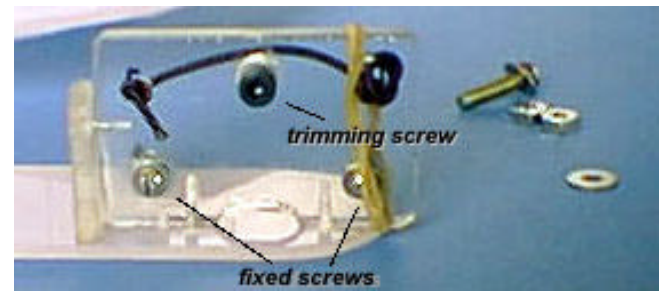
Both mirrors must be supported by three contact points (from geometry, we know that three points are required to define a plane). I used three supporting screws to position each mirror. Some of the screws are adjustable, for mirror trimming, and some are fixed. For the adjustable screws, I used Allen screws, which have large heads and are easy to turn by hand. The fixed points are regular inox nut screws.

Make a point in all screw tips, to reduce the contact area between mirror and screw to a point. I also added thin metal plates to prevent the mirrors from moving sideways while trimming.

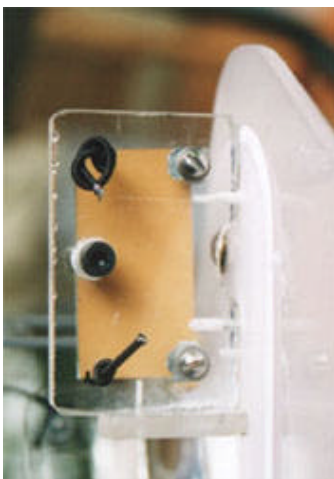
To ensure a perfect contact between the three screws and mirror, I used rubber bands. These press the mirrors against the screws. Commercial sextants use metal springs for this function, but I could not find any suitable part in my junk collection.



Arm mirror setup

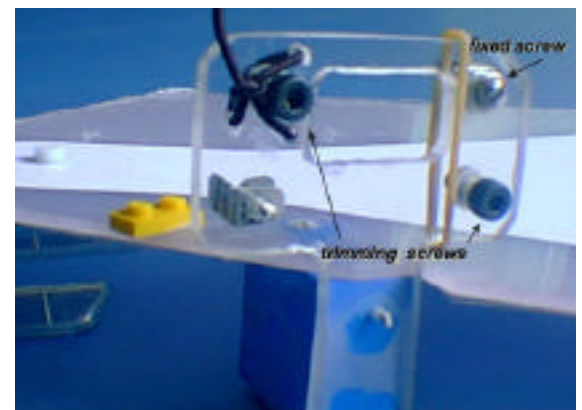


Backview



The *arm mirror holder* is basically a rectangle with a side supporting plate. The arm mirror has one adjustable screw (top screw in the figure above). Make a 1 mm deep housing for the adjustable screw nut and bond it to the acrylic, so it won't move when you trim the screw.

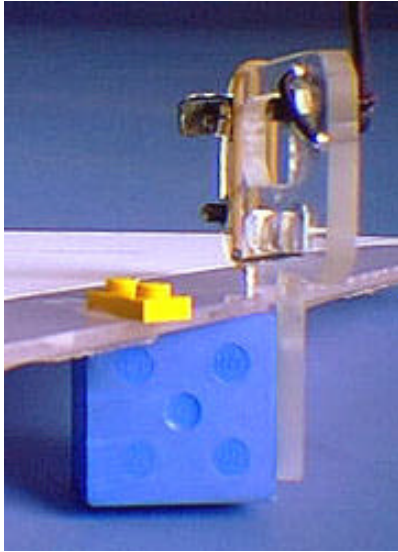
The *frame mirror holder* is a T shaped part, with two adjustment screws. Cut a window, so that the sight thru the glass part of the frame mirror is clear.



After completing the two mirror holder setups (i.e., after drilling, cutting, sanding, and securing the mirror screws), you can bond them to the frame and arm. Start with the arm mirror.

The arm mirror assembly must be positioned so that the center of the mirrored surface (the back surface of the mirror) is over the arm axis center. This way the center of the mirrored surface (i.e. the back of the mirror) remains fixed while the arm is moved.

Make sure you have space to introduce and remove the arm axis screw, or you won't be able to assemble and disassemble the arm. After bonding with Loctite, use small flathead self-tap screws to secure the assembly to the arm. Make a housing for the screw head to avoid interfering in the arm movement.



After securing the arm mirror assembly, set the arm to $0^{\circ}00'$ reading and place the frame mirror assembly parallel to the arm mirror. I used a Lego Duplo block (the large blue piece) to support the frame mirror assembly. This way the right angle between the frame mirror and instrument's plane is guaranteed.

I like to use Lego parts because they are widely available (at least in my house floor), have good dimensional precision and include all sorts of blocks and devices.

Make sure both mirror holders are firm by bonding and securing with screws. Having reached this point, you already have a sextant to take twilight sights. But you still need shades to take sun sights.

Shades

As shades for sun and moon sights, I used 35 mm dark negative photography film (there is one in the end of every film roll). The negatives were mounted in slide frames. I used double negatives for the sun frame and single for the moon.

Both slide frames are removable and are attached to the instrument frame using Lego blocks (the yellow one in the pictures above). I must say I'm not happy with this fixation solution. A more skilled (less lazy) craftsman would probably do a better job with some pivoting design.

The thing to watch here is the shade position. The filter surface must be orthogonal to the line connecting both mirror centers. This is to avoid introducing a refraction error. Try to position the slide center in the line connecting the two mirror centers.



Sun shade

Don't make the same mistake I did, letting the shade support interfere with the arm at large angles. The arm must go at least up to 90° (for the octant).

No eyepiece?

I was looking for a good 2x or 3x small telescope that I could use as an eyepiece for my sextant. I played with small toy telescopes, but results were poor. In the end, I decided to use no eyepiece. This actually gives a lot of freedom handling the sextant.

When taking a sight, remember to hold the instrument so that your eye is on a plane parallel to the instrument's and containing the fixed mirror silver-glass division. This is easy to find: Turn the instrument up until you face the fixed mirror. In this position, you should see half of your eye in the silvered part of the mirror. Move it sideways until you see it. Then turn the instrument back down to observation position.

Trimming the mirrors

Trimming this octant is no different than any other sextant. First trim the arm mirror adjustment screw. The arm mirror must be perpendicular to the arm/frame plane. This may be checked by looking at the index scale reflected in the arm mirror. The reflected index must be perfectly aligned with the index part you see directly (green arrow on the right).

Then trim the frame mirror. This is a little trickier, because two screws have to be trimmed simultaneously. Set the arm to 0°00' and point the instrument to a far object (like a star or boat far away). Then trim the two screws until the object remains a single image while you swing and rock about the instrument axis.



As future improvements, I would change to a better shade positioning system, add a nice handle and a case (I'm currently using a cardboard box). The case is probably the most important of the three, for a sextant – like a violin – is not be left hanging around if it is to last long.

There are many materials, design ideas, and garage junk devices that can be used to build a sextant. If you build such an instrument – using these ideas or not – I would like to hear about it. I would also be happy to publish other design solutions here.

A sextant is a fun thing to build, and getting a precise reading from your own instrument is one thing that will make you feel good.

Sextant field test

I did some tests comparing the same vertical angles, measured by three different instruments:

1. A Kern theodolite
2. A Davis MK15 plastic sextant
3. My Octant

The theodolite (a survey instrument) is presumably more precise than the sextants and was used as a benchmark. Sextant angles were corrected for index error. I measured four vertical objects, obtaining the following results:



Sun sight

Object #	Kern theodolite	Davis sextant		My Octant	
1	7°41'	7°42'	+1	7°42'	+1'
2	22°24'	22°19.5'	-5'	22°25'	+1'
3	41°37'	41°44.5'	+7'	41°42'	+5'
4	56°42'	57°01'	+19'	56°55'	+13'

Highlights from Recent Science-teaching Periodicals

from *The Physics Teacher*

— summaries available on-line at: <http://scitation.aip.org/tpt/>

“The Sparking Chaotic Pendulum: Trajectories of a Chaotic Pendulum Revealed” by Fabio Cássaro, et.al. Previously, *The Physics Teacher* articles described an easy way to create, using magnets, a pendulum that exhibits chaotic behavior. Another paper showed how a spark generator coupled to a spherical pendulum could be used to “trace” and study two-dimensional trajectories such as Lissajous patterns, ellipses, and circles.

In this paper, those two ideas were joined to develop an experimental apparatus, the “chaotic sparking pendulum,” that reveals chaotic two-dimensional orbits of a pendulum sliding over a set of magnets.

—Jan. 2004, Volume 42, Issue 1, pp. 47–48.

“Wheelies and Headers” by William M. Wehrbein

Where we determine the conditions required in order to keep both tires touching the ground at all times.

— Feb. 2004, Volume 42, Issue 2, pp. 27–30.

“Centrifugal Icicles and an Inertial Paradox” by Donald F. Collins

During a North Carolina ice storm, as freezing rain fell freezing on the perimeter of the spinning toy windmill, it formed unusual icicles radiating radially outward from the perimeter of the wheel (Fig. 1). “Although easy to understand from a conceptual standpoint” — centrifugal force, explanations from an inertial perspective prove to be very difficult, especially if one is reminded of the tendency of water drops to actually follow tangential trajectories when the water breaks away from a spinning wheel.



— Feb. 2004, Volume 42, Issue 2, pp. 79-81.

“Rollover of Sport Utility Vehicles” by Desmond Penny

Despite their rugged image, SUV’s have caused persistent safety concerns about rollovers. In light of recent documentaries on the issue of SUV rollover accidents, this article examines types of rollovers (tripped and untripped) and the physics of Static Stability Factor (SSF), and although the US-DOT rating system is a good first step, it is insufficient. The NHTSA has been charged with developing and implementing a dynamic on-road handling test to gauge and score rollover propensity.

— Feb. 2004, Volume 42, Issue 2, p. 86-91.



“Trick of the Trade—Conservation of Angular Momentum with a Plastic Dish” by Adolf Cortel

How to demonstrate conservation of angular momentum—the fact that the direction of the axis of rotation does not change—using only a thin and flexible rod, an ordinary dish, and a cheap fan

— Feb. 2004, Volume 42, Issue 2, p. 122.

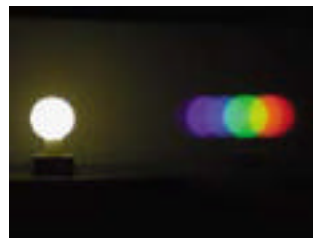
“Outdoor Vector Lab” by Paul Erdman

A vector lab that focused on reinforcing the concept of length and direction of vectors, Erdman describes an outdoor lab exercise that forces students to use vectors in the solution of a location problem that is more challenging than it first appears (finding distance between two points that are on opposite sides of a building).

— March 2004 Vol. 42, No. 3, p. 146–148.

“Compact Fluorescent Lamp Observed Through a Diffraction Grating” by L. M. Gratton, M. Perini, and V. Zanetti

This article examines interesting and unexpected color phenomena from a compact fluorescent lamp observed through a diffraction grating. Viewed close to the lamp, some of the different colored images become superimposed. Colors seen in the overlapping areas are quite different from those of the original disks. The appearance of these new colors has to do with how we perceive color.



— May 2004, Vol. 42, No. 5, pp. 270–271.

“A Big Sunbird” by J. Güémez, R. Valiente and C. Fiolhais, M. Fiolhais

After explaining how to construct a bobbing ‘drinking bird’ toy apparatus, its thermal physics and the work done while bobbing is analyzed.

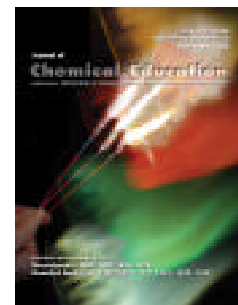
— May 2004, Vol. 42, No. 5, pp. 307–309.

In *Physics Today* July 2003, we have a fascinating account of the life and work of Marie Curie, from the Journal of Chemical Education on-line at: <http://jchemed.chem.wisc.edu/>

“The Chemistry of Photographic Color Dye Formation by Bruce E. Kahn “

This piece describes laboratory activities converting black and white photographs to color images in a variety of ways, involving a number of chemical concepts such as oxidation/reduction, stoichiometry, acids and bases, pH, nucleophilic reactions, conjugation, complexation, solubility, and reversibility.

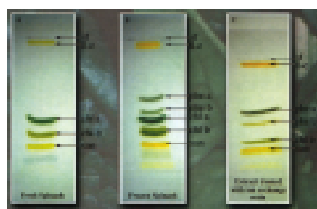
— May 2004, Vol.81, No 5, p 693.



“Quantitative Assay for Starch by Colorimetry Using a Desktop Scanner”

A procedure to produce a standard curve for quantification of starch concentration using colorimetry. The colorimetry is performed by image analysis of a picture of solutions obtained using a desktop scanner. The analysis is performed using a Visual Basic computer program (COLORS.EXE) that measures red, green, and blue pixel intensities from the image.

— May 2004, Vol.81, No 5, p702.



“Chromatography of Spinach Extract” Plant Pigments in Spinach. Three thin-layer chromatography plates show the separation of plant pigments in various spinach extracts. The separated pigments are xanthophyll, chlorophyll a and b, pheophytin a and b, and β -carotene. A direct method of extracting plant pigments from spinach leaves into a dry organic solvent and the subsequent chromatographic separation of the pigments is described in the article “An Improved Method for the Extraction and Thin-

Layer Chromatography of Chlorophyll a and b from Spinach” by Hao T. Quach, Robert L. Steeper, and G. William Griffin.

— March 2004, Vol.81, No 3, p385.

“Water, Arsenic, electrochemical removal of metal cations”

— Feb. 2004, Vol.81, No 2.

“Chemistry Perfumes Your Daily Life” by Anne-Dominique Fortineau, at Quest International (one of the big fragrance companies).

A very readable summary of the basics of fragrance and perfumes (relevant to grade 9 block topic on: chemistry of natural products).

— Jan. 2004, Vol. 81, No 1, p 45.

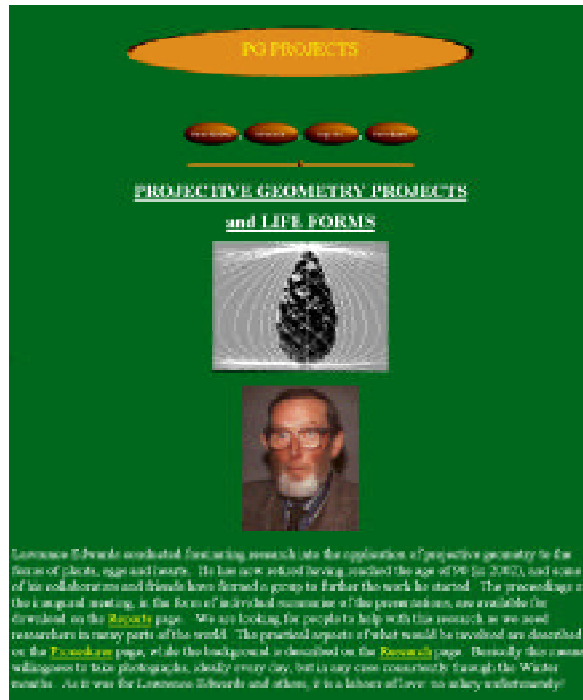


Websites of Interest

The Vortex of Life website

This web-site ><http://www.anth.org.uk/vortexoflife>< has a wealth of information on the Path Curves—mathematical forms investigated by Lawrence Edwards and published in his book “The Vortex of Life” (formerly “Field of Form”) by Floris Books (1993) ISBN: 0-86315-148-5. Unfortunately, it is now out of print—perhaps some copies are still available in your local anthroposophical bookshop.

The web pages include a brief but clear introduction to path curves, as well as the fascinating ongoing research work of several people investigating how path curves occur in Nature.



Some very useful resources available on this web site include:

Instructions on “Photographing

Instructions on “Photographing Leaf Buds” by Graham Calderwood—these documents are available for download (in Microsoft Word-6 format):

Practical Bud Observation, Measurement and Analysis Part 1 (63k); *Part 2* (128k)

Software

Graham Calderwood has developed a sophisticated “Bud Workshop” program which can be used to analyze the scanned photographs, as well as saving results in a data archive (for later trends analysis). This software program is available for download by interested researchers. Until now, he was the only one using it for bud path-curve analysis, but it is hoped this tool will be used by more researchers to do their own analyses. If we increase the number of researchers—as we hope—it will become too much for one part time person! However, the purpose of the whole exercise would be lost if these results were not consolidated with those of other people, as the “Aggregate-Graphs” of phase-shifts (time-trends) which have proved so informative, depend upon that. More on that if you join us!

Download basic bud workshop at:

<http://www.anth.org.uk/vortexoflife/Procedures.htm#Software>

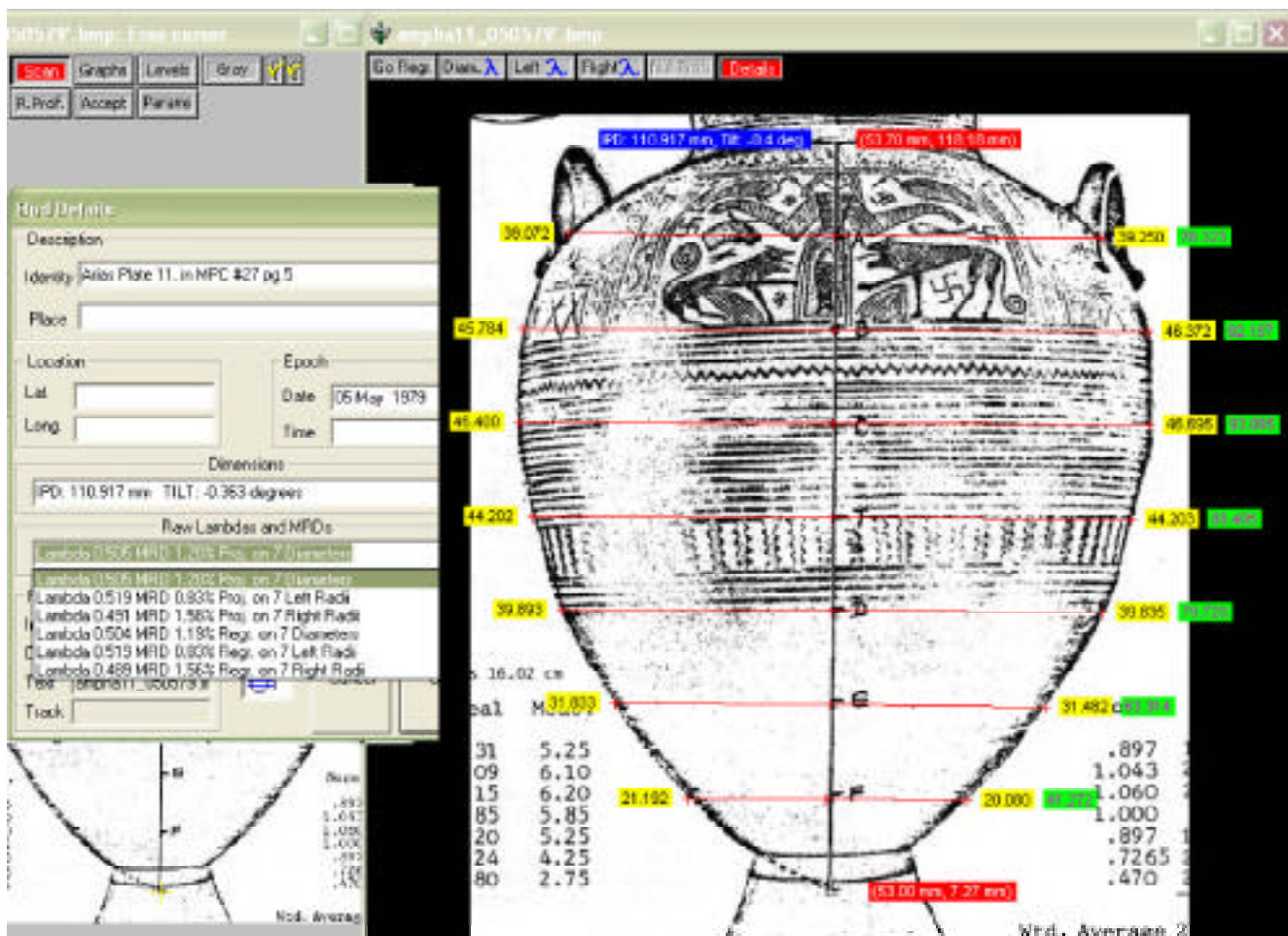
Windows Program (582Kb); optional help files (159Kb) optional WAV files (1.1Mb)

The above are ZIP files which need expanding. The WAV files are for verbal advice/comment

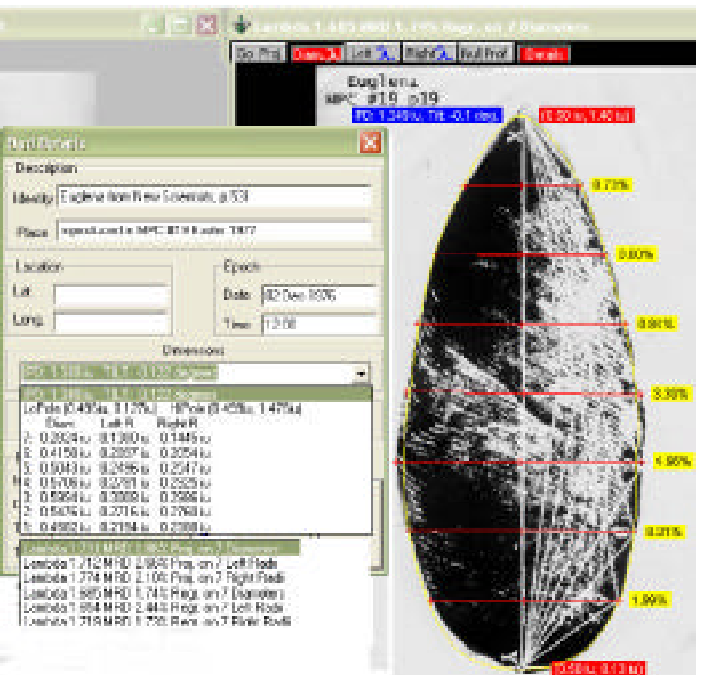
*Note: the EXE file available at present is an older Oct-2002 interim version; if you intend to use it regularly, contact G. Calderwood for a more recent version if for no other reason than to get the complete help files <graham@gcalderwood.freemove.co.uk> .

The BUD-WORKSHOP program will load TIFF or JPEG graphic images, and allow one to easily analyze the dimensions of the form, calculating the path curve lambda-value (by the L. Edwards' original "projective method" as well as the "least squares" method developed by Barry Christian). Some examples of its results are shown in the illustrations below.

The duck egg-forms are taken from illustrations in Lawrence Edwards book. Analysis using BUDWORKSHOP shows similar results to ones Edwards reported in his book.



The interesting analysis of Greek amphora that was described in Steven Eberhardt's Mathematical Physical Correspondences, (see the back issue from May 1979) is shown (right). Again, the analysis is very easy in BUDWORKSHOP, and yields results corresponding to the ones reported in MPC.



Index of Past Issues

Waldorf Science Newsletter: edited by David Mitchell & John Petering

This newsletter is published twice each year and is dedicated to developing science teaching in the Waldorf schools. Teachers are invited to pose questions, seek resource material, discuss experiments, write about their classes (successful and not very successful), and investigate phenomena. The editors also translate relevant science articles from Waldorf periodicals from around the world. The following past editions are available from:

AWSNA Publications	e-mail awsna@awsna.org
3911 Bannister Road	fax: 916/ 961-0715
Fair Oaks, CA 95628	phone: 916/ 961-0927

Available from www.awsna.org on-line at: http://www.awsna.org/books_sciencenews.htm

Volume 1, #1

Partial contents – Acoustics in Grade 6; Teaching about Alcohol in Grade 8 Chemistry; The Chemistry Curriculum: The Debate over Teacher Demonstration vs. Student Experimentation; Spiritual Aspects of 20th Century Science; Overview of the Waldorf Science Curriculum; Water; Characteristics of the Major Sugars; Goethe's Meditation on Granite; Book Reviews; Humor; Poetry; Conferences; and Sample Experiments

Volume 1, #2

Partial contents – The Characteristics of Drugs; Eratosthenes Revived; The Golden Number; Educational Guidelines for a Chemical Formula Language; The Properties of Acids and Bases; Walter Lebedörfer on Chemistry; Biology in the 11th Grade; What Is Home?; the Waldorf Environmental Curriculum; Environmental Education; Women in Science; Book Reviews; Humor; Poetry; Conferences; and Sample Experiments

Volume 2, #3

Partial contents – Grade 12 Physics – Von Mackensen; Biology Teaching in the 11th Grade; Euclid's Algorithm; The Logos and Goethean Observation; Nature Education; Aristotle's Taste Spectrum; Book Reviews; Humor, Poetry; Conferences; and Sample Experiments

Volume 2, #4

Partial contents – Current Research; Strange Theories; Science Education and Wonder; The Human Earth; Steiner's Counterspace Examined; The Cow; Language and the Book of Nature; Book Reviews; Humor; Poetry; Conferences; and Sample Experiment

Volume 3, #5

Partial contents – Book Reviews; First Lessons in Astronomy; Steps in the Development of Thinking (Power of Judgment); Computer Science and Computers in the Waldorf School; Technology; Computers in Education; Some Characteristics of the Computer; Computers and Consciousness; Experiments

Volume 3, #6

Partial contents – Space and Counter Space; New Eyes for Plants; Experiments of Academia dell Cement; Physics and Chemistry in the Grades; Goethean Science Credits; Chemistry Workshop; Table of Important Salts; Goethe's Scientific Imagination; To Infinity and Back in Class 11; π and Trigonometry; Science in the Waldorf Kindergarten; A Note on Pascal's Triangle; Experiments

Volume 4, #7

Partial contents – The Message of the Sphinx; Honey; Cell Cosmology; Einstein's Question; What is Goethean Science?; Prototype Computer Program; River Watch as a Classroom Activity; Thoughts on Curriculum Standards; Comments on Building a Waldorf School; Experiments

Volume 4, #8

Partial contents – Towards Holistic Biology; How DNA Computers Work; Solar System Facts; What is Goethean Science?; Human Movement and the Nervous System; What Is Science?; What Is Meant by “Teaching the Children to Breathe?”; Experiments

Volume 5, #9

Partial contents – The Globe Inside our Planet; Music, Blood and Hemoglobin; Standards in Science; Cognitive Channels—the Learning Cycles and Middle School Students; 8th Grade Physics, From Dividing to Extracting Roots; What is Lambda?; Waldorf Science Kits

Volume 5, #10

Partial contents – Reading the Rocks; Why the Arts are Important to Science; The Three Groups of Rocks; Introduction to Geology; The Rock Cycle; Mineralogy for Grade 6; Metals and Minerals, Precious Stones—Their Meaning for Earth, the Human Being, and the Cosmos; Experiments

Volume 6, #11

Partial contents – A Chemistry of Process; Sponges and Sinks and Rags; How to Read Science; Experiences and Suggestions for Chemistry Teaching; Experimentation as an Art; Biographies—Dmitri Mendeleev, Joseph Priestley, Marie Curie; Destructive Distillation; Experiments

Volume 6, #12

Partial contents – Light and Darkness in 6th Grade Physics; The Relation of “Optical Elevation” to Binocular Vision; Description of Curves in Connection with Elevation Phenomenon; Water Treatment at the Toronto Waldorf School; A Lime Kiln that Can Be Assembled and Disassembled; Experiments

Volume 7, #13

Partial contents – Thoughts on Returning to an “Education Towards Freedom”; Pedagogical Motives for the Third Seven- Year Period; Social Education through Mathematics Lessons; A Vision for Waldorf Education; Our Approach to Math Doesn’t Add Up; International Mathematics Curriculum

Volume 7, #14

Partial contents – Conferences; Physiology, Update on Taste; Pictorial Earthquake; Boiling with Snow; Towards a Waldorf High School Science Curriculum for the 21st Century; The Thermal Decomposition of Calcium Carbonate; Crystal Reveals Unexpected Beginnings; Cosmic Ray Studies on Skis; Experiments

Volume 8, #15

Partial contents – Book Reviews; Arabic Science; Arabic Mathematics: Forgotten Brilliance; Making Natural Dyes; Exploring the Qualities of Iron; Von Mackensen Chemistry Conference; Oxalic and Formic Acid; Hydraulic Rams; What the Water Spider Taught Me

Volume 8, #16

Partial contents – Waldorf High School Research Papers; Inside the Gulf of Maine; How Do Atomistic Models Act on the Understanding of Nature in the Young Person?; The House of Arithmetic; Origami Mathematics; Sixth Grade Acoustics; Sixth Grade Kaleidoscopes; Tricks with Mirrors; The Flour Mill and the Industrial Revolution; Web Gems; Understanding Parabolic Reflectors; The Capacitor; Oscillation and Waves; Crystal Radio; Qualifications for High School Mathematics Teaching

Volume 9, #17

Partial contents – Book Reviews; Acknowledgement from a Waldorf Parent; Raising Money for Science; the Twelve Year-old Child and Orpheus; Towards a Sensible Kind of Chemistry, Part One ; The Lightning Bug; The Ladybug; Exploratory Experimentation: Goethe, Land, and Faraday; Faraday’s Synthetic Investigation of Solenoids; Faradays Analytic Investigation of Induction; Geometric Addition Table: A Curious Configuration;

Volume 9, #18

Partial contents – Book Reviews; Towards a Sensible Kind of Chemistry, Part Two; The Evolution of the Fast Brain; Professors Vie with Web for Class Attention; The Teenage Edge; Oscillator Coil Demonstration Using an Ultra-Low Frequency LC- “Tank” Circuit; Thermodynamic Experiments for the Middle School.

Volume 10, #19

Partial contents – Book Reviews; The Beaver; Nature in the Human Being; Astronomy Verses for the Middle School; Child Development and the Teaching of Science; Bibliography for Middle School Teachers; What is Phenomenology?; The Design of Human and Animal Bodies; The Brain and Finger Dexterity; Observations of a Neurophysiologist

Volume 10, #20

Partial contents – Book Reviews; A Number Story for the Six table; Trigonometry; An Introduction to Sine and Tangent; Toss Out the Toss-Up: Bias in Heads-or-Tails; Phlogiston Theory; Song of Rain; Refrigeration in Physics – Heat Studies; The Poetry of Astronomy; Build Your Own Sextant; Highlights from Science Periodicals, Websites of Interest